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GHGs EMISSION REDUCTION TARGETING BASED ON HORIZONTAL EQUITY CONCEPT AT A COUNTRY LEVEL

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Abstract

This research attempts to evaluate the target of 15-30% emission cut by 2020 of developing countries which were discussed in COP17 of UNFCCC in late 2011. Iran is ranked amongst the top ten large emitters of GHGs and would soon be required to reduce its emissions. Thus, this research suggests and applies different combinations of some principles in order to explore different kinds of burden sharing rules at a country scale for Iran. The focus is on "Horizontal Equity" on the premise of reduction target setting, economic development and the fulfillment of regional equity. Amongst the models examined for the appropriateness in a developing country such as Iran, the model which assigns a greater weight to the criteria of CO_2 per Added Value demonstrated to be the most viable economic choice to both address the developed as well as less developed provinces at the national level. It can be argued that asking developing countries (e.g. Iran), which have energy-dependent economies, for reducing emissions means freezing the standard of living at this stage of their development and remaining one step behind the others forever. Therefore, instead of selecting a particular rate for emissions cut among countries, conversion into a "number game" with focus on the ratio of GDP loss, is proposed to be mathematically a logical approach. The results of this study show that a 20% cut in Iran's GHGs emission will lead to high rates of reduction in GDP over the period 2010-2020.

Keywords: allocation, climate change, economy, equity, reduction

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1. Introduction

Climate change and its consequences, particularly global warming, have been the most challenging threats during the past decades. This phenomenon requires being urgently addressed which represents a potentially irreversible risk to human societies and our planet as a whole. The concentration of greenhouse gases (GHGs) have been rising by 2.3 ppm CO_2 equivalent per year and have been at the highest levels during the last 650,000 years (Stern, 2006). One of the most important GHGs, carbon dioxide (CO_2), increased from 280 ppm in the pre-industrial era to 406.75 ppm in December 2017 (NOAA, 2018). The rapid rise in GHGs concentration led to some changes in the climate, at a rate faster than some living forms may be adapted to. Scientific evidence revealed that setting a limit on total CO_2 emissions until 2050 would make a realistic chance for control of global warming under 2°C (Messner et al., 2010).

The Intergovernmental Panel on Climate Change (IPCC) reports (IPCC, 2007; Rübbelke, 2011) state that climate policy should include two kinds of pillars: the first "Mitigation" of climate change and the second "Adaptation and Vulnerability" to climate change. While "Mitigation" efforts try to reduce the potential effects of global warming using actions which decrease the intensity of radiative forcing, "Adaptation" is defined as actions which concentrate to reduce the vulnerability of natural and human systems to cope with changing

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the climate. IPCC noted that if the annual rate of carbon emissions reduced to approximately half, before 2050, actions for mitigating climate change would be considered as successful (He and Gao, 2011). Also, in 1995, the German Advisory Council on Global Change (Schellnhuber, 2009) suggested that in order to effectively combat the threat of global warming and prevent dangerous anthropogenic interference with the climate system, global warming should be limited to a maximum of 1.5°C or 2°C above pre-industrial levels (Messner et al., 2010). It is clear that in order to combat climate change, global emissions would have to be cut by more than 50% in a period of 20 years or over 95% by the end of this century. So, the global emissions should be reduced as given in Fig. 1 (Keohane and Goldmark, 2008).

A study (Edenhofer et al., 2011) recommends that such reduction in GHGs emission needs a comprehensive and global effort which could be defined in two principle pathways: first, a basic change in energy supply of developed and industrialized countries and second, utilization of low carbon technologies and emerging markets in developing countries. However, the loss of public welfare is a remaining challenge for both industrialized and developing countries. The Kyoto Protocol is an international agreement affiliated to the United Nations Framework Convention on Climate Change (UNFCCC), concluded in December 1997 as one of the major outcomes of COP5 in Kyoto- Japan that came into force on February 16th, 2005. The major feature of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries and the European community (the so-called Annex I countries list to the UNFCCC) for reducing their collective emission of GHGs. This amount is an average of 5.2% compared to the year 1990 over the five-year period, 2008-2012. As of September 2011, 191 UN member states have signed and ratified the protocol (UNFCCC, 2011). The only large emitter remaining signatory not to have ratified the protocol yet is the United States. In 2011, through decisions adopted at 17th sessions of the Conference of Parties (COP17), Durban-South Africa, parties decided to extend the role of the Kyoto Protocol in mitigation efforts, for the second commitment period of the Kyoto Protocol without any delay. During COP18, Doha-Qatar 2012, it was concluded that Kyoto Protocol extended for another eight years (1 January 2013 and end on 31 December 2020 (COP17, 2011a)).

Another important decision of COP17 was that the aggregate GHGs emission by the Annex I countries, which include CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3, should be reduced by at least 25-40 percent below 1990 levels by 2020. In addition, by 2020, all the non-Annex I countries will have pledged a reduction in GHGs emission in the range of e.g. 10-30 percent below that of a reference year. In this path, developed countries as one group should reduce their emissions in the range of 30-50 percent from 1990 level by 2020. It should be noted that the range of deviation by developing countries for post-2020 reduction targeting is completely a function of the level of support provided by the developed countries (COP17, 2011b).

Recent reports (Germanwatch, 2016; Statista 2017) introduced top ten emitter countries worldwide in 2016 as China (28.21%), United States (15.99%), India (6.24%), Russia (4.53%), Japan (3.67%), Germany (2.23%), Korea (1.75%), Iran (1.72%), Canada (1.71%) and Saudi Arabia (1.56%), respectively.

For painting a realistic picture of the future concentration of GHGs and global mean temperature projections, at first, it is necessary to understand how to distribute and allocate the reductions to each country. The second step would be to focus on allocating emission allowances and emission reduction strategies within a country (Han et al., 2015; Kolios and Howe, 2014). This point should be considered that because of the causal relationship between economic growth and GHGs emission in some countries, such as Iran (Lotfalipour et al., 2010; Mossalanejad, 2011, 2013), different regions may resort different strategies to shoulder emission reduction burdens. In addition, for achieving climate change mitigation targets, each party member to the UNFCCC should be given sufficient incentives to join and remain in the coalition (Bosetti et al., 2013).

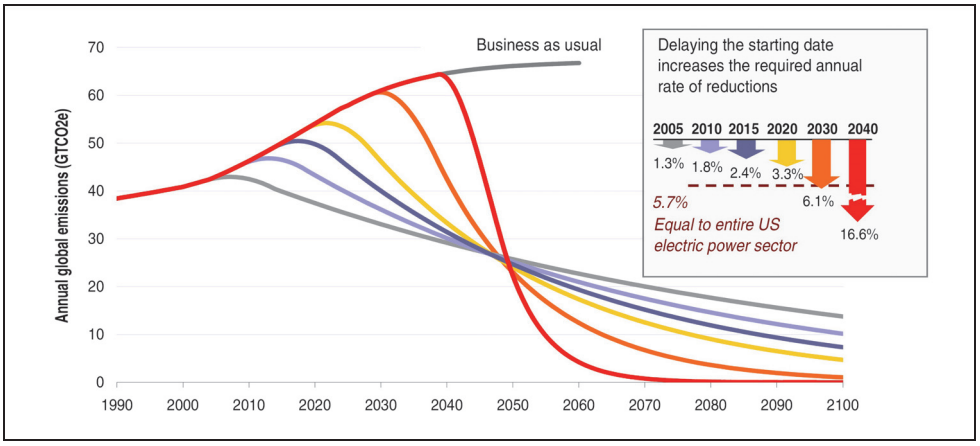

Fig. 1. GHGs emission pathways consistent with 2ºC warming (Keohane and Goldmark, 2008)

This incentive can be in the form of "Equity" and "Right to grow". The researches and literature on burden sharing in the context of emission allowances are of a rather recent date. The "equity" perspectives and principles which have been proposed, focused on the burden sharing and CO_2 emission allocation across nations and not within countries (Calvo and Rubio, 2013; Hsu, 2011; Mattoo and Subramanian, 2012; Pan, 2003).

A wide range of academic and applied researches focused on highlighting the different principles for determining emission allocations among nations (Dietz et al., 2007; Dubash, 2009; Kanitkar et al., 2010; Mironiuc and Huian, 2017; Novelli et al., 2017; Posner and Weisbach, 2010; Tavakoli, 2018). The significance and novelty of this research/article in line with COP18 decisions for developing countries GHGs emission reduction target setting are to explore different kinds of burden sharing rules at a national scale as a roadmap for reduction of GHGs in a global perspective. It should be noted that the focus of this approach is on the achievement of "Horizontal Equity". It means that individuals under the same circumstances should be treated equally to ensure that the holistic objective of emission reduction targets, economic development, and regional equity may be simultaneously achieved.

2. Case-study presentation

2.1. Equity principles and burden sharing rules

During the past decade, a distinct body of research started to investigate the concepts and principles of "equity". Although there is no commonly accepted definition of "equity", some principles of fairness have been identified as relevant in the broader context of climate change (ABARE and DFAT, 1995; Burtraw and Toman, 1992; Cazorla and Toman, 2000; Janissen et al., 1995; Ringius et al., 2002; Rose, 1992; Tavakoli et al., 2016).

The egalitarian principle- equal rights for all persons to use a common resource- in the context of climate change can be defined as every individual has an equal right to use the atmosphere as a sink for GHGs from the perspective of enjoying the environmental services of the atmosphere, and so would be entitled to the same amount of permits. This concept has been evaluated by a number of researchers and is considered a relevant indicator in line with "equity" (Frankel, 2007; Posner and Sunstein, 2008; Posner and Weisbach, 2010; Schellnhuber, 2009; Winkler et al., 2006).

The sovereignty principle denotes that each individual has an equal right to the atmosphere based on current emissions level. The principle of "Horizontal Equity"- which resembles some degree, the principle of sovereignty- implies equal treatment of members that belong to a group and require an equal percentage reduction in welfare or burden of abatement cost among individuals (Ringius et al., 1998).

Two kinds of equity principles are faced with different aspects. Vertical Equity tries for a progressive distribution of burdens. It means that when the ability to pay grows, the burdens would increase, simultaneously. Horizontal Equity aimed for equal treatment among equals (Cazorla and Toman, 2000; Ringius et al., 2002).

The party who emits is responsible for making pollution and should pay for the damage done to the natural environment. A rule considered as polluter pays principle (PPP), which is known as extended producer responsibility (EPR), pay to this responsibility. In a simple word, the burden should be distributed in accordance with an individual's contribution in emissions. It could be concluded that an increase in ability to pay by polluter could lead to a chance for him to increase its emission levels.

The principles selected for the formulation of equity and burden sharing rules can provide a solution based on a rich set of simple principles which ultimately will improve the process of decision making in the selection of the appropriate scenarios. These principles can be divided into two main groups. The first group is those which are static and focus on one point in time such as population, land area or per capita of current emissions. The second group is more dynamic and includes cumulative emissions, development, economic growth, etc. Also, the equity indicator might be summarized in single criteria (for example population, per capita of GDP, per capita of emissions or so on) or in the form of a comprehensive indicator which combines different criteria (emissions per capita, the percentage of GDP, cumulative emissions and so forth). The analysts believe that "multi-criteria rules" are preferred to "single criterion rules". This is mainly because they are more "robust" in the sense that they yield less difference between the smallest and the largest target for a country (Kawashima, 1996; Ringius et al., 1998). The focus of this research is to determine the principles for emission reduction share of individual provinces of Iran according to COP17 decisions. Thus, CO_2 emissions per capita, GDP, CO_2 emissions per unit of GDP, GDP per capita, population, accumulated CO_2 emissions and CO_2 per unit of added value are selected. These indicators can be used as the different linear combinations in order to quantify the burdens that each province might shoulder.

1) Per capita emissions: Per capita of CO_2 emissions as the first criterion of fairness, reflect the sovereignty and the polluter pay principles. The degree of inequality in per capita of emissions determines the different degree of responsibilities in the contribution to the efforts targeted at the climate change problem (Duro and Padilla, 2006).

2) GDP: The second variable in quantifying burden sharing rules is GDP. This criterion points to Horizontal Equity and reflects the economic size of individuals.

3) CO_2 emissions per unit of GDP: Carbon intensity of growth or CO_2 emissions per unit of GDP is a measure of emissions to make income. So the reduction of this index in a region (for example China fell by 15 percent, 2005-2011 (IEA, 2012) means finding less carbon consuming ways to grow.

4) GDP per capita: It is apparent that mitigation will impose economic costs- in terms of reduced consumption and growth because of higher prices of carbon and energy (Mattoo and Subramanian, 2012). The ability to pay for mitigation or abatement can easily be captured as per capita GDP of an individual (vertical equity principle). In this relation, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) suggested that UNDP's Human Development Index (HDI) could be used as an indicator of capability (GTZ, 2004).

5) Population: Each province's percentage share of the population is another factor that in combination with the percentage share of CO_2 emissions and GDP can be suggested for burden sharing rules.

6) Accumulated CO_2 emissions: Atmosphere could be estimated with a reservoir. The limited capacity of this reservoir leads to an environmental problem as climate change. The more gas being spewed into it, less space remains for subsequent emissions. The amount of GHGs emitted from many years ago interpreted as accumulated CO_2 emissions or "the historical responsibility" with a long and illustrious pedigree in the climate change negotiations.

This concept which is related to "polluter pays principle", means that greater reduction burden might be proportional to the bigger historical responsibility.

7) CO_2 per unit of added value (AV): This criterion is selected as the indicator of emission reduction potential and can show the amount of emissions to create a unit of economic activity as measured by added value (climate-friendly income). The provinces which use clean fuels or advanced technologies can reduce the amount of emissions, in comparison to AV, and this factor can be considered as an encouraging factor in burden sharing rules.

Before anything, it is necessary to recognize the most important principles and determine allocation, so it is important to see whether "Equity" should be applied to emissions allocation or emissions cut. These analyses are also at an individual or regional scale.

2.2. Data Reference and Processing

The critical information for this research includes the amount of GHGs emissions from all sectors based on Provincial distribution during one decade (2001-2010). Based on the proposed method suggested by IPCC guideline, four groups of information related to energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU) and finally waste and wastewater are needed. Energy balance sheets (MOE, 2013), Ministry of Petroleum, Ministry of Energy, Ministry of Industry, Mine and Trade, National Iranian Oil Products Distribution Company (NIOPDC) and National Iranian Gas Company (NIGC) provide necessary data related to energy consumption of this period. Ministry of Jihad-e-Agriculture provides the statistics of livestock and poultry population by type and district and rice cultivation areas. Demographic statistics in each province or region and GDP information are provided by Statistical Centre of Iran. IPCC waste model is used for estimation of emissions from landfills and solid wastes (IPCC, 2006). Based on guideline published by IPCC for National Greenhouse Gas Inventories, all data are used and the amount of GHGs emissions calculated.

Global Warming Potential (GWP) with a time horizon of 100 years are applied to convert different GHGs into comparable CO_2 equivalents (CO_{2eq}). Table 1 presents indicator values for provinces in Iran.

2.3. Allocation of emission reduction targets at a country scale- Iran

The main objective of this study is to provide answers to the question of fair emission cuts and hence it needs to have a baseline from which cuts could be measured. As mentioned earlier, during COP17 it was discussed to put the target of 10-30% reduction in GHGs emission, for developed countries (Annex I countries), over the reference year by 2020. Thus, the allocation target of this evaluation is based on 20% GHGs emission cut from 2010 levels by 2020. The units of analysis are provinces/states of a country, in this case, Iran which listed under Annex I countries, as the building block for any "Equity" consideration. It means that the GHGs emission reduction burden is quantified for each province so that the sum of total emissions reduction is equivalent to 20% for Iran. So far, the most important principles effective on "Equity" and burden sharing are only defined broadly. Thus a "Comprehensive Index" needs to be constructed based on multiple criteria and weighting coefficients to provide better and more integrated representation for "Equity" and fair distribution of emission cuts.

In this section, three formulas are proposed for the calculation of the comprehensive index of fair emission cuts. The economic aspects of each approach are also examined.

Formula I: The share of GHGs emission, GDP, GHGs emission per unit of GDP and GDP per capita for each province to Iran averages for the same indicators are selected for this formulation as below (Eq. 1):

$$ER_i=\left(w_{E_{capita}}\times\frac{E_{capita_i}}{\overline{E}_{capita}}+w_{GDP}\times\frac{GDP_i}{\overline{GDP}}+w_{EI}\times\frac{EI_i}{\overline{EI}}+w_{GDP_{capita}}\times\frac{GDP_{capita_i}}{\overline{GDP}_{capita}}\right)\times Z \quad (1)$$

where:
ER_i: Emission reduction target for province i (%); E_{capita}: GHGs emission per capita; EI: Emissions per unit of GDP; GDP_{capita}: GDP per capita; Z: Correction factor (the average equal 0.1524); w: Weighting coefficient as $\sum w = 100$.

The weighting allocations of the five choice preference cases (include equally weighting, preferring CO_2 per capita, preferring CO_2 per GDP, preferring GDP per capita and Analytic Hierarchy Process (AHP)) and the result of this allocation for provinces are shown in Table 2 and Fig. 2, respectively.

Formula II: In formula II, each province percentage share of the population, GHGs emission, and GDP in comparison to Iran's total, are used to calculate the comprehensive index of reduction (Eq. 2). Formulas I and II have been used for evaluation of burden sharing rules across OECD countries (Ringius et al., 1998) and are also used here with some changes:

$$ER_i = \left(w_P \times P_i + w_E \times E_i + w_G \times G_i\right) \quad (2)$$

where:
P_i: Share of population for province i (%);
E_i: Percentage share of CO_2 emission for province i;
G_i: Percentage share of GDP for province i;
w: Weighting coefficient as $\sum w = 1$.

Table 1. Indicator values for provinces in Iran, 2010

Province	*CO_{2eq}* per capita*	*GDP*	*CO_{2eq}*/GDP*	*GDP per capita*	*Accumulated CO_{2eq}**	*CO_{2eq}*/AV*
	ton	**10^{12} Rial**	**kg/10^6 Rial**	**10^3 Rial**	**10^{10} kg**	**kg/10^4 Rial**
Ardabil	7.82	47.82	203.27	38476.82	6.70	5.82
Azerbaijan East	8.32	161.38	190.29	43718.92	27.09	6.01
Azerbaijan West	7.19	101.09	214.51	33513.96	17.24	7.65
Bushehr	28.94	87.07	313.61	92275.35	15.38	3.75
Chahar Mahaal and Bakhtiari	7.00	32.36	193.04	36236.78	4.54	6.58
Fars	8.96	187.64	216.34	41434.88	32.83	6.66
Gilan	8.14	108.59	183.93	44258.61	17.54	7.69
Golestan	5.64	61.52	154.77	36465.96	6.84	5.38
Hamadan	9.87	69.37	241.73	40816.03	13.75	7.09
Hormozgan	12.46	72.19	268.98	46307.69	15.06	8.38
Ilam	5.51	20.18	154.67	35631.37	2.38	0.89
Isfahan	15.41	272.72	271.56	56763.27	60.54	7.02
Kerman	7.85	121.72	190.12	41297.84	19.43	3.79
Kermanshah	8.90	75.61	224.28	39676.28	12.73	8.56
Khorasan	7.82	307.15	189.95	41192.54	45.26	7.39
Khuzestan	11.16	210.37	237.20	47047.88	41.82	1.09
Kohgiluyeh and Boyer-Ahmad	4.80	20.69	155.23	30916.75	2.28	0.34
Kurdistan	6.80	47.41	210.43	32306.01	7.92	8.63
Lorestan	5.22	54.29	169.18	30877.55	7.78	6.56
Markazi	16.55	86.90	265.20	62410.80	19.71	5.99
Mazandaran	10.81	169.17	194.07	55697.07	26.92	5.81
Qazvin	19.21	70.33	331.07	58009.97	18.87	7.15
Qom	7.97	44.75	200.91	39686.20	7.76	8.72
Semnan	10.31	39.78	183.93	63706.47	5.73	4.44
Sistan and Baluchistan	6.52	48.37	368.21	17696.73	12.99	18.28
Tehran & Alborz	6.94	1348.26	76.20	91128.50	83.91	5.07
Yazd	12.46	65.16	203.83	61134.50	9.72	4.63
Zanjan	6.75	41.91	164.71	42618.05	4.93	3.77
Iran (Total)	9.18	3973.80	172.64	53173.15	547.65	4.24

* *Calculated by the authors*

Table 2. Weighting Coefficients under five decision preferences

Values	*Case 1, Equally weighting*	*Case 2, Preferring CO_2 per capita*	*Case 3, Preferring CO_2 per GDP*	*Case 4, Preferring GDP per capita*	*Case 5, AHP approach*
W_A (CO_2 per capita)	25	55	15	10	45.45
W_B (GDP)	25	15	15	10	15.15
W_C (CO_2 per GDP)	25	15	55	10	9.09
W_D (GDP per capita)	25	15	15	70	30.30

Again in formula II weights are given to each of three indicators and one case is calculated based on AHP method (Table 3). The result of emission cuts for each province based on five cases in formula II are represented (Fig. 2).

Formula III: This equation has used two new criteria of cumulative emissions and GHGs emission per unit of added value. There is a correlation between cumulative emissions and the level of wealth and economic development in a region. As discussed previously, cumulative emissions are a historical responsibility and so the greater and the earlier the responsibility is met, the lower the future share should be. About the time horizon of historical emissions, some researches relate this principle to this ethical notion that "thou shalt not harm others". Based on this idea, the year 1990 as the starting point after which no government could plead ignorance about the effects of GHGs seems appropriate (Mattoo and Subramanian, 2012). However, in this article based on the data available at the provincial level, the sum of GHGs emission in each province from 2001 to 2010 is considered as cumulative emissions. This formula (Eq. 3) is more comprehensive than the others because on the one side, lies the effect of previous emissions as a responsibility for past behaviors and on the other side, the income which results from GHGs emission are given consideration. Consequently, besides the indicator of GHG emission and standard of living for each province, the share of each region in human induced climate changes and economic value of emissions are well attended to (Fig. 2).

It is evident that considering different principles or putting different weights on the indicators could lead to high rate of changes in the level of GHG emissions and income by provinces. But from a governmental point of view, a loss in national income change (as GDP) is one of the most important selection criteria. So it is vital to calculate the amount of GDP reduction at a national scale for each case. Considering the relationship that exists between GHGs emission and GDP for each province, calculation of GDP reduction at a regional scale is possible. The sum of GDPs will again present the total GDP for the whole country.

Accordingly, the cost of emission reduction by 2010 as added value and comparison of that by GDP in the target year (2020) for different scenarios are calculated. The results of emission cuts by 20% (to 2010 level) from three formulas and five cases for each formula and percentage of national GDP, show that the national income in percentage of GDP will be reduced in the range of 7.72% (Formula III, Case 3) to 8.99% (Formula II, Case 1).

$$ER_i = \left(w_{E_{capita}} \times \frac{E_{capita\ i}}{\overline{E_{capita}}} + w_{GDP_{capita}} \times \frac{GDP_{capita\ i}}{\overline{GDP_{capita}}} + w_{CE} \times \frac{CE_i}{\overline{CE}} + w_{E_{AV}} \times \frac{E_{AV\ i}}{\overline{E_{AV}}} \right) \times Z \quad (3)$$

where:
ER_i: Emission reduction target for province i (%);
E_{capita}: GHGs emission per capita;
GDP_{capita}: GDP per capita;
CE: GHGs cumulative emission;
E_{AV}: GHGs emission per unit of added value;
Z: Correction factor (the average equal 0.1466);
w: Weighting coefficient as $\sum w = 100$, Table 4.

Table 3. Weighting Coefficients for formula II

Values	*Case 1, Equally weighting*	*Case 2*	*Case 3*	*Case 4*	*Case 5, AHP approach*
W_P (population)	0.33	0.05	0.05	0.05	0.14
W_E (emission)	0.33	0.6	0.8	0.35	0.57
W_G (GDP)	0.33	0.35	0.15	0.6	0.29

Table 4. Weighting Coefficients for formula III

Values	*Case 1, Equally weighting*	*Case 2, Preferring CO_2 per capita*	*Case 3, Preferring CO_2 per GDP*	*Case 4, Preferring GDP per capita*	*Case 5, AHP approach*
$W_{Ecapita}$ (CO_2 per capita)	25	30	20	20	41.67
$W_{GDPcapita}$ (GDP per capita)	25	30	20	20	27.78
W_{CE} (CO_2 cumulative)	25	20	20	40	16.67
W_{EAV} (CO_2/AV)	25	20	40	20	13.88

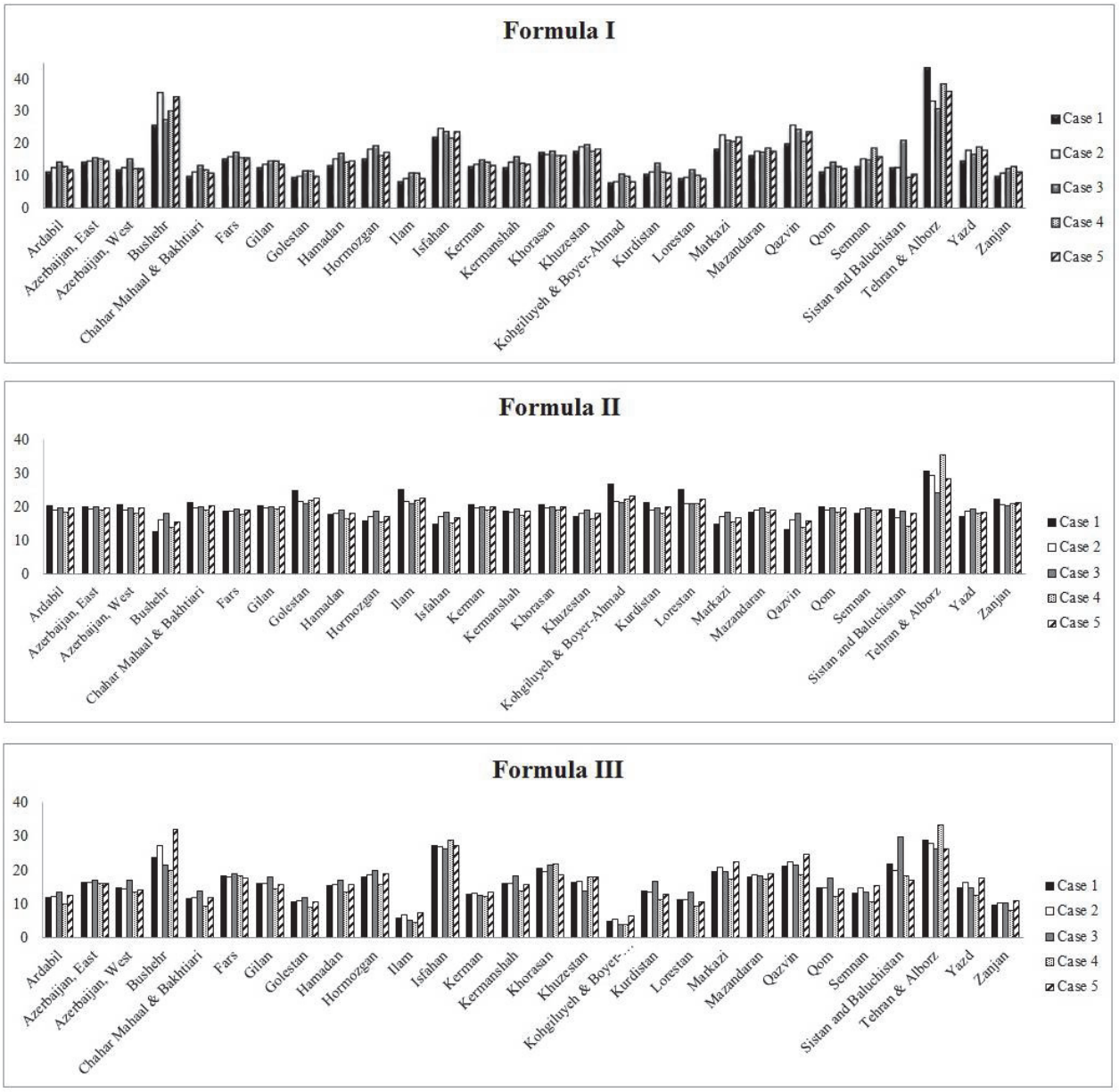

Fig. 2. GHGs emission reduction burdens for Iran provinces fewer than 15 decision preferences

3. Results and discussion

During recent decades, combating the adverse effects of climate change and GHGs emission reduction has received increasing attention. These emissions exhibit a negative externality, not only in the country of origin but also in other countries. Consequently, international organizations are trying to force countries to emissions cut. In late 2011 and during COP17 of UNFCCC it was agreed for all countries to take up commitments to reduce GHGs emission for post-2020. This was on the top of the agreement for the ambitious reduction targets of Annex I (developed countries) over 2015-2020 period. The ambitious targets for the initial period, starting on 2015, calls for high target settings in the order of 45-55% reduction in comparison to 1990 level by the developed countries.

Lack of authorities and accountability at the provincial or state level may lead to the weak implementation of national policies in the area of emission cuts. So, this article has explored the distribution of commitments to GHGs emission cuts in a country. In this way, national targets are disaggregated to provincial targets making them more achievable. In an attempt to allocate reduction targets in coherence with the principles of "Equity", the present article having made a mathematical approach in order to quantify equity and fairness, considered Iran as a rapidly developing country ranked amongst the top ten large emitter of GHGs if it was required to undertake a committal level of reduction and its subsequent effects on the country's GDP. The country of interest is Iran and the target for emission reduction is considered 20% reduction from 2010 levels as of 2020. This country has 28

provinces (as data are collected) and GHGs emissions from different sectors such as fuel combustion (energy transformation, industry, transport, domestic and commercial buildings, agriculture, refinery, petrochemical, other and biomass fuel), fugitive emissions from coal mining, mineral production, agriculture (enteric fermentation, animal waste, rice cultivation and agricultural waste burning), waste (municipal solid waste and wastewater) for each province are calculated by author. Seven criteria including CO_2 emissions per capita, GDP, CO_2 emissions per unit of GDP, GDP per capita, population, accumulated CO_2 emissions and CO_2 per unit of added value are selected as effective parameters to motivate provinces for participation during 15 different combinations. For each formula, a few parameters with different weighting coefficients were combined. In order to achieve reduction targets, economic development and regional equity need to be considered, simultaneously. As should be expected, percentage distribution of commitments to emission cut indicates the distribution of national income losses which present as the GDP. So, selection of appropriate alternatives which provide the most cost-effective means for a country to restrain the growth of GHGs emission revolve around an economic evaluation of available options.

Based on results of this research and evaluation of historical data about carbon dioxide (2001-2010), added value and GDP, it has been demonstrated that a reduction target of 20% of GHGs emission imposes a 7-9% reduction in Iran's GDP. However, all of the suggested combinations lead to 20% emission reduction at a national scale but, from an economic point of view, the best combination for emission cuts is Formula III-Case 3. In this formula, criteria of CO_2 per Added Value has the highest weight among different factors and encourages provinces to use clean fuels and high technologies. Based on this combination, provinces such as Bushehr, Isfahan, Khorasan, Qazvin, Sistan-Baluchistan, Tehran and Alborz should reduce their emissions by more than 20%. Provinces such as Ilam and Kohgiluyeh and Boyer-Ahmad should experience minimum reductions. Another research in 1996 presents the application of the model of Climate Framework for Uncertainty, Negotiation, and Distribution (FUND), which is an integrated assessment model of climate change, for nine regions in order to discuss world economy and its interactions with climate. The results of FUND model about economic growth or economic output differed depending on using top-down or bottom-up parameterization and cost functions. Top-down models, by and large reflect an economist's view of the energy system, assume that energy is currently supplied in an optimal way (for example at minimum costs) and so emission reduction is expensive. Bottom-up models, by and large, reflect an engineer's view of the energy system, assume that moving energy supply to the technological frontier would reduce emissions and improve economic situation at the same time (Hourcade et al., 1996). So, the emission abatement might be beneficial or at least cheap. The results of this study show that the total costs of one or ten percent decrease in emissions of carbon dioxide in the region of Middle East and Iran for top-down models is 0.01 to 0.6 percent of GDP, respectively and for bottom-up approach of this region are 0.00 to 0.88 percent of GDP for one or ten percent reduction, respectively (Toi, 1997).

4. Conclusions

The work presented in this article points to need for a deeper look into the concept of Equity about emission cuts. Based on this analysis application of simple, fixed principles of equity at a regional scale could be used as a tool for allocation of emission reduction and economic growth, simultaneously. From a decision maker's point of view, the costs of mitigating GHG emissions should have the minimum effect on economic situation and GDP.

So, for developing countries, the cost of this reduction should be compensated by the cooperation of developed and industrialized countries through different forms such as clean development mechanism projects (CDM).

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