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The Effect of Regional Price Adjustment of Household Expenditures on Poverty Indices in Iran's Urban Areas

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Accurate Measuring of poverty and its distribution in various areas, in addition to being crucial for cognitive purposes, could have different policy implications and affect policy assessments. The Household expenditures criteria is typically used to measure poverty, and poverty is often assessed using a poverty line and alternative indices. A major difficulty associated with this method is, however, that it fails to take the purchasing power of money in different areas into account. In fact, households with the same amount of expenditures living in areas with higher price levels enjoy lower levels of welfare in comparison with those living in areas with lower price levels. Since the consumer price index cannot reflect the difference between price levels in different areas, this index is not useful for evaluating differences in purchasing power. In this paper, we shall first present an index which reflects price levels in the Iranian year ending in March 2012, and then we shall test the equality of poverty measures hypothesis before and after adjusting expenditures with the proposed price level index using statistical tests and the dominance approach. According to the results, and regardless of the defined poverty line, adjusting expenditures based on all poverty measures characterized by a week monotonicity, will reduce the calculated poverty measures. Furthermore, after adjustment, the ranking of provinces with respect to poverty will drastically change. This could change the share of each province in reducing poverty budgets.

Keywords: Sen Index, Watt Index, FGT Measures, Price Index, First Order Stochastic Dominance
JEL Classification: C40, E31, I32

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1 Introduction

The study of poverty dates back to more than 100 years ago by (Booth, 1888) and (Rowntree, 1901). Although systematic investigation of this phenomenon started no earlier than the 1970s, following (Sen, 1976). The measurement and analysis of poverty, is crucial for cognitive purposes (to know what the situation is), for analytical purposes (to understand the factors determining this situation), for policymaking purposes (to design interventions best adapted to the issues), and for monitoring and evaluation purposes (to assess the effectiveness of current policies and to determine whether the situation is changing).

Measuring poverty involves three main components, namely selecting relevant variables for measuring welfare, selecting the poverty line or poverty threshold, and developing an index for measuring poverty. This measure, in fact, is an agenda for aggregating information.

The present paper will focus on the first component. Household expenditures are usually used to measure monetary poverty based on a poverty line and various measures. The main problem with this procedure is that instead of the purchasing power of the expenditures, their amount is considered. In practice, however, two households with equal income living in two different areas where resident households face different levels of prices should not be expected to have similar welfare (poverty) conditions.

There are two solutions to this problem. First, we can define the poverty line differently for each area (with different price levels). In practice, however, due to problems caused by the small sample size for each area (here the provinces of a country), calculating separate poverty lines for each province would not be efficient, leading to other difficulties. An alternative solution would be to adjust household expenditures using regional prices. This approach has been adopted for the purposes of the present paper. The results show that although price adjustments has no tangible influence on changes in poverty levels across the time, it nevertheless reduces the quantity of poverty during the whole time period under investigation, thus affecting the distribution of poor people across different provinces.

2 Literature Review

2.1 The Cost of Basic Needs and Welfare

The cost of basic needs varies from a region to another. Since consumer costs are considered as the proxy for real household welfare, these costs need to be

adjusted with the current prices so that household welfare in different regions of the country could be compared. The larger a country is and the more variety it has, regional adjustments would be more important (Coudouel, Hentschel, & Wodon, 2002).

The basic model in which differences in price and welfare levels in different regions are considered was developed by (Haurin, 1980) and (Roback, 1982) in urban economics. In this model, geographical locations are differentiated in terms of facilities, prices and wages. To model such differences, all consumer goods are classified into two major categories, namely goods with the same price in different regions (tradable goods) and goods with different prices in different regions (local goods). Furthermore, in order to make comparison among possible utility functions, household expenditures are adjusted with the regional living cost index. In the model developed by Haurin and Roback, the consumer solves the problem of optimum maximization among different regions when choosing the region in which they want to live. Therefore, assuming that there only two cities (geographical locations), the maximization problem can be formulated based on the indirect optimality function in the following manner (Black, 2011):

$$\begin{aligned} U_0 &= A_0 h(W_0, P_x, P_{z,0})` \\ U_1 &= A_1 h(W_1, P_x, P_{z,1}) \end{aligned} \quad (1)$$

Where h represents the indirect utility function, A stands for the facilities of any region, x stands for tradable goods, and z stands for local goods. In the next stage, the regional cost of living index is calculated for each region based on $U_0 = U_1 = U$ as an indicator of purchasing *power* in that region. Using this indicator, it would be possible to compare different regions in terms of their respective expenditures function (e).

$$K_R(U, A_1, A_0, P_x, P_{z,0}, P_{z,1}) = \frac{e(U/A_1, P_x, P_{z,1})}{e(U/A_0, P_x, P_{z,0})} \quad (2)$$

The $K_R(\cdot)$ index is the same index called "economic index" by Samuelson & Swamy (1974) because it is based on consumer preferences.

The introduction of the cost of living index to discussions of poverty was based on the argument that prices vary from one region to another region due to various reasons including differences in land price and wages. These differences lead to differences in cost of living for each region. Therefore, household living standards in more expensive areas will not be equal with those living in cheaper areas in terms of consumption, even though their

expenditures are the same. Thus, welfare level in more expensive areas, ceteris paribus, will be much lower than in cheaper areas.

2.2 Household Expenditures Adjustment

The first way to adjust household expenditures in different regions is the use of the consumer price index. In this method, given the availability of the consumer price index for different areas (provinces), each household's expenditures are adjusted with the regional (provincial) price index, with the adjusted figures being used to measure various poverty measurements.

However, the problem is that the consumer price indices based on Laspeyres formulation reflect temporal differences in prices and cannot show different price levels at different regions. The Laspeyres index is calculated using the following formula:

$$L = \frac{\sum_{i=1}^{n} p_1^i q_0^i}{\sum_{i=1}^{n} p_0^i q_0^i} = \frac{p_1^1 q_0^1 + p_1^2 q_0^2 + \cdots + p_1^n q_0^n}{p_0^1 q_0^1 + p_0^2 q_0^2 + \cdots + p_0^n q_0^n} \quad (3)$$

Where n is the number of goods, p_1^i is the price of i in the basic year, $p_0^i$is the price of i in the current year, and q_0^1 is the amount of i in the basic year.

The denominator of the fraction of the total costs (value) of a household's consumption basket is a fixed quantity represented by the letter A. Separating the above fraction would give us the following result:

$$L = \frac{p_1^1 q_0^1}{A} + \frac{p_1^2 q_0^2}{A} + \cdots + \frac{p_1^n q_0^n}{A} \quad (4)$$

Now, we multiply the numerator of the fraction associated with each of the goods in their base-year price, and divide it by that price:

$$L = \frac{p_1^1 q_0^1 \frac{p_0^1}{p_0^1}}{A} + \frac{p_1^2 q_0^2 \frac{p_0^2}{p_0^2}}{A} + \cdots + \frac{p_1^n q_0^n \frac{p_0^n}{p_0^n}}{A} \quad (5)$$

Reformulating the above equation will yield the following:

$$L = \frac{\frac{p_1^1}{p_0^1} p_0^1 q_0^1}{A} + \frac{\frac{p_1^2}{p_0^2} p_0^2 q_0^2}{A} + \cdots + \frac{\frac{p_1^n}{p_0^n} p_0^n q_0^n}{A} \quad (6)$$

In fact, $\frac{p_0^i q_0^i}{A}$ represents the share of i-th good in the total household consumer cost or the importance factor of i, which can be represented bys_i. Furthermore, $\frac{p_1^i}{p_0^i}$ represents the ratio of i's current price to its basic-year price

which can be shown as r_i. Therefore, the Laspeyres index can be summarized as $L = r_i s_i$.

2.3 Calculating the Cost of Living Index Based on Purchasing Power Parity

To overcome the above-mentioned difficulties in using the consumer price index calculated through Laspeyres formulation, the price index should be developed in such a way as to reflect the price level experience by each consumer. To develop such an index on the basis of the purchasing power parity index, the following measures were adopted:

The data related to the price level of various goods across different regions (provinces) are collected and then based on each region's population ratio to the whole country's population and using the weighted average, each of the goods price at the national level is calculated.

Then, the regional price index of each of the goods was calculated as a percentage of the price of those goods at the national level.

Finally, the price index for each region (province) was developed based on the share of each of the goods in the household consumption basket (importance factor), reflecting differences in price among different regions.

$$P^r = \sum_i \phi_i^r \left(\frac{P_i^r}{\sum_r S^r P_i^r} \right) \quad (7)$$

Where, S^r is share of each region in total population and ϕ_i^r is the importance factor.

2.4 Poverty Measurements[1]

Take *x* as the household income or expenditures. Since the households have been randomly selected, we can take *x* as a random variable with a probability density function of *f(x)*. Furthermore, we shall define *z* as the poverty line (a threshold of expenditure or income below which households are considered to be in poverty). Thus, we can formulate poverty measurements using the following formula:

[1] See Kakwani, 1993

$$P = \int_0^z \theta(z,x) f(x) d(x) \tag{8}$$

$\theta(z,x)$ can be regarded as the degree of deprivation experienced by households with an income of *x*. Specifically, when *z* and $\theta(z,x)$ are constant, poverty (*P*) is a decreasing function of the value of *x*.

Foster, Greer, & Thorbecke (1984) have developed a set of poverty measures resulting from the replacement of $\theta(z,x) = ((z-x)/z)^{\alpha}$ in equation (8):

$$P_{\alpha} = \int_0^z (\frac{z-x}{x})^{\alpha} f(x) dx \qquad \alpha \geq 0 \tag{9}$$

Where α is a parameter specified depending on the goal in question. If $\alpha = 0$, P_{α}would be equivalent to the headcount ratio (H), defined as the ratio of people living below poverty line. Furthermore, when $\alpha = 1$, P_{α}would be equal to the poverty gap ratio defined as:

$$G = \frac{H(z-\mu)}{z} \tag{10}$$

Where μ is the average income (expenditures) of people suffering from poverty? Watt (1968) developed a poverty measure which is obtained by replacing $\theta(z,x) = \frac{2(z-x_i)(q+1-i)}{(q+1)z}$ in equation (8):

$$W = \int_0^z (\log z - \log x) f(x) dx \tag{11}$$

Furthermore, the Sen Index was obtained by replacing $\theta(z,x) = \frac{2(z-x_i)(q+1-i)}{(q+1)z}$ in equation (8), where q is the number of poor people and *i* is the ranking of a poor household among other poor households.

$$S = \int_0^z \frac{2(z-x_i)(q+1-i)}{(q+1)z} f(x) dx \tag{12}$$

2.5 Statistical Inference on Poverty Measurements[1]

Since poverty measures have been development using sample observations, it should be clarified whether or not the differences observed are statistically significant. In a sample of *m* households whole income and expenditures are shown as $x_1, x_2, \ldots, x_m$, a consistent estimation of the poverty measures presented in equation (8) would be as follows:

[1] See Kakwani (1993) and Zheng (2001)

$$\hat{P} = \frac{1}{m}\sum_{i=1}^{q} \theta(z, x_i) \tag{13}$$

Where q is the number of households classified as poor. $\sqrt{m}(\hat{P} - P)$ is thus distributed as an asymptotic normal distribution with an average of zero and a variance of $\sigma^2(P)$. If $\hat{\sigma}^2(P)$ is a consistent estimation for $\sigma^2(P)$, then $\hat{\sigma}^2(\hat{P})/\sqrt{m}$ would be the standard deviation for $\hat{P}$, which can be represented as $SE(\hat{P})$. Then,

$$t = \frac{\hat{P} - P}{SE(\hat{P})} \tag{14}$$

Will have an asymptotic normal distribution with an average of zero and a variance of 1. Therefore, t could be used to create the confidence interval around the specified quantity of P for poverty measures. Now, if $\hat{P}_1$ and $\hat{P}_2$ are different estimations of the P poverty indicator, and if $\hat{\sigma}_1^2$ and $\hat{\sigma}_2^2$ are sample estimations of $\sqrt{m_1}\hat{P}_1$ and $\sqrt{m_2}\hat{P}_2$ variance distributions respectively, then the standard deviation for $(\hat{P}_1 - \hat{P}_2)$ would be as follows:

$$SE(\hat{P}_1 - \hat{P}_2) = \sqrt{\frac{\hat{\sigma}_1^2}{m_1} + \frac{\hat{\sigma}_2^2}{m_2}} \tag{15}$$

Under such circumstances, the statistic related to the testing of the equality of the two measures would be as follows:

$$\eta = \frac{\hat{P}_1 - \hat{P}_2}{SE(\hat{P}_1 - \hat{P}_2)} \tag{16}$$

which has an asymptotic normal distribution with an average of 0 and a variance of 1. Thus, the η statistic can be used to test the poverty gap significance hypothesis. However, obtaining statistics t and η would require calculation of variances associated with different poverty measurements.

Therefore, we define the I_i variable in the following manner:

$$I_i = \begin{cases} 1 & if \;\; x_i < z \\ 0 & if \;\; x_i \geq z \end{cases} \tag{17}$$

The poverty estimation introduced in equation (8) can be formulated as follows:

$$\hat{P} = \frac{1}{m}\sum_{i=1}^{m} M_i \tag{18}$$

in which

$$M_i = I_i\theta(z, x_i) \tag{19}$$

And so,

$$E(M_i) = \int_0^z \theta(z,x)f(x)dx = P \tag{20}$$

The above equation implies that $\hat{P}$ is an unbiased estimator of P. However, since $x_i$and x_j sampling observations are independently distributed, $M_i$and M_j would also be independently distributed. Applying central limit theorem to equation (15), it is concluded that $\sqrt{m}(\hat{P} - P)$ has an asymptotic normal distribution with an average of 0 and the following variance:

$$\sigma_m^2 = E(M_i - P)^2 = \int_0^z \theta^2(z,x)f(x)dx - P^2 \tag{21}$$

The sampling-based estimation of σ_m^2 is as follows:

$$\hat{\sigma}_m^2 = \frac{1}{m}\sum_{i=1}^{q}\theta^2(z, x_i) - \hat{P}^2 \tag{22}$$

Given this general condition, we can obtain the variances of the measures in section 2.4 separately.

If $\theta(z,x) = 1$, P would be the same as the headcount ratio for H. Then the H sample estimation would be $\hat{H} = \frac{1}{m}\sum_{i=1}^{m} I_i$. Based on equation (18), $\sqrt{m}(\hat{H} - H)$has a normal distribution with an average of 0 and a variance of $H(1-H)$. Therefore, the standard deviation for $\hat{H}$would be calculated as $\sqrt{\hat{H}(1-\hat{H})/m}$ and given the results obtained from equation (9), different hypotheses can be tested in connection with different measures.

For the FGT indices: $\text{var}(\sqrt{m}\hat{P}_\alpha) = \hat{P}_{2\alpha} - \hat{P}_\alpha^2$.

For the Watt Index: $\text{var}(\sqrt{m}\hat{W}) = \frac{1}{m}\sum_{i=1}^{q}(\log z - \log x_i)^2 - \hat{W}^2$.

And for the Sen Index: $\text{var}(\sqrt{m}\hat{S}) = \frac{1}{m}\sum_{i=1}^{q}(\frac{2(z-x_i)(q+1-i)}{(q+1)z})^2 - \hat{S}^2$

2.6 The Stochastic Dominance Approach and Comparing Poverty in Two Distributions

In addition to statistical tests mentioned above, the dominance approach could also be used to compare poverty measures. This approach provides a framework to show whether or not it would be possible to provide accurate comparisons of poverty levels in terms of some or all of the poverty indicators and their different values.

According to definition, if

$$\int \theta(x)dF(x) \geq \int \theta(x)dG(x) \quad (23)$$

is true, for all the none-decreasing functions, then distribution *F* would have first order dominance over distribution *G* (Mas-Colell, Whinston, & Green, 1995, p. 195).

Furthermore, it could be demonstrated that if, and only if $F(x) \leq G(x)$ is true for all the *x*'s, or in other words, if for all the values of *x* the cumulative distributive function *F(x)* is on the lower right part of the cumulative distributive function of *G(x)*, distribution *F* would have first order stochastic dominance over distribution *G* (ibid.).

The dominance approach has been widely used in measuring and analyzing poverty and inequality (Atkinson, 1970, 1987 & Foster & Shorrocks, 1988). If any particular level of outcome (*x*) is taken as the poverty line, the value of the cumulative distribution function in *z* will be equal to the headcount ratio. In other words, the first order stochastic dominance requires that the headcount ratio in distribution *F* should be equal to or less than that in distribution *G* for all the defined poverty lines. However, stochastic dominance has outcomes beyond the headcount ratio. As demonstrated by Atkinson (1987), if a distribution has first order stochastic dominance over another distribution, then based on all the poverty measures which provides weak monotonicity (and any monotonic transformation of those measures) and based on all the defined poverty lines, the level of poverty in the former would be lower than in the latter. Therefore, demonstrating first order stochastic dominance eliminates the need for defining poverty lines and selecting poverty measures in ranking two different distributions in terms of poverty level.

2.7 Relevant Experimental Studies

Although numerous studies have been conducted to measure the phenomenon of poverty, few studies have explicitly concerned themselves with price adjustment. In what follows, we shall point out to some of these few instances.

Gaddis (2016) studied poverty measurements in Africa. Discussing different price indicators which can be developed using consumer price data, he demonstrated to what extent the different methods used to develop price indices could affect poverty measurements. He paid particular attention to price adjustments over time without offering any specific recommendations for regions.

Using the 1983 statistics for Ruanda and through theoretical arguments, Muller (2008) showed that seasonal changes in regional prices, could lead to

significant changes in indicators related to the standard of living. By contrast, poverty measures were found to be highly sensitive to regional price adjustments used the FGT family of measures, adjusting annual household expenditures using seasonal and annual price indices developed by Laspeyres and Paasche citing the absence of an adequate cost of living index as the main reason for failure to adjust poverty indicators based on the cost of living index in different regions.

Khandker & Mitchell (1998) developed a cost of living index for 300 big cities in the US in 1990 using data published by the US Chamber of Commerce. Having developed such an index for different regions, they adjusted poverty measures on the basis of the lognormal and Pareto distribution for households' income. They came to the conclusion that poverty rates significantly reduced following the adjustment process.

3 Calculating Poverty Measures and Comparing Them with Unadjusted Indicators

Fig. 1 illustrates the cost of living index developed based on the three-step process described in section 2.3 for different Iranian provinces in the Iranian year ending in March 2012. As shown in fig. 1, the province of Tehran (and the province of Alborz which had not become an independent province at the time) have had the highest, and the province of Southern Khorasan has had the lowest cost of living index.

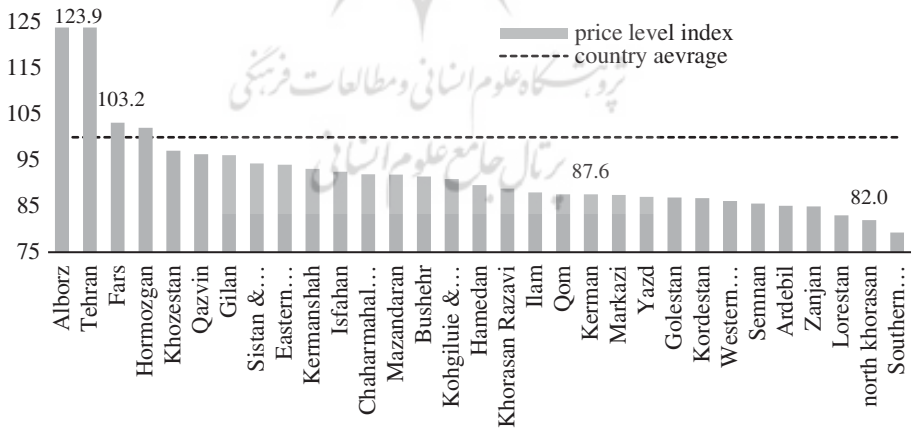

Figure 1. Comparison of price level index in different Iranian provinces (for the Iranian year ending in March 2012). *Source*: research findings.

Table 1
A Comparison of Poverty Measurements

Poverty Measures	Per Capita Expenditures	Per Capita Expenditures after Price Adjustment	The Difference	The Difference Standard Error	Related Statistic
Headcount ratio	0.2165	0.1806	0.0358	0.0041	8.7127
Income Gap ratio	0.0576	0.0452	0.0124	0.0013	9.1162
FGT; α=2	0.0226	0.0173	0.0053	0.0007	7.4729
Sen Index	0.0799	0.0636	0.0163	0.0022	7.1552
Watt Index	0.0328	0.0256	0.0072	0.008	8.4511

Note. The comparison in for before and after adjusting per capita expenditures with regional prices in the Iranian year ending in March 2012. *Source*: research findings.

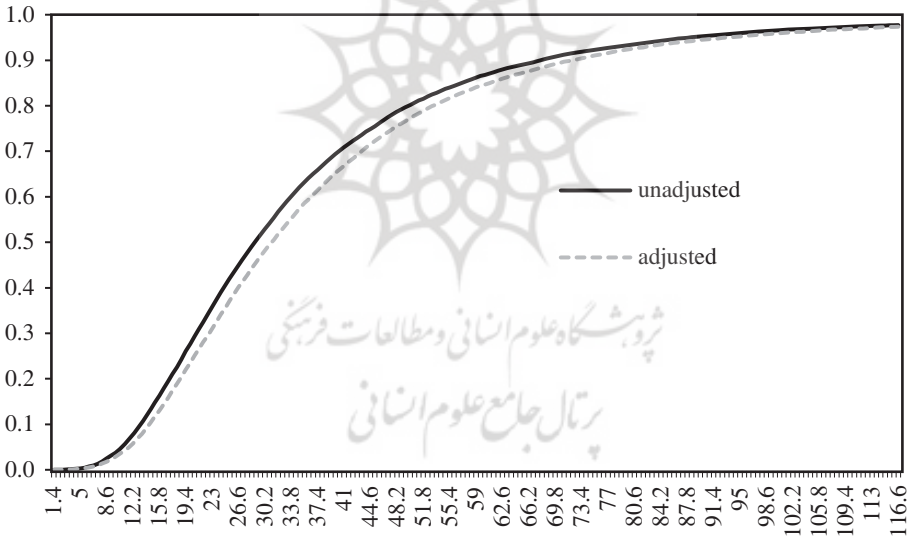

Figure 2. Cumulative distribution of household expenditures before and following the adjustment process (for the Iranian year ending in March 2012). *Source*: research findings.

Based on the absolute food poverty line and the per capita household expenditures adjusted with the prices level index described above, all the poverty measurements quantified for the Iranian year ending in March 2012

have decreased, in compare with the measures before adjustment. Therefore, given the results obtained from the measures equality test, the null hypothesis is rejected in all cases.

Figure 2 illustrates the cumulative distribution of Iranian urban households' income along with that of household expenditures adjusted with the cost of living index for the Iranian year ending in March 2012.

As shown in fig. 2, the adjusted expenditures distribution has a first order stochastic dominance over the unadjusted distribution. This means that regardless of the value defined as poverty line and for all the poverty measures, the level of poverty decreases when the expenditures are adjusted with regional prices. This conclusion fully supports the above results obtained using statistical tests. As demonstrated, the value of poverty measures decreases after adjusting household consumption expenditures based on the cost of living index. However, some details are overlooked because of this focus on general poverty indicators. As shown in fig. 1, price levels in some provinces are higher or lower than the average level (groups 1 and 2 respectively). Therefore, some households (in the provinces classified in the first group of provinces) who would not be considered poor prior to price adjustments, are expected to be classified as poor following the adjustment process. In contrast, some families previously considered to be poor (in the second group of provinces) are no longer considered as such, following the adjustment of prices. Looking at the poverty indicators, we notice that each of these two changes is partially counterbalanced by the other, with changes in the general indicator being an outcome of this process. In other words, adjusting expenditures with regional prices has implications beyond reducing general poverty measures.

An examination of changes in the level of poverty in different provinces can illustrate this point more clearly. Fig. 3 shows the headcount ratio for different provinces for the Iranian year ending in March 2012, before and after adjusting the expenditures with the cost of living index.

The headcount ratio for the province of Alborz has more than doubled (reaching from 15 to 31 percent), changing its place from the 22nd to the second poorest province in the country. The headcount ratio for the province of Tehran has almost doubled, changing its rank from the 31st to the 21st poorest province in the country. In the province of Southern Khorasan, the headcount ratio has decreased from 28 to 15 percent, changing its rank from the 6th to the 15th poorest province in the country.

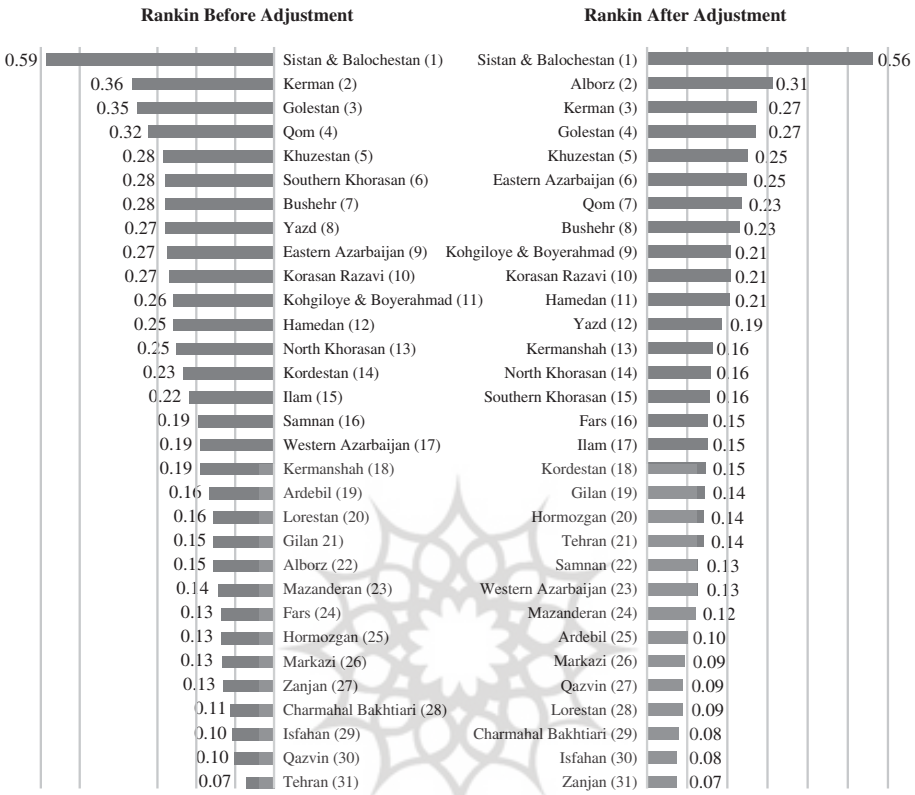

Figure 3. Comparison of headcount ratios for different provinces before and after adjusting expenditures with regional prices for the Iranian year ending in March 2012. *Source*: research findings.

4 Conclusion

A more accurate measurement of poverty can provide a more nuanced picture of the current situation, paving the way for more rigorous analyses of the factors contributing to it in the first place. Under such circumstances, policy goals are more properly designed, and the evaluation of such goals will be carried out more efficiently in light of more accurate measurements.

Following an explanation of the significance and necessity of adjusting household's income (expenditures) at the regional level for measuring poverty, it was demonstrated that traditional price indices are not suitable for adjusting income (expenditures) with differing prices at different regions. To overcome this difficulty, a cost of living index was developed using pricing

data for different provinces, so as to reflect different price levels across the provinces. Then, household expenditures were adjusted using the designed index, and five different poverty measures were calculated. All the poverty measures showed a marked decrease after adjusting expenditures with regional prices.

To make sure that the differences in the quantity of the calculated measures are statistically significant, the variance of each of the poverty estimators was calculated, and the equality hypothesis test was carried out for each of the measures before and after expenditures adjustment. Value difference for all the measures were found to be statistically significant.

Furthermore, the dominance approach as was also described and adopted as one of the main approaches to the study of poverty and inequality in recent years. The results also showed that regardless of the amount of expenditures used as the poverty line, the level of poverty at adjusted expenditures would be lower for all poverty measures provide week monotonicity.

Finally, the status of different regions evaluated in terms of the level of poverty. It was shown that adjusting expenditures with the cost of living index significantly changes the rank of each province in terms of poverty level. For example, a province (Tehran) which prior to the adjustment process ranked 31st in terms of poverty level, had its rank changed to the 21st poorest province following the adjustment process. Furthermore, the adjustment process doubled the headcount ratio in a province like Alborz compared to the time before it.

The present paper contains two main conclusions. First, regardless of the procedure used to identify poor people and the criteria used as poverty indicators, the calculated values for poverty would not be sufficiently accurate without taking price differences among different regions into account. Given the differences in price levels in different regions, the purchasing power of money in all regions would obviously not be the same. Therefore, defining a single poverty line and classifying all the individuals with expenditures below that poverty line as poor, would distort our estimations of the level of poverty in society.

The second important conclusion of this study concerns changes in the rank of different provinces following the adjustment of the expenditures variable. In fact, when expenditures are adjusted, the province of Tehran is replaced by the province of Zanjan as the province with the lowest level of poverty. These changes in ranking would have significant implications for policies oriented towards reducing poverty. The most Important of these Implications concern

policy functions related to the distribution of resources allocated for eliminating poverty.

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