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Sustainable development goals and transportation modes: Analyzing sustainability pillars of environment, health, and economy

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ABSTRACT

Based on the scores and trends of Sustainable Development Goals, Iran, our case study, has been unsuccessful in nearly all the pillars of sustainable development despite the variations in socioeconomic variables related to the SDGs. This implies a comprehensive underdevelopment in Iran, necessitating the improvement of infrastructure which significantly affects all the pillars of sustainable development including environment, health, and economy. This study, takes transportation as an important infrastructure which has various direct and indirect impacts on all pillars of sustainable development, especially in the case study of Iran. To evaluate this, the present study aims to investigate 1) which sustainability perspective dominates in Iran (strong sustainability, weak sustainability, or health-centered sustainability); and 2) the consistency degree of each transportation mode with each pillar of sustainability including environment, health, and economy. We employ VAR and simultaneous equations system to find which perspective of sustainable development dominates Iran; and to rank the transportations modes in accordance with their consistency with sustainable development in Iran during 1979–2016. Overall, the results of this study is found to be significant and support the strong sustainability perspective in Iran. The most compliant transportation modes with the sustainable development in Iran are then ranked as: a) rail, b) air, c) road, and d) maritime transportation. These results suggest the policy-makers to: 1) value the environmental issues at the top of the agenda for the sustainability strategies; and 2) to shift the load of passenger and goods to the rail transportation by investing and developing the rail network.

1. Introduction

Starting from the industrial revolution, the vast increase in the production of consumer goods, as well as urbanization has been taking place all around the world. Although such development has had a positive impact on the livelihood of societies, its social reliance and impact on natural resources has increased considerable concerns on this transition. According to the latest data published by the World Bank, the world's total population has already passed 7.76 billion, and is expected to reach over 9.7 billion by 2050 (World Bank, 2022). Such large population require an ever-increasing dependence on natural resources and the environment [70]. Having foreseen such sustained growth in population, the United Nations (UN) has been one of first intergovernmental entities to organize a series of comprehensive actions over the last few decades to incorporate sustainable means in this socio-technological development. Agenda 21, for instance, has been firstly introduced by the UN in 1992, as a comprehensive plan of actions to enhance the human lives and conserve the environment at the Earth summit in Rio de Janeiro. Later in 2015, the UN published a set of 17 goals, commonly referred to as Sustainable Development Goals (SDGs or also agenda 2030) which outline the objectives necessary to end poverty, inequality, environmental degradation, as well as advocating peace and justice [46,66]. Since then, the doctrine of global sustainability has advanced and become a key element of international sustainability studies and developmental

Abbreviations: UN, United Nations; SDG, Sustainable Development Goal; CO2, Carbon Dioxide; GDP, Gross Domestic Product; VAR, Vector Auto-Regression; GMM, Generalized Method of Moments; 2SLS, Two-Stage Least Squares; DW, Durbin-Watson; PCSD, President's Council on Sustainable Development; WHO, World Health Organization; CST, Center for Sustainable Transportation.

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agendas [13,56]. Following this, numerous studies have used the 17 set of goals as a playground to incorporate sustainability in various fields and industries.

In general, sustainability refers to creating a condition that human and nature can co-exist in a productive harmony that allows the socioeconomic development of the current and future generations [54,88]. In many developing countries, however, the minimum infrastructure for applying sustainability is not available or the logistics does not allow its use at any capacity [53]. Reporting from Adshaed et al. [2], about 72% of the SDG targets are directly linked to the provision of infrastructure which is a precondition for sustainable social growth. In general, the effect of infrastructure provision can be viewed as cumulative in which each part of the infrastructure provision has an exponential influence on the growth and development [38,55].

Transportation, for instance, is the major means for international trade, connectivity, social development, among others, that is enabled through its logistical network of its various modes [87]. As the social reliance on various modes of transportation has increased in recent decades, its direct and indirect impact on other factors such as the impact of pollution on public health has become more clear [39]. In this sense, transportation sector is one of the main areas that requires careful planning and investment since it has a large impact on social resiliency [97]. In developing countries, however, lack of sustainable technology and the direct impact of transportation on economic activities inadvertently causes traffic, noise and air pollution [22]. To make matter even worse, certain countries that have a relatively higher reserves of petroleum, transportation is a means to simulate the economy at the expense of environmental degradation and unsustainable growth [21,23,103]. This can be seen in Refs. [71,80] that tend to be the opposite of the SDGs, particularly, goals 3, 7, 11, 12, 13 and 15, among others.

To closely evaluate the impact of transportation on sustainable development in developing countries, this study chooses the number one country in subsidizing fuel as a means for economic stimulus. Iran, is a country located in western Asia, with petroleum reserves of exceeding 209 billion barrels, ranking as the world's third and second largest reserve holder of oil and natural gas, respectively, in 2020 [33]. With a population of over 80 million, its transportation system consists of air, rail, road and sea [78].

Based on the scores and trends of SDGs in, our case study, Iran, has been unsuccessful in nearly all the pillars of sustainable development in spite of certain variations in socioeconomic variables related to the SDGs. Fig. 1 and 2 show the scores of Iran in the SDGs, based on a three-pillar-categorization of sustainable development in. The left pillar covers the environmental goals with one red, two orange and two yellow colors, representing the status of major challenges remain, significant challenges remain and challenges remain, respectively. As can be seen in this figure, except for goal 4 (quality education), in almost all pillars, Iran has been unsuccessful in following the SDGs. From a closer perspective than that of the sustainable development pillars, the failure in following the SDGs, can imply a systematic mismanagement and infrastructural underdevelopment of Iran.

Although various factors have contributed to this, but the unique natural resources of the country make it prone to over subsidize fuels and stimulate the economy through cheaper transportation infrastructure. This, in effect, results in heavy use of petroleum emitting CO2 emissions and polluting the environment [31]. In a continuing cycle, this causes very high traffic death, significant air pollution and environmental degradation, all of which, negatively affect the health and social pillars of sustainable development [6]. For the most part, this is basically caused due to the high amount of fossil fuel subsidy, limiting budget and depressing the economy in Iran [6,74]. These are clear signals for challenges that would avoid the transportation sector to function as a positive contributor of the sustainable development. Reporting from Refs. [49,59] transportation is commonly considered as the main booster of many economic sectors in both industrial and non-industrial sectors, such as trade and tourism, respectively. In general, transportation was first mentioned in Agenda 21 as part of sustainable human settlement and the protection of atmosphere (chapters 7 and 9, respectively) [25]. From that point, in the majority of sustainability or climatic initiatives transportation has gradually become a major influencer. This ranged from the President's Council on Sustainable Development (PCSD) in the United States, Centre for Sustainable Transportation (CST) in Canada, international sustainable initiates and to the more recently organized SDGs [25]. In this sense, a sustainable transportation system is required to meet the health and environmental quality objectives, mostly advised by the World Health Organization (WHO), while be consistent with ecosystem integrity, and should not lead to adverse global phenomena, such as the climate change or ozone depletion [25]. To achieve the mentioned aims, it should provide the highest accessibility, follow sustainable planning (e.g., limit urban sprawl) and environmental protection, as well as having economic viability [10]. Accordingly, this study focuses on the various modes of transportation and their respective impact on sustainability in the unique case study of Iran.

The main question of the study is which transportation modes are the most consistent with the sustainable development, in the case study. To answer the question, this study investigates: 1) which sustainability perspective dominates in Iran (e.g., strong sustainability, weak sustainability, or health-centered sustainability); and 2) evaluate the consistency degree of each transportation mode with each pillar of sustainable development. This would further show how to shift the load of passenger and goods from one type of transportation to another, based on their sustainability impact on the pillars or goals of SDGs. In this regard, the result of this study would help the policy-makers in the modification, redistribution, and improvement of the transport infrastructure, as it fosters the sustainable development at full capacity. Finally, this study ranks the 4 various transportation modes in Iran, according to their consistency with the sustainable development pillars and provides further suggestions on future research not only in other case studies but also in general sustainability – transportation interface area.

2. Literature review

2.1. Transportation and sustainable development

Transportation is a major contributor to the various pillars of sustainable development, including the environment, social, and economy. In this case study of Iran, the main types or modes of transportation are those of air, sea, drive and rail road, all of which, are believed to have insufficient infrastructure [73]. In addition, the old technology utilized in different modes of transportation increases the inefficiency and traffic death. In our sample study, Iran is the 17th largest country in the world with the 1394 kms railroad and more than 150,000 kms of drive road [17,85]. Iran's car industry since the Islamic revolution in 1979 has been trimmed to be domesticated and in doing so vast tariffs started to impose on import of foreign vehicles. [35] showed the difference in average fuel consumption for domesticated vehicles in Iran versus those of the world's standard vehicles. They revealed that these domestic cars are highly inefficient in consuming fuel, requiring about two times more than those of the international standard vehicles.

From a purely environmental perspective, the transport is the biggest sector in consuming the oil products that is almost entirely built on pollutant fossil fuels with a large amount of CO2 emissions [76]. In 2017, it was reported that transportation had consumed more that 66% of all the oil products in Iran; and the fuel portfolio of transportation had involved 85% of total oil products [31]. This, in effect, can result not only in air and sea pollution but also lead to significant inefficiency, especially when almost no alternatives are available for the public. Under such scenario, transportation would adversely affect all the three main SDG pillars of environment, economy and even social.

It is important to note, however, that it is the health sector with a highest damage from the transportation, since traffic death in the coun-

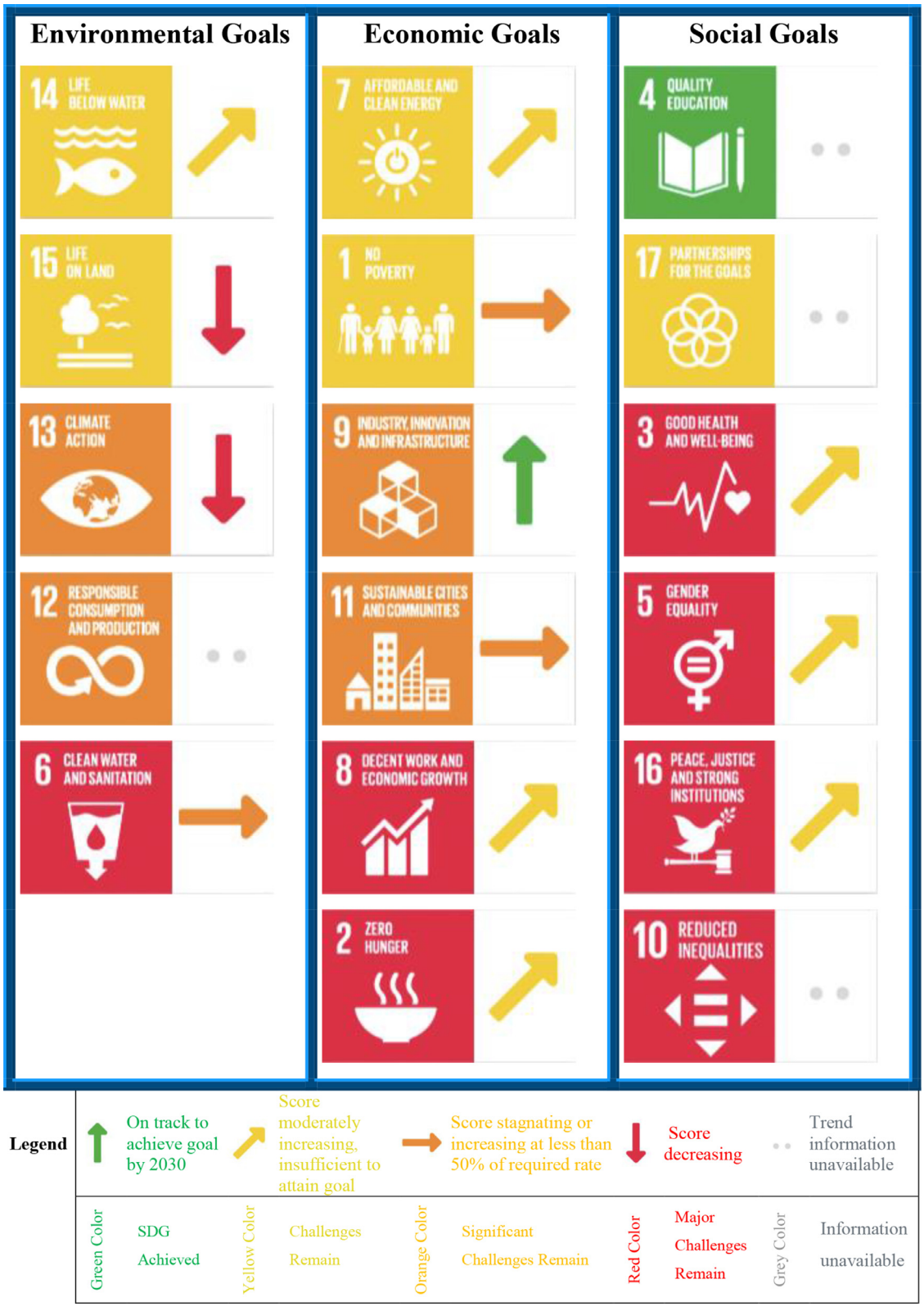


Fig. 1. Scores and trends of sustainable development pillars in Iran in 2019. Source: Elaborated by authors, based on [86].

try has been considered as the 3rd biggest contributory factor in mortality of Iran [5]. Until 2014, the road traffic accidents in Iran were higher than its average value in each region or each income group of countries in the world [99]. The cost of road traffic accidents is estimated about 7–40 billion US Dollar each year in Iran which would translate about 2–4% of the country's total GDP [63]. Moreover, it is reported that each patient of road traffic accident costs 15 time more than that of the other patients for hospitalization, a calamity both for the patient and the healthcare system [6]. In this sense, a clean connection between the social and economic pillar can be drawn and the

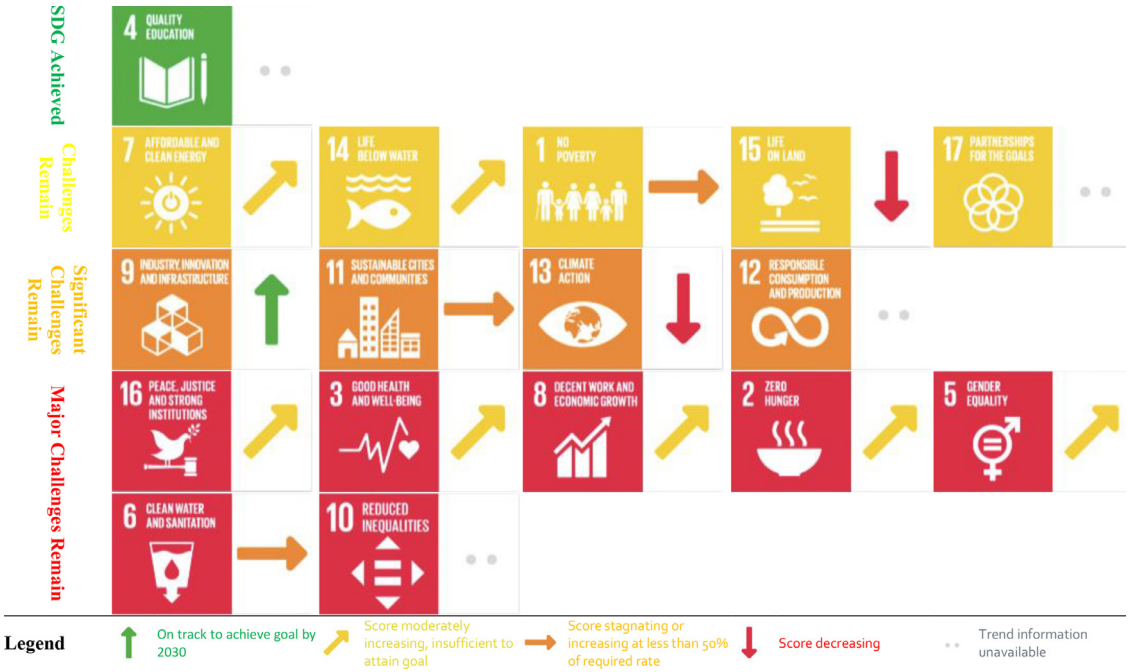


Fig. 2. Scores and trends of SDGs in Iran. Source: Elaborated by authors, based on [86].

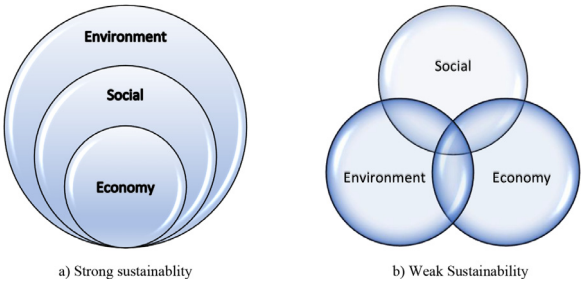


Fig. 3. Sustainability perspectives. Source: [11,48,57].

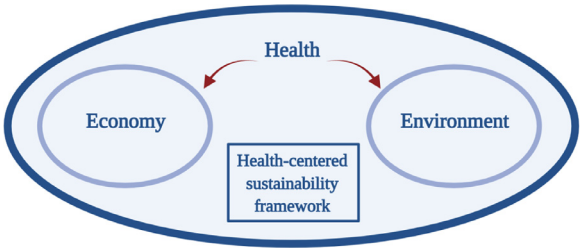


Fig. 4. Health-centered sustainability framework for the transportation modes effects in Iran. Source: Researchers' findings based on [94,96].

fact that the transportation infrastructure can be a key player in its outcome.

From the economy pillar, the transport sector spends a large share of budget in Iran. It is reported that Iran ranks the 2nd and 1st country, respectively, in 2016 and 2018 in the absolute value of fossil fuel subsidies, which the transport sector has the main share in it [32,47]. In addition to spending the budget, it limits the economy via unrealistic pricing and hence no optimal allocation of resources in the energy market, reducing the efficiency level of the economy [74,80,82]. Thus, the transport sector in Iran degrades all the pillars of sustainability and the development of each transportation mode has various effects on the pillars of sustainability, due to the distinctive, specific, and unique characteristics of each.

2.2. *Perspectives of sustainable development*

The literature of sustainability proposes three different perspectives for sustainable development: a) strong sustainability, b) weak sustainability, and c) health-centered or social sustainability [11,48,57]. Each can propose a special and distinctive strategy for the development of transportation infrastructure, since each perspective sustainability assumes different importance to each pillar of sustainable development (e.g., social, environmental, and economic) [52,75].

Based on Fig. 3, the strong sustainability attaches the greatest importance to the environmental pillar. It emphasizes on the consequences of transportation for the environment [77]. After that, the social pillar is in the 2nd place before the economic one at the 3rd place. These pillars, however, have an equal role in the sustainable development from the perspective of weak sustainability [4]. In this scenario, all the consequences of transportation system are considered equally, irrespective of the different pillars of sustainability. Nonetheless, there are numerous studies on the two perspectives of sustainability and both are the best-known and reported in the literature. Additionally, the literature about the entire concept of strong and weak sustainability, there are tremendous researches which confirm the interrelationship between sustainability pillars as displayed in Table 1. These studies, in general, accept the strong and weak sustainability [11,48,57]. Further to these two classical perspectives of sustainable development, the World Health Organization (WHO) recently proposed another perspective in which the health (as a social sector) plays the leading role in the sustainability [94,96].

According to WHO, the center of sustainability is the health sector. It claims that SDG 3, Good Health and Wellbeing, can be located at the heart of sustainable development [96]. This implies that the development of health paves the way for the other sectors to be developed, leading to the sustainable development. We refer to this perspective as the "Health-Centered Sustainability" which is displayed in Fig. 4. Based on this figure, the health sector is placed as the dominating pillar which is remained from social. This perspective is supported by a large number of studies which are classified in Table 2. In fact, this strong research background is the basis on which the WHO claims the health-centered

Table 1
Supportive studies for the interconnection of sustainability pillars.

Environment – Economy E-Y	Health – Environment H-E	Health – Economy H-Y
Natural resources as input	Environmental health theories	Productivity theories
Environmental Kuznets hypothesis	Mental health	Health expenditure
Grossman and Kruger [24]	Lu et al. [40]	Ayubi [9]
Han et al. [26]	Mandal and Kaur [42]	Chaabouni and Abdennadher [14]
Taghvaee and Parsa [81]	Nerisa et al. [50]	Mehrara et al. [43]
Theobald et al. [84]	Wendling et al. [89]	Miller et al. [44]
Taghvaee and Hajiani [79]	World Bank and United Nations [100]	Richmond and Kaufmann [64]
Sarkodie and Strezov [67]	WHO [94]	
Mohamad Taghvaee et al. [104]	WHO [95]	
	Yale University [101]	
	Zaidi and Saidi [102]	

sustainability. In the early 2020, the pandemic (Coronavirus or COVID-19), showed the strong role of the health for other socioeconomic pillars [1]. Thus, the new perspective, "Health-Centered Sustainability", can be considered as a new approach to the older concepts such as the strong and weak sustainability. In this sense, the present study investigates which sustainability perspective dominates in Iran's various modes of transportation and what infrastructure is best to follow sustainable development.

Fig. 5 displays the main sustainability perspectives mentioned in the literature review including Traditional, weak, strong, health-centered, and integrated sustainability [45,83].

The health centered sustainability puts the improvement of transportation infrastructure at the top of the agenda in Iran. In this regard, this study considers the SDG 3 as a major target as illustrated in Fig. 6. The figure provides information on the traffic death which is categorized by the U.N. as major challenges remain, suggesting the development of transportation infrastructure as the most urgent and important plan for fostering the sustainable development in Iran.

3. Methodology and data

This study ranks the various modes of transportation in Iran according to the sustainability criteria. Beforehand, it investigates which sustainability perspective dominates the nexus of sustainable development in Iran.

For the investigation of sustainability, this research employs HEY model (Health, Environment and Economy), displayed in Fig. 7 with health as an index for the social pillar. These pillars are interrelated to each other on the basis of the theories and hypotheses, mentioned in the figure. This figure is a benchmark for the specification of the following regression.

Following [8,29,58,72], and to investigate which perspective of sustainability dominates Iran, this research employs the HEY model based on data derived from the World Bank during 1979–2016, developed as follows:

$$H_t = \sum_{i=1}^{m} \delta_{1i} H_{t-i} + \sum_{j=1}^{m} \delta_{2j} E_{t-j} + \sum_{k=1}^{m} \delta_{3k} Y_{t-k} + \varepsilon_{1t} \quad (1)$$

$$E_t = \sum_{i=1}^{n} \pi_{1i} E_{t-i} + \sum_{j=1}^{n} \pi_{2j} H + \sum_{k=1}^{n} \pi_{3k} Y_{t-k} + \varepsilon_{2t} \quad (2)$$

$$Y_t = \sum_{i=1}^{z} \gamma_{1i} Y_{t-i} + \sum_{j=1}^{z} \gamma_{2j} E_{t-j} + \sum_{k=1}^{z} \gamma_{3k} H_{t-k} + \varepsilon_{3t} \quad (3)$$

where H is health whose proxy is the expected life years, derived from [98]; E is environmental pollution whose proxy is CO2 emissions in metric tons per capita derived from [98]; and Y is economic growth whose proxy is GDP per capita in constant 2010 US dollar, from [98] as in Appendix. All the variables are in natural logarithm.

This triple-equation-system estimates the causal relationship among the sustainable development pillars in Iran. The direction and significance of estimated causal relationships show which pillar plays a more leading role in the development of other pillars, or rather the sustainability. The health-centered sustainability is confirmed, in the case of unidirectional causal nexus from health to the other pillars. In turn, if there is a unidirectional causal relationship from environment to the other pillars, as well as from health to economy, the strong sustainability is confirmed. Finally, the weak sustainability is accepted, if the there is a relatively equal causal relationship among the pillars. The result of HEY model helps us to study the nexus of each transportation mode with the sustainable development in Iran. In fact, this study plugs the transportation into the HEY model to develop THEY model as shown in Fig. 8.

THEY model estimates which transportation mode is more consistent with the sustainable development pillars in Iran to transport the load of passengers and goods across the country.

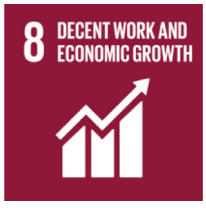
$$H_t = \alpha_1 + \alpha_2 MA_t + \alpha_3 AI_t + \alpha_4 RO_t + \alpha_5 RA_t + e1_t \quad (4)$$

$$E_t = \theta_1 + \theta_2 MA_t + \theta_3 AI_t + \theta_4 RO_t + \theta_5 RA_t + e2_t \quad (5)$$

$$Y_t = \beta_1 + \beta_2 MA_t + \beta_3 AI_t + \beta_4 RO_t + \beta_5 RA_t + e3_t \quad (6)$$

where MA is maritime transportation; AI is air transportation; RO is road transportation; RA is rail transportation; their proxies are the weight of goods transported in ton, derived from the Central Bank of Iran [12]. The RO data is available within 1996–2016 and this research estimates it for 1979–1995 with linear manipulation. Since, all the variables are in natural logarithm, the coefficients show the elasticity [74]. So, they can be compared with one another. The coefficients of MA, AI, RO, and RA show the nexus of each transportation mode with their corresponding dependent variables. α_2, α_3, α_4, and α_5 show the connection of health with each transportation mode, including maritime, air, road, and rail transportation, respectively. The more they are, the more the corresponding transportation value improves the health pillar of sustainable development. θ_2, θ_3, θ_4, and θ_5 show the connection of environmental pollution, or rather the CO2 emissions with each transportation mode, including maritime, air, road, and rail transportation, respectively. The higher their value are, the more the corresponding transportation mode degrades the environmental pillar of the sustainable development. β_2, β_3, β_4, and β_5 show the nexus of economic growth with each transportation mode, including maritime, air, road, and rail transportation, respectively. The greater their value are, the more the corresponding transportation mode boosts the economic pillar of sustainable development. These coefficients show how each transportation mode affects the pillars of the sustainable development pillars. α_1, θ_1, and β_1 are the intercept of the Eqs. (4)-(6); $e1$, $e2$, and $e3$ are the residual series of the Eqs. (4)-(6), respectively; and the remaining symbols are as described previously. The estimated residual series are put in the robustness test

Table 2
Previous studies, explaining the interconnection of health with all SDGs.

Synergistic Goal	Study	Synergistic Goal	Study
	[7] [84] [18] [60] [19] [61] [16] [20] [34] [36] [51]		[84] [18] [60] [19] [61] [16] [20] [34] [36] [51]
	[16] [20] [34] [36] [51]		[16] [20] [34] [36] [51]
	[62] [84] [18] [60] [19] [61] [16] [20] [34] [36] [51]		[16] [20] [34] [36] [51]
	[7] [18] [41] [69] [27] [30] [84] [92] [91] [90] [60] [16] [20] [34] [36] [51]		[16] [20] [34] [36] [51]
	[16] [20] [34] [36] [51]		[16] [20] [34] [36] [51]
	[16] [20] [34] [36] [51]		[16] [20] [34] [36] [51]
	[93] [92] [91] [68] [37] [84] [60] [19] [61] [16] [20] [34] [36] [51]		[84] [18] [60] [19] [61] [68] [37] [16] [20] [34] [36] [51]
	[28] [16] [20] [34] [36] [51]		[84] [18] [60] [19] [61] [16] [20] [34] [36] [51]

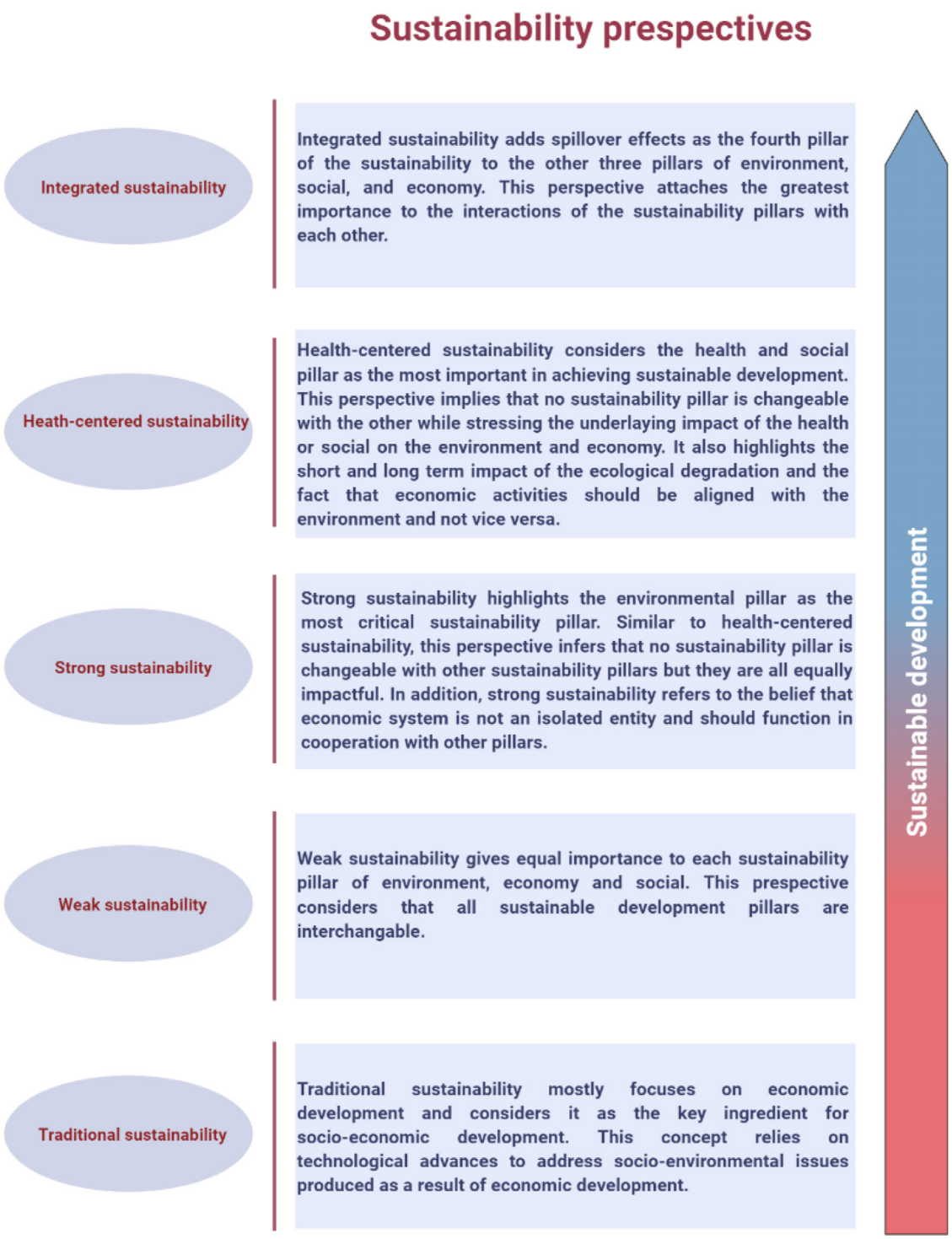


Fig. 5. Various sustainability concepts according to the literature review.

for Autocorrelation, the Durbin Watson test. However, before running the model, we put the variables into the preliminary tests.

4. Result

This section presents the results of HEY and THEY model, using VAR and simultaneous equations system during 1979–2016 that reveal the causal relationships among the various pillars of sustainable development; and their interactions with different modes of transportation in Iran during 1974–2016. Our estimations cover various cases of "intercept only", "intercept and trend", and "trend only" to search any possible stationarity [3,15,58]. Beforehand the variables are put in the unit root tests, represented in the Appendix.

Fig. 9 presents how the various pillars of sustainability affect each other, based on the results of VAR model in Iran which supports the strong sustainability perspective. As in Fig. 9, CO2 and life expectancy have a unidirectional causal nexus from CO2 to life expectancy; CO2 and GDP have a unidirectional nexus from CO2 to GDP, consistent with [74]; and life expectancy and GDP have a unidirectional relationship from life expectancy to GDP. Implicitly, the environment affects both the health

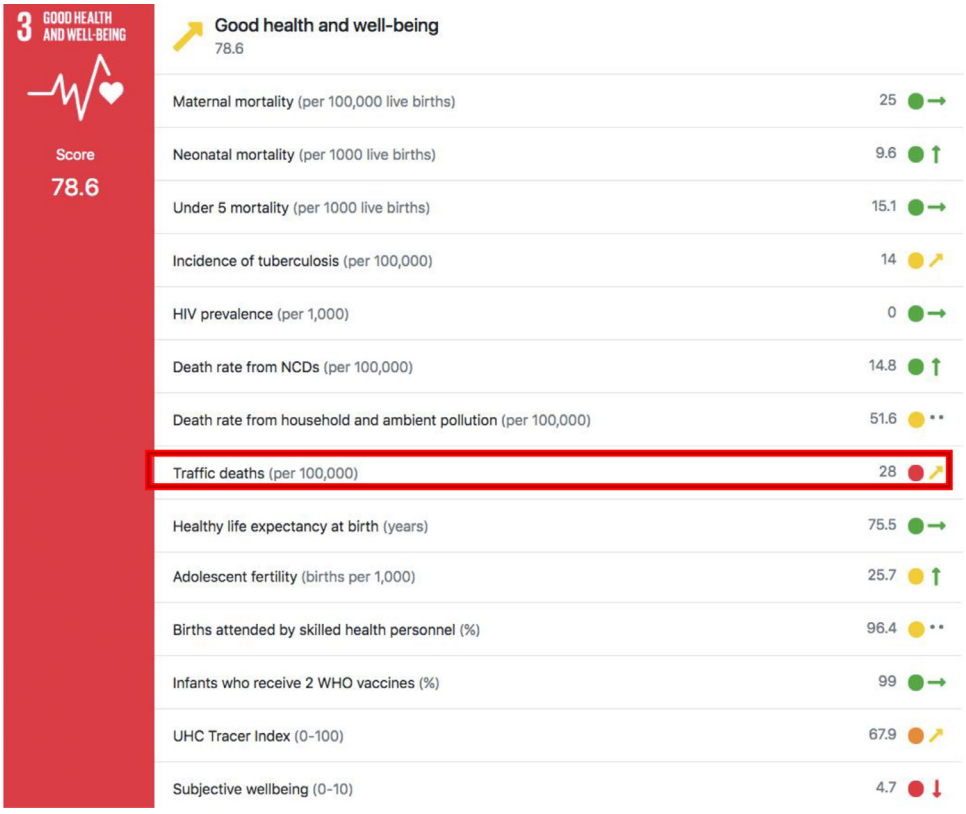


Fig. 6. Decomposition of SDG 3, Good health and well-being in Iran in 2019. Source: [65].

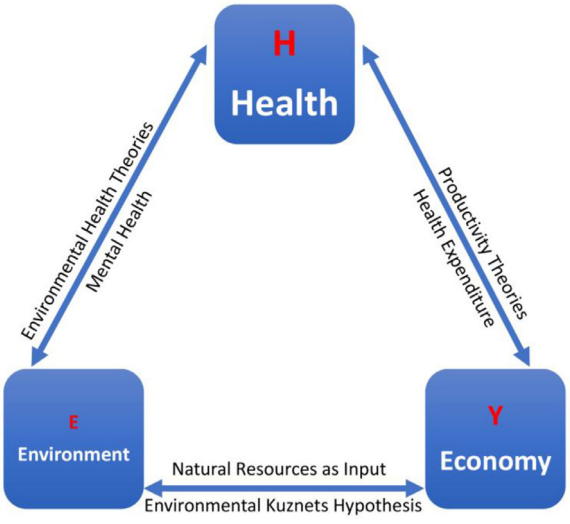


Fig. 7. Interconnection of sustainable development pillars in HEY model. Source: Elaborated by authors.

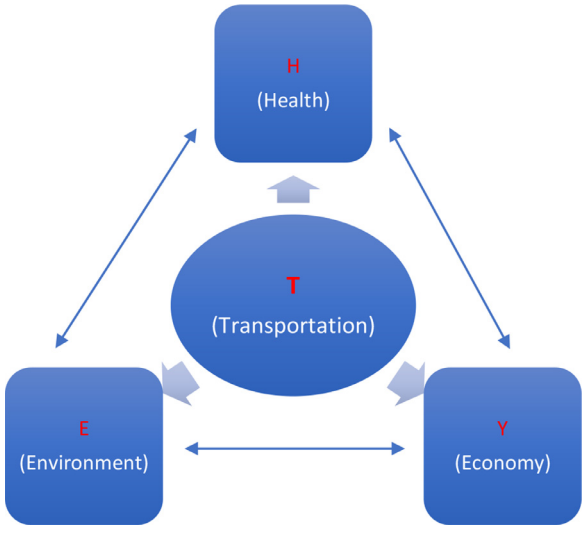


Fig. 8. Interconnection of transportation with sustainable development pillars. Source: Elaborated by author.

and economy, playing the most dominant role in the other pillars. In the 2nd place is health as a proxy for social pillar which only affects the economy. Finally, the economy is found not to have causal effect on the other pillars. In other words, environment is found to be the background for both the social and economy pillars; and social is background for the development of economy. This supports the perspective dominance of strong sustainable development in Iran, rather than the weak or health-centered ones, as in Fig. 3, consistent with [11,48,57] and in consistent with [94,96].

Fig. 10 shows the response functions of GDP and life expectancy. It displays how a variable responds to a shock in another variable while being equal to standard deviation. Based on Fig. 10, the response of GDP to CO2 is considerably greater than to life expectancy; and the response of life expectancy to CO2 is positively increasing. This confirm that the economy responds to the environment more than to the health; and the health itself responds positively to the environment which is consistent with the perspective of strong sustainability.

We employ the GMM and 2LS methods to investigate the THEY model, for the estimation of the interaction among the transportation, on one side, and the three pillars of sustainable development including economic, environmental, and social pillars, on the other side, in Iran during 1974–2016.

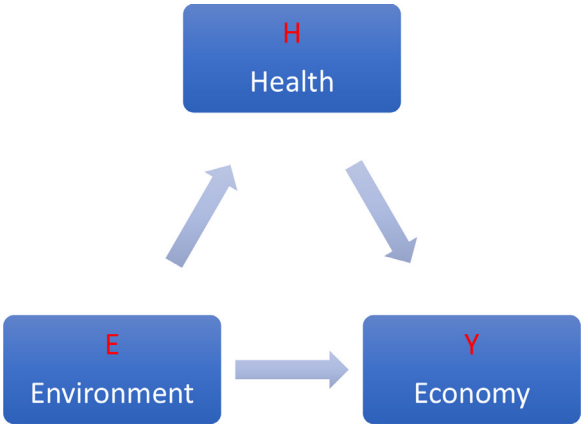


Fig. 9. Causal relationships among the pillars of sustainable development in Iran. Source: Researchers' findings.

Table 3 and Table 4 display the estimated coefficients and statistics of the THEY model as a simultaneous equations system, with two techniques, GMM and 2SLS, in Iran. It is divided into three parts, each assigned to one equation. The results of each equation are represented in four distinctive cases: 1. no trend and no dummy variable; 2. with trend; 3. with dummy variable; and 4. with both the trend and the dummy variable. Despite some minor differences in the results of the tables, there is a high similarity between each of these items.

According to the health equations in the Table 3 and Table 4, the social pillar of sustainable development, which shows the most statistical significance in the explanatory variables, is compared with the other pillars, the environmental and economic equations. Accordingly, except for the trend-only case, all the four transportation modes have statistically significant effect on the life expectancy, as the health proxy, in both the tables. This conclusion implies that the effect of transport system is mostly on the health status, compared to the other pillars of sustainable development. Thus, it would be an effective policy-making decision to decide and manage each transportation mode with its own particular characteristics in Iran.

Given the available data and based on the results of both the tables, the rail transportation is found as the healthiest mode. In the health equation, except for the trend-only cases, the rail mode coefficient is 0.03 for all the other six cases which is greater than the other modes. All of the coefficients of rail mode show 99% statistical significance level, confirming the highest possible effectiveness of the rail mode on life expectancy, or rather the health status. Following the railroad is air transportation mode which shows the greatest positive effect on health. Except for trend-only cases, its coefficient is 0.01 with 99% statistical significance level.

The road mode, despite its various statistical significance level, its coefficients are near to zero in all the cases, confirming an almost negligible positive impact on health. This shows that the road mode has been unsuccessful to increase the health status in Iran. This issue might be rooted in its negative effects originating directly from the traffic death and accidents and indirectly from the greenhouse gas emissions. Above that, the low quality and high price of the cars can be other reasons in reducing the life expectancy, or rather the health status in Iran, in spite of its positive capabilities for a great positive effect on health.

Further, it can be seen that the maritime transportation is negatively affecting the health status in Iran. Its coefficients, except for the trend-only cases, are −0.01 or −0.02 which are statistically significant at 99% level. Although there is no clear evidence for this direct negative-effect of maritime transportation on life expectancy, its indirect effect can be seen when considering the pollutions of this transportation mode such as greenhouse gas emissions as well as sea pollution.

In general, CO2 emissions are found to negatively affecting the life expectancy, confirming one side of the HEY model, the connection of environmental and social pillars of the sustainable development. Based on the health equation results of Table 3 and Table 4, the coefficients of CO2 are −0.06, −0.07, and −0.33, which are statistically significant at 99%. This confirms that CO2 emissions are an effective factor to damage the health status in Iran, that are the byproduct of transportation system, particularly the maritime mode.

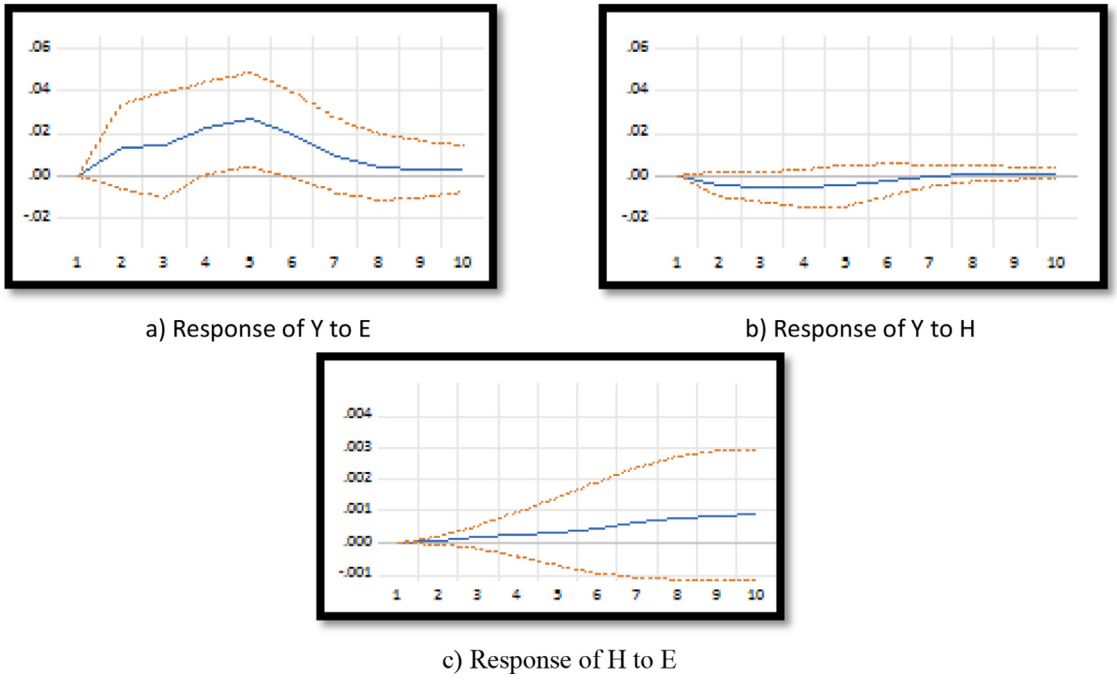


Fig. 10. functions of life expectancy and GDP to CO2 and life expectancy. Source: Researchers' findings.

Table 3
GMM estimations with life expectancy as the health proxy.

	No-trend and dummy variable		Trend-only		Dummy variable-only		Trend and dummy variable	
	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.
Health equation								
C	0.71	0.00	6.15	0.00	0.95	0.00	0.96	0.00
AI	0.01	0.00	−0.02	0.17	0.01	0.00	0.01	0.00
MA	−0.02	0.00	−0.05	0.20	−0.01	0.00	−0.01	0.00
RA	0.03	0.00	0.14	0.01	0.03	0.00	0.03	0.00
RO	0.00	0.00	−0.01	0.47	0.00	0.00	0.00	0.02
E	−0.07	0.00	−0.33	0.00	−0.07	0.00	−0.06	0.00
Y	0.01	0.60	0.58	0.00	0.01	0.29	0.01	0.69
H_{t-1}	0.96	0.00	−0.00	0.20	0.88	0.00	0.87	0.00
Trend					0.01	0.12	0.01	0.13
D					0.01	0.12	0.01	0.13
R2 value	0.99		0.93		0.99		0.99	
DW stat.	1.45		1.19		1.40		1.47	
Environment equation								
C	0.49	0.71	−0.84	0.44	−1.29	0.18	−2.30	0.02
AI	0.01	0.71	0.06	0.10	−0.00	0.94	0.01	0.60
MA	0.13	0.05	0.10	0.08	0.11	0.03	0.08	0.11
RA	0.04	0.61	−0.08	0.49	0.03	0.59	−0.02	0.82
RO	0.00	0.04	−5.31	0.81	0.00	0.00	0.00	0.26
Y	−0.05	0.74	0.14	0.33	0.19	0.11	0.33	0.01
E_{t-1}	0.49	0.00	0.41	0.00	0.37	0.00	0.28	0.00
Trend					0.11	0.00	0.11	0.00
D			0.01	0.05			0.01	0.02
R2 value	0.97		0.97		0.98		0.98	
DW stat.	1.93		1.93		1.85		1.67	
Economic equation								
C	5.35	0.00	5.22	0.00	5.12	0.15	6.54	0.05
AI	0.06	0.13	0.07	0.15	0.02	0.58	0.02	0.70
MA	0.09	0.16	0.09	0.22	0.12	0.03	0.13	0.04
RA	−0.05	0.54	−0.05	0.63	−0.03	0.78	−0.02	0.90
RO	0.00	0.11	0.00	0.64	0.00	0.48	8.68	0.75
H	−0.37	0.16	−0.44	0.23	−0.54	0.51	−0.89	0.28
Y_{t-1}	0.49	0.00	0.54	0.00	0.61	0.00	0.60	0.00
Trend					0.02	0.79	0.05	0.53
D			0.00	0.82			0.00	0.86
R2 value	0.85		0.86		0.86		0.87	
DW stat.	1.43		1.49		1.65		1.64	

Source: Researchers' findings.

According to the environment equation of the Table 3 and Table 4, maritime transportation has the highest positive effect on the CO2 emissions. This shows the coefficient range of 0.10–0.13 with the statistical significance of 95% and 90% levels. It further implies that maritime transportation has negative affected not only the health, as the social pillar, but also on the environmental pillar, proposing it as the most inconsistent transportation mode for sustainable development in Iran. The other transportation modes have inconsiderable effect on the CO2 emissions as the environmental pillar of sustainable development.

Further from the economic equation of the Table 3 and Table 4, it can be seen that all the transportation modes are ineffective on the economic pillar of sustainable development, but the maritime mode shows a statistically significant and positive impact. This might be rooted in the high potential of marine transportation to carry the large amount of cargo, increasing the trade volume and economic growth. Despite its positive effect on the economic pillar of sustainable development, its effects are negative on the other two pillars, health and environment, proposing it as a transportation mode with asymmetric effects on the various pillars of sustainable development. Thus, the results winnow out the maritime transportation from the list of transportation modes which are consistent with the sustainable development.

In general, all the results show robustness with the R-squared values and Durbin-Watson (DW) statistics. In this regard, all the R-squared values are above 85, showing that the explanatory variables are explaining at least 85% of the changes in the dependent variables; and all the DW statistics claim no autocorrelation. Thus, the results are substantially reliable for ranking the transportation modes in accordance with their consistency with the sustainable development.

Finally, the results suggest the rail transportation mode as the most consistent one with the sustainable development, especially with the health, as the social pillar. After the air mode, in the third place is the maritime transportation mode; and the road is the most inconsistent transportation mode with sustainable development in Iran.

5. Discussion

The results of this study show that the effects of the transportation modes are highly distinctive on the various pillars of the sustainable development. Fig. 11, for instance, displays how the various sustainable development pillars are affected by the impacts of the four transportation modes during 1979–2016.

Based on Fig. 11, the rail and air modes of transport have considerable effects on the health pillar. Despite the positive sign of both, the rail mode has a higher effect than that of the air. This phenomenon can be rooted in the lower share of rail and air transportation in traffic death as a direct effect on health, on the one hand; and their positive effects on the welfare, utility, leisure, travel, and life expectancy, on the other hand.

Although, road transportation is ineffective in health in Iran, it could have a highly positive effect due to its great potential for providing a high level of privacy, as well as independency in this mode of transport. Although, it must be appeared in a considerable positive effect, its adverse impacts undo the positive ones, as the results point out to. In

Table 4
2SLS estimations with life expectancy as health proxy.

	No-trend and dummy variable		Trend-only		Dummy variable-only		Trend and dummy variable	
	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.
Health equation								
C	0.67	0.01	6.46	0.00	0.95	0.00	0.95	0.00
AI	0.01	0.00	−0.02	0.44	0.01	0.00	0.01	0.00
MA	−0.02	0.00	−0.06	0.19	−0.02	0.00	−0.02	0.00
RA	0.03	0.00	0.14	0.12	0.03	0.00	0.03	0.00
RO	0.00	0.00	−8.14	0.67	0.00	0.00	0.00	0.08
E	−0.07	0.00	−0.37	0.03	−0.06	0.00	−0.06	0.01
Y	0.01	0.64	0.62	0.00	0.01	0.50	0.00	0.91
H_{t-1}	0.96	0.00	−0.00	0.51	0.88	0.00	0.86	0.00
Trend					0.01	0.11	0.01	0.07
D					0.01	0.11	0.01	0.07
R2 value	0.10		0.92		0.10		0.99	
DW stat.	1.31		1.22		1.51		1.59	
Environment equation								
C	−0.25	0.89	−1.19	0.50	−2.38	0.08	−2.91	0.03
AI	0.03	0.48	0.06	0.22	−0.00	0.89	0.01	0.70
MA	0.13	0.04	0.10	0.10	0.12	0.01	0.10	0.04
RA	0.02	0.84	−0.11	0.39	0.04	0.56	−0.05	0.64
RO	0.00	0.38	−0.00	0.53	0.00	0.05	0.00	0.89
Y	0.03	0.90	0.19	0.42	0.32	0.06	0.41	0.02
E_{t-1}	0.53	0.00	0.41	0.01	0.29	0.01	0.22	0.07
Trend					0.12	0.00	0.10	0.00
D			0.01	0.16			0.01	0.24
R2 value	0.97		0.98		0.98		0.98	
DW stat.	2.04		2.00		1.72		1.63	
Economic equation								
C	4.17	0.02	3.88	0.07	8.40	0.01	8.18	0.02
AI	0.06	0.22	0.05	0.35	0.02	0.67	0.01	0.74
MA	0.09	0.11	0.10	0.12	0.12	0.04	0.12	0.05
RA	−0.07	0.53	−0.05	0.74	0.06	0.66	0.07	0.66
RO	0.00	0.35	0.00	0.49	0.00	0.18	0.00	0.42
H	−0.21	0.61	−0.14	0.78	−1.32	0.12	−1.26	0.16
Y_{t-1}	0.56	0.00	0.56	0.00	0.56	0.00	0.55	0.00
Trend					0.13	0.13	0.12	0.14
D			−0.00	0.80			−0.01	0.89
R2 value	0.86		0.86		0.89		0.88	
DW stat.	1.57		1.56		1.59		1.58	

Source: Researchers' findings.

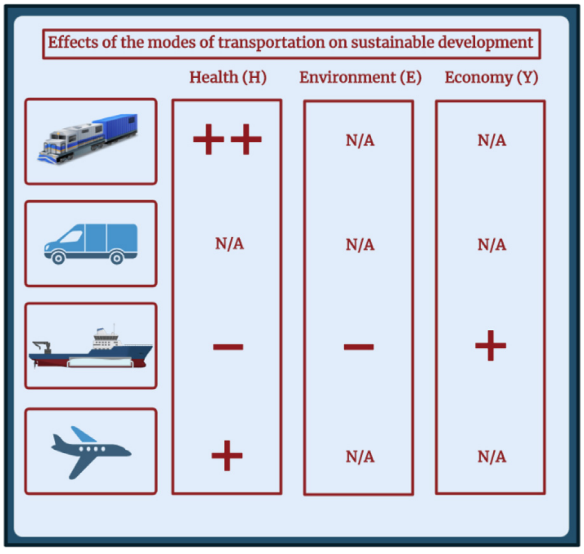


Fig. 11. Transportation modes' effects on the sustainable development pillars in Iran.

other words, although the road transportation has a very high potentially positive impact, the outdated infrastructure in Iran as well as the highly inefficient domesticated vehicles offset this impact for it to be almost zero. In addition, the road mode of transport is the most passive one with zero effects on all the sustainable development pillars, due to its low capacity in carrying goods and passengers, compared with the other modes of transport, especially with the maritime transportation.

The maritime transportation, in this regard, is found to affect health pillar negatively. This can be due to the indirect impact of maritime transportation on air and sea pollution. Hence, the effect of maritime transportation must be negative on the environment which affects the health pillar as well. Similar results, has been reported in the authors' previous researches as in [72,73]. However, the maritime transportation has positive effect on the economy, potentially for its large capacity in carrying a large amount of cargo, increasing the trade volume and economic growth. In fact, this can explain the reason as to why the maritime transportation is the most active mode of transportation in affecting all the pillars of sustainable development considerably, albeit asymmetrically, as displayed in Fig. 11.

The mentioned different effects require a classification to pave the way for ranking, prioritizing, and comparing the transportation modes, on the basis of their effects on the pillars of sustainable development. As a result, this study ranks the sustainability friendliness of transportation modes in Iran as follows: 1) train, 2) air, 3) road, and 4) maritime. The ranking shows robustness from all the perspectives on sustainability: health-centered, strong, and weak sustainability, albeit this study's supportive findings in confirming the strong sustainability in Iran.

Based on the Fig. 12, the rail and air transportation modes are affecting positively the 2nd main pillar of sustainability, the health as a social item. The rail and road are the most sustainability-friendly modes of transport, in the 1st and 2nd places, respectively; and the road trans-

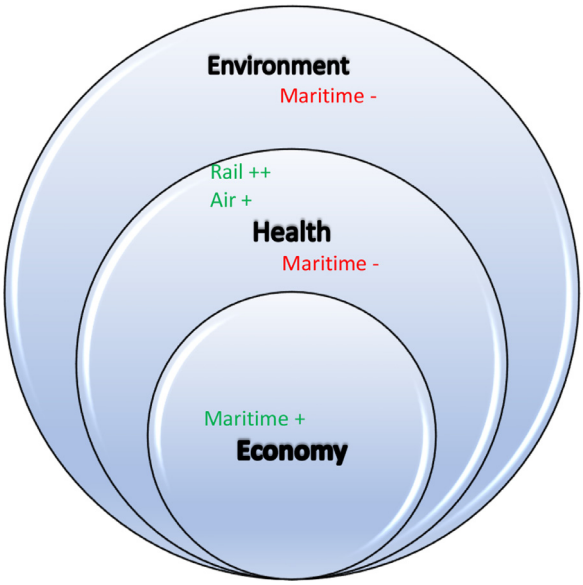


Fig. 12. Strong sustainability framework for the transportation modes effects in Iran. Source: Researchers' findings based on Table 3 and Table 4.

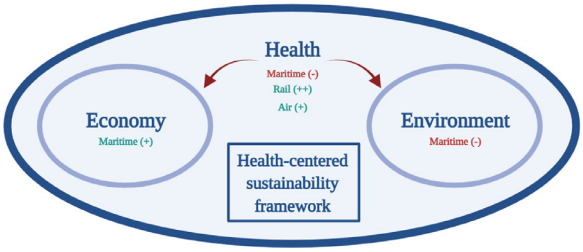


Fig. 13. Health-centered sustainability framework for the transportation modes effects in Iran. Source: Researchers' findings based on Table 3 and Table 4.

portation is in the 3rd place due to its neutral role. The maritime is at the end of the ranking due to its damaging effect to the 1st and 2nd main pillars, the environment and the health, despite its positive impact on the most minor pillar, the economy. Although, our findings support this perspective of sustainability for Iran, the other perspectives of sustainability (the health-centered and the weak ones) confirm the above ranking of transportation modes in Iran.

From the health-centered sustainability perspective which can be seen in Fig. 13, rail and air transportations affect the health pillar, proposing the rail and air as the most consistent transportation mode with sustainable development, respectively, in the 1st and 2nd places. In the 3rd place is the road mode with its neutral role. However, the maritime transportation mode, despite, has a positive effect on the economy as a minor pillar, it has a negative effect on both the environment as a minor pillar, and the health as the central pillar. Hence, its total effect is negative in the health-centered sustainability. So, the ranking is as follows: 1) rail, 2) air, 3) road, and 4) maritime modes of transport, according to the health-centered sustainability.

The weak sustainability, also, confirms the same ranking as the other sustainability perspectives: 1) rail, 2) air, 3) road, and 4) maritime transportations, as in Fig. 14. The rail and road show a positive effect on one pillar, the health; and road has no effect. The maritime transportation, however, show negative effect on a couple of pillars, the health and environment, despite its positive effect on only one pillar, the economy. The sum of its effect is negative, introduced as the most inconsistent mode of transport with sustainability. Thus, the above-mentioned ranking is correct in the weak sustainability.

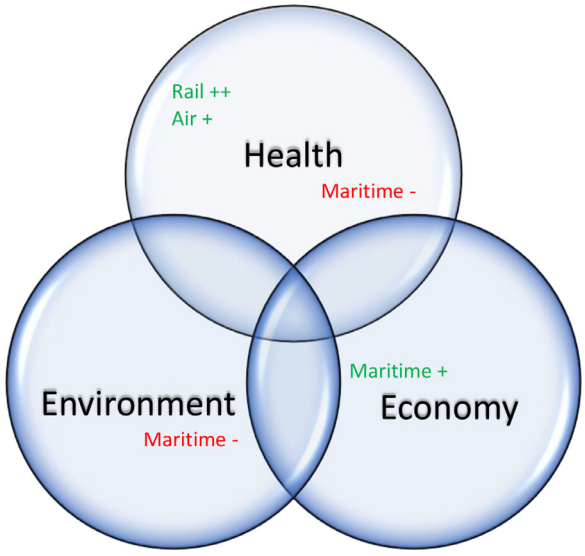


Fig. 14. Weak sustainability framework for the transportation modes effects in Iran. Source: Researchers' findings based on Table 3 and Table 4.

Overall, the ranking of transportation modes is as follows according to their level of sustainability friendliness in Iran: 1) rail, 2) air, 3) road, and 4) maritime transportations. In addition, this ranking is confirmed from all perspectives of the sustainable development, despite the results mostly supporting strong sustainability.

6. Conclusion

Based on the score of Sustainable Development Goals (SDGs), Iran has been unsuccessful in almost all of the sustainable development goals and pillars. This implies a comprehensive underdevelopment in Iran in various dimensions including environment, social, and economic. To evaluate this, the present study focuses on transportation, since it plays a key role in each single sustainable development pillar in Iran.

This research tries to find the most consistent transportation mode with the sustainable development pillars in Iran. To find a more accurate ranking of transportation modes, we investigate which perspective of sustainable development dominates in Iran by producing and using HEY model with VAR approach based on World Bank data during 1979–2016. The findings point that the strong sustainability perspective is most effective in case of Iran which implies that the environment plays the most important role in sustainable development, before the social and economic pillars.

Then, this study ranks the transportation modes on the basis of their consistency with sustainable development pillars. For this, the methodology employs THEY model in a simultaneous equations system to have an estimation within 1979–2016. The results show that, it is the rail mode whose expansion benefits the sustainable development pillars in Iran mostly, compared with the other modes of transportation. The air mode is in the 2nd place, promoting the health pillar. The road mode has an insignificant role in the sustainable development due to the neutralization of its benefits by its significant underdevelopment adversely affecting the role it could play in sustainable development. Finally, the most damaging transportation mode is found to be the marine one. Although, it promotes the economic pillar of the sustainable development, it damages both the health and environment which are more highlighted in the strong sustainability perspective.

In spite of the dominance of strong sustainability in our findings about Iran, the above-mentioned ranking coincides with the other perspectives of sustainable development. In other words, the order of the most-to-the-least beneficial transportation mode is found to be: 1) rail,

2) air, 3) road, 4) maritime, from all the viewpoints of sustainable development.

On the basis of this study, policy makers are advised to invest further in the rail transportation mode to expand it throughout the country. The air mode needs international support to upgrade its own fleet which suffers from the global and the US sanctions on Iran's aviation industry. The road challenges, however, relate to the domestic policies. Not only the governmental support does not help the domestic car industry in Iran, but also it damages the other sectors of the country. This study claims that the removal of domestic industry is one of the most urging and necessary factors to achieve the sustainable development in Iran. The sustainable development requires a considerable improvement of the maritime transportation infrastructure to get well-adapted for supporting the environment and health pillars of the sustainable development, as it supports the economic pillar.

As a future study, researchers can estimate how much load of passenger and goods should be moved from one transportation mode to another, and their respective impact on the pillars of sustainable development as well as achieving the SDGs. This can be applied to not only a case study but also regionally or even internationally to find the most suitable mode or type of transportation for achieving the SDGs.

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Availability of data and material

The data employed in this research are available in the appendix.

Code availability

The EViews software file is available upon request.

Ethics approval

Not applicable.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

Declaration of Competing Interest

No conflict or competing interests

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.wds.2022.100018.

Reference

[1] Adhanom, T. (2020, March 13). WHO director-general's opening remarks at the media briefing on COVID-19 - 13 March 2020. Retrieved March 2020, from World Health Organization: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-mission-briefing-on-covid-19—13-march-2020

[2] D. Adshead, S. Thacker, L.I. Fuldauer, J.W. Hall, Delivering on the sustainable development goals through long-term infrastructure planning, Glob. Environ. Chang. 59 (2019) 101975, doi:10.1016/j.gloenvcha.2019.101975.

[3] A. Ahmad, Y. Zhao, M. Shahbaz, S. Bano, Z. Zhang, S. Wang, Y. Liu, Carbon emissions, energy consumption and economic growth: an aggregate and disaggregate analysis of the Indian economy, Energy Policy 96 (2016) 131–143.

[4] H. Ahmadi, M. Mohebi, H. Nikbeen, K. Rasoli, Y. Sharifpour, A. Soleymani, V.M. Taghvaee, A. Yousefi, Sustainable development and modern customs: a review on customs conventions of world customs organization, Global Trade and Customs J. (2021) 363–383 http://www.kluwerlawonline.com/api/Product/CitationPDFURL?file=Journals%5CGTCJ%5CGTCJ2021040.pdf.

[5] E. Ainy, H. Soori, M. Ganjali, H. Le, T. Baghfalaki, Estimating cost of road traffic injuries in Iran using willingness to pay (WTP) method, PLoS ONE 9 (12) (2014) 1–16.

[6] M.M. Amiri, M. Bahadori, A. Mehrabi-Tavana, The dilemma of road traffic accidents in Iran, Int. J. Medical Rev. 4 (3) (2017) 91–92.

[7] T. Antonucci, M. Bial, C. Cox, R. Finkelstein, L. Marchado, The role of psychology in addressing worldwide challenges of poverty and gender inequality, Zeitschrift für Psychologie 227 (2019) 95–104.

[8] M.B. Arvin, R.P. Pradhan, N.R. Norman, Transportation intensity, urbanization, economic growth, and CO2 emissions in the G-20 countries, Utilities Policy 35 (2015) 50–66.

[9] A.J. Ayubi, The relationship between public social expenditure and economic growth in Nigeria: an empirical analysis, Int. J. Financ. Accounting 3 (3) (2014) 185–191.

[10] N. Caïd, P. Crist, R. Gilbert, P. Wiederkehr, Environmentally sustainable transport: concept, goal and strategy - The OECD's EST Project, Proc. Inst. Civ. Eng. Transp. 153 (4) (2002) 219–226, doi:10.1680/tran.2002.153.4.219.

[11] M.S. Cato, Green Economics: An Introduction to Theory, Policy and Practice, Earthscan, London, 2009.

[12] Central Bank of Iran. (2019). Economic Time Series Database. Tehran, Iran. Retrieved from https://tsd.cbi.ir/DisplayEn/Content.aspx

[13] T. Cernev, R. Fenner, The importance of achieving foundational Sustainable T Development Goals in reducing global risk, Futures 115 (102492) (2020).

[14] S. Chaabouni, C. Abdennadher, The determinants of health expenditures in Tunisia: an ARDL bounds testing approach, Int. J. Information Syst. Service Sector 6 (4) (2014) 60–72.

[15] L. Charfeddinea, A. Al-Malk, K. Korbi, Is it possible to improve environmental quality without reducing economic growth: evidence from the Qatar economy, Renewable Sustainable Energy Rev. 82 (2018) 25–39.

[16] G. Christie, S. Ratzan, Beyond the benchand bedside: health literacy is fundamental to sustainable health and development, Information Services and Use 39 (2019) 79–92.

[17] Curtis, G.E., & Hooglund, E. (2008). Iran: a country study (Fifth Edition ed.). Washington, United States of America.

[18] S. Davies, B. Bennett, A gendered human rights analysis of Ebola and Zika: locating gender in global health emergencies, Int. Aff. 92 (5) (2016) 1041–1060.

[19] S. Dey, M. Flather, G. Devlin, D. Brieger, E. Gurfinkel, P. Steg, K. Eagle, Global registry of acute coronary events investigators. sex-related di erences in the presentation, treatment and outcomes among patients with acute coronary syndromes:. the global registry of acute coronary events, Heart 95 (1) (2009) 20–26.

[20] E. Eckermann, SDG3: a Missed opportunity to transform understandings and monitoring of health, well-being and development? Appl. Res. Quality Life 13 (2018) 261–272.

[21] P. Erickson, H. van Asselt, D. Koplow, M. Lazarus, P. Newell, N. Oreskes, G. Supran, Why fossil fuel producer subsidies matter, Nature 578 (7793) (2020) E1–E4, doi:10.1038/s41586-019-1920-x.

[22] A. Faiz, Sustainable transport for the developing world: the social and environmental Nexus, J. Transp. Eng. 126 (6) (2000) 451–454, doi:10.1061/(ASCE)0733-947X(2000)126:6(451).

[23] B. Fattouh, L. El-Katiri, Energy subsidies in the Middle East and North Africa, Energy Strategy Rev. 2 (1) (2013) 108–115, doi:10.1016/j.esr.2012.11.004.

[24] G. Grossman, A. Kruger, Environmental Impact of a North American Free Trade Agreement, National Bureau of Economic Research. Oxford, Oxford, 1991.

[25] Gudmundsson, H., Hall, R.P., Marsden, G., & Zietsman, J. (2016). Transportation and Sustainability (pp. 81–109). https://doi.org/10.1007/978-3-662-46924-8_4

[26] T. Han, C. Zhang, Y. Sun, X. Hu, Study on environment-economy-society relationship model of Liaohe River Basin based on multi-agent simulation, Ecol. Modell. 359 (2017) 135–145.

[27] O. Hankivsky, Women's health, men's health, and gender and health: implications of intersectionality, Social Sci. Med. 74 (11) (2012) 1712–1720.

[28] P. Harris, E. Riley, A. Dawson, S. Friel, K. Lawson, Stop talking around projects and talk about solutions": positioning health within infrastructure policy to achieve the sustainable development goals, Health Policy (New York) (2018) First Online.

[29] J. Hartwig, Is health capital formation good for long-term economic growth? – Panel Granger- causality evidence for OECD countries, J. Macroecon. 32 (2010) 314–325.

[30] S. Hawkes, K. Buse, Gender and global health: evidence policy and inconvenient truths, Lancet 18 (381) (2013) 1783–1787.

[31] IEATotal Final Consumption. International Energy Agency, Consumption by Sector, International Energy Agency, 2017.

[32] IEAFossil-fuel Consumption Subsidies By Country, International Energy Agency, 2020.

[33] IEA. (2022). International - U.S. Energy Information Administration (EIA) - Iran oil and gas reserves.

[34] International Council of SciencesA Guide to SDG interactions: from Science to Implementation, International Council of Sciences, Paris, 2017.

[35] H.H. Jafari, A. Baratimalayeri, The crisis of gasoline consumption in the Iran's transportation sector, Energy Policy 36 (7) (2008) 2536–2543.

[36] K. Jilcha, D. Kitaw, Industrial occupational safety and health innovation for sustainable development, Eng. Sci. Technol. 20 (2017).

[37] A. Langer, A. Meleis, F. Knaul, R. Atun, M. Aran, H. Arreola-Ornelas, …, J. Frenk, Women and health: the key for sustainable development, Lancet 19 (386) (2015) 1165–1210.

[38] K.-.W. Li, Role of Government, in: Redefining Capitalism in Global Economic Development, Elsevier, 2017, pp. 31–43, doi:10.1016/B978-0-12-804181-9.00003-3.

[39] T. Litman, Transportation and public health, Annu. Rev. Public Health 34 (2013) 217–233, doi:10.1146/annurev-publhealth-031912-114502.

[40] Z. Lu, H. Chen, Y. Hao, J. Wang, X. Song, T. Mok, The dynamic relationship between environmental pollution, economic development and public health: evidence from China, J. Clean. Prod. 166 (2017) 134–147.

[41] V. Magar, Gender, health and the sustainable development goals, Bull World Health Orga 93 (11) (2015) 743.

[42] R. Mandal, S. Kaur, Impact of environmental pollution on trace elements in vegetables and associated potential risk to human health in industrial town Mandi-gobindgarh (India), Chemosphere 219 (2019) 547–587.

[43] M. Mehrara, G. Sharzei, M. Mohaghegh, The relationship between health expenditure and environmental quality in developing countries, J. Health Administration 14 (46) (2014) 79.

[44] D. Miller, M. Page, A. Stevens, M. Filipski, The economy and health: why are recessions good for your health, Am. Econ. Rev. 99 (2) (2009) 122–127.

[45] V. Mohamad Taghvaee, A. Assari Arani, L Agheli, Sustainable development spillover effects between North America and MENA: analyzing the integrated sustainability perspective, Environ. Sustainability Indicators (2022) 100182, doi:10.1016/j.indic.2022.100182.

[46] S. Morton, D. Pencheon, G. Bickler, The sustainable development goals provide an important framework for addressing dangerous climate change and achieving wider public health benefits, Public Health 174 (2019) 65–68.

[47] M.H. Mousavi, S. Ghavidel, Structural time series model for energy demand in Iran's transportation sector, Case Stud. Transport Policy 7 (2) (2019) 423–432.

[48] Z. Nasrollahi, M.-s. Hashemi, S. Bameri, V.M. Taghvaee, Environmental pollution, economic growth, population, industrialization, and technology in weak and strong sustainability: using STIRPAT model, Environ., Development and Sustainability, 22 (2018) 1105–1122.

[49] S. Nazneen, X. Hong, N. Ud Din, B. Jamil, Infrastructure-driven development and sustainable development goals: subjective analysis of residents' perception, J. Environ. Manage. 294 (2021) 112931, doi:10.1016/j.jenvman.2021.112931.

[50] J. Nerisa, D. Olivaresa, F. Velascoa, F. Luzardoa, L. Correiaa, L. Gonzálezb, HHRISK: a code for assessment of human health risk due to environmental chemical pollution, Ecotoxicol. Environ. Saf. 170 (2019) 538–547.

[51] M. Nilsson, E. Chisholm, D. Griggs, P. Chapman, D. McCollum, P. Messerli, …, M. Smith, Mapping interactions between the sustainable development goals: lessons learned and ways forward, Sustainability Sci. 13 (2018) 1489-150.

[52] M. Nodehi, A.A. Arani, V.M. Taghvaee, Sustainability spillover effects and partnership between East Asia & Pacific versus North America: interactions of social, environment and economy, Lett. Spatial and Resource Sci. (2021), doi:10.1007/s12076-021-00282-5.

[53] M. Nodehi, V.M. Taghvaee, Sustainable concrete for circular economy: a review on use of waste glass, Glass Struct. Eng. (2021), doi:10.1007/s40940-021-00155-9.

[54] M. Nodehi, V.M. Taghvaee, Alkali-activated materials and geopolymer: a review of common precursors and activators addressing circular economy, Circular Econ. Sustainability (2021), doi:10.1007/s43615-021-00029-w.

[55] M. Nodehi, V.M. Taghvaee, Applying circular economy to construction industry through use of waste materials: a review of supplementary cementitious materials, plastics, and ceramics, Circular Econ. Sustainability (2022), doi:10.1007/s43615-022-00149-x.

[56] M. Nodehi, V.M. Taghvaee, Sustainable concrete for circular economy: a review on use of waste glass, Glass Structures and Eng. (2021) First Online.

[57] H. Parsa, H. Keshavarz, V.M. Taghvaee, Industrial growth and sustainable development in Iran, Iranian Econ. Rev. 23 (2) (2019) 319–339.

[58] K. Pinzón, Dynamics between energy consumption and economic growth in Ecuador: a granger causality analysis, Econ. Anal. Policy 57 (2018) 88–101.

[59] R.P. Pradhan, T.P. Bagchi, Effect of transportation infrastructure on economic growth in India: the VECM approach, Res. Transport. Econ. 38 (1) (2013) 139–148, doi:10.1016/j.retrec.2012.05.008.

[60] R. Raine, Does gender bias exist in the use of specialist health care? J. Health Services Res. Policy 5 (4) (2000) 237–249.

[61] Regitz-Zagrosek, V. (2011). Sex and gender di erences in cardiovascular disease. In sex and gender aspects in clinical medicine (pp. 17-44). London.

[62] S. Reysen, I. Miller, A model of global citizenship: antecedents and outcomes, Int. J. Psychol. 48 (5) (2013) 858–870.

[63] S. Rezaei, M. Arab, B.K. Matin, A.A. Sari, Extent, consequences and economic burden of road traffic crashes in Iran, Int. J. Injury and Violence 6 (2) (2014) 57–63.

[64] A.K. Richmond, R.K. Kaufmann, Is there a turning point in the relationship between income and energy use and/or carbon emissions? Ecol. Econ. 56 (2006) 176–189.

[65] J. Sachs, G. Schmidt-Traub, C. Kroll, G. Lafortune, a.G Fuller, SDG Index and Dashboards Report 2018. Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN), United Nations, New York, 2018.

[66] J. Sachs, G. Schmidt-Traub, C. Kroll, G. Lafortune, G. Fuller, Sustainable Development Report 2019. Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN), United NAtions, New York, 2019.

[67] S. Sarkodie, V. Strezov, A review on Environmental Kuznets Curve hypothesis using bibliometric and meta-analysis, Sci. Total Environ. 649 (2019) 128–145.

[68] K. Scott, A. George, S. Harvey, S. Mondal, G. Patel, K. Sheikh, Negotiating power relations, gender equality, and collective agency: are village health committees transformative social spaces in northern India? Int. J. Equity Health 16 (1) (2017) 84.

[69] G. Sen, P. Ostlin, Unequal, unfair, Ine ective, Ine cient. Gender inequity in health: Why It Exists and How We Can Change it. IIM Bangalore and Karolinska Institute, IIM Bangalore and Karolinska Institute, Bangalore, 2007.

[70] J.K. Shirazi, V.M. Taghvaee, M. Nasiri, A. Assari Arani, Sustainable development and openness in oil-exporting countries: green growth and brown growth, J. Econ. Struct. 9 (1) (2020), doi:10.1186/s40008-020-00216-2.

[71] S. Solaymani, Energy subsidy reform evaluation research – reviews in Iran, Greenhouse Gases: Sci. Technol. 11 (3) (2021) 520–538, doi:10.1002/ghg.2064.

[72] S. Taghvaee, B. Omaraee, V. Taghvaee, Maritime transportation, environmental pollution, and economic growth in Iran: using dynamic log linear model and Granger causality approach, Iranian Econ. Rev. 21 (2) (2017) 185–210.

[73] V.M. Taghvaee, L. Agheli, A.A. Arani, M. Nodehi, J.K. Shirazi, Environmental pollution and economic growth elasticities of maritime and air transportations in Iran, Marine Econ. Manage. 2 (2) (2019) 114–123.

[74] V.M. Taghavee, A.S. Aloo, J.K. Shirazi, Energy, environment, and economy interactions in Iran with cointegrated and ECM simultaneous model, Procedia Econ. Financ. 36 (2016) 414–424, doi:10.1016/S2212-5671(16)30056-9.

[75] V.M. Taghvaee, A.A. Arani, S. Soretz, L. Agheli, Sustainable development in MENA and Europe: regional interactions of social, environment, and economy, Iranian Econ. Rev. (2021), doi:10.22059/IER.2021.83906.

[76] V.M. Taghvaee, A.A. Arani, S. Soretz, L. Agheli, Diesel demand elasticities and sustainable development pillars of economy, environment and social (health): comparing two strategies of subsidy removal and energy efficiency, Environ., Develop. Sustainability (2022), doi:10.1007/s10668-021-02092-7.

[77] V.M. Taghvaee, A.A. Arani, S. Soretz, L. Agheli, Comparing energy efficiency and price policy from a sustainable development perspective: using fossil fuel demand elasticities in Iran, MRS Energy & Sustainability (2022), doi:10.1557/s43581-022-00024-0.

[78] Taghvaee, V.M., Assari Arani, A., Nodehi, M., Khodaparast Shirazi, J., Agheli, L., Neshat Ghojogh, H.M., Salehnia, N., Mirzaee, A., Taheri, S., Mohammadi Saber, R., Faramarzi, H., Alvandi, R., & Ahmadi Rahbarian, H. (2021). Sustainable development goals: transportation, health and public policy. Review of economics and political science, ahead-of-p(ahead-of-print). doi:10.1108/REPS-12-2019-0168.

[79] V. Taghvaee, P. Hajiani, Price and income elasticities of gasoline demand in Iran: using static, ECM, and dynamic models in short, intermediate, and long run, Modern Econ. 5 (2014) 939–950.

[80] V.M. Taghvaee, C. Mavuka, J.K. Shirazi, Economic growth and energy consumption in Iran: an ARDL approach including renewable and non-renewable energies, Environ., Development and Sustainability 19 (6) (2017), doi:10.1007/s10668-016-9862-z.

[81] V. Taghvaee, H. Parsa, Economic growth and environmental pollution in Iran: evidence from manufacturing and services sectors, Custos e Agronegocio Online 11 (1) (2015) 115–127.

[82] V.M. Taghvaee, J.K. Shirazi, M.A. Boutabba, A. Seifi Aloo, Economic growth and renewable energy in Iran, Iranian Econ. Rev. 21 (4) (2017), doi:10.22059/ier.2017.64081.

[83] V.M. Taghvee, M. Nodehi, A.A. Arani, Y. Jafari, J.K. Shirazi, Sustainability spillover effects of social, environment and economy: mapping global sustainable development in a systematic analysis, Asia-Pacific J. Regional Sci. (2022), doi:10.1007/s41685-022-00231-0.

[84] S. Theobald, E.E. MacPherson, L. Dean, J. Jacobson, C. Ducker, M. Gyapong, …, P.S. Mbabazi, 20 years of gender mainstreaming in health: lessons and re ections for the neglected tropical diseases community, BMJ Global Health 11 (12) (2017) 1–6.

[85] Trans-Iranian Railway. (2017). Iranian cultural heritage, handicrafts and tourism organization.

[86] UN. (2019). Sustainable development dashboard report. United Nations: united Nations.

[87] J.C. Villa, M. Boile, S. Theofanis, Trade and transportation relationship, in: International Trade and Transportation Infrastructure Development, Elsevier, 2020, pp. 3–31, doi:10.1016/B978-0-12-815741-1.00001-2.

[88] T. Waas, J. Hugé, A. Verbruggen, T. Wright, Sustainable development: a bird's eye view, Sustainability 3 (10) (2011) 1637–1661, doi:10.3390/su3101637.

[89] Z. Wendling, J.W. Emerson, D.C. Esty, M.A. Levy, A. de Sherbinin, et al., 2018 Environmental Performance Index, Yale Center for Environmental Law & Policy, United States: New Haven, CT, 2018.

[90] WHOGender and blindness, Gender and Health Information Sheet, World Health Organization, Geneva, 2002.

[91] WHOGender, Health and Malaria, World Health Organization, Geneva, 2007.

[92] WHOSex, Gender and Influenza, World Health Organization, Geneva, 2010.

[93] WHOWorld Health Report On Ageing and Health, World Health Organization, Geneva, 2015.

[94] WHO (2018 a). Infographic in WHO website. Retrieved from World Health Organization: http://www.who.int/phe/infographics/environmental-impacts-on-health/en/

[95] WHO. (2018 b). World Health Organization. Retrieved from http://www.who.int/airpollution/en/

[96] WHOSustainable Development Goals, World Health Organization, 2019 World Health Organization.

[97] World Bank, Building Urban Resilience, in: A.K. Jha, T.W. Miner, Z. Stanton-Geddes (Eds.)Building Urban Resilience, The World Bank, 2013, doi:10.1596/978-0-8213-8865-5.

[98] World Bank. (2019). World Development Indicator.

[99] World BankMortality Caused By Road Traffic Injuries, World Bank, World Development Indicators, 2020.

[100] World Bank and United NationsA Joint Report, World Bank and United Nations, 2018.
[101] Yale UniversityEnvironmental Performance Index, United States: Yale University, 2018.
[102] S. Zaidi, K. Saidi, Environmental pollution, health expenditure and economic growth in the sub- saharan Africa countries: panel ARDL approach, Sustainable Cities and Society 41 (2018) 833–840.
[103] X. Zhao, D. Luo, K. Lu, X. Wang, C. Dahl, How the removal of producer subsidies influences oil and gas extraction: a case study in the Gulf of Mexico, Energy 166 (2019) 1000–1012, doi:10.1016/j.energy.2018.10.139.
[104] V. Mohamad Taghvaee, M. Nodehi, B. Saboori, Economic complexity and CO_2 emissions in OECD countries: sector-wise Environmental Kuznets Curve hypothesis, Environ Sci Pollut Res (2022) In press, doi:10.1007/s11356-022-21491-5.