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GIOVANNI MARIA GIORGI (*)

Bibliographic portrait of the Gini concentration ratio (**)

CONTENTS: 1. Introduction. — 2. Genesis. — 3. Evolution. — 4. Estimation from grouped data. — 5. Sampling properties. — 6. Decomposition. — 7. Some extensions and interpretations. A selected bibliography. Summary. Riassunto. Key Words.

1. INTRODUCTION

At the meeting of the Royal Venetia Institute for Science, Letters and the Arts on 29th March 1914, Corrado Gini presented a paper entitled "Sulla misura della concentrazione e della variabilità dei caratteri" in which he introduced his concentration ratio, R. More than 75 years later, this index is still extremely relevant and widely used, not only in economics but also in other sectors and for completely different purposes. This has been largely due to the new and original interpretations and extensions suggested by different authors, which have rekindled its fame, making it a modern and practical instrument of analysis.

Some of the many reasons for the success and the relevance of the Gini index are its simplicity, certain interesting properties and useful decomposition possibilities and these have been analyzed in a

(*) Istituto di Statistica, Facoltà di Scienze Economiche e Bancarie, Piazza San Francesco 17, 53100 Siena, Italy.

(**) This paper, based on a critical analysis of 385 bibliographic references, is preliminary to a broader study (partially financed by the Italian Ministry for Education) on the foundations of the concentration ratio, which is the subject of a monograph of over 300 pages, by the same author, soon to be published.

previous paper (Giorgi 1984b). Relations linking the Gini ratio to the Lorenz curve and the mean difference have made it possible to extend the results of both to R and to make new extensions. The controversies periodically provoked by the concentration ratio have certainly contributed to its success and brought it up to date, and in this sense have gone contrary to the intentions of its opponents. For instance, after the article by Atkinson (1970) criticising the Gini index on utilitarian grounds, the limits of which are well known and have been clearly indicated by Sen (1972, p. 344), there was a proliferation of studies on R, not only to justify its traditional use, but also to recover and exploit the most unthought-of characteristics. In truth, however, some supporters of the concentration ratio go to similar extremes to prove their points.

It emerges from the present study that the Gini index is an index like any other as sustained by Benedetti (1980a, p. 27), with its advantages and disadvantages, and that its success and notoriety have developed over the years as the result of a series of events.

The aim of this study has been to critically examine the concentration ratio and its evolution, and to invite a more attentive and precise evaluation of the international literature (including foreign language papers). It is also hoped that this study will be invaluable to those who, approaching the complex and far-reaching questions connected with the Gini index, might otherwise feel discouraged or lost in the face of the enormous amount of literature.

The selected bibliography is taken from personal archives containing more than 700 journal articles, working papers, research reports and monographs dealing with the concentration ratio, the Lorenz curve and the mean difference from a variety of viewpoints. This literature forms the basis of a monograph soon to be published.

In order to keep this paper within the editorial and typographic limits of the journal, only 385 of these papers were considered. In most cases, papers concerned with simple applications or which do not clarify previous results or introduce new elements have been excluded. Articles on the Lorenz curve and mean difference or generic papers on the measurement of concentration and inequality without direct and explicit reference to the Gini index have not been considered. On the other hand, several articles dealing only marginally with R but giving its explicit formula for certain principal theoretical distributions, have been included.

2. Genesis

Careful consideration of the literature suggests that the concentration ratio, R, is the result of a series of studies performed by Corrado Gini on the measurement of the concentration of wealth and income. He first examined the question in 1909 (Gini 1909), proposing an index δ for describing the relations between social classes and distribution of wealth. His next study (Gini 1910) went deeper, laying the foundations for the theory of concentration, which he took up again (Gini 1914) and related to the concentrations curves (1) and the mean difference, deducing the concentration ratio. Between 1910 and 1914 Gini made a detailed study of variability, introducing the mean difference Δ into statistics (Gini 1912). This index plays an important role in later studies on R, especially as regards inferential aspects and certain interpretations. However the mean difference was not completely new, since it had already been used long before by certain German astronomers (2) in the study of the theory of observation errors. Gini ascribed great importance to the mean difference, considering it to be particularly useful in the study of certain phenomena, such as wealth and income, for which the analysis of variability improves if an index like Δ, which reveals the intensity of the difference between effective quantities, is used. In this context and in an attempt to obviate certain disadvantages of the index δ (which he nevertheless considered to be better than Pareto's α) Gini (1914) deduced the concentration ratio. As usual, he developed his argument fully and clearly, not restricting his description of the new index to analytical terms, but showing its relation to the Lorenz (1905) diagram and the mean difference (3). He gave special algorithms for

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(1) By convention, I shall refer indifferently to the concentration curve or Lorenz curve, since, to quote Pietra (1917, p. 315), it is "the same curve arranged this way or that, depending on the choice of axes".

(2) For the bibliography of the German astronomers (Jordan, von Andrae and Helmert) on the subject and for several comments, see Gini (1912, pp. 58-59).

(3) Precisely this link with mean difference directly and indirectly led R into an endless debate on the use of certain variability and concentration indices and on the paternity of certain theoretical results inherent to them. For details see Bresciani Turroni (1916, 1936), Ricci (1916) Pietra (1917, 1931a,b, 1935a,b, 1937), Bortkiewicz (1931a,b), Gini (1931a,b), Savorgnan (1931), D'Addario (1934), Mortara (1935), Castellano (1935).

the calculation of R from grouped data and examined the influence that lower truncation of the distribution (4) may have on R, illustrating his arguments with appropriate empirical applications.

3. Evolution

Soon after the publication of Gini's article (1914), many studies developing the theory behind the concentration ratio and its possible applications appeared in the literature. Within a few months, two scientific communications by Pietra (1915) were published in which the Lorenz curve was defined for the first time in the continuum, and the graduation function, known also as the inverse of the cumulative distribution function, introduced. In the framework of the concentration diagram, the relations between the mean deviations from the mean (S_μ) and median (S_{me}) and the concentration area emerged, along with a geometric interpretation of $R = \Delta / 2\mu$, $I_\mu = S_\mu / 2\mu$, $I_{me} = S_{me} / 2\mu$ (5). The range of these indices, the causes of their discordance (6) and the limits of this discordance were also determined.

Since the concentration ratio may be expressed as relative mean difference, i.e. as ratio between Δ and its maximum, another line of research was directed to the determination of maxima of Δ and other variability indices in special cases. Gini took up the question, extending his previous results (Gini 1912, p. 80) to upper (Gini 1930) and to lower bounded variables and variables bounded at both ends (Gini 1932, pp. 28-36). Galvani (1932) then established the transformations to apply to the parametric equations of the Lorenz curve in the above three cases, so that R can always be calculated as ratio between the concentration area and the theoretical area of the triangle of maximum concentration. Many years later, the question was resumed by Bellettini (1954b) who formulated a more general scheme.

In order to identify a relation between R and other concentration

(4) For the effect on R of truncation of the distribution, see for example Bhattacharya (1963), Rodriguez Ponga (1976), Ord et al. (1983), Bhandari (1986) and Fichtenbaum & Shahidi (1988).

(5) Later Bellettini (1954a) expressed these indices in trigonometric terms.

(6) The problem of discordance among concentration indices and among variability indices is a difficult one; see detailed study by Zanardi (1985, 1986).

indices, other authors devised algebraic expressions of the original formulae or deduced these indices from the same general expression. Those expressing the concentration indices in terms of mean values (7), for instance, belong to the first case, e.g. De Vergottini (1940), Amato (1947), Fortunati (1955). Instead the work of Amato (1948, p. 509), Giaccardi (1950a,b) and De Vergottini (1950) (8) belongs to the second case. More recently, this theme was taken up again by Benedetti (1980a) who drew attention to a general formula which he derived at the beginning of the fifties but which was not published at once because, according to the author, Gini was hostile towards anything tending to depreciate his concentration ratio or likening it to other indices. In turn, Buscemi (1980) proposed an algorithm of the Giaccardi-Benedetti type from which an even greater number of concentration indices could be derived.

Among the contributions tending to extend the work of Gini, there is the noteworthy paper by Zanardi (1963) deriving the so-called mean deviation curve from the Lorenz curve and increasing the investigative possibilities of R. With this generalization he introduced the k-order concentration ratio and a new and original interpretation of R (Zanardi 1965a).

There have also been attempts to obviate certain disadvantages of R. To overcome its insensitivity to changes in low incomes, Michal (1978) weighted the standard formula with marginal utility of income, whereas Kakwani (1984b) proposed a generalization of the Gini index based on the relative deprivation curve. On the other hand, in order to gain extra information when R assumes the same values for different distributions because the intersections of the Lorenz curves enclose the same concentration area, Giurovich (1959) proposed an index of asymmetry of the Lorenz curve. This line of study was also followed by Zanardi (1964) who, besides deriving the indices aimed to measure the displacement of the Lorenz curve from the condition of maximum height which corresponds to the median ordinate, also introduced (Zanardi 1965c) a new measure of statistical asymmetry of

(7) For a detailed treatment of features inherent to the concentration ratio expressed as a function of mean values, see also Fortunati (1957, 1961, 1963, 1965) and De Simoni (1966a,b, 1967a,b,c,d).

(8) From the general formula of De Vergottini (1950, p. 453) it is deduced that the Gini index can be expressed as the product of a constant term, the coefficient of variation, and the coefficient of linear correlation.

the Lorenz curve (see Tarsitano 1988b). Hagerbaumer (1977) added another algorithm to R to measure the relative position of the poor. Patino (1977) in turn defined an index D, with its maximum and range (Patino 1980), to add to the concentration ratio. Dividing the Lorenz curve in two parts, this auxiliary index D specifies the differences in shape of the parts and the size of the difference as the ratio of semi-areas of concentration to maximum area. A further index of asymmetry of the Lorenz curve was obtained by multiplying D by a proportionality factor (Patino 1978). Finally Koo et al. (1981) divided the Lorenz curve into uniform intervals and proposed Lorenz coefficients based on this division, expressing R as the weighted mean of these coefficients (see also Thon 1983; Koo et al. 1983).

4. Estimation from grouped data

Although the concentration ratio has been used in many fields, its main application has been in the study of income and wealth. For reasons of confidentiality, the official statistical agencies publish this data in grouped form. Gini also tackled this aspect (1914, pp. 1211-1223) and depending on the information available, proposed different formulae for the calculation of R from grouped data and devised solutions to the problems arising when the lower limit of the first class and/or upper limit of the last class are not known. Using empirical tests (Gini 1914, p. 1213) he showed that the bias of the estimate of R increases with increasing concentration and increasing width of the classes.

A first method of estimating the concentration ratio is based on the hypothesis that all members of a given class earn the same income. This procedure, known as the trapezoidal rule underestimates R. A second method consists in assuming that the character in question has a certain type of distribution and the inequality index is obtained from the parameters of the fitted function. A third method consists in assuming a certain type of distribution for each interval and the inequality indices are calculated by linking the assumed functions. In particular, Kakwani (1976a) proposed the use of a Pareto curve in the first and last income classes, which are generally openended.

A distribution-free approach to the calculation of R from grouped data was proposed by Gastwirth (1972) and consists in determining the lower and upper bounds on the concentration ratio rather than a single value. This method is especially useful if the bounds are narrow (9). Giorgi & Pallini (1987a) pointed out that Gastwirth was preceded by Pizzetti (1955) in the determination of the upper bound on R, and that both used algorithms which are not rigorously correct in mathematical terms. Mehran (1975a) estimated the above bounds by a geometric method using only the observed points on the underlying Lorenz curve. Although this procedure gives slightly wider bounds than the method of Gastwirth, unlike the latter, it can be applied even if the mean income and the limits of the classes are unknown. Later Nygard & Sandström (1981, pp. 297-298) used the secant method to determine the upper bound. Murray (1978) in turn derived the maximum and minimum values of the Gini index when the mean income of each class is unknown but the mean income of the population is known. Finally Bomsdorf (1989) suggested methods for calculating the bounds when information is incomplete in various ways.

On the basis of relations between R and the standard deviation, the coefficient of variation, the mean deviation from the mean or median, the moments expressed in a certain way or with geometric-type relations, different authors have proposed other bounds on R, e.g. Piesch (1975, pp. 196, 198), Gastwirth & Krieger (1975), Krieger (1979), Moothathu (1981, 1983), Bhandari & Mukerjee (1986), Rigo (1985, 1987), Giorgi & Pallini (1986, 1987a, 1989a,b), Pallini (1988).

Cowell & Mehta (1982) provided a theoretical and empirical support for the so-called "1/3, 2/3" rule which permits point estimates of R from its standard grouping bounds.

The inferential use of bounds on the concentration ratio derived from sample data necessitates condideration of the sampling variation, as shown by McDonald & Ransom (1981) and Gastwirth et al. (1986). In the latter article, the authors also obtained the asymptotic distribution of the bounds for random samples grouped in classes.

Many other methods have been proposed and used to improve the estimation of the concentration ratio from grouped data or to simplify calculation, e.g. Brittain (1962), Förster (1972), Gastwirth & Glauberman (1976), Kakwani & Podder (1976), Fuller (1979),

(9) Gastwirth & Smith (1972) also proposed the use of these bounds to test the fit of a distribution to grouped data. This method was later criticised by Dagum (1980).

Bomsdorf (1982), Brown & Mazzarino (1984), Piesch (1985), Silber (1990). The attempts to optimize grouping of Aghevli & Mehran (1981), Aggarwal (1984) and Davies & Shorrocks (1989), are of special interest.

Other authors have analysed the different methods (parametric and non parametric) of estimating R, using empirical and theoretical-methodological comparisons, e.g. Petersen (1979), McDonald (1981), Chakrabarty (1982), Latorre (1986), Schader & Schmid (1988), Maurer (1989).

5. Sampling properties

If valid information is to be obtained from sampling data, it is necessary to know the sampling properties (10) of the statistic R_n used to estimate the concentration ratio R. In order to evaluate, albeit approximately, the reliability of the sampling estimate, certain authors have determined the sampling variance $V(R_n)$ of the Gini index. For discrete distributions, the question was tackeld by Michetti & Dall'Aglio (1957) and later, using different approaches, by Glasser (1962) and Cucconi (1965). The latter considered a finite population in which the character is grouped in classes.

The sampling variance of R_n is also determined for specific distributions; for instance for the *Pareto distribution,* Michetti & Dall'Aglio (1957, p. 231, 241-244) derived an approximate algorithm for $V(R_n)$, and Girone (1968) studied the sampling distribution of R_n by the Monte Carlo method. Moothathu (1985a) determined the exact sampling distribution $f(R_n)$ and the moments of the maximum likelihood estimators of the Gini index, demonstrating their asymptotic normality (see also Latorre 1987).

For samples drawn from an *exponential distribution,* Girone (1971) showed that $f(R_n)$ is identical to that of the mean of samples of size $(n-1)$ drawn from a special rectangular population. Independently and by a different procedure, Cicchitelli (1976, p. 227) and later Gail & Gastwirth (1978, p. 353) also obtained $f(R_n)$.

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(10) For a more detailed examination, and the inherent theoretical and formal aspects of the difficult question dealt with in this section, see the monograph by the author (Giorgi 1988).

Moothathu (1985b) derived $f(R_n)$ and the moments of the maximum likelihood estimators.

For a *rectangular distribution,* Michetti & Dall'Aglio (1957, p. 230) determined $V(R_n)$ using an approximate formula, whereas Girone (1972) derived $f(R_n)$ by a direct method in a special case. Later Cicchitelli (1976) obtained a more general result by a different method.

Iyengar (1960) considered the maximum lilelihood estimators of the Gini index in the framework of a *log-normal distribution* and demonstrated their asymptotic normality, and Scala (1973a) proposed an approximation of them. Ullah & Tewari (1972) derived the asymptotic expansion for the mathematical expectation and variance of exact sampling distribution of the above mentioned estimators, but Raghavachari (1974) showed that their results were erroneous and gave the correct version. Finally Moothathu (1989) determined a strongly consistent, asymptotically normal, unbiased estimator (11) for R and the uniformly minimum variance unbiased (best) estimator.

Another important aspect is the study of the asymptotic behaviour of the concentration ratio sampling estimators; Hoeffding (1948 p. 314) was the first to examine this question. Expressing R as the ratio of two U-statistics, he demonstrated its asymptotic normality. Later the same result was reached by others by different procedures, e.g. Dall'Aglio (1965), Cucconi (1965), Goldie (1977), Sendler (1979), Sandström (1982, 1983), Giorgi & Pallini (1990). Sandström (1983 pp. 51-63) not only showed the asymptotic normality of R_n but also demonstrated the same property for the so-called pseudo-Ginis, Subgroup Inequality Weights and Factor Inequality Weights (see also Sandström 1987) which play an important role in the decomposition of the Gini index. The possibility of using the asymptotic properties of the sampling estimators for the construction of confidence intervals of R, depends mainly on the speed of convergence to the limit distribution of these estimators. In other words, it is necessary to have information on the minimum sample size from which these properties are valid (12). Giorgi & Pallini

(11) Unbiased estimators of R have also been derived by Taguchi (1978) and Maiti & Pal (1988). The latter consider estimators based on sampling design.

(12) McDonald & Jensen (1979) hold that for a gamma distribution, sample size must be at least $n=1000$ for the sampling distribution of R to be approximately normal.

(1987b, 1990) examined this question in two articles in which they determined, using the Monte Carlo method, the speed of convergence to the normal distribution of the inequality indices belonging to the so-called Gini family, for a log-logistic parent distribution. Using a Berry-Esseen type bound, they then identified the factors influencing the above speed of convergence.

Nygard & Sandström (1985a,b, 1989) and Sandström et al. (1985, 1988) stimulated investigation into the sampling properties of the concentration ratio. The latter first studied the sampling distribution of an R estimator for simple random sampling and compared four alternative sampling variance estimators; later they extended these studies to probability sampling. Regarding the use of the currently very fashionable approximation procedures for the estimation of the Gini index, we find a forerunner in Manfredi (1974) who used the jackknife to achieve less biased estimates than can be obtained by traditional methods. Dixon et al. (1987) considered bootstrap confidence intervals of R and evaluated their accuracy.

6. Decomposition

An important contribution to the evolution of the concentration ratio has been due to various proposals for decomposition according to income sources and according to groups or sub-populations (13).

Decomposition by sources is based on the hypothesis that total income is the sum of different components, such as wages, salaries, self-employment earnings, capital income, transfer income etc. Rao (1969) expressed the concentration ratio as the difference between the weighted mean of Gini indices of each source and a non-negative term. Later Fei et al. (1978) hypothesized that income sources are linear transformations of total income and expressed R as the weighted sum of the so-called pseudo-Ginis of the various components. According to Pyatt et al. (1980) this procedure should be used with caution since if the decomposition is valid, the interpretation of the components is not. Fields (1979a,b) sought to at least

(13) The questions related to decomposition are so vast that only a brief summary is given here. The reader is referred to the monograph on the subject by the present author (Giorgi 1986).

partly overcome this difficulty by introducing Factor Inequality Weights. A new and original decomposition was derived by Lerman & Yitzhaki (1985) who took the contribution of each income component to overall inequality to be the product of the source's own Gini index, its share of total income and its correlation with the rank of total income (14).

Decomposition by groups or sub-populations aims to explain the contribution to total inequality of certain characters which influence the formation of income, e.g. age, sex, education, geographical area etc.

Bhattacharya & Mahalanobis (1967) supplied a concentration ratio decomposition quite similar to analysis of variance although the Gini index is not additively decomposable in the within + between ($w+b$) sense. Mehran (1975b) showed that if R is not $w+b$ decomposable, then it is within + across ($w+a$) decomposable. He also showed that if the between term is desired in the decomposition algorithm, it can be introduced and the difference between it and the across component is defined as the interaction component (15). Hence the new algorithm within + interaction + between ($w+i+b$) of Mehran seems to give more information than the more traditional $w+b$, as confirmed by Nygard & Sandström (1981, p. 313). The proposal of Mehran differs from that of Bhattacharya & Mahalanobis in that the latter did not separate the interaction term from the within term. Pyatt (1976) reached a similar result to Bhattacharya & Mahalanobis by a different approach based on an original interpretation of R in terms of a statistical game.

Another decomposition was given by Rao (1969) who broke down the concentration ratio into the sum of two elements, one of which is the weighted mean of the Gini indices in the different groups whereas the other depends on the inter sub-population differences in relation to per capita income. This procedure differs from that of Soltow (1960), Piesch (1975) and Mangahas (1975) in the weights used for the within component.

Paglin (1975) adopted a procedure which seems atypical

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(14) For some interesting applications of this decomposition, see for example Stark et al. (1986) and Yitzhaki (1988b).

(15) For an interpretation of the interaction component see Mehran (1975b, p. 148) and Ferrari & Rigo (1987, pp. 351-357).

compared to the above: he split R into age-Gini and Paglin-Gini on the basis of what he called "*a more careful and explicit definition of perfect equality*". This gave rise to many comments, criticisms and interesting extensions (16) to which the author replied on different occasions (Paglin 1977, 1979).

Later other original proposals and interesting extensions were made by various authors, for example Kakwani (1984b) who decomposed the Gini index in terms of relative deprivation, and Barbut (1986) who adopted a procedure based on the relation between mean diameter and mean deviation. Yitzhaki (1988a) and Yitzhaki & Lerman (1989) divided the total inequality expressed by R into within and between inequality and an index indicating the degree of overlap in the group's income distribution, which in turn was used to construct a stratification index. Nevertheless in our opinion the most innovative of recent contributions has been that of Frosini (1989a,b,c) who proposed an ordinal approach to decomposition of the concentration ratio, based on a previous direct computation of the within inequality via the definition and use of aggregate units, while the between component results as a residual quantity.

Many other studies contributing a special approach, modification, extension, criticism or comparison of methods of decomposition of the Gini index exist in the literature, for instance Love & Wolfson (1976), Mangahas & Gamboa (1976), Riva (1979), Lorenzen (1979), Toyoda (1980), Das & Parikh (1982), Braulke (1983), Zagier (1983), Shorrocks (1984), Satchell (1987), Berrebi & Silber (1987b), Cowell (1988), Silber (1989a).

7. Some extensions and interpretations

The extensions and interpretations of the Gini index are so numerous and varied that only those aiding comprehension of the evolution and present status of this index, and the debate implied, will be considered here.

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(16) For details of the debate provoked by the work of Paglin, see for example Danziger et al. (1977), Johnson (1977), Minarik (1977), Nelson (1977), Atack & Bateman (1979), Murray (1979), Needleman (1979), Wertz (1979), Formby & Seaks (1980), Morley (1981), Mookherjee & Shorrocks (1982), Friesen & Miller (1983), Friesen (1986).

In this context, the multivariate extension of R is one of the most interesting. At the beginning of the seventies, Lunetta (1972a,b) and Taguchi (1972-1973) independently proposed a two-dimensional version of the concentration ratio. Lunetta also suggested a procedure for calculation on a frequency table, whereas Taguchi identified new relations and coefficients for correlation and regression. Later De Simoni (1979) expressed the concentration ratio in an Euclidean vector space S_n for a multivariate r.v. whith continuous p.d.f. and Taguchi (1981) also extended his results to any dimension and went into more detail (Taguchi 1988, 1989a). On the other hand, Girone (1974) and Cicchitelli (1979) independently proposed the concentration ratio as a test for homogeneity of variances, while Gail & Gastwirth (1978) suggested R as a scale-free goodness-of-fit test for the exponential distribution (see also Gail & Ware 1978). Chandra & Singpurwalla (1981), revealing a close relation between R and certain functions or transforms of Reliability Theory, showed that the said test of exponentiality is identical to that based on "*total time on test transform*" (see also Rinne 1988). Finally, De Simoni (1974) tried a first approach to the use of the Gini index to construct a new criterion for cluster analysis.

When R was set up in a welfare context, the debate began again, giving rise to another of the controversies that have periodically characterized the long history of the concentration ratio and ensured it a degree of topicality which would otherwise have been impossible. The debate arose over the position taken by Atkinson (1970) (17) who heavily criticised the concentration ratio and certain other conventional summary measures bacause they do not rank income distributions according to strictly concave social utility functions, thus making a sharp distinction between objective and normative measures (18). Nevertheless, if Atkinson had heeded Gini's (1921) reply to Dalton (1920), he perhaps would not have been so rigid in his conclusions and R would have progressively slipped into oblivion, as it seemed to be doing. In fact, Gini (1921, p. 124) pointed out to Dalton that the purpose of his index and of those proposed by other

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(17) The debate provoked by Atkinson is too complex to be reported in detail. For a first examination, see the article on the subject by Giorgi (1984b).

(18) This sharp distinction is not justified, as has been shown again recently (Giorgi 1984a, Giorgi & Pallini 1985, Muliere 1987).

Italian authors "*is not to estimate the inequality of economic welfare but the inequality incomes and wealth, independently of all hypotheses as to the functional relations between these quantities and economic welfare or as to the additive character of the economic welfare of individuals*". Apart from this, the debate still showed the forcing of certain of Atkinson's conclusions derived in a utilitarian context, the limits of which are known and clearly set out in Sen (1972, p. 344). In fact Sheshinski (1972) disputed the additive condition and Kats (1972) tried to reinforce the results, while Rothschild & Stiglitz (1973), though not agreeing completely with the former, regarded the constraints placed by Atkinson (1970) and Newbery (1970) on the social welfare function as highly restrictive. Sen (1973a,b) also showed that additive separability was rather untenable and strict concavity too strong a condition; he considered (1973a, pp. 49-53) non-additive, non-individualistic social welfare functions and weaker conditions of concavity (see also Dasgupta et al. 1973). Sen (1974) did not restrict his argument to this, but also tried to frame R in a welfare context. Dagum (1990) in turn showed that the individualistic utility functions considered by Atkinson would not accord with social values, since their specification did not consider the income of other members of society. This would not occur with the social welfare interpretation of the Gini concentration ratio. Some, nevertheless, consider the welfare interpretation of R to be too broad. Benedetti (1986, p. 423) for instance, likens it to the restoration of something originally conceived for a limited purpose, to which the restorer wishes at all costs to ascribe completely new aspects and meanings. If the welfare context is accepted, albeit with every possible precaution, it opens the way for interpretations and extensions which Gini and his contemporaries could never have imagined. Thus, in 1976, Sen proposed a new poverty measure based on R and this stimulated many other studies, e.g. Takayama (1979), Kakwani (1980a,b) (19), Sen P.K. (1986), Dagum et al. (1988). This was not the end of the new interpretations: for example Chipman (1974) expressed social welfare as a function of R and mean income in the framework of portfolio analysis, a special branch of the theory of risk-taking; Yitzhaki (1979) expressed the

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(19) For a discussion of several of the problems connected with the Kakwani approach, see Thon (1981).

Gini index in terms of relative deprivation (20), then extended and developed (Yitzhaki 1982) these concepts in the welfare context, even analyzing (Yitzhaki 1983) one of its parametric variants. Several features inherent to life tables and occupational segregation were studied by Hanada (1983) and Silber (1989c) respectively, and Silber (1989b) also considered a new measure of the distance, also related to R, between relative price vectors.

This summary of the principal aspects of R is intended as the introduction to a monograph, soon to be published, containing a formal detailed analysis of the topic. It is hoped that this brief history of the first 75 years of existence of the Gini index, based on a selection of 385 papers, has been able to give a reasonably clear picture of the various complex problems and the main reasons for the success and longevity of this index.

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(20) See also Hey & Lambert (1980) and Yitzhaki (1980). For an alternative interpretation of R in terms of relative deprivation, see Berrebi & Silber (1985b) and Kakwani (1984b).

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SUMMARY

Through critical analysis of a selection of 385 papers dating from the beginning of the century up to 1989, the author outlines the main features of the genesis and evolution of the Gini concentration ratio . Some of the reasons for the success and surprising longevity of this index are surveyed. The paper gives detailed bibliographic references for the various aspects discussed.

RIASSUNTO

L'Autore delinea, attraverso l'analisi critica di 385 lavori scelti dagli inizi del secolo al 1989, le principali caratteristiche della genesi e dell'evoluzione del rapporto di concentrazione di Gini. Sono evidenziati inoltre alcuni dei motivi che hanno concorso alla insospettabile longevità ed alla fortuna di questo indice. Dettagliati riferimenti bibliografici vengono forniti per l'approfondimento dei vari aspetti trattati.

KEY WORDS

Inference and bounds on Gini index; decompositions, new interpretations and extensions of the concentration ratio.