The Quarterly Review of Economics and Finance 53 (2013) 268–276

Contents lists available at SciVerse ScienceDirect

The Quarterly Review of Economics and Finance

journal homepage: www.elsevier.com/locate/qref

Robust growth-equity decomposition of change in poverty: The case of Iran (2000–2009)

Esfandiar Maasoumi [a,*], Vahid Mahmoudi [b]

[a] Department of Economics, Emory University, Atlanta, GA, USA
[b] Department of Finance, Tehran University, Tehran, Iran

ARTICLE INFO

Article history:
Received 24 February 2011
Received in revised form 24 June 2012
Accepted 3 July 2012
Available online 26 July 2012

Keywords:
Poverty
Growth
Redistribution
Quantiles
Decomposition
Iran
Income inequality
Policy
Nonparametric
Stochastic dominance
Robustness
Lorenz

ABSTRACT

This paper examines a robust nonparametric methodology for decomposition of change in poverty into growth and redistribution components. The decomposition is exact, symmetric and free of residual terms. It is equivalent to the Shapley value decomposition in this two-component case. We avoid parametric assumptions about the underlying distributions and Lorenz functions. All of the currently popular poverty measures may be decomposed as suggested in this paper. We identify the issues that arise with parametric approaches to decomposition. An empirical application is given based on recent data on real consumption in rural and urban areas of Iran in 2000, 2004 and 2009 (covering the country's third and fourth five-year development plans). We find that both 'pure growth' and 'redistribution' components are present in a striking change in poverty, especially among rural households. It would appear that stochastic dominance rankings of the consumption distributions make poverty analyses and decompositions robust to the choice of a poverty line, or poverty measure.

1. Introduction

There is a common belief that economic growth is an effective way to eradicate poverty in developing countries. But there are dissenting views and empirical evidence is not consistently supportive of a simple consensus view. Some economists interpret the historical evidence as suggesting that the benefits of growth have not reached the poor, or may have been counteracted by adverse changes in inequality. Economists and international institutions, notably the World Bank and the IMF, have supported growth-oriented economic policies, on the ground that they create opportunities for the poor to increase their incomes. It is acknowledged, however, that the *pattern* of growth plays an important role in determining its impact on poverty (World Bank, 1990).

The relation between change in poverty and economic growth bears further thorough analysis and empirical examination. The experience of economic policies of developing countries suggests that incomes of "the poor" usually grow slower than the average (Kakwani, 1993). In an empirical study covering the 1980s, Ravallion (1995) concluded that, in developing countries, the growth process typically had neither strongly adverse impact on the relative position of the poor, nor was it associated with a tendency for "inequality" to either increase or decrease. Much of this literature tends to take for granted the existing univariate definitions of "the poor" and poverty lines, and similar notions of "inequality", typically in some measure of income. Recent literature on multi-attribute analysis of well-being has exposed the complex notion of "poverty frontiers" in many dimensions, revealing the challenges in the choice of dimensions of well being, and the technical issues surrounding the definition of multidimensional "quantile sets", as well as the additional aggregation issues. See Maasoumi and Lugo (2008), Maasoumi and Racine (2012), and Maasoumi and Salehi (2009). This paper deals with a single measure of wellbeing, which may be an aggregate of wellbeing based on several attributes. The choice of such aggregators is discussed in Maasoumi (1986), Maasoumi and Lugo (2008), Maasoumi et al. (2005), and in Maasoumi and Salehi (2009), the latter two being examinations of multidimensional well-being in Iran.

* Corresponding author. Tel.: +1 404 727 9817.
E-mail addresses: emaasou@emory.edu (E. Maasoumi), vmahmodi@ut.ac.ir (V. Mahmoudi).

1062-9769/$ – see front matter
http://dx.doi.org/10.1016/j.qref.2012.07.003

As an empirical matter, to understand the "contribution" of "growth" and "redistribution" to changes in poverty, one needs robust measurement of its components, one being the growth in average income, and the other being the redistribution of income. This is difficult, as has been pointed out by Shorrocks (1999), who singles out a number of problems with existing decomposition approaches.

Several methods for decomposition of poverty changes have been proposed, for example by Kakwani and Subbarao (1990), Datt and Ravallion (1992), Shorrocks (1999), and Tsui (1996). Shorrocks (1999) is based on Shapley (1953), and extending Owen (1977), when there is a hierarchical set of attributes and components. The Shapley approach is compatible with our method here where there is symmetry with respect to the order in which the contribution of each of our two components (growth and inequality) is eliminated. The Datt and Ravallion and other approaches extant, tend to have several limitations. Firstly, the growth and redistribution components are not symmetric with respect to the base and final years, or the elimination process. Secondly, the decompositions are not exact and contain a 'residual' component (see the next section). A more desirable decomposition method is one that exactly sums the contributions of determining factors of total changes. A further limitation of the current methods is due to their specificity with regards to measures of inequality or poverty. Another, less widely appreciated limitation is due to parametric choice of the distribution function (alternately, the Lorenz functions). This paper proposes a nonparametric method for estimating the components of change in poverty (growth and redistribution components) and illustrates the proposed approach with recent data for Iran. We are able to exactly decompose poverty changes into two components, based on the empirical CDF (cumulative distribution function), without residuals, and symmetrically with respect to the reference point in time. Our components are estimated and statistical significance is indicated for each component of change in poverty. This paper is about "measurement" to accurately identify certain well defined components of changes in the distribution of a measure of well being. It is not about identifying economic policies that may be conducive to "growth" or "equality", much less the mechanism by which such policies may be transmitted. Our measures help establish "what is" the state of poverty, at various points in time. This provides an "equilibrium metric" which may be helpful in evaluating economic outcomes. Attribution to specific economic policies is a far more challenging task that is not addressed in this paper.

The paper is organized as follows. Section 2 presents a short review of economic growth, inequality and poverty, including in Iran. Section 3 exemplifies current decomposition methods such as the one described in Datt and Ravallion (1992). Section 4 describes our proposed approach to decomposing these effects. Section 5 provides a sketch of recent experience in Iran. Section 6 presents our empirical application of the proposed methodology to recent data on real consumption in rural and urban areas in Iran in 2000, 2004 and 2009. Conclusions are in Section 7.

2. A brief review of the relationship between economic growth, inequality and poverty

The debate concerning the relationship between growth and poverty, and inequality and poverty, has a long history, going back to Ricardo and Malthus, and the more recent "inverted U" curve of Kuznets (1955). Generally the pre 1970s view is one of "exchange" between growth and poverty. In the 1970s there was a shift toward poverty reduction independent of growth (for instance, see Chenery & Ahluwalia, 1974). During the next decade and later, growth has been considered as necessary for poverty reduction. Challenges to this view have emerged with conflicting empirical evidence since 1990s. Some believe economic growth benefits the poor; others see it as ultimately detrimental to the poor. Although there are other ideas that exist between these two extreme beliefs, most of them are somewhat in agreement with the relationship between growth-poverty and also inequality-poverty (especially the second relationship). The empirical evidence which would appear to contradict these "relationships" is exemplified by Ravallion (1995), who argues that in developing countries, the growth process has not had a significant negative effect on the relative situation of the poor, while according to Fosu (2011), in most developing countries, growth has been the main factor decreasing poverty. The diversity of the inferences increases when inequality changes are examined as well. For instance, some have suggested that China has been able to reduce poverty without increasing inequality (Ravallion & Chen, 2007), while in Botswana economic growth has not reduced poverty (Fosu, 2011).

The decomposition of poverty changes into the two components of growth and inequality plays an important role in clarifying these issues, without attributing causal relations to specific policies. Studies like those of Datt and Ravallion (1992) and Kakwani (1993) are important primary examinations of this kind. There are also empirical studies of poverty changes in Iran. These include Piraee (2004) who has decomposed the poverty changes of the first development plan into three areas: urban areas, rural areas and the whole economy. The results show that in all three areas, growth has been "associated" with a rise in poverty, while inequality has had a positive association. Mahmoudi (2001) has also provided a decomposition in urban and rural areas during the first plan in Iran. His results indicate an association between reduced poverty and both net growth and redistribution, especially in rural areas. Salehi-Isfahani (2006) has examined the association between growth, inequality and poverty over 25 years since the Islamic revolution of 1979. His findings indicate an improvement in poverty and growth indicators over that period. Salehi-Isfahani (2009) examined the same association between poverty, inequality and growth during different presidencies. He concluded that poverty has been consistently decreasing with growth, but inequality has remained stable. We will examine these questions for Iran based on our techniques, for the decade ending in 2009.

3. Growth-equity decomposition of a change in poverty

Let x denote income, $F(x)$ denote its cumulative distribution function (proportion of population with income less than x), and $L(F;\ p)$ the Lorenz curve, giving the fraction of total income that the holders of the lowest pth fraction of incomes possess. Lorenz curve is a mean-normalized integral of the inverse of a distribution function

$$L(p) = \frac{1}{\mu}\int_0^p F^{-1}(\pi)\ d\pi \tag{1}$$

If $L'(p)$ denotes the slope of the Lorenz curve, then:

$$x = F^{-1}(p) = \mu L'(p)$$

where μ is mean income. The distribution function evaluated at the poverty line is the well-known "headcount ratio" poverty index. For a poverty line z, and the poverty rate, P_0:

$$L'(P_0) = \frac{z}{\mu} \tag{2}$$

From (2) it is clear that any change in the poverty rate P_0 may be related to the change in the Lorenz curve, $L\,(F;\ p)$ and the change in mean income, μ. These are the two components whose effects we seek to identify. Aggregate additive poverty measures can be expressed in a general form by:

$$P(F;z) = p(L_F, \mu_F, z) = \tilde{p}(L_F, \delta\mu_F, \delta_z)\forall\delta \quad \text{by scale invariance}$$
$$= \tilde{p}\left(L_F, 1, \frac{z}{\mu_F}\right)\forall\delta = 1/\mu_F = \tilde{\tilde{p}}\left(L_F, \frac{z}{\mu_F}\right) \quad (3)$$

where z is the absolute poverty line, μ_F is the mean income per capita and, L_F is the Lorenz curve corresponding to F. Datt and Ravallion (1992) point out that decomposition of changes in poverty between two dates (t = 1, 2) can be written as the sum of a growth component (ΔP^G), a redistribution component (ΔP^R) and a "residual" or error term (e),[1]

$$\Delta P = P\left(\frac{z}{\mu_2};L_2\right) - P\left(\frac{z}{\mu_1};L_1\right) = \left[P\left(\frac{z}{\mu_2};L_1\right) - P\left(\frac{z}{\mu_1};L_1\right)\right] + \left[P\left(\frac{z}{\mu_1};L_2\right) - P\left(\frac{z}{\mu_1};L_1\right)\right] + \text{residual} = \Delta P^G + \Delta P^R + e \quad (4)$$

Where the initial year is taken as the reference point. To implement this decomposition Datt and Ravallion (1992) proposed formulas based on the class of Foster, Greer and Thorbecke (GFT) poverty indices (P_α) using a *parametric form* of the Lorenz curve. There are a number of ways of specifying a parametric form for the Lorenz curve (or the underlying distribution). Two examples are the Beta model of Kakwani (1980) and the general quadratic (GQ) model of Villasenor and Arnold (2000) which Datt and Ravallion used in their paper.

One interpretation is that the residuals indicate miss-specified components in the decompositions. Indeed, the "residual" in Datt–Ravallion's method shows the inability of the method to separate pure growth and redistribution components completely, in addition to the sensitivity of the various components to the parametric choice of the underlying distribution.

To demonstrate the sensitivity of component estimates to the choice of the "reference point" in this approach, Datt and Ravallion (1992), Table 6, reports a redistribution component of −1.95. But reversing the reference and terminal points, a value of −0.54 may be computed for redistribution (computation is based on their footnote 3)! Given the total change in poverty is −1.20, the example shows the importance of this lack of invariance to reference point selection. To overcome the problem, one solution is to take an average of the two decompositions, thus eliminating the residual.[2] This averaged change is given below:

$$\Delta P = P\left(\frac{z}{\mu_2};L_2\right) - P\left(\frac{z}{\mu_1};L_1\right) = \frac{1}{2}[G(1,2,r_1) + G(1,2,r_2)] + \frac{1}{2}[R(1,2,r_1) + R(1,2,r_2)] = \Delta P^G + \Delta P^R \quad (5)$$

where r_i refers to the reference date and G and R functions refer to growth and redistribution respectively. Eq. (5) indicates that there are only two components. In the Shapley decomposition proposed by Shorrocks (1999), averaging over all sequences in which each of a number of components are eliminated, removes the residual as well.

4. An alternative approach

The most commonly used measures of poverty are the headcount, the poverty, and the poverty sensitive indices. These indices are fully defined as functions of the cumulative distribution of income and a poverty line.[3] Given the direct relationship between the distribution function (CDF) and the poverty measures, relying on the changes in the CDF to decompose poverty changes is natural and often better implemented empirically, and nonparametrically. This method is also more easily related to other fundamental concepts such as stochastic dominance. The latter are partial rankings which avoid cardinal choice of *both* the distribution functions *and* poverty measures. Dominance rankings are also testable with new statistical procedures; see Davidson and Duclos (2000), and Linton, Maasoumi, and Whang (2005, 2007).

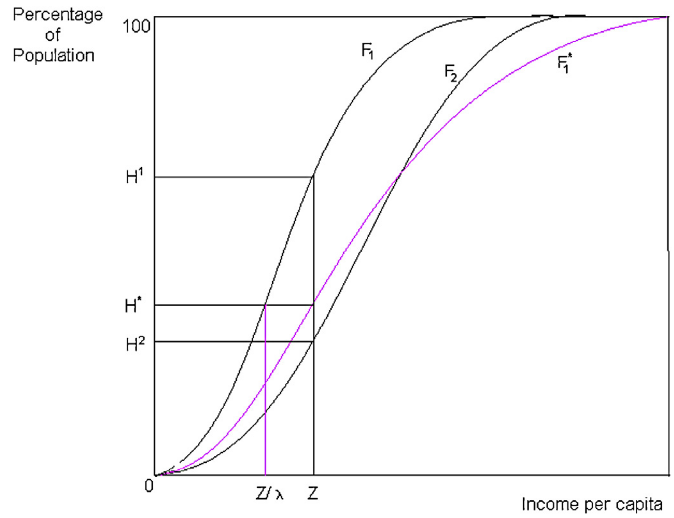

Fig. 1. A CDF based growth-redistribution decomposition of the change in poverty.

4.1. A nonparametric decomposition

An exact, simple, nonparametric approach to decompose a change in poverty into growth and redistribution components is introduced here based on the empirical CDF (alternately, empirical Lorenz curve). Denote the CDF and poverty line at time t by F_t and z_t, respectively, so that $F_t(x)$ represents the proportion of households with income less than or equal to x at time t.

The change in a poverty index, P, may be represented as follows:

$$\Delta P = P(F_2;z) - P(F_1;z). \quad (6)$$

We assume that "income" is expressed in real terms, and the poverty line is the same at both dates ($z_1 = z_2 = z$). The "pure growth" component is obtained by the ratio of changes in the two mean incomes. If all incomes in period 1 are scaled up by $\lambda = \mu_2/\mu_1$ where μ_1 and μ_2 are the mean incomes, one can construct a new intermediate distribution F_1^*. This is illustrated in Fig. 1.

[1] The residual is the difference between the growth (redistribution) components evaluated at the final and initial Lorenz curves (mean incomes).

[2] Datt and Ravallion (1992) do mention this point. They state that it is arbitrary.

[3] The additive class of poverty measures developed by Foster, Greer, and Thorbecke (1984) can be expressed in a continuous form as: $P_\alpha(F;z) = (1/z^\alpha)\int_0^{F(z)}[z - F^{-1}(p)]\,dp, \quad \alpha \geq 0$, where α measures the aversion to poverty among the poor. When this parameter equals zero, the above aggregate poverty measures collapses to the well-known head count index – the percentage of people with an income below the poverty line. The headcount index is totally insensitive to differences in the depth of poverty. Concerns about the depth of poverty may be factored in just by getting the poverty aversion parameter to unity. This yields the poverty gap index which is a normalized sum of the shortfalls of the poor. These two indices are not sensitive to the distribution among the poor. Considering $\alpha = 2$ overcome this problem which is a weighted sum of shortfalls of the poor, where the weights are the shortfalls themselves. Thus it attaches greater weight to lower incomes amongst the poor.

In this example, F_2 first order stochastically dominates F_1 for two possible reasons, one is a possible mean shift, the other is a possible reduction in "inequality". By constructing a potential distribution which differs from the original only by the mean shift, and no other distribution changes, one can sort out the two components of the movement between the two distributions. This is similar to the Shapley elimination sequence. Suppose the initial income distribution, F_1 (with mean μ_1) shifts to the right in a distributionally neutral fashion, yielding F_1^* with the same mean μ_2 as F_2. Because F_1 and F_2 have the same mean by construction, the graphs would cross each other if there is redistribution. For F_1^*, the poverty line z implies a headcount ratio of H^* (alternatively, by defining an equivalently adjusted poverty line, z/λ, with income growth factor λ, referencing F_1). The "pure growth" effect of poverty would be equal to $H^* - H_1$ and the redistribution effect is equal to $H^2 - H^*$. Therefore,

$$F_1^*(\lambda x) = F_1(x) \quad \text{for all } x \tag{7}$$

Equivalently:

$$F_1^*(x) = F_1\left(\frac{x}{\lambda}\right)$$

where F_1^* is the F_1 distribution only scaled up to the same mean as F_2. Thus, the poverty change may be additively decomposed into the growth and redistribution effects as follows:

$$\Delta P = \Delta P^G + \Delta P^R = [P(F_z^*; z) - P(F_1; z)] + \left[P(F_2; z) - P(F_1^*; z)\right] \tag{8}$$

We may further clarify how the CDF can be used to reveal a pure 'redistribution' effect. Since F_2 and F_1^* have the same mean μ_2 by construction, we can write:

$$\mu_2\left[L_2(p) - L_1^*(p)\right] = \int_0^p \left[F_2^{-1}(\pi) - F_1^{*-1}(\pi)\right] d\pi. \tag{9}$$

This shows that redistribution (Lorenz changes) is captured by CDF changes when the mean is the same. One may recall that this is the advantage of Generalized Lorenz (mean unadjusted Lorenz!), for measuring Second Order stochastic dominance between distributions with unequal means! See Shorrocks (1983). Note that the analysis does not depend on a first order dominance ranking as in Fig. 1. Indeed, two other possible situations are straightforward extensions of this graphical depiction. One is when the first distribution crosses the second above any poverty line of interest *with second order dominance*. The other is when the distributions cross at a sufficiently "high" quantile for second order dominance to hold generally. Note that when the distributions cross, existence of second order dominance depends on the concavity of the welfare function, i.e., its relative aversion to unequal distributions. Thus with crossing CDFs, ranking of poverty states, and decompositions, *depend on areas under the CDF functions up to the poverty line*. Later on in this paper we will offer the corresponding decompositions for the FGT family of poverty measures with different underlying degrees of distributional sensitivity. Statistical tests for second order rankings, possibly up to a desired poverty line, are given in the literature; e.g., see Linton et al. (2005, 2007). One robust approach is to first test for statistically significant ranking of distributions, find the poverty line below which such ranking is uniform, and then compute the two components as offered in this paper. Such an approach will have an additional robustness property toward the choice of a poverty line. When rankings are established for points above any conventional poverty lines, discussion of an "ideal" poverty line is rendered moot. This happens to be the case in our empirical example for Iran! In our implementation, the CDFs are estimated by the empirical CDFs, which avoid parametric specification and identification of Lorenz curves. It is a fundamental statistical property that empirical CDF is generally a consistent estimator of the true CDF.

To illustrate the approach more specifically, we focus on the headcount ratio. The change in headcount ratio can be written as:

$$\Delta H = H(F_2; z) - H(F_1; z) = F_2(z) - F_1(z) \tag{10}$$

Then the change in headcount ratio attributable to the growth effect, denoted by ΔH^G, is represented by:

$$\begin{aligned}\Delta H^G &= H(F_1^*; z) - H(F_1; z) = F_1^*(z) - F_1(z) = F_1\left(\frac{z}{\lambda}\right) - F_1(z)\\ &= F_1\left(\frac{z\mu_1}{\mu_2}\right)\end{aligned} \tag{11}$$

Similarly, the change in headcount ratio attributable to redistribution, denoted by ΔH^R is:

$$\Delta H^R = H(F_2; z) - H(F_1^*; z) \tag{12}$$

So far F_1 has been taken as the reference distribution with a pure growth effect being a proportional *increase* in all incomes. Suppose now that F_2 is taken as the reference distribution and the pure growth effect is a proportional *decrease* in all incomes. If all incomes are scaled down proportionately by λ, then we have a new distribution F_2^*:

$$\begin{aligned}&F_2^*\left(\frac{x}{\lambda}\right) = F_2(x) \quad \text{for all } x,\\ &\qquad \text{or}\\ &F_2^*(x) = F_2(\lambda x)\end{aligned} \tag{13}$$

F_2^* is the F_2 distribution scaled down to the same mean as F_1. We can now decompose the poverty change as:

$$\Delta P = \Delta P^G + \Delta P^R = \left[P(F_2; z) - P(F_2^*; z)\right] + \left[P(F_2^*; z) - P(F_1; z)\right] \tag{14}$$

Thus, there are two possibilities for decomposition: one referencing the initial distribution and the other referencing the final distribution. To avoid this index-numbers issue we take an average of (8) and (14). Contributions of growth and redistribution on poverty changes can be expressed "symmetrically" as follows[4]

$$\begin{aligned}\Delta P^G &= \tfrac{1}{2}[P(F_1^*; z) - P(F_1; z) + P(F_2; z) - P(F_2^*; z)]\\ \Delta P^R &= \tfrac{1}{2}[P(F_2; z) - P(F_1^*; z) + P(F_2^*; z) - P(F_1; z)]\end{aligned} \tag{15}$$

or equivalently as:

$$\begin{aligned}\Delta P^G &= \frac{1}{2}\left[P\left(\frac{z}{\mu_2}, L_1\right) - P\left(\frac{z}{\mu_1}, L_1\right) + P\left(\frac{z}{\mu_2}, L_2\right) - P\left(\frac{z}{\mu_1}, L_1\right)\right]\\ &= \frac{1}{2}[G(1,2,r_1) + G(1,2,r_2)]\\ &= \frac{1}{2}\left[P\left(F_1; \frac{z}{\lambda}\right) - P(F_1; z) + P(F_2; z) - P(F_2; \lambda z)\right] \quad \forall \lambda = \frac{\mu_2}{\mu_1}\end{aligned}$$

$$\begin{aligned}\Delta P^R &= \frac{1}{2}\left[P\left(\frac{z}{\mu_2}, L_2\right) - P\left(\frac{z}{\mu_2}, L_1\right) + P\left(\frac{z}{\mu_1}, L_2\right) - P\left(\frac{z}{\mu_1}, L_1\right)\right]\\ &= \frac{1}{2}[R(1,2,r_1) + R(1,2,r_2)]\end{aligned}$$

This is exactly the same as (5) but with different derivation. There is no residual intrinsically, i.e., this is an exact decomposition in which eliminating one of the two components directs all contribution to the remaining component. This is a main property of Shapley-type decompositions. Empirically, a parametric choice

[4] Shorrocks (1999) also derives a similar average result by appeal to Shapley value.

for the Lorenz curve is possible but unnecessary. Empirical CDF or smoothed nonparametric methods provide inferences that are robust to parametric misspecifications.

4.2. Some issues with parametric decompositions

To highlight some of the drawbacks of specific parametric choices of the Lorenz functions, here we derive the decomposition formula based on specific choices suggested in Kakwani (1993), who argues that the Lorenz curve change can be summarized by:

$$L_2(p) = L_1(p) - \gamma[p - L_1(p) \tag{16}$$

which suggests that when $\gamma > 0$ ($\gamma < 0$), it shows a downward (upward) shift in the Lorenz curve resulting in higher (lower) inequality. Kakwani argues that γ is equal to proportional change in the Gini index of inequality. If $\gamma = 0.01$ (-0.01), it indicates that the Gini index has risen (fallen) 1%.

Recall that the slope of Lorenz curve in the final distribution evaluated at the poverty line can be represented as:

$$L_2\prime(H^2) = \frac{z}{\mu_2} \tag{17}$$

Differentiating of (16) with respect to p at $p = H^2$, yields

$$L'_2(H^2) = L'_1(H^2) - \gamma[1 - L'_1(H^2). \tag{18}$$

For the Lorenz curve $L_1(p)$, H is the proportion of individuals with income less than or equal to z such that $L^*_1(H^*) = z/\mu_2$. When substituting H^2 for H in this equation, z must change to a new level z^*. In that case:

$$L'_2(H^2) = \frac{z^*}{\mu_2}. \tag{19}$$

Substituting (17) and (19) in (16) gives (Kakwani, 1993):

$$z^* = \frac{z + \gamma\mu_2}{(1+\gamma)}. \tag{20}$$

The change in poverty given in (8) can be rewritten as:

$$\Delta P = \left[P(F^*_1; z) - P(F_1; z)\right] + \left[P(F^*_1; z^*) - P(F^*_1; z)\right] + \text{residual} \tag{21}$$

Alternatively, when the final distribution is the reference, (8) can be expressed as:

$$\Delta P = \left[P(F_2; z) - P(F^*_2; z)\right] + \left[P(F^*_2; z) - P(F_2; z^{**})\right] + \text{residual} \tag{22}$$

where

$$z^{**} = \frac{z + \gamma\mu_1}{(1+\gamma)} \tag{23}$$

The residuals in (22) and (23) vanish if the Lorenz curve remains unchanged over the decomposition period, which is when all of the change in poverty is due to the growth component. When there is no redistribution (no change of inequality), there is no residual. When there is redistribution, each parametric form will represent it in a form specific to that parametric form. But inequality in a distribution can be parameterized and "indexed" in numerous ways. Thus parametric numerical estimates lack invariance to the choice of functional forms and indices. Nonparametric methods, based on the CDF are invariant, and robust, in this sense.

It would seem that a nonparametric implementation of the general decomposition formula in (15) would avoid many of the highlighted problems with residuals and asymmetry.

4.3. An elasticity-based presentation of our approach

This section aims to explain the decomposition process in an alternative way, using an elasticity approach. This further clarifies the method and would also help to obtain an approximation of the poverty components based on the slope of the distribution function around the poverty line. The reduction in poverty depends on where the poor are in relation to the poverty line. If they are concentrated just below the line, the increase in their income will have a bigger effect on poverty than if they are spread more evenly below the line. Hence the slope of distribution function at the poverty line is an important determinant of the incidence of poverty (headcount ratio). In other words, if the density of households around the poverty line is generally high, we can expect poverty to be highly elastic with respect to the poverty line. If the slope is less steep it implies that few people are located immediately below the poverty line. In this case the same increase in income moves only a few of the poor above the poverty line and the reduction in the incidence of poverty (headcount ratio) will be much smaller (World Bank, 1990).

Using the slope of the distribution function as a determining component of poverty changes, and holding the distribution function constant, the change in headcount ratio is:

$$dH = F\prime(z)dz \tag{24}$$

and the elasticity of headcount ratio with respect to poverty line can be stated as:

$$\eta_H = \frac{dH}{dz}\frac{z}{H}. \tag{25}$$

Expression (11) allows us to focus on the initial distribution in order to see the impact of changes in mean income on poverty. Hence, from (24) and (25) it is possible to define the growth component of the headcount ratio changes as follows:

$$\Delta H^G \approx (z - \frac{z}{\lambda})F'_1(z) = \frac{\lambda - 1}{\lambda}\eta_{H^1}H(F_1; z) = \frac{\mu_2 - \mu_1}{\mu_2}\eta_{H^1}H(F_1; z) \tag{26}$$

where η_{H^1} is the elasticity of the headcount ratio $F_1(z)$, with respect to the poverty line and λ defined as before. Alternatively, starting from F_2 the "pure growth" effect is given by:

$$\Delta H^G \approx (\lambda - 1)F'_2(z)z = (\lambda - 1)\eta_{H^2}H(F_2; z) = \frac{\mu_2 - \mu_1}{\mu_1}\eta_{H^2}H(F_2; z) \tag{27}$$

where η_{H^2} is the elasticity of the headcount ratio, $F_2(z)$ with respect to the poverty line.

Headcount ratio is insensitive to the "intensity of poverty", that is the distribution of poverty below the poverty line. But, our approach can be extended to members of P_α family of measure which includes the headcount ratio. Similar to (26) and by normalizing the "poverty deficit curve" with poverty line (z), and the "poverty severity curve" by z^2/z we can express the contribution of changes in P_α caused by 'pure growth' effect as[5]:

$$\Delta P^G_\alpha = \frac{\mu_2 - \mu_1}{2}\left[\frac{1}{\mu_2}\eta_{P_{\alpha,1}}P_\alpha(F_1; z) + \frac{1}{\mu_1}\eta_{P_{\alpha,2}}P_\alpha(F_2; z)\right] \tag{28}$$

where η_{P_α} is the elasticity of P_α with respect to the poverty line. Notice that (29) is an average of the two decompositions, first using the initial year as the reference and next using final year as the reference.

[5] The "Poverty Deficit Curve" (PDC), defined as the area under CDF up to some poverty line z: $D(F; z) = \int_0^z F(x)\,dx = zP_1(F; z)$. The "Poverty Severity Curve" is the area underneath the PDC up to some poverty line z: $S(F; z) = \int_0^z D(x)\,dx = (1/2)z^2P_2(F; z)$; (see Ravallion, 2004 and Deaton, 1997).

Table 1
Descriptive statistics.

	Rural Gini	Urban Gini	Economic growth
Mean	0.399236	0.413009	06.5762
Maximum	0.418100	0.420300	12.8199
Minimum	0.383700	0.406100	−4.2923
Std. Dev.	0.009937	0.004701	5.3101

Sources: Statistical Center of Iran and Central Bank of Iran.

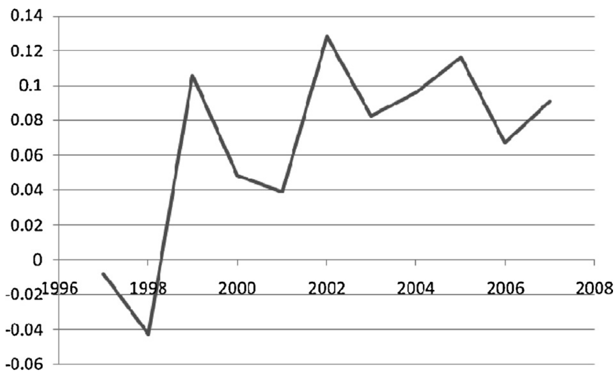

Fig. 2. Economic growth in Iran.

5. A brief review of growth and redistribution of income in Iran

In the period before 2009, economic growth and the Gini coefficient in urban and rural areas of Iran indicate that growth in incomes has accompanied a more equal distribution, generally, while inequality between the urban and rural areas has increased somewhat. Regional inequality in rural areas has a higher variance than the urban parts of the country.

To exemplify, we provide a sketch of growth and income distribution in rural and urban areas of Iran for the period 1997–2007. The sources of all the statistical data here are the office of Bureau of Population, labour force statistics, and a census which is affiliated with Statistical Center of Iran. Table 1 displays a summary of the Gini and annual income growth for this period.

Fig. 2 shows the lowest and highest growth occurred in 1998 (−4.29%) and 2002 (12.81%), respectively. This suggests that, although the average growth rate over this period is high (about 6.5%), it has fluctuated.

Fig. 3 shows, the difference between the lowest and highest Gini coefficient in urban areas is small (0.02), with the largest inequality recorded in 1997, and smallest in 2005, with an average of 0.41 in urban areas.

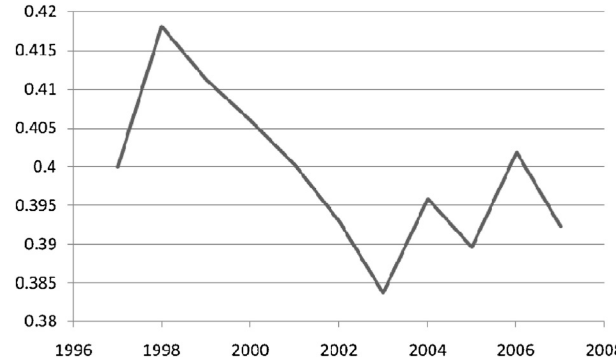

Fig. 4. Gini coefficient in rural Iran.

Table 2
Correlation coefficients.

	Y	RU	RG
Y	1	−0.4399	−0.6021
RU	–	1	0.3917
RG	–	–	1

Fig. 4 shows that the largest and least inequalities in rural areas occurred in 1998 and 2003, respectively. Moreover, the average of rural Gini is near 0.4, not very different from the urban average over the same period. We note that while Gini is the most commonly reported index, it is notoriously insensitive to tail areas of distributions and would not adequately reflect the changes in such areas. When extreme poverty reduction is a policy goal, Gini is not the most appropriate measure of inequality.

The pattern of changes in Gini and economic growth is consistent with an inverse relation between growth and inequality. This can be formalized by examining the correlations between these two annual measures in Table 2.

Fig. 5 reveals that, except for the earlier part of the decade, “within group” inequalities for urban and rural areas are quite different. The “within rural” inequality declined more and is somewhat lower than “within urban” inequality.

Over this particular period income inequality in Iran is somewhat high compared to ‘average Gini coefficient’ of ‘High Income Countries’, ‘Eastern Europe’ and ‘South Asia’ (Deininger & Squire, 1996). Income inequality in the whole country decreased during the Islamic Republic’s third and forth five-year plans (2000–2009). Other, more tail sensitive measures of inequality than Gini confirm this view; see Maasoumi and Salehi (2009).

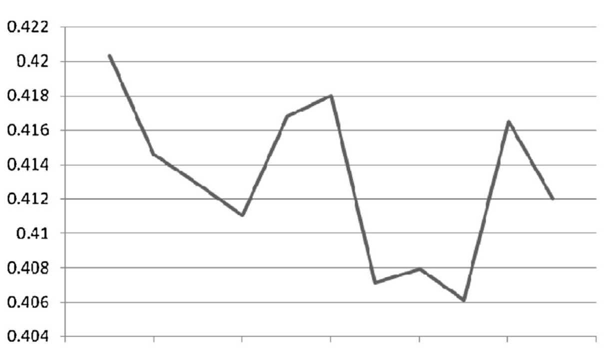

Fig. 3. Gini coefficient in urban areas of Iran.

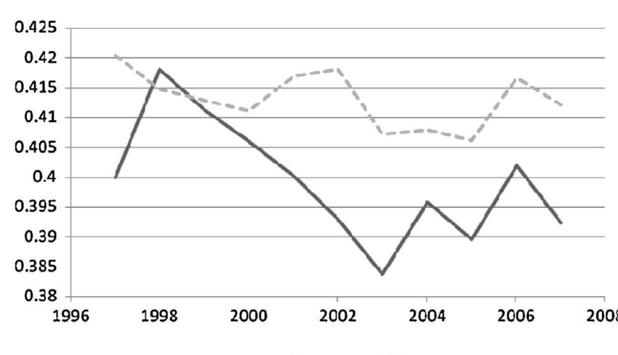

Fig. 5. Within group inequality – rural and urban groups.

6. Decomposition of poverty changes in Iran

The methodology developed in this paper (formula (15)) is applied to adjusted consumption expenditure data obtained from the Iranian household survey, conducted by Statistical Centre of Iran (SCI). We draw on micro-data sets of SCI Budget Household Survey (SCIBHS) for the years 2000, 2004 and 2009. The SCIBHS is a nationally and regionally representative household survey carried out by SCI. The sampling unit is a household. Information for the SCIBHS was collected by personal interview over a 24-h period for rural, and a 48-h period for urban areas, for food items, and month by month for non-food items throughout the year. The sampling methodology can be described as multi-stage random sampling with geographical stratification and clustering. The sample size for our analysis is as follows: the 2000 sample contains 26,941 households––54% rural households and 46% urban households. The 2004 sample covered 24,534 households––53% rural households and 47% urban. The 2009 sample covered 36,869 households––49% rural households and 51% urban. We focus on the distribution of adjusted household expenditure.

In adjusting the data to the 2000 price levels we used a modified version of Iran's consumer price index (CPI) for rural and urban areas separately. The ordinary CPI is far from ideal for our purpose because it is particularly problematic in the case of the dual-price systems in transitional economies implementing adjustment policies. Following a policy in which *coupon* prices are gradually phased out (as has partially occurred in Iran since 1989), using ordinary CPI would not to be recommended because it fails to properly reflect the inflation which poor households experience. We have re-weighted the CPI so as to better reflect the consumption pattern of the poorer households. Notice that, because of considerable differences in the cost of living, the data were adjusted by regional CPI for urban and rural areas separately. The differences in needs are considered by using an equivalent scale. For more detail see Mahmoudi (2008) and Mahmoudi (2011).

Fig. 6 provides an overall picture of the dominance dynamics in expenditures over this period of time. This provides a graphical impression, without statistical measures of significance which may be obtained from the stochastic dominance tests of Linton et al. (2005).

The distribution in 2004 (right most) appears to first order dominate both of the distributions in 2000 and 2009, and 2009 (middle) dominates 2000. This would suggest that poverty unambiguously decreased during the third development plan (1999–2004), but it increased during the fourth development plan (2004–2009). Per capita constant absolute poverty line is about 2,500,000 Rials (about $750 PPP) per the year 2000, see Mahmoudi (2008) and Mahmoudi (2011). This renders moot the question of sensitivity of the empirical findings to the choice of a particular poverty line. To highlight the factors that contributed most to the poverty changes of urban and rural poverty over time, we decompose poverty change between 2000 and 2004 and also between 2004 and 2009, into growth and inequality components. The results are presented in Tables 3–6 based on the decomposition formula (15). Where the growth component is the largest part of the change in poverty it indicates that growth has played a more important role than redistribution in achieving the change in poverty and vice versa.

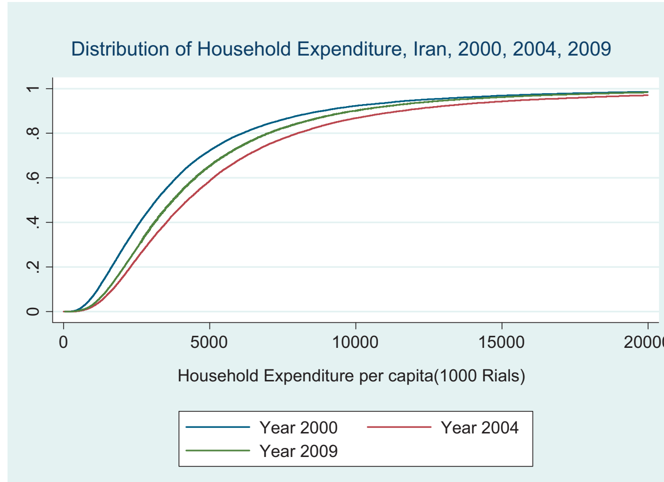

Fig. 6. Distribution of household expenditure, Iran, 2000, 2004, 2009.

It should be noted that with FGT poverty measures, a decline in poverty headcount ratio (P_0) indicates that the number of household living below the poverty line declines; a decline in poverty gap (P_1) indicates that the average income of the poor households increases; a decline in poverty severity (P_2) indicates the poorest benefit more than the "less" poor.

Table 3 illustrates that in urban areas the contribution of growth is larger than that of the redistribution component. The most

Table 3
Decomposition of change in poverty into growth and redistribution components in urban areas of Iran, 2000, 2004.[a,b]

FGT	Period 1 (2000)	Period 2 (2004)	t-statistic[c] for 2000–2004 difference	Total change	Growth effect	Redistribution effect
P_0	27.15	18.81	−3.8	−8.34	−5.83	−2.51
P_1	8.28	5.39	−0.9	−2.89	−1.98	−0.91
P_2	3.68	2.33	−3.7	−1.35	0.93	−0.42

[a] The calculated values of P_α have been multiplied by 100.
[b] 1000s of Rials ($1 > 9000 Rials).
[c] $t = (P_\alpha^{04} - P_\alpha^{00})/\text{standard error of}\left(P_\alpha^{04} - P_\alpha^{00}\right)$. Standard error of P_α is an estimate of the asymptotic variance of poverty ($\pi = t/p = \sum_{i=1}^{N} w_j h_j \pi_j / \sum_{i=1}^{N} w_j h_j$) that is; $AV(\pi) = 1/p^2[\mathrm{Var}(t) + \pi^2(p) - 2\pi \mathrm{cov}(t, p)]$, where w_j is sampling weight, h_j is household size; in the case of, P_α, $\pi_j = \pi_\alpha(y_j) = I(y_j < z)[1 - y_j/z]^\alpha$ (Cowell, Howes, & Jenkins, 2004; Howes & Lanjouw, 1998).

Table 4
Decomposition of change in poverty into growth and redistribution components in rural areas of Iran, 2000, 2004.[a,b].

FGT	Period 1 (2000)	Period 2 (2004)	t-statistic[c] for 2000–2004 difference	Total change	Growth effect	Redistribution effect
P_0	35.94	27.96	−6.4	−7.98	−5.95	−2.03
P_1	12.2	8.43	−5.8	−3.77	−2.23	−1.54
P_2	5.2	23.77	−6.2	−1.45	−0.90	−0.55

a, b, c: The same as Table 3.

Table 5
Decomposition of change in poverty into growth and redistribution components in urban areas of Iran, 2004, 2009.[a,b]

FGT	Period 1 (2004)	Period 2 (2009)	*t*-statistic[c] for 2004–2009 difference	Total change	Growth effect	Redistribution effect
P_0	18.81	25.20	−3.5	6.39	5.50	0.89
P_1	5.39	8.45	−1.1	3.06	2.55	0.51
P_2	2.33	3.25	−3.8	0.92	0.69	0.23

a, b, c: The same as Table 3.

Table 6
Decomposition of change in poverty into growth and redistribution components in rural areas of Iran, 2004, 2009.[a,b]

FGT	Period 1 (2004)	Period 2 (2009)	*t*-statistic[c] for 2004–2009 difference	Total change	Growth effect	Redistribution effect
P_0	27.96	35.11	−5.8	7.15	6.13	1.02
P_1	8.43	12.08	−5.3	3.65	2.70	0.95
P_2	3.77	5.02	−6.7	1.25	0.95	0.30

a, b, c: The same as Table 3.

striking finding is that the redistribution component is negative for all poverty measures!

Equally striking is the finding that all poverty measures show a decline in rural areas. Both the increase in mean consumption and redistribution are notable components of the decrease in poverty in rural areas (Table 4).

Estimates in Tables 5 and 6 indicate poverty has somewhat increased between 2004 and 2009. The growth component is the largest part of the change in poverty during the fourth development plan.

Our findings are generally consistent with earlier views of association between poverty and inequality. Prior findings have been influenced by estimates of Gini which, as we noted, may not be a good measure of changes in the tail areas, where the poor reside by definition. Our examination is therefore able to uncover changes that are free of parametric specifications of the distributions, and are based on poverty measures that have increasing sensitivity to changes in the tail areas. Poverty indices (especially P_1) are also useful to estimate the size of the resources needed to "eradicate" poverty. If it were possible to perfectly target resources to the poor, then, in 2004 a total amount of 11,470 milliard Rials ($P_1 \times$ the poverty line $\times$ population) would have been needed to bring the expenditure of all poor households up to the level of poverty line.[6] This represents about 2.5% of real GDP in that year.

7. Conclusions

The present method has the merit of exact decomposition without residuals and the simplicity and robustness of nonparametric implementation. We decompose the aggregate value of poverty changes which are estimated directly from conventional poverty indices rather than from specific parametric functional forms of Lorenz curves. This affords much needed robustness, and avoids mis-specification issues. Our approach is applicable to all decomposable poverty measures. We have also highlighted the value of examining robustness to the choice of poverty lines by means of dominance ranking of distributions. When dominance to an appropriate order holds only beyond most reasonable "poverty lines", a further degree of robustness is gained.

The empirical application to Iran is consistent with an inverse association between poverty and growth; the "growth" component accounts for more of the reduction in poverty. There is also an association between reduced poverty and reduced inequality. Both redistribution and growth components contributed to the change in poverty in rural and urban area of Iran. Note that the growth component is the larger component of changing poverty in Iran. As the World Bank (1990) argues, priority should be given to those growth-based policies that create opportunities for the poor to increase their income. The *pattern* of growth is likely an important determinant of the effect of growth on poverty.

Acknowledgements

We thank Firouz Vakil for very helpful comments on an earlier version of this paper; two referees and editors who advanced significant improvement in this paper, and participants at the Conference on Iranian Economy, University of Chicago, Fall 2010.

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[6] $P_1 \times$ the poverty line $\times$ population (nzP_1) represents the amount of resources required to eradicate poverty. Total income of the poor before transfer is $P_0\ \mu_z$, $\mu_z = \int_0^z xf(x)\,dx$. After the transfer, it is equal to $P_0 z$. Total amount of transfer is: $P_0 z - P_0\mu_z = zP_1$. It represents the lowest cost at which poverty could be eliminated. If resources are not available, it identifies the extent of the equivalent 'redistribution' required (see, for example, Kanbur, 1987 and Essama-Nssah, 1997).

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