

Using Weighted Goal Programming Model for Planning Regional Sustainable Development to Optimal Workforce Allocation: An Application for Provinces of Iran

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Abstract:

Due to the urbanization and economic growth, planning of regional sustainable development has become one of the major challenges in the world. The key indicators such as Gross Domestic Product (GDP), electricity and energy consumption and Greenhouse Gas Emission (GHG) are considered in sustainable development planning. This paper determines number of required workforce in different sectors of each province in Iran considering targets/goals for sustainable development indicators in the 2030 macroeconomic and regional planning. First, the relative goals are designed for GDP, electricity, energy and GHG emission and then, two Weighted Goal Programming (WGP) models are applied to allocate the optimal workforce among four sectors: agriculture, industry, services and transportation. The first model minimizes recruitment of new workforce and allows current workforce exchange among the four sectors in each province in order to achieve the goals, while the second model indicates equitable distribution of new workforce recruitment in different sectors within each province. In both models, the workforce changes have been investigated based on achieving the desirable growth rates of GDP, GHG, electricity and energy consumption as planned by the government. Based on the results of this paper, policy makers can manage workforce and the government can make optimised decisions to macroeconomic and regional planning.

Keywords: Sustainable development, Weighted goal programming, Regional planning, Optimal workforce allocation

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1. Introduction

Sustainable Development (SD) is considered as a fundamental, vital and central debate in twenty-first century. Nowadays, it is an important topic in the conferences, research institutes and international organizations. SD can be defined as management of relationships among human systems and ecosystems in order to use of resources and facilities efficiently and to provide welfare for current and future generations (San Cristóbal, 2012). The concept of SD is not only referring environmental issues but also includes general concept of politics, economy, culture, society and so on. Indeed, the SD addresses three issues: economic development, social development and environmental protection.

One of the most important steps in assessing sustainability is the selection of suitable development's indicators to consider interaction among economic, society and environment. In recent years, several indicators have been proposed for measurement of SD. In 1992, United Nation introduced SD indicators in Agenda 21 report. Numerous organizations have evaluated the SD and proposed some indicators such as World Bank, World Resource, World watch Institute United Nations, Department of Economic and Social Affairs, International Atomic Energy Agency, European Union, Eurostat, European Environment Agency, Organization for Economic Cooperation and Development and the International Energy Agency (Bolcárová and Kološta, 2015). In this section, three issues related to definition of SD including economic, social and environmental are explained.

1.1. Economic development

Economic development is an increase in an economy's ability to advanced production such as physical, human and social capacities. In economic development, the quantitative production growth is achieved along with social changes. Social change is an alternation to social institutions and viewpoints as well as continuously and dynamically increase in utilization of existing resources (Todaro and Smith, 2011). Some of the indicators are related to the economy such as Gross Domestic Product (GDP) (Beckerman, 1992; CEC, 2001; OECD, 2001).

1.2. Social development

Social development represents the main aspects of the development process related to social justice, satisfaction of human needs and improving the quality of life (World Summit for Social development Copenhagen 1995). Social development includes the aspect of development that emphasizes humans' interactions, institutions and social

relations, etc. To measure countries' achievement in respect to social development goals and changes in the degree of development over time, different indexes and standards have been designed such as determinants of population growth, labor force, education and illiteracy, science and technology, income and poverty, expenditure on food, housing, fuel and power, transport and communication, life and job satisfaction and investment in medical care and education.

1.3. Environmental development

Beside the economic indicators such as GDP, there are other important indicators for planning regional SD. One of them is environmental issues such as greenhouse gas emissions and pollution which are highly regarded. Due to the facts that SD is threatened by factors such as industrial pollution and greenhouse gas emissions, determination of the environmental policies is necessary. Another remarkable item is energy that play fundamental role in every nation's future. With urbanization and industrialization, GHG and energy consumption has become important issues in the world (Kilkış, 2016).

SD is a multidimensional concept so that it needs models and techniques to deal with the conflict objectives of SD and design programs and framework for policy makers to achieve goals (Henriques & Antunes, 2012). Multi-Criteria Decision Making models (MCDM) are suitable approach to dealing with sustainability (Munda, 2005). The interaction between economic, environment and social items can be investigated by using MCMD techniques (Henriques & Antunes, 2012).

The rest of this paper is organized as follows: Section 2 discusses the literature review on SD indicators and analytical methods for evaluation the SD. Section 3, includes the explanation of the related data. In this section the proposed models are also presented. In section 4, the proposed models are applied to a real application from agriculture, industry, service and transportation system in the provinces of Iran. This is followed by the discussion of the results in section 4. Finally, the summarization of the paper and direction for future research are given in section 5.

2. Literature review: sustainable development indicators and analytical methods

Many studies have surveyed the SD indicators construction such as Niemeijer and Groot (2008), Wilson et al. (2007), Donnelly et al. (2007) and etc. More details definition and various aspects of the SD indicators have been

discussed by Sébastien and Bauer (2013), Hak et al. (2012), Rinne et al. (2013), Greaker et al. (2013), Bečić et al. (2012) and Ciegis et al. (2015), etc. Ozyurt (2010) investigated energy renewable issue to achieve the SD in Turkey. He studied fossil fuels and renewable resources, energy utilization, climate change, greenhouse gases emission and air quality in Turkey along with the regulatory and economic instruments to gain sustainability. San Cristóbal (2012) developed a Goal Programming (GP) framework to propose optimum values of GHGs and wastes emissions, energy, labor and coal requirements. Bao and Fang (2013) explored effective factors on renewable energies, coal resources and energy consumption in China and offered some items to the Chinese government in order to achieve SD in renewable energy. Iddrisu and Bhattacharyya (2015) considered commercial energy consumption, consumption of electricity in the residential sector, share of modern fuels in total residential energy sector consumption and share of population criteria to evaluate the status of energy sustainability. Jayaraman et al. (2016) investigated SD in Gulf Cooperation Council Countries by considering eight important sectors, including: agriculture, crude oil, natural gas and mining, manufacturing and electricity, construction and real estate, trade and transport, restaurants and hotels, banking and financial services. Kılıkış (2016) introduced a composite indicator to evaluate performance of environment, energy and water systems in 12 Southeast European cities. These indicators consisted of seven dimensions such as energy consumption, carbon dioxide emission, water and environmental quality and so on. Following these literature, we found that, the most and common important indicators in SD planning are GDP, energy consumptions, GHG and number of workforce (Jayaraman et al. 2015). These indicators have undeniable effects on development of each country, region and city.

Policymakers need proper methods for planning of SD at different scales such as global, country, regional and city. Some researchers have used analytical methods for analyzing different issues in SD context. Tsai and Chou (2009) presented a synthetic approach based on decision making trial and evaluation laboratory (DEMETAL), Analytical Network Process (ANP) and zero-one goal programming for selection of management system with resource limitation to achieve SD in Small and Medium Enterprises (SMEs). The aim of their study was selecting a suitable management system i.e. ISO 9001, ISO 14001, OHSAS 18001 and SA 8000 for SD in SMEs. Ren et al. (2010) expanded Multi-Objective Linear Programming (MOLP) models to investigate operation of Distributed Energy Resource (DER) systems in Japan and selection of optimal strategy considering environmental and economic objectives. Henriques and Antunes (2012) applied MOLP model based on input-output analysis to investigate the interactions between main axes of sustainable development: economic growth, energy consumption,

environmental and social concerns. They also proposed a model to deal with uncertainty in data by using interval programming tools. Zolfani and Zavadskas (2013) presented a new hybrid model based on MCDM techniques to investigate SD of rural areas' building structures in regions of Iran. They used Step-wise Weight Assessment Ratio Analysis (SWARA) technique for weighting climate-based criteria and then used Complex Proportional Assessment (COPRAS) method for evaluating them. Abou-Ali and Abdelfattah (2013) applied Principal Component Analysis (PCA) and composite indicator to create overall SD indicator and Millennium Development Goals (MDG) and world development indicator data to measure resource intensity. Then an integrated paradigm presented to study the impact of economic growth, environment and natural resource availability to achieve sustainable development using a panel of 62 countries. Limaie et al. (2014) applied goal programming model to achieve sustainability in forest management of Iranian Caspian forests. They considered parameters such as volume, wood price, growth and harvesting costs and determined optimal harvest volume in their case study. Butnariu and Avasilcai (2015) assessed companies' sustainable development performance with using composite indicator (CI). They considered economic, environmental and social indicators based on the conventional model of sustainable development such as air pollution, electricity consumption, water consumption, training programs for employees, operational profit, investments, expenses, etc. They also applied this model in evaluating performance of textile manufacturing company. Sayed et al. (2015) presented a new methodology using Meta-Goal Programming Benefit of Doubt (MGP-BoD) to determine CI values. They used MGP-BoD to suggest a new Human Development Index (HDI). Jayaraman et al. (2015a) used a weighted goal programming model for optimal allocation of human resources for the sustainability of environmental, economic and energy in the United Arab Emirates for 2030. The results expressed some changes in human resources to achieve the desired growth rate in different sectors. In another study, Jayaraman et al. (2015b) applied fuzzy goal programming model for optimal resource allocation in the economic sectors of the United Arab Emirates. They determined suitable goals for GDP, GHG, electricity consumption and labors and estimated the optimal workforce for achieving these goals. In a similar study, Jayaraman et al. (2016a) designed some scenarios for growth rate in different sectors of United Arab Emirates and then, by using a scenario-based stochastic goal programming model, they determined the optimal value of the labors. Also, Jayaraman et al. (2016b) used weighted goal programming model to achieve the predefined goals of GDP, GHG, energy consumption and employees in Gulf Cooperation Council Countries. Pérez et al. (2016) evaluated tourism sustainability based on composite indicators. They combined Data Envelopment Analysis (DEA), PCA and goal

programming methods in order to ranking of Cuban tourist destinations. Zhang (2016) applied an integrated ANP-GP approach to find out the priority in the development of Taking Xizang tourism industry. In his study, ten criteria and nine decision variables were determined by using the interviews with stakeholders based on Delphi method. Iribarren et al. (2016) presented a hybrid model based on life cycle assessment and DEA to screen the socio-economic indicators for sustainability assessment. Sayed et al. (2017) studied ranking contradictions in human development and used goal programming model to solve the rank reversal problem. Ifaei et al. (2017) presented a renewable Techno-Econo-Socio-Environmental Multivariate Analysis (TESEMA) in order to investigate sustainable development in Iran. At first related raw data which includes demand load, biogas, hybrid solar, wind and weather items was analyzed with seven dynamic models to select the best prediction model. Then, Social Development Index (SDI) was constructed using TOPSIS technique and Air Pollution Index (API) created by applying Geographic Information Systems (GIS). Finally, PCA, K-nearest neighborhood (KNN), and partial least square (PLS) regression used to investigate SD in cities in Iran.

Many individuals and groups that working on SD are seeking for a way to create harmony between society, environment and economic interests. Indeed, policymakers are facing with different challenges and issues in the realization of SD. Hence, presenting of suitable methods for achieving SD programs is inevitable. The main purpose of this paper is to develop a model that can be used for regional human resources assignment in Iran to satisfy the determined goals which include multiple conflicting objectives as economic criteria (GDP), social criteria (number of employees) and environmental criteria (GHG, energy and electricity consumption) for achieving SD. This study considers two targets minimizing recruitment new workforce and fair distribution of recruitment of new workforce in four sectors agriculture, industry, service and transportation for provinces in Iran. As mentioned, previous literature did not consider these two items. Hence, this paper proposes a WGP model to satisfy these targets. It should be noted that the goal of this model is not competition between sectors and provinces but allocating the resources in an optimum possible way.

The economy of Iran is not solely private, it is the government of Iran to decide about the long-term planning, allocation of resources and investing in different sectors. The allocation of the workforce in different sectors is usually done by Management and Planning Organization (MPO) which is a government-controlled agency.

MPO, which is the largest governmental organization of this kind, has been established in 1948. In addition to allocating and hiring manpower in different sectors of each province, MPO has variety other duties including the evaluation of the country's resources, preparation and monitoring of development plans, preparation of annual budgets, etc. This paper proposes a mathematical model which can be used by MOP in order to plan and determine number of required workforce in each sectors and provinces by considering targets/goals for each indicator in long-term of the next government plan in 2030. Based on the results of this paper, MPO can manage workforce and the government and other responsible authorities are able to optimise their decisions to macroeconomic and regional planning.

Therefore, the research questions that arise in this paper are as follows:

- 1) How many workforce is required in each of the agriculture / industry / transportation and service sector of Iran's provinces to achieve determined growth of SD indicators in 2030 horizon?
- 2) How many workforce is required for fair distribution of recruitment among the provinces and sectors in order to achieve determined growth rate of SD indicators in 2030 horizon?

In most cases, we are dealing with problems which includes different objectives for decision making. Therefore, researchers have been focused on Multi-Objective Decision Models (MODM) in recent decades. The MODM models allow to simultaneously survey various goals (sometimes contradictory) in a problem and select most satisfactory solution in a set of accessible solutions. One of the popular MODM techniques is goal programming model. Therefore, to achieve the purpose of this study two weighted goal programming models are proposed. In the first model, four objective functions for GDP, energy and electricity consumption are considered. We have also introduced two objective functions for GHG and total number of employees. Then, the growth rates are designed for selected criteria in agriculture, industry, service and transportation sectors. The model minimizes recruitment of new workforce and allows trade-off for the current workforce among four sectors agriculture, industry, services and transportation in each province.

Second model has been designed to find a fair distribution of recruitment of new workforce among the provinces and sectors. For this reason, we have revised the first model by adding several new constraints. It should be noted that the second model allows the reduction in number of labor in order to achieve defined goals. Reduction in workforce is based on the preferences determined by policy makers. In this study, the proposed model allows authorities to determine the optimal workforce by trade-off workforce between different sectors in each province.

3. Data and Methodology

3.1. Data

In this paper, the indicators are selected based on previous studies. Five important criteria including GDP, GHG, energy consumption, electricity consumption and number of employees are selected which includes various aspects of SD. Also, four important sectors including agriculture, industry, services, and transportation are considered that have most workforce in Iran. The GHG is the sum of eight different gases consist of NO_x, SO₂, SO₃, CO, SPM, CO₂, CH₄ and NO₂ and belong to agriculture, industry, transportation and service sectors, power stations and refineries. The education, health, illiteracy, science and technology and housing are considered in service sector. Due to the importance of transportation, this sector was considered separately.

The data is gathered from provinces of Iran. Iran has 31 provinces where Tehran is the capital of it. Iran is an energy superpower so that it has the huge source of fossil fuels including natural gas and oil sources. Hence, energy plays a key role in Iran policy. Tehran, Isfahan, East Azerbaijan, Yazd, Ghazvin and Khorasan Razavi are considered as the most industrialized provinces of Iran. They have large number of active factories and industrial producers.

As mentioned in section 2, several organizations such as World Bank, UN, and International Energy Agency present several SD indicators. Since, the data in Iran is not usually reported in these organizations, hence, the related data is gathered from different sources. The GDP, GHG and number of employees have been obtained from Statistical Center of Iran (www.amar.org.ir). The Electricity consumption in different sectors is collected from publication of Electricity Power Industry Statistics (<http://amar.tavanir.org.ir>). The energy consumption in different sectors has been extracted from Iran Energy Efficiency Organization (www.saba.org.ir). Only 26 provinces in Iran have been included in this study as the data is available for them in 2014. Table (1) shows the statistical summary of all indicators used in this research.

[Table 1 here]

According to Table (1), the highest and lowest GDP in industry sector belong to Hormozgan and Golestan, respectively. Yazd has the highest value of electricity indicator. The electricity consumption in transportation sector is very low in Iran and it is negligible for the provinces. So, the zero value was considered for all provinces. Based

on Table (1), the highest and lowest energy indicator belong to Hormozgan, in industry sector, and Zanjan, in service sector, respectively. Due to the unavailability data for GHG in each sector, separately, this indicator is considered for all sectors. The highest and lowest GHG belong to Hormozgan and Kohgiluyeh-Buyer Ahmad, respectively. Finally, highest and lowest number of employees' indicator belong to Tehran and Alborz in service sector and Ilam in industry sector, respectively.

3.2. Methodology

Decision making is one of the most important tasks for managers in order to achieve organizational goals. Nowadays, MCDM techniques are used by managers which has capacity to consider different conflict criteria for decision making. There are two main categories of MCDM: Multi-Attribute Decision Making (MADM) and Multi-Objective Decision Making (MODM). In MODM techniques, decision makers (DM) searches the problem space to find out the Pareto solutions which satisfy related constraints. Some of the MODM techniques are: weighted sum method, goal programming, goal attainment, epsilon-constraint approach, etc. In this paper, weighted goal programming model, as discussed in the following paragraph, has been used.

Goal programming was introduced by Charnes and Cooper (1955), then expanded by Lee (1972) and Lee and Clayton (1972). It is a powerful and popular MODM technique to incorporate the DM judgments in the real-world applications. In GP model, decision makers want to achieve several goals, simultaneously. Namely, DM determines the value of goals for objective functions and then, sum of the deviation of goals are minimized. Nowadays, this approach is used in many areas including: accounting and financial aspect of stock management, marketing, human resources, quality control, production and operations management to solve multi objective problems (Jayaraman et al. 2015a).

Related to the problem structure, GP model can formulate as linear, nonlinear or integer programming. GP models are solved by three general approaches: weighted GP, lexicographic GP and Chebyshev GP (Jones and Tamiz, 2010). The general formulation of a GP model is as follows:

Model (1):

$$\text{Min} \sum_{k=1}^K (d_k^- + d_k^+) \quad (1)$$

$$f_k(x_k) + d_k^- - d_k^+ = b_k \quad k = 1, 2, \dots, K \quad (2)$$

$$x_k \in S \quad (3)$$

$$d_k^-, d_k^+ \geq 0 \quad k = 1, 2, \dots, K \quad (4)$$

where S is the feasible set, b_k is the goal level for k^{th} objective function and d_k^- and d_k^+ are the negative and positive deviations with respect to the goal level b_k , respectively. Another type of GP is weighted goal programming model which considers weights for deviations. The standard WGP model formulation is as follows:

Model (2):

$$\text{Min} \sum_{k=1}^K (w_k^- d_k^- + w_k^+ d_k^+) \quad (5)$$

$$f_k(x_k) + d_k^- - d_k^+ = b_k \quad k = 1, 2, \dots, K \quad (6)$$

$$x_k \in S \quad (7)$$

$$d_k^-, d_k^+ \geq 0 \quad k = 1, 2, \dots, K \quad (8)$$

where w_i^- and w_k^+ are the related weights for negative and positive deviations, respectively.

3.3. Proposed models

In this paper, two types of weighted GP are formulated for planning the workforce in different provinces of Iran. It should be noted that we have assumed that Iran has a public economic where MPO is responsible for allocating labor forces. Due to the political situation and the existence of sanctions, the foreign labor forces and investments are not considered. In total, we have included 26 provinces in four sectors. The main criteria included in this model are: GDP, Electricity consumption, Energy consumption, GHG and total number of employees. The goal of this model is not competition between sectors and provinces. In fact, this study presents a strategy to determine the optimal work force in each sector of provinces in Iran.

Let's consider indices, parameters and variables as follows:

Sets:

i : Number of province

j : Number of sector

k : Number of objective function

Parameters:

A_i^k : Coefficient of k th objective function in i th province

q_i^j : Number of current employees of i th province in j th sector

w_k : Weight of k th objective function

w_p : Weight of i th province

b_k : Goal of k th objective function

α : Recruitment growth rate

λ : Goals growth rate

Variables:

x_i^j : Number of employees in j th sector of i th province

d_k^+ : Positive deviation in k th objective function

d_k^- : Negative deviation in k th objective function

dp_i^+ : Positive deviation in number of workforce for i th province

dp_i^- : Negative deviation in number of workforce for i th province

Based on the current economy of Iran, we assumed that the country growth rate is $\lambda = 4\%$, however this assumption can easily be changed in the model. Also, all relative weights for objective functions are considered to be equal to one. Indeed, based on the decision makers' opinion, the importance of four sectors is the same and hence, the relative weights are considered equal to one.

For GDP, four objective functions in four sectors are considered. First one, f_1 belongs to agriculture and formulated as follows. The current value for GDP in agriculture sector is 693,153 billion Rials. With growth rate 4%, the relevant goal is $b_1 = 693153 + 0.04 * 693153 = 720879.1$. It is notable that the goals for others objective functions are calculated similar to b_1 .

$$f_1 = A_1^1 x_1^1 + A_2^1 x_2^1 + \dots + A_{26}^1 x_{26}^1 \quad (9)$$

Second objective function, f_2 , belongs to GDP in industry sector. The current value for GDP in industry sector is 1027893. By considering growth rate 4%, its goal is $b_2 = 1069009$. f_2 is formulated as follows:

$$f_2 = A_1^2 x_1^2 + A_2^2 x_2^2 + \dots + A_{26}^2 x_{26}^2 \quad (10)$$

Finally, f_3 and f_4 are representing to GDP for service and transportation sectors, respectively. The relative goals are $b_3 = 3186733$ and $b_4 = 586416.5$, respectively. f_3 and f_4 are expressed as follows:

$$f_3 = A_1^3 x_1^3 + A_2^3 x_2^3 + \dots + A_{26}^3 x_{26}^3 \quad (11)$$

$$f_4 = A_1^4 x_1^4 + A_2^4 x_2^4 + \dots + A_{26}^4 x_{26}^4 \quad (12)$$

Another criterion is electricity consumption. Four objective functions f_5 , f_6 , f_7 and f_8 belong to electricity consumption in agriculture, industry service and transportation sectors, respectively. The relative goals are $b_5 = 3283488$, $b_6 = 6882408$ and $b_7 = 1729936$. The formulations of objective functions are as follows:

$$f_5 = A_1^5 x_1^1 + A_2^5 x_2^1 + \dots + A_{26}^5 x_{26}^1 \quad (13)$$

$$f_6 = A_1^6 x_1^2 + A_2^6 x_2^2 + \dots + A_{26}^6 x_{26}^2 \quad (14)$$

$$f_7 = A_1^7 x_1^3 + A_2^7 x_2^3 + \dots + A_{26}^7 x_{26}^3 \quad (15)$$

$$f_8 = A_1^8 x_1^4 + A_2^8 x_2^4 + \dots + A_{26}^8 x_{26}^4 \quad (16)$$

Energy consumption is the next criterion which has four objective functions $f_9, f_{10}, f_{11}, f_{12}$. The goals for four objective functions are $b_9 = 3896517$, $b_{10} = 4961095$, $b_{11} = 1500930$ and $b_{12} = 438962.2$. The objective functions belong to agriculture, agriculture, industry, service and transportation can be formulated as follows:

$$f_9 = A_1^9 x_1^1 + A_2^9 x_2^1 + \dots + A_{26}^9 x_{26}^1 \quad (17)$$

$$f_{10} = A_1^{10} x_1^2 + A_2^{10} x_2^2 + \dots + A_{26}^{10} x_{26}^2 \quad (18)$$

$$f_{11} = A_1^{11} x_1^3 + A_2^{11} x_2^3 + \dots + A_{26}^{11} x_{26}^3 \quad (19)$$

$$f_{12} = A_1^{12} x_1^4 + A_2^{12} x_2^4 + \dots + A_{26}^{12} x_{26}^4 \quad (20)$$

For GHG emission, only one objective function, f_{13} , is considered which shows total greenhouse gas emission in Iran. The goal for GHG emission is $b_{13} = 5921191.567$.

$$f_{13} = \sum_{i=1}^{26} \sum_{j=1}^4 A_i^{13} x_{ij} = A_1^{13} (x_1^1 + x_1^2 + x_1^3 + x_1^4) + A_2^{13} (x_2^1 + x_2^2 + x_2^3 + x_2^4) + \dots + A_{26}^{13} (x_{26}^1 + x_{26}^2 + x_{26}^3 + x_{26}^4) \quad (21)$$

Total number of employees, f_{14} in agriculture, industry, service and transportation sectors is considered as last criteria. The goal for this objective function is $b_{14} = 16228811$.

$$f_{14} = \sum_{i=1}^{26} \sum_{j=1}^4 x_{ij} = (x_1^1 + x_1^2 + x_1^3 + x_1^4) + (x_2^1 + x_2^2 + x_2^3 + x_2^4) + \dots + (x_{26}^1 + x_{26}^2 + x_{26}^3 + x_{26}^4) \quad (22)$$

3.3.1. First WGP model

First, using the WGP model we minimize recruitment of new workforce. If there is enough labor force, the model allows trade-off between the current workforce among four sectors agriculture, industry, services and transportation and within each province with respect to their own requirements. The proposed WGP model is formulated as follows:

Model (3):

$$\text{Min } z = \sum_{k=1}^{14} w_k (d_k^+ + d_k^-) = w_1 (d_1^+ + d_1^-) + w_2 (d_2^+ + d_2^-) + \dots + w_{14} (d_{14}^+ + d_{14}^-) \quad (23)$$

Subject to:

$$A_1^1 x_1^1 + A_2^1 x_2^1 + \dots + A_{26}^1 x_{26}^1 + d_1^- - d_1^+ = b_1 \quad (24)$$

$$A_1^2 x_1^2 + A_2^2 x_2^2 + \dots + A_{26}^2 x_{26}^2 + d_2^- - d_2^+ = b_2 \quad (25)$$

$$A_1^3 x_1^3 + A_2^3 x_2^3 + \dots + A_{26}^3 x_{26}^3 + d_3^- - d_3^+ = b_3 \quad (26)$$

$$A_1^4 x_1^4 + A_2^4 x_2^4 + \dots + A_{26}^4 x_{26}^4 + d_4^- - d_4^+ = b_4 \quad (27)$$

$$A_1^5 x_1^1 + A_2^5 x_2^1 + \dots + A_{26}^5 x_{26}^1 + d_5^- - d_5^+ = b_5 \quad (28)$$

$$A_1^6 x_1^2 + A_2^6 x_2^2 + \dots + A_{26}^6 x_{26}^2 + d_6^- - d_6^+ = b_6 \quad (29)$$

$$A_1^7 x_1^3 + A_2^7 x_2^3 + \dots + A_{26}^7 x_{26}^3 + d_7^- - d_7^+ = b_7 \quad (30)$$

$$A_1^8 x_1^4 + A_2^8 x_2^4 + \dots + A_{26}^8 x_{26}^4 + d_8^- - d_8^+ = b_8 \quad (31)$$

$$A_1^9 x_1^1 + A_2^9 x_2^1 + \dots + A_{26}^9 x_{26}^1 + d_9^- - d_9^+ = b_9 \quad (32)$$

$$A_1^{10} x_1^2 + A_2^{10} x_2^2 + \dots + A_{26}^{10} x_{26}^2 + d_{10}^- - d_{10}^+ = b_{10} \quad (33)$$

$$A_1^{11} x_1^3 + A_2^{11} x_2^3 + \dots + A_{26}^{11} x_{26}^3 + d_{11}^- - d_{11}^+ = b_{11} \quad (34)$$

$$A_1^{12}x_1^4 + A_2^{12}x_2^4 + \dots + A_{26}^{12}x_{26}^4 + d_{12}^- - d_{12}^+ = b_{12} \quad (35)$$

$$\sum_{i=1}^{26} \sum_{j=1}^4 A_i^{13}x_{ij} = A_1^{13}(x_1^1 + x_1^2 + x_1^3 + x_1^4) + A_2^{13}(x_2^1 + x_2^2 + x_2^3 + x_2^4) + \dots + A_{26}^{13}(x_{26}^1 + x_{26}^2 + x_{26}^3 + x_{26}^4) + d_{13}^- - d_{13}^+ = b_{13} \quad (36)$$

$$\sum_{i=1}^{26} \sum_{j=1}^4 x_{ij} = (x_1^1 + x_1^2 + x_1^3 + x_1^4) + (x_2^1 + x_2^2 + x_2^3 + x_2^4) + \dots + (x_{26}^1 + x_{26}^2 + x_{26}^3 + x_{26}^4) + d_{14}^- - d_{14}^+ = b_{14} \quad (37)$$

$$x_i^j \geq \alpha q_i^j \quad \forall i = 1, 2, \dots, 26 \quad , \quad \forall j = 1, 2, 3, 4 \quad \alpha \in [0, 1] \quad (38)$$

$$\sum_{j=1}^4 x_i^j \geq \sum_{j=1}^4 q_i^j \quad \forall i = 1, 2, \dots, 26 \quad (39)$$

$$d_k^+, d_k^- \geq 0 \quad k = 1, 2, \dots, 14 \quad (40)$$

$$x_i^j \text{ are integer} \quad i = 1, 2, \dots, 26 \quad , \quad j = 1, 2, 3, 4 \quad (41)$$

where α represents recruitment growth. In model (3), the constraint (38) expresses that the optimal workforce should be greater than α % of the current workforce in each sector of provinces with respect to the goals. For example, if $\alpha = 90\%$, to achieve the goals, the province i^{th} can reduce workforce in sector j^{th} up to 10%. Also, the constraint (39) represents that sum of the optimal workforce in four sectors should be greater than sum of the current optimal workforce for each province. Indeed, the constraints (38) and (39) allow trade-off between the current workforce in each province.

3.3.2. Second WGP model

The aim in the second WGP model is to find the optimal distribution of new workforce in each provinces and sectors. In this model, the provinces can reduce their number of workforce to gain the predefined goals. In the second model, new constraint (42) has been added while constraint (39) has been removed from the first WGP model.

$$\sum_{j=1}^4 x_i^j + dp_i^- - dp_i^+ = \sum_{j=1}^4 q_i^j (1 + \lambda) \quad \forall i = 1, 2, \dots, 26 \quad , \quad \lambda \in [0, 1] \quad (42)$$

where λ is the country growth rate (assumed to be 4% in this case). In a similar way we can set growth rate for each province. In constraint (42), the numbers of workforce for each province can increase up to λ percent. By defining dp_i^+ and dp_i^- as positive and negative deviations in number of workforce for i th province, the objective function of second WGP model can be expressed as follows:

$$\text{Min } z = \sum_{k=1}^{14} w_k(d_k^+ + d_k^-) + \sum_{i=1}^{26} wp_i(dp_i^+ + dp_i^-) = w_1(d_1^+ + d_1^-) + \dots + w_{14}(d_{14}^+ + d_{14}^-) + wp_1(dp_1^+ + dp_1^-) + \dots + wp_{14}(dp_{14}^+ + dp_{14}^-) \quad (43)$$

4. Results and discussion

In this section, the proposed models are applied to planning sustainable development of 26 provinces in Iran for the year 2030 planning program. First, the WGP model (3) is solved for workforce optimization. This model helps policy makers to employ optimal number of workforce in each sector and for each province with respect to the goals as defined the 2030 macroeconomic and regional planning. It is assumed that the growth rate is equal to 4% for all goals. The results of the first WGP model with $\alpha = 100\%$ are shown in Table (2) and Figure (1). $\alpha = 100\%$ shows that the number of workforce for each sector in each province should be at least equal to the current values. The results indicate that Hormozgan has highest changes in workforce with 37.82% growth. As can be seen, in of each province there are either minor or no changes in workforce. A few provinces need to employ new workforce. For example, Yazd province should employ 24816 new workforce to achieve growth rate of 4%. In order to achieve desirable goals, overall Iran needs to employ 359341 new workforce which should be distributed in some provinces according to Table (2).

[Table 2 here]

[Figure 1 here]

Table (3) reports the positive and negative deviation variables. As shown in Table (3), many objective functions have nonzero deviations. The value of d_{12}^+ is 3781827.930 which shows that the transportation sector needs to more

energy resources to achieve growth rate 4%. Also, the value of d_4^- is 22554.480 which shows that the GDP produced by transportation sector is enough. The results indicate that the transportation sector need a suitable planning for achieving growth rate 4%.

[Table 3 here]

According to this, the workforce is enough in some provinces but they are not distributed correctly between various sectors. Therefore, it is not necessary to increase workforce but this model helps to reallocate the workforce to different sectors according to their need.

The data provided by Statistical Center of Iran¹ in the last five years shows that the agriculture, industry, service and transportation sectors have dedicated 18.3%, 16.68%, 51% and 9.86% of workforce. The results of first WGP model demonstrates relative distribution of workforce for each sector in year 2030 will be 22.1%, 20.4%, 47% and 10.5% respectively. Changes in the distribution of workforce in four sectors are reported 3.8%, 3.72%, -4% and 0.64%, respectively, in comparison with the current situation. In addition, in second model, relative distributions are 22.44%, 19.51%, 47.4% and 10.65%, showing that changes in the sectors are 4.14%, 2.83%, -3.6% and 0.79%, respectively.

Table (4) shows the results of first WGP model, assuming $\alpha = 90\%$ which allows the provinces to have trade off workforce between different sectors up to 10%. For example, Hormozgan province should increase 78641 and 8619 labors in agriculture and service sectors and in contrast, it should reduce 932 and 1674 labors in industry and transportation sectors. In other words, Hormozgan needs to employ 84664 new workers to achieve growth rate of 4%. Also, similar to $\alpha = 100\%$, in $\alpha = 90\%$ case, Hormozgan has highest changes with 36.03% growth in workforce. Table (5) shows the values for positive and negative deviations. Similar to Table (3), most deviations have occurred in objective functions related to transportation sector.

[Table 4 here]

¹ www.amar.org.ir

[Table 5 here]

Now, the results of second WGP model are discussed. In the second model, the growth rate 4% is considered for each province, separately. In other words, the growth rate of 4% in the whole country probably causes that the new workforce has not been allocated fairly among provinces and sectors. So, to allocate equitable new workforce among provinces, it is assumed that all provinces should increase the workforce up to 4% ($\lambda = 4\%$). The results of second WGP model are shown in Table (6) and Figure (2). As can be seen, Ilam has the largest changes of 3.85% growth in employees. Namely, Ilam should employ 4669 new employees to achieve the growth rate of 4%. The numbers of new employees are shown in Table (6) for other provinces.

[Table 6 here]

[Figure 2 here]

Table (7) shows deviation variables for each province and objective functions. The results express that the Semnan ($dp_{11}^+ = dp_{11}^- = 0$), Ghazvin ($dp_{14}^+ = dp_{14}^- = 0$) and Golestan ($dp_{20}^+ = dp_{20}^- = 0$) do not have any deviation and other provinces have negligible low deviations. Also, similar to the first model, there are very high positive and negative deviations in energy and GDP for transportation sector, respectively.

[Table 7 here]

The results of the second model for $\alpha = 90\%$ are summarized in Table (8) and (9). It is clear that Ilam has the highest workforce changes with 3.84% growth. The results reported in Table (8) show that all provinces increase or decrease workforce in different sectors. Due to growth rate of 4%, the goal for all provinces is increasing the workforce equal to 4% of current level ($\lambda = 4\%$).

[Table 8 here]

[Table 9 here]

Table (10) and Figures (3) and (4) show the changes in workforce with changing α value. The values for α are considered equal to 80%, 90% and 95%. The Figures (3) and (4) compare these changes in both models for all provinces.

[Table 10 here]

[Figure 3 here]

[Figure 4 here]

The results of these two models indicate that GDP and energy consumption in transportation sector have unfavorable deviation values. Hence according to these results, it is necessary for the government to invest more in transportation system and planning to use renewable sources in this section.

4.1. Sensitivity Analysis

In this study, the relative goals are designed for GDP, electricity, energy and GHG emission by decision makers in Iran and the optimal workforce are determined with respect to 4% growth rate as set by the Government. With respect to the existence of international sanctions, in addition to decline of the growth rates, the Iranian economy suffered a radical shift during the years of the boycott. The oil, automotive, and construction sectors fell further than other sectors so that the growth rate of GDP was -1.9% in 2013 (Devarajan & Mottaghi, 2015). In addition, available data reported by Statistical Center of Iran shows that the average energy and electricity consumption in four mentioned sectors are 1.2% and 1.63%, respectively in 2013. Also, the average of GHG emission in four sectors is 1.93%. The mean of growth rate of GDP for period 2001-2013 was 3.51 (www.amar.org.ir). Therefore, due to unsustainable economic condition in Iran, growth rate of GDP has been set to 4%.

Unfavorable trend of economic growth in Iran has led to increase in unemployment rate in recent years. The latest reports of Central Bank of Iran reveal that the unemployment rate is 12.4% while employment growth is close to 1%

currently. The following items can be considered as factors which leads to low growth of employment in the Iran: economic fluctuations, the lack of adequate distribution between incomes and facilities, the lack of recruitment of workforce in industrial and manufacturing centers, the disparity between the growth rate of population and job opportunities, the weakness of laws and regulations and the lack of proportional training with the needs of the job market. Hence, in this study, the growth of workforce has not been considered in high level and it is set equal to 4%. To evaluate the trend of workforce changes, several growth rates for GDP, energy consumption, electricity consumption and GHG have been analysed at three recruitments rates-100%, 95% and 90%. Figure (5) shows the workforce changes under growth rates of 2%, 4%, 6%, 8%, 10% and 12% for GDP. As can be seen, there are no changes up to 10%, while noticeable changes have been observed in higher growth rates.

[Figure 5 here]

Figure (6) shows that workforce, for electricity consumption, there are no changes in range 2%-10% except in growth rate 8% under recruitment rates 90% and 95%. Similar to the GDP, in higher rates, the changes of workforce under three recruitments are observed.

[Figure 6 here]

Figure (7) shows the workforce changes in seven mentioned growth rates and three recruitment rates in energy consumption. It expresses that changes pattern is similar to the GDP. Also, the workforce changes based on GHG growth rates are shown in Figure (8).

[Figure 7 here]

[Figure 8 here]

5. Conclusions and direction for future research

This paper presents two weighted goal programming models for planning sustainable development in 26 provinces of Iran by the year 2030. Some important criteria include GDP, electricity and energy consumption, GHG and number of human resource in four sectors agriculture, industry, service and transportation are considered. The aim of this study is providing a framework for the authorities and government to studying the interaction between economic, environment and social items and make a suitable decision to macroeconomic and regional planning. The proposed WGP models allocate optimal level of workforce to simultaneously satisfy predefined multiple conflicting goals including social, economic and environmental factors. In Iran, the government decides about the long-term planning, allocation of resources in required sectors and it is usually done by MOP which is a government-controlled agency. Both models show that the GDP and energy consumption in transportation sector need to be improved, hence it is important for the government to make serious decisions to achieve the goals. One way to take forward is a proper plan for the use of clean energy such as solar, wind, atomic, hydropower energy to attain goal of energy consumption.

Due to the existence political sanctions, indicators such as foreign labor forces and investments are not included in the proposed model which can be considered as a research limitation, this might be subject of future studies.

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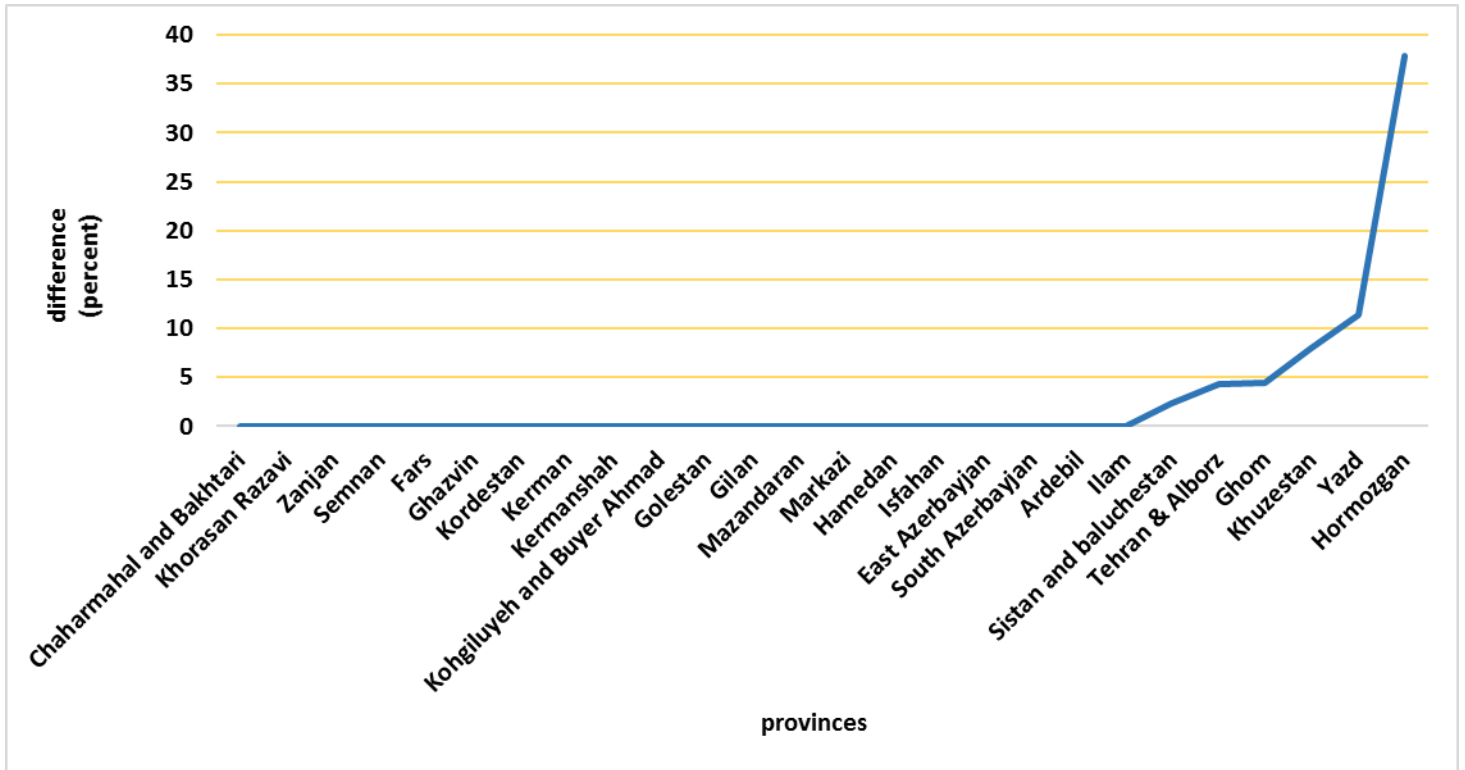


Figure 1: Differences between optimal workforce and current values in the first WGP model

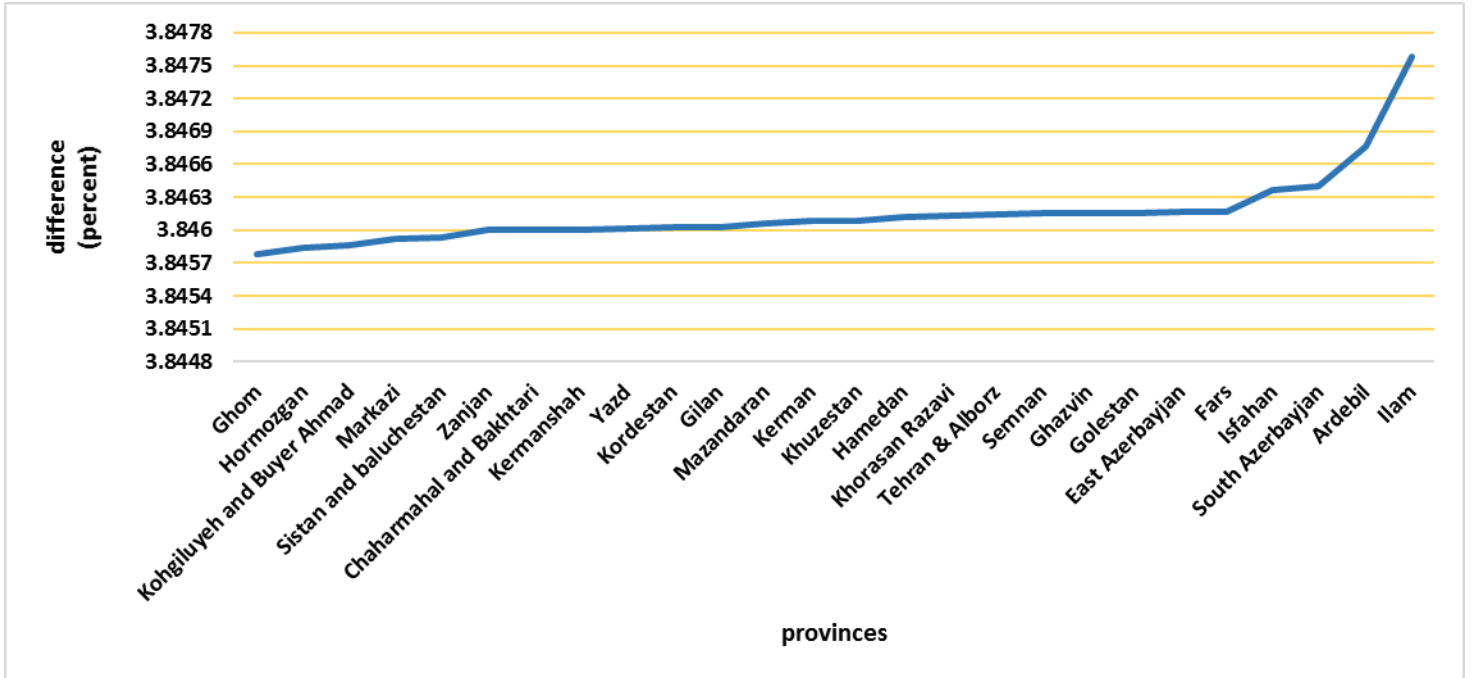


Figure 2: Differences between optimal workforce and current values in the second WGP model

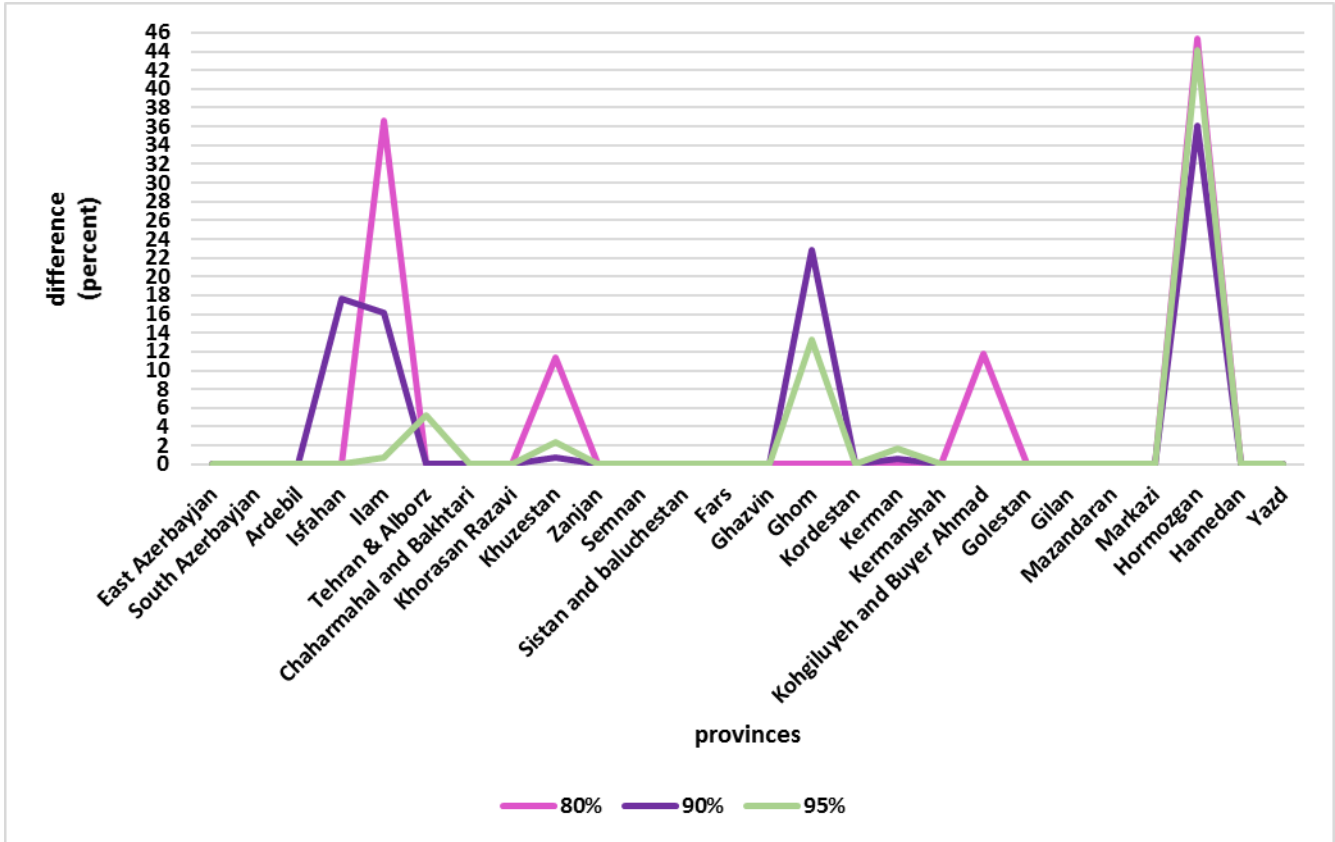


Figure 3: The results of the first WGP model with changing α

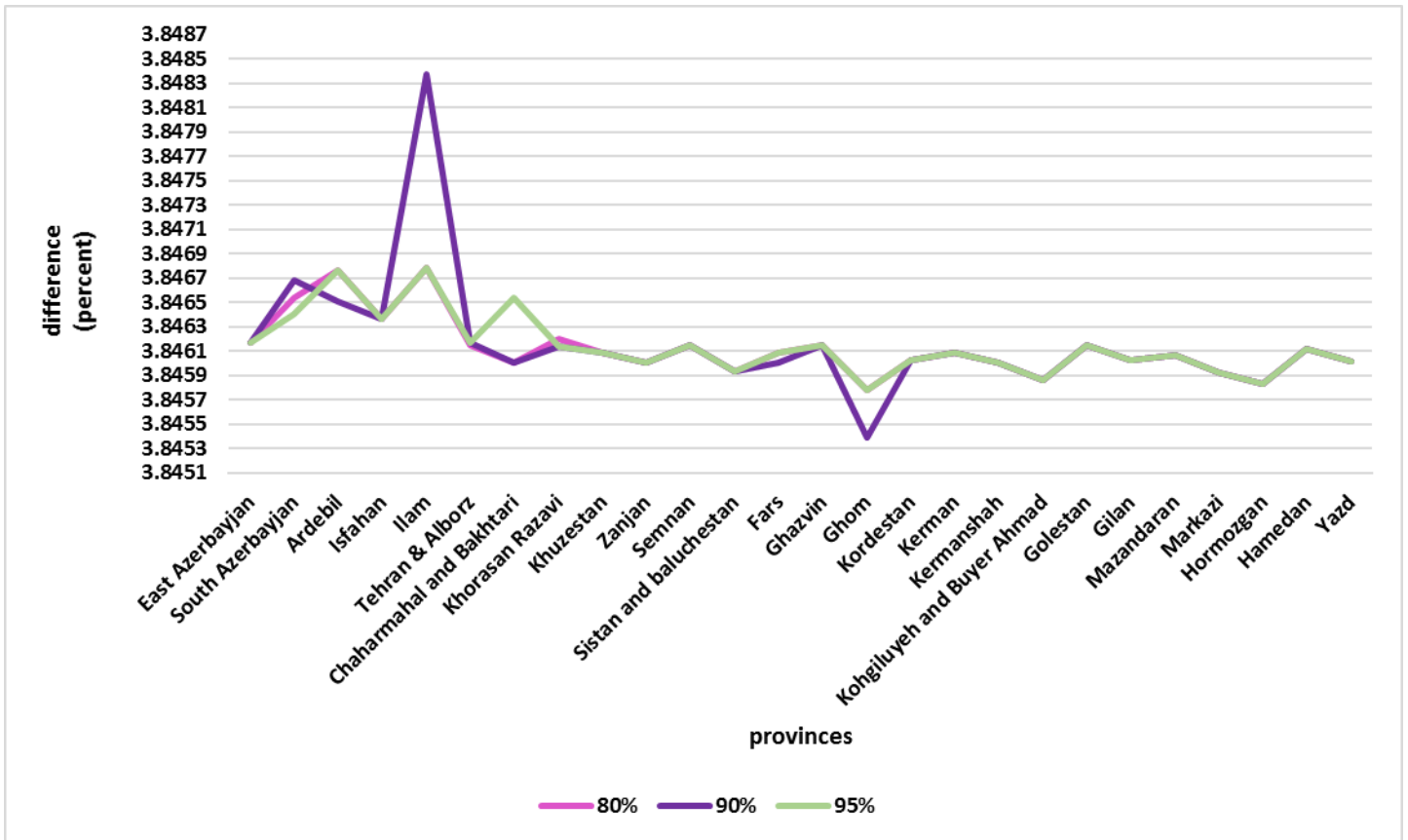


Figure 4: The results of the second WGP model with changing α

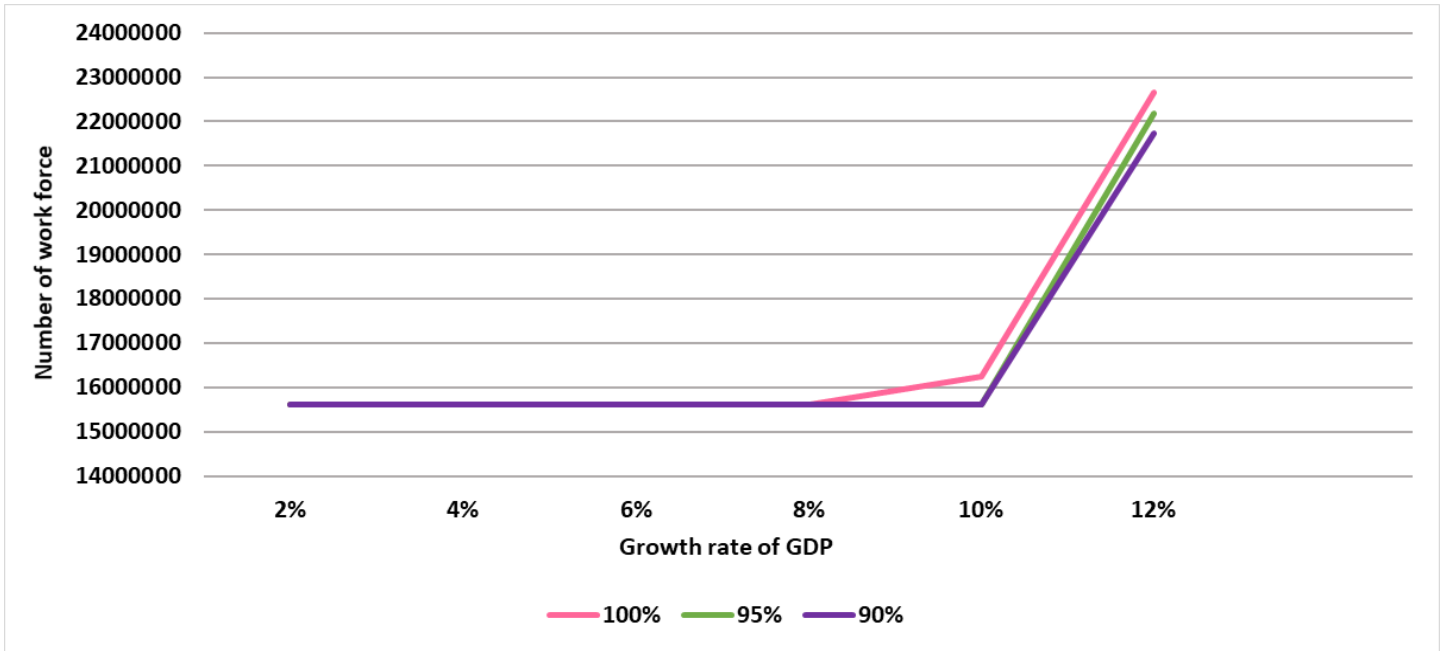


Figure 5: The change of workforce with GDP growth rates

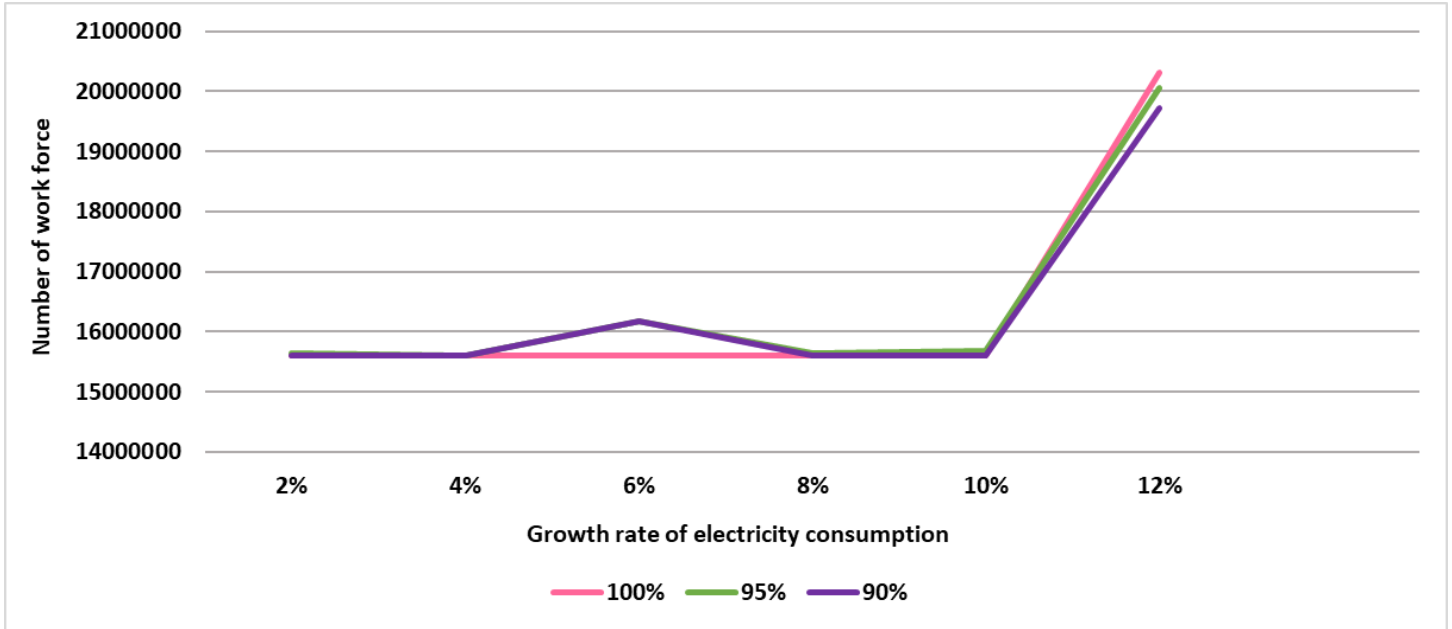


Figure 6: The change of workforce with electricity consumption growth rates

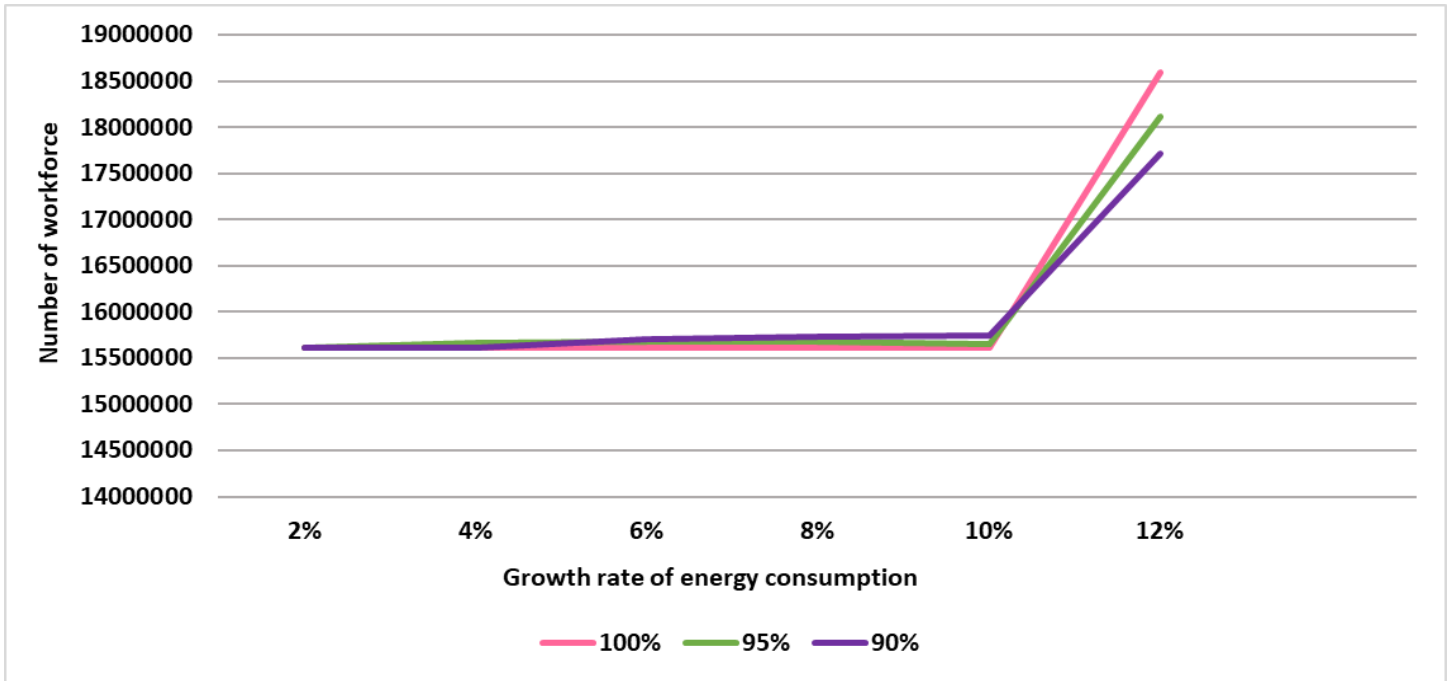


Figure 7: The change of workforce with energy consumption growth rates

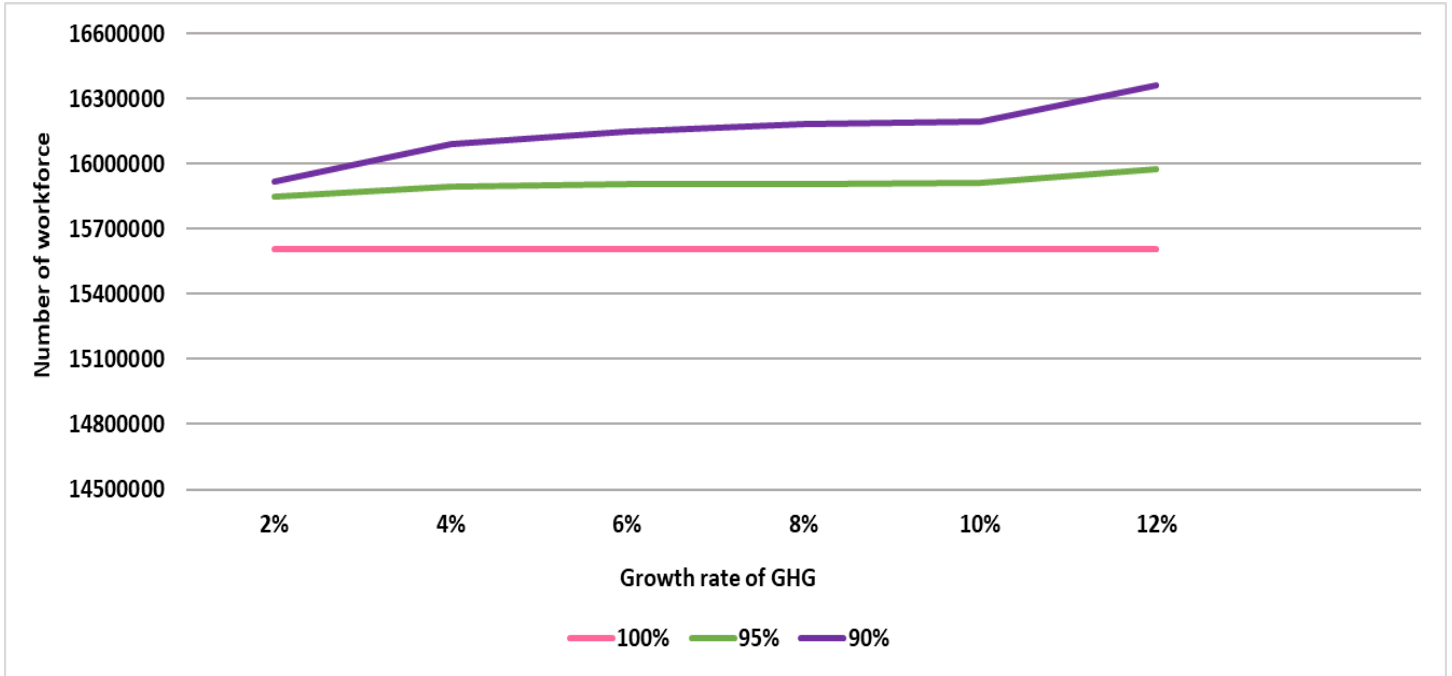


Figure 8: The change of workforce with GHG emission growth rates

Table 1: Summary statistics of indicators in each sector

Indicator	/ Sector	Max	Min	Average	SD
GDP per capita (Billion Riyals)	Agriculture	0.513786	0.108241	0.229167	0.102543
	Industry	5.692654	0.07992	0.625535	1.135482
	Service	0.88175	0.244621	0.372751	0.131877
	Transportation	1.98591	0.10338	0.291315	0.358402
Electricity per capita (Million KWh)	Agriculture	3.294334	0.180941	1.053248192	0.804824919
	Industry	40.29304	0.573714	4.058321038	7.493958881
	Service	1.774497	0.078136	0.264412385	0.313174061
	Transportation	0	0	0	0
Energy per capita (Thousand liters)	Agriculture	4.073226	0.349984	1.254892	0.836899
	Industry	38.05973	0.236651	5.059698	9.05681
	Service	5.272885	0.031247	0.394463	0.992739
	Transportation	10.97885	1.24943	3.032113	1.901455
GHG per capita (Ton)	All sectors	0.010733	0.002129	0.003749	0.001809
Number of employees	Agriculture	354664	19579	133625.2	88574.33
	Industry	960437	6815	118591.3	187215.4
	Service	2062904	52605	282548.7	385772.4
	Transportation	402336	9980	65412.73	76917.67

Table 2: Optimal workforce for each province based on the first WGP model ($\alpha=100\%$)

Row	Sector				Total difference	
	Province	Agriculture	Industry	Service		Transportation
1	East Azerbaijan	239859	238194	348592	84052	1
2	South Azerbaijan	234258	86373	274501	65350	1
3	Ardebil	123798	38664	159978	26603	1
4	Isfahan	149503	350706	505123	114606	1
5	Ilam	47280	6815	52606	9980	1
6	Tehran & Alborz	90734	960439	2216351	402336	160251
7	Chaharmahal and Bakhtari	49374	23362	76109	23362	0
8	Khorasan Razavi	354664	258431	610103	138884	0
9	Khuzestan	183600	120108	403770	86830	63745
10	Zanjan	84392	49272	89737	17284	0
11	Semnan	23031	30652	70666	13301	0
12	Sistan and baluchestan	66548	47897	171183	52341	7949
13	Fars	266713	168380	499750	146827	0
14	Ghazvin	75600	73150	111650	35700	0
15	Ghom	30716	73527	118747	24574	11140
16	Kordestan	115526	30454	137763	30868	0
17	Kerman	254509	59478	227537	48412	0
18	Kermanshah	110977	38059	194582	52023	0
19	Kohgiluyeh- Buyer Ahmad	27684	8486	54610	11153	0
20	Golestan	190625	87500	165625	51250	0
21	Gilan	212710	86298	274337	67302	0
22	Mazandaran	232521	110523	336482	83442	0
23	Markazi	81578	88613	123110	28394	0
24	Hormozgan	159267	9325	56407	16749	91435
25	Hamedan	130945	57573	153476	43935	0
26	Yazd	44460	12346	134944	25173	24816

Table 3: Positive and negative deviations in the first WGP model ($\alpha = 100\%$)

	Value		Value
d_1^+	0.127	d_1^-	0
d_2^+	0.538	d_2^-	0
d_3^+	0.046	d_3^-	0
d_4^+	0	d_4^-	22554.480
d_5^+	0	d_5^-	0.495
d_6^+	0	d_6^-	0.401
d_7^+	0	d_7^-	0.174
d_8^+	0	d_8^-	0
d_9^+	0	d_9^-	0.203
d_{10}^+	0.44	d_{10}^-	0
d_{11}^+	0	d_{11}^-	0.753
d_{12}^+	3781827.930	d_{12}^-	0
d_{13}^+	0	d_{13}^-	0
d_{14}^+	0	d_{14}^-	0

Table 4: Optimal workforce in each province based on the first WGP model with $\alpha = 90\%$

Row	Sector Province	Agriculture		Industry		Service		Transportation		Total difference
		value	difference	value	difference	value	difference	value	difference	
1	East Azerbaijan	215873	-23985	305444	67250	313733	-34859	75647	-8405	1
2	South Azerbaijan	210833	-23425	77735	-8637	313098	38597	58815	-6535	0
3	Ardebil	111418	-12379	69700	31036	143981	-15997	23943	-2660	0
4	Isfahan	134553	-14950	315635	-35070	806114	300991	103146	-11460	239511
5	Ilam	42552	-4728	6134	-681	81396	28791	8982	-998	22384
6	Tehran & Alborz	75539	-8393	864395	-96042	2207573	144669	362103	-40233	1
7	Chaharmahal and Bakhtari	44437	-4937	38245	14883	68499	-7610	21026	-2336	0
8	Khorasan Razavi	319198	-35466	368795	110364	549093	-61010	124996	-13888	0
9	Khuzestan	230625	47025	101702	3191	325460	-36162	78147	-8683	5371
10	Zanjan	100020	15628	44345	-4927	80764	-8973	15556	-1728	0
11	Semnan	20728	-2303	27587	-3065	77364	6698	11971	-1330	0
12	Sistan and baluchestan	92894	26346	35954	-3994	154065	-17118	47107	-5234	0
13	Fars	269374	2661	230376	61996	449775	-49975	132145	-14682	0
14	Ghazvin	97650	22050	65835	-7315	100485	-11165	32130	-3570	0
15	Ghom	17622	-1957	159605	86079	106871	-11874	22117	-2457	69791
16	Kordestan	135433	19907	27409	-3045	123987	-13776	27782	-3086	0
17	Kerman	291379	36870	53531	-5947	204784	-22753	43571	-4841	3329
18	Kermanshah	99880	-11097	34254	-3805	214686	20104	46821	-5202	0
19	Kohgiluyeh-Buyer Ahmad	35107	7423	7638	-848	49151	-5459	10038	-1115	1
20	Golestan	171563	-19062	128249	40749	149063	-16562	46125	-5125	0
21	Gilan	191439	-21271	141732	55434	246904	-27433	60572	-6730	0
22	Mazandaran	209269	-23252	175767	65244	302834	-33648	75098	-8344	0
23	Markazi	105589	24011	79752	-8861	110799	-12311	25555	-2839	0
24	Hormozgan	149241	78651	8393	-932	62268	8619	15075	-1674	84664
25	Hamedan	117851	-13094	51816	-5757	176720	23244	39542	-4393	0
26	Yazd	57695	13235	9583	-1064	102173	-9654	22656	-2517	0

Table 5: Positive and negative deviations in the first WGP model with $\alpha = 90\%$

	Value		Value
d_1^+	0	d_1^-	0.128
d_2^+	0	d_2^-	0.124
d_3^+	0	d_3^-	0.088
d_4^+	0	d_4^-	78937.273
d_5^+	0.15	d_5^-	0
d_6^+	0	d_6^-	0.811
d_7^+	0.291	d_7^-	0
d_8^+	0	d_8^-	0
d_9^+	0.049	d_9^-	0
d_{10}^+	0.135	d_{10}^-	0
d_{11}^+	2.475	d_{11}^-	0
d_{12}^+	3359777.852	d_{12}^-	0
d_{13}^+	0.141	d_{13}^-	0
d_{14}^+	0	d_{14}^-	0.04

Table 6: Optimal workforce in each province based on the second WGP model ($\alpha = 100\%$)

Row	Sector				Total difference	
	Province	Agriculture	Industry	Service		Transportation
1	East Azerbaijan	239858	274622	348592	84052	36428
2	South Azerbaijan	234258	86373	300921	65350	26421
3	Ardebil	123798	52626	159979	26603	13964
4	Isfahan	149504	350706	549921	114606	44800
5	Ilam	47281	6883	57205	9980	4669
6	Tehran & Alborz	83932	1005291	2158434	402336	140384
7	Chaharmahal and Bakhtari	49374	23362	82997	23362	6888
8	Khorasan Razavi	374293	293285	610103	138884	54483
9	Khuzestan	189033	98511	385411	86830	29222
10	Zanjan	94019	49272	89737	17284	9627
11	Semnan	23031	30652	76172	13301	5506
12	Sistan and baluchestan	68400	41535	180944	52341	13200
13	Fars	295147	183213	499750	146827	43267
14	Ghazvin	87444	73150	111650	35700	11844
15	Ghom	19579	81136	120591	24574	9456
16	Kordestan	115526	30454	150347	30868	12584
17	Kerman	254509	59478	251134	48412	23597
18	Kermanshah	126802	38059	194582	52023	15825
19	Kohgiluyeh-Buyer Ahmad	27684	12563	54610	11153	4077
20	Golestan	190625	107300	165625	51250	19800
21	Gilan	212710	111923	274337	67302	25625
22	Mazandaran	248791	124771	336482	83442	30518
23	Markazi	81578	88613	135977	28394	12867
24	Hormozgan	76602	9325	53649	16749	6012
25	Hamedan	146382	57573	153476	43935	15437
26	Yazd	44460	10647	119511	25173	7684

Table 7: Positive and negative deviations in the second WGP model ($\alpha = 100\%$)

	Value		Value		Value		Value
dp_1^+	0.16	dp_1^-	0	d_1^+	0	d_1^-	0.124
dp_2^+	1.76	dp_2^-	0	d_2^+	0.7	d_2^-	0
dp_3^+	2.32	dp_3^-	0	d_3^+	0	d_3^-	0.067
dp_4^+	2.52	dp_4^+	0	d_4^+	0	d_4^-	22554.48
dp_5^+	1.8	dp_5^-	0	d_5^+	0	d_5^-	0.325
dp_6^+	0	dp_6^-	0.36	d_6^+	0	d_6^-	0.029
dp_7^+	0	dp_7^-	0.28	d_7^+	0.232	d_7^-	0
dp_8^+	0	dp_8^-	0.28	d_8^+	0	d_8^-	0
dp_9^+	0	dp_9^-	0.52	d_9^+	0	d_9^-	1.139
dp_{10}^+	0	dp_{10}^-	0.4	d_{10}^+	0	d_{10}^-	0.317
dp_{11}^+	0	dp_{11}^-	0	d_{11}^+	0	d_{11}^-	0.109
dp_{12}^+	0	dp_{12}^+	0.8	d_{12}^+	3781827.93	d_{12}^-	0
dp_{13}^+	0.2	dp_{13}^-	0	d_{13}^+	0	d_{13}^-	0
dp_{14}^+	0	dp_{14}^-	0	d_{14}^+	0	d_{14}^-	0
dp_{15}^+	0	dp_{15}^-	0.96				
dp_{16}^+	0	dp_{16}^-	0.44				
dp_{17}^+	0	dp_{17}^-	0.44				
dp_{18}^+	0	dp_{18}^-	0.64				
dp_{19}^+	0	dp_{19}^-	0.32				
dp_{20}^+	0	dp_{20}^-	0				
dp_{21}^+	0	dp_{21}^-	0.88				
dp_{22}^+	0	dp_{22}^-	0.72				
dp_{23}^+	0	dp_{23}^-	0.8				
dp_{24}^+	0	dp_{24}^-	0.52				
dp_{25}^+	0	dp_{25}^-	0.16				
dp_{26}^+	0	dp_{26}^-	0.28				

Table 8: Optimal workforce in each province based on the second WGP model with $\alpha = 90\%$

Row	Sector Province	Agriculture		Industry		Service		Transportation		Total difference
		value	difference	value	difference	value	difference	value	difference	
1	East Azerbaijan	215873	-23985	341871	103677	313733	-34859	75647	-8405	36428
2	South Azerbaijan	210835	-23423	77736	-8636	339518	65017	58815	-6535	26423
3	Ardebil	111419	-12378	83662	44998	143981	-15997	23943	-2660	13963
4	Isfahan	134554	-14949	315636	-35069	611401	106278	103146	-11460	44800
5	Ilam	42554	-4726	6358	-457	63456	10851	8982	-998	4670
6	Tehran & Alborz	75539	-8393	1021375	60938	2190977	128073	362103	-40233	140385
7	Chaharmahal and Bakhtari	44438	-4936	21026	-2336	92605	16496	21026	-2336	6888
8	Khorasan Razavi	387867	33203	354609	96178	549093	-61010	124996	-13888	54483
9	Khuzestan	184277	677	88660	-9851	408701	47079	78147	-8683	29222
10	Zanjan	109647	25255	44345	-4927	80764	-8973	15556	-1728	9627
11	Semnan	20728	-2303	27587	-3065	82870	12204	11971	-1330	5506
12	Sistan and baluchestan	66351	-197	41530	1582	188232	17049	47107	-5234	13200
13	Fars	339596	72883	203419	35039	449775	-49975	132145	-14682	43265
14	Ghazvin	109494	33894	65835	-7315	100485	-11165	32130	-3570	11844
15	Ghom	17622	-1957	92811	19285	113329	-5416	22117	-2457	9455
16	Kordestan	103974	-11552	27409	-3045	168030	30267	27782	-3086	12584
17	Kerman	229059	-25450	53531	-5947	287372	59835	43571	-4841	23597
18	Kermanshah	155267	44290	34254	-3805	175124	-19458	46821	-5202	15825
19	Kohgiluyeh-Buyer Ahmad	24916	-2768	21907	13421	49149	-5461	10038	-1115	4077
20	Golestan	171563	-19062	148049	60549	149063	-16562	46125	-5125	19800
21	Gilan	191439	-21271	167357	81059	246904	-27433	60572	-6730	25625
22	Mazandaran	266205	33684	149349	38826	302834	-33648	75098	-8344	30518
23	Markazi	73421	-8157	79752	-8861	155834	32724	25555	-2839	12867
24	Hormozgan	84572	13982	8393	-932	48285	-5364	15075	-1674	6012
25	Hamedan	171879	40934	51816	-5757	138129	-15347	39542	-4393	15437
26	Yazd	40014	-4446	9583	-1064	127538	15711	22656	-2517	7684

Table 9: Positive and negative deviations in the second WGP model with $\alpha = 90\%$

	Value		Value		Value		Value
dp_1^+	0.16	dp_1^-	0	d_1^+	0.108	d_1^-	0
dp_2^+	3.76	dp_2^-	0	d_2^+	0	d_2^-	0.221
dp_3^+	1.32	dp_3^-	0	d_3^+	0	d_3^-	0.077
dp_4^+	2.52	dp_4^+	0	d_4^+	0	d_4^-	78937.273
dp_5^+	2.8	dp_5^-	0	d_5^+	0	d_5^-	0.437
dp_6^+	0.64	dp_6^-	0	d_6^+	0	d_6^-	0.564
dp_7^+	0	dp_7^-	0.28	d_7^+	0	d_7^-	0
dp_8^+	0	dp_8^-	0.28	d_8^+	0.247	d_8^-	0
dp_9^+	0	dp_9^-	0.52	d_9^+	0	d_9^-	0.744
dp_{10}^+	0	dp_{10}^-	0.4	d_{10}^+	0	d_{10}^-	0.249
dp_{11}^+	0	dp_{11}^-	0	d_{11}^+	0	d_{11}^-	0.316
dp_{12}^+	0	dp_{12}^+	0.8	d_{12}^+	3359777.852	d_{12}^-	0
dp_{13}^+	0	dp_{13}^-	1.8	d_{13}^+	0	d_{13}^-	0
dp_{14}^+	0	dp_{14}^-	0	d_{14}^+	0	d_{14}^-	0
dp_{15}^+	0	dp_{15}^-	1.96				
dp_{16}^+	0	dp_{16}^-	0.44				
dp_{17}^+	0	dp_{17}^-	0.44				
dp_{18}^+	0	dp_{18}^-	0.64				
dp_{19}^+	0	dp_{19}^-	0.32				
dp_{20}^+	0	dp_{20}^-	0				
dp_{21}^+	0	dp_{21}^-	0.88				
dp_{22}^+	0	dp_{22}^-	0.72				
dp_{23}^+	0	dp_{23}^-	0.8				
dp_{24}^+	0	dp_{24}^-	0.52				
dp_{25}^+	0	dp_{25}^-	0.16				
dp_{26}^+	0	dp_{26}^-	0.28				

Table 10: Total differences between optimal workforce and current values in the first and the second WGP model with changing α

Row	α provinces	80%		90%		95%	
		First WGP (%)	Second WGP (%)	First WGP (%)	Second WGP (%)	First WGP (%)	Second WGP (%)
1	East Azerbaijan	0	3.84617009	0.00011	3.84617	0.00022	3.84617
2	South Azerbaijan	0	3.846540196	0	3.84668	0.000303	3.8464
3	Ardebil	0	3.846768373	0	3.846503	0	3.846768
4	Isfahan	0	3.846361883	17.61825	3.846362	0	3.846362
5	Ilam	36.68777436	3.846787751	16.09619	3.848372	0.710548	3.846788
6	Tehran & Alborz	0	3.846144362	2.85E-05	3.846171	5.193413	3.846171
7	Chaharmahal and Bakhtari	0	3.846003518	0	3.846004	0	3.84654
8	Khorasan Razavi	0	3.846202718	0	3.846135	0	3.846135
9	Khuzestan	11.41759637	3.846088038	0.729821	3.846088	2.325404	3.846088
10	Zanjan	0	3.846000192	0	3.846	0	3.846
11	Semnan	0	3.846153846	0	3.846154	0	3.846154
12	Sistan and baluchestan	0	3.845929724	0	3.84593	0.000909	3.84593
13	Fars	9.24496E-05	3.846085466	0	3.846	0	3.846085
14	Ghazvin	0	3.846153846	0	3.846154	0.000338	3.846154
15	Ghom	0	3.845778429	22.7915	3.845387	13.25004	3.845778
16	Kordestan	0.000317852	3.846024542	0	3.846025	0	3.846025
17	Kerman	0	3.846084889	0.561132	3.846085	1.612726	3.846085
18	Kermanshah	0	3.846004287	0	3.846004	0	3.846004
19	Kohgiluyeh- Buyer Ahmad	11.83867982	3.845863598	0.000981	3.845864	0	3.845864
20	Golestan	0	3.846153846	0	3.846154	0	3.846154
21	Gilan	0	3.846026848	0	3.846027	0	3.846027
22	Mazandaran	0	3.846066597	0	3.846067	0	3.846067
23	Markazi	0	3.845923924	0	3.845924	0	3.845924
24	Hormozgan	45.33734813	3.845834	36.03076	3.845834	44.11242	3.845834
25	Hamedan	0	3.846115516	0	3.846116	0	3.846116
26	Yazd	0	3.84601909	0	3.846019	0.000521	3.846019