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Institutional analysis on impediments over fuel consumption reduction at Iran's transportation niches

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ABSTRACT

The transportation sector is one of the sustainable development wheels that requires a lot of energy to operate, therefore it is concerned as one of the main factors in greenhouse gas emissions and global warming. In Iran, like rest of the world, the light-duty vehicles are the effective factors in the pollution of the metropolitan cities. Although the management of their fuel consumption is a vital action in decreasing the cost and air pollution, that's inextricable link with the public welfare and the economy of the car manufacturers creates barriers. An accurate analysis concerning the barriers to reducing the fuel consumption can be obtained by using the game theory method in the light-duty vehicles. For this purpose, the effective factors including the people, car manufacturer and government are modeled and their utility are considered. By examining the relationships among the players and their actions we can conclude that the penalty option can significantly help the management of the fuel consumption. Also, forcing the government to lend to the car manufacturer to improve the fuel consumption of motor vehicles reduces fuel consumption. In addition, standard setting for the average fuel consumption of the producing cars should be staged and stepped.

1. Introduction

1.1. Background

Atmospheric changes and climate disruptions which made by greenhouse gas (GHG) emissions, are so harmful to natural and environments and threaten human health and welfare (Kellner, 2016). The impacts of GHG emissions contribute to global warming (Porter, 1999; Ching-Shin Norman et al., 2009). A study undertaken by the United States Environmental Protection Agency represent that 27% of the GHG emissions is caused by the transportation sector, and 60% of these emissions coming from light-duty vehicles (United State Environmental Protection Agency, 2017).

In order to identify GHG-cutting opportunities and best practices, standards for the assessment of GHG emission are needed (Jenn et al., 2016; Honga et al., 2016; Chenga et al., 2015). Some guidelines concerning how to quantify transport-related GHG emissions have been recently published by several organizations (COFRET (Carbon Footprint of Freight Transport), 2011; Christopher frey et al., 2008). Although some convergences about a unified approach have been formed, there is not any single globally recognized and accepted standard to calculate GHG emissions which covers entire transportation sector (Davydenkoet al, 2014; McKinnon, 2010; Olson, 2010; Olsthoornet al, 2001; Wick et al., 2011; Cui and Li, 2015).

Also, a large portion of the energy is used by the transportation sector (U.S. Energy Information Administration, May 2018). At present, 94% of the total transportation fuel demand is formed by oil, and it will be fallen to 85% in 2040 (B.P, 2018). As a connector factor between the supply and demand centers and a linking element among the economic activities form two aspects of national development and the final price of goods and services, the transportation sector plays a key role in the country, so that an accurate and comprehensive attention to each of the characteristics of transportation infrastructure factors is one of the main requirements of growth and development in the countries (Botzoris et al., 2015). The transportation is an intermediary link among all the economic sectors and it is important in the supply chain and added value; therefore, the added value formation in all the economic sectors, directly or indirectly, is affected by the activities of the transportation sector.

Beside it, the energy plays a major role in the process of production

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and development of the societies. The necessity of paying more attention to the energy issue and its optimal use is inevitable from at least two aspects. First, the available energy resources are limited, or more use of those needs to spend a lot of money; Second, as one of the factors of production, energy is complementary to other factors, such as labor and capital, and has a very low degree of elasticity.

The road transportation has the major part of the energy consumption in Iran's transportation sector (Energy Balance Sheet, 2015). Depending on the type of the vehicle used, the road transportation can be divided into 'light-duty vehicles' and 'heavy vehicles' sections. Heavy vehicles which mostly use diesel fuel, often travel on interurban roads. So, they do not make a significant impact on the pollution of the cities. However, the light-duty vehicles which make up the largest portion of all the country's cars, often use gasoline. Iran achieves the security of the gasoline supply just by importing it from abroad (Greene, 2012). Also, the main problem of urban pollution is the use of light-duty vehicles. The increasing consumption of gasoline and the lack of self-sufficiency in responding to domestic demand has led Iran to be an importer of gasoline for 37 years (Energy Balance Sheet, 2015).

1.2. Research objective

The present research tries to provide the operational solutions in line with Iran's current reality by a comprehensive view of the influential institutions in the transportation sector of light-duty vehicles. As a result, the practical solutions can be suggested, by recognizing the institutional impediments over fuel consumption reduction in the country. Game Theory method is chosen because it can facilitate the recognizing process of institutional impediments (Zhu and Dou, 2007).

To consider the role of government and its interests in the management of light-duty vehicle fuel consumption is the innovation in this research. Although in other studies factors like prices, loans, quotas, etc. are considered as effective government tools (Chenga et al., 2015; Giblin and McNabola, 2009; Greene, 2011; Karplus et al., 2013; Sperling and Eggert, 2014), the government's interest in these issues has been less addressed. The game theory method is mostly used in order to model the competition among the firms to increase their market share and profits (Batabyal, 1996). Another innovation of this research is to apply this method to the transportation sector and to represent the relationship between people, government, and car-manufacturer as the main factors of the issue.

2. Literature review

The previous studies over the related issues can be investigated from two perspectives of 'research method' and 'subject of research'. Related issues can be divided into several categories: (1) technological Studies, (2) transport studies as part of macroeconomics, and (3) fuel economy. These issues are investigated from four categories: (1) computable general equilibrium (CGE) (K. Y, 2011; Solaymani et al., 2015), (2) mathematical programming, and (3) game theory (Jørgensen et al., 2010).

2.1. Technological studies

The technology used in vehicles is one of the major factors which plays a significant role in the fuel consumption of the transportation sector. The car manufacturer has to adapt itself to the circumstances in which the policymaker creates as a standard for it. The effect of technology management by the policymaker, and then the degree of realization by automobile companies are the important factors to determine the fuel consumption of the transportation sector. So, all of the researches over this area are about the relationship between the government as a lawmaker and the companies as its executer. The global experience has proven that to set the standard is not an access factor to achieve goals by itself, especially in the situation that the car manufacturer always puts an eye on the customer and another eye on its own interests. Therefore, in order to make decisions in line with existing facts, governments must have a thorough look at the interests and costs of the car manufacturers before making any decision (Karplus et al., 2013; Shiau et al., 2009; Austin and Dinan, 2005; Hu et al., 2010; Mraihi et al., 2013; Ahn et al., 2008).

2.2. Transportation studies as part of macroeconomics

All of the studies in this section are about the analysis of the effects of the price changes and subsidy (tax) on the economy, especially the transportation sector. The researchers, after modeling and extracting a model compatible with existing conditions, have investigated the effect of varying different parameters on the economic and transportation, however, in real condition, the way the variables affect each other varies in each case and does not necessarily follow a historical pattern. In the real situation, the various actors play a role and can increase or decrease the effects of the changes in the parameters (Solaymani et al., 2015; Hu et al., 2010; Mraihi et al., 2013; Muratori et al., 2013; Oktaviani et al., 2005; Parmeh, 2005; Soleymanikari., 2014; Brons et al., 2008; Wasserfallen and Guntensperger, 1988).

2.3. Fuel economy

The fuel consumption in the transportation sector can be investigated from three perspectives of the relationship between: (1) the consumer and policymaker, (2) the policymaker and the car manufacturer, and (3) the car manufacturer and the consumer (Innes, 1996). So, the sensitivity analysis of the outcomes of the models can be done by making changes to the effective parameters of the problem.

Related studies offer the suggestions that it is not clear if they are executable or not, and also other effects of those are not considered (Frondel et al., 2011; Huoa et al., 2012). In addition, three actors including government, people, and car manufacturer have not been considered simultaneously.

In summary, the previous researches over the transportation sector more rely on macroeconomic models or fuel pricing, while this issue and its main actors has never been addressed by game theory.

In addition, the examination of government decisions shows that the government's behavior was not necessarily aligned with the environmental, national or people's interests. Therefore, to model the behavior and interests of the government can help to improve predictions in order to get closer to reality.

3. Methodology

3.1. Game theory

Game theory is a set of analytical tools designed to better understand the decisions of the intelligent rational decision-makers which have multilateral engagement (Osborne and Rubinstein, 1994). The application of game theory is where a number of actors interact with each other to decide on a variety of issues, and each decision is effective on the utility of itself and other actors. This situation is called 'strategic condition'. Game theory is mainly used in economics, political science, and psychology, as well as in logic and computer science (Soleymanikari., 2014; Osborne, 2004).

Government, car manufacturer, and people are the major actors of the light transportation (Innes, 1996). All these actors have some choices to take action. There are the external factors that have an impact on the game. Some of them are added to the model as an external variable and others are not considered for their negligible effect. The actions of each actor are as follows:

I. Government
- Fuel Price (FP): Government can change the fuel price based on

its own interests.
- Tax (T): Because the sales tax is fixed for all the firms, so only the profit tax for the car manufacturer is considered.
- Penalty (P): After setting the standard for the average consumption, the government has the power to penalize the car manufacturer for its high consumption and its difference with the standard.
- Car Charges (CC): Car charges is another tool for the government.
- Loan (L): The government can loan the car manufacturer to enhance the car fuel consumption.

II. Car manufacturer
- Car Price (CP): The car manufacturer set the price for its products based on the ceiling made by the Competition Council or Consumer Protection Organization.
- The Average of Car Fuel Consumption (Ƞ): By spending money, the car manufacturer can reduce fuel consumption of its products.

III. People
- Car Quantity (CQ): Finally, depending the possession expenditures and costs of use, people decide if purchase the car or not.

3.2. Assumptions

- All prices are based on the Rials of 2012.
- Just one car manufacturer is considered.
- Motorcycle fuel consumption is not considered.
- Calculations have been done for the whole population, regardless of the different deciles.
- Calculations have been made for the 'average car', in terms of both price and consumption.
- The error occurred due to the size of the computational steps is ignored.
- Just gasoline is considered as a fuel for light-duty cars.

3.3. Utility functions

All of the actors choose the option based on their own interests to maximize the utility. The utility of each actor is equal to the amount of income, minus its expenses. All the characters in each utility function are measured by the monetary unit and ultimately the utility of each actor will be determined based on the unit of the Rials.

3.3.1. People utility

In this game, the people's interests are the sense of personal ownership of a car and the welfare of having it. For its calculation, the expenses that people have been willing to pay for the car ownership is considered as the people utility. For this purpose, the cost per kilometer (car insurance, third party insurance, the cost of reducing car prices over time, fuel costs and repairs) is multiplied by the distance which car traveled (Information of Transporta, 2013). So the expenses that are paid for the car ownership is equal to people's utility. Eventually, their utility calculates by eq. (1).

$$U = 3 \times 10^{14} \ln(CQ) - 4 \times 10^{14},\ R^2 = 0.9878 \quad (1)$$

By reducing the cost of ownership and using the car including the car charges, car price, and fuel price, the people's utility function can the achieved. The car charges are multiplied by 10 because the average life is assumed 10 years. The car price is equal to the car quantity multiply by the average car price. Also, the fuel price will change according to the fuel price and the average fuel consumption.

The amount of the vehicle kilometer traveled (VKT) is important for calculating the fuel price (Sierra, 2016; Sadri et al., 2014). To facilitate the solving process, the variable of the amount of distance traveled is estimated by the car quantity, so people only have one choice and that is the car quantity. The validity of the assumption is represented by the fact that there are no significant changes in the average distance traveled by cars over the recent years.

$$VKT = 17899\ CQ - 4\ 10^9,\ R^2 = 0.999 \quad (2)$$

According to the costs aforementioned, the people's utility calculates by eq. (3):

$$S = 3 \times 10^{14} \ln(CQ) - 4 \times 10^{14} - (CQ \times CP \times ct) - (CP \times CQ) - FP \times 1.2\eta/100 \times (17899\ CQ - 4 \times 10^9) \quad (3)$$

3.3.2. Car-manufacturer utility

In this game, the car sale is the only car manufacturer profit. It is assumed that the car sale is 10% of the net profit. The car manufacturer expenses include the cost of motor improvement and reducing its consumption, the tax on the profit that the firm give to the government and the penalty that the government receives from the firm for the average consumption of light-duty vehicles. The cost of reducing one liter of fuel consumption in 100 km is estimated at 15 million Rials.

Also, the government sets a standard over the average consumption for the firms based on the best practice of the international firms. This amount is considered 6 L per 100 km, and the government will receive a desired penalty from the firm for the difference between the actual consumption and the determined amount. The consumption of the cars which belonged to the people is 20% more than the consumption of the produced cars. Therefore, the car manufacturer utility calculates by eq. (4):

$$C = 0.1(CP \times CQ) - CQ(15000000 - L)(7.93 - \eta) - T(0.1(CP \times CQ) - CQ(15000000 - L)(10 - \eta)) - CQ(\eta - 6)p \quad (4)$$

In order to ensure that the balance of the game is not achieved at unfeasible points, the reasonable options for car manufacturer choices are considered. Therefore, car manufacturer adjusts its car consumption between 7.93 and 5 L per 100 km. Given inflation, the ceiling for the average price of the vehicles is 125 million Rials and its floor is 100 million Rials.

In the real situation, the price ceiling will be determined by the competition council based on the price of the previous year, but because the actual prices are calculated on the basis of the year 2012, it can be assumed that each year the competition council allows increasing the car price as much as the inflation rate of the last year. So, the car average price is as same as the average car prices in the throughout history.

3.4. Government's utility

The government utility includes the tax on the profit which receives from the firms, the annual tax from people, and the penalty from the car manufacturers. On the other hand, each government is thinking of providing welfare for the people, and it also tries to ensure that the interests of the people are met in order to vote at least for another period. Therefore, the government considers 51% of the people's utility in its own utility.

The government's expenditures are the loan which will be given to the firms, the difference between the internal price of gasoline and the price for exportation, and the external cost of producing carbon dioxide in the cities, which is equal to 100 Rials per kilogram. One liter of gasoline produces 2.31 kg of carbon dioxide. The price of gasoline for export is assumed 6000 Rials per liter. This is considered according to the international prices. The number of employees is another cost of government, which now are approximately 48,500. This amount will change according to the rate of car production.

$$employees = 13013 \ln(CQ) - 170122,\ R^2 = 0.9441 \quad (6)$$

So, by using Eq. (6), the number of people who get employed or lose their job due to the change in the policy of the government or car

manufacturer can be calculated. The cost of job creation is 2.2 billion Rials per person. Consequently, the rise in car production increase the government's utility vice versa. Eventually, the utility function of government equates to Eq. (7).

$$G = t(0.1(CP \times CQ) - CQ \times (15000000 - L)(7.93 - \eta)) - 100 \times 2.31 \times 1.2\eta/100 \times VKT - 2200000000(13013 \ln(CQ) - 170122 - 359000 + (CC \times CQ \times CP) + ((FP - 11000) \times 1.2\eta \times VKT/100) + CQ(\eta - 6)p - CQ \times L + 0.51S \quad (7)$$

To meaningfully obtain the range of the selected variables by the government, it is possible to use a ceiling or a floor for them. As a result, the annual tax which is currently 0.15%, is considered to be between 0% and 1%. The gasoline price is considered between zero to 6000 Rials (price for export). Because the car manufacturer is about 15 million Rials, the penalty rate is considered between zero to 20 million Rials. Tax on the car manufacturer profit is between zero to 50%. Also, the loan which government can give to the car manufacturer for enhancing the car consumption can be as much as zero or equal to the whole expenditure to do it.

3.5. Game solution

The game considered is the one-step, sequential with perfect information. At first, the government initiates the game by using its options in order to maximize its utility. Second, the car manufacturer sets the car prices and their average consumption based on the government's actions. And finally, according to the decisions of two previous players, people decide if they will purchase the car or not. The best practice function for people is presented in Eq. (8).

$$CQ = 3E14/(CC(ct + 1) + FP \times 1.2 \times \eta \times 178.99) \quad (8)$$

4. Results

According to the previous equations and the methodology used, the equilibrium is obtained based on the choices of the players in the in accordance with Table 1.

The daily fuel consumption can be calculated with Eq. (9):

$$Fuel\ Consumption = 1.2\eta(17899 \times CQ - 4E9)/36500 \quad (9)$$

Therefore, the fuel consumption per day is 84,206,000 L per day. So, the government is excepted to set the price of gasoline equal to the balanced price, while this measure will not be taken place in reality because this measure is not following the rational behavior or the measures differ from the reality.

The car charges balances in the maximum level of itself and presents that the government raises this amount like 2014. The large difference between 1% that is obtained and 0.15% in reality is also because of the reasons aforementioned. The fundamental problem in this regard is the government lacks authority in determining the rate of the car charges and according to the law, its determination is the responsibility of the parliament.

Table 1
The balance of the player's choices.

Player	choice	Amount
government	fuel price	6000 Rials
government	car charges	1% of car price
government	tax	0%
government	penalty	15 million Rials
government	loan	0
car manufacturer	car price	140 million Rials
car manufacturer	average consumption of the vehicles	7.93
people	car quantity	18,268,000

On the other hand, the government prefers to neither to take any tax from the car manufacturer nor to loan it for reducing the fuel consumption. Also, sets the penalty exactly equal to the cost of technology. This decision does not make any changes in the car manufacturer behaviors for reducing the fuel consumption. So it seems that the government does not take any risks and it needs to determine the rate of penalty by another organization.

Because of the people's utility function, the car manufacturer sets the car price on the maximum level of it. This function changes in such a way that the rise of car price does not decrease the purchasing by the people.

Although the government sets the penalty for the high fuel consumption exactly equal to the cost of reducing it, the car manufacturer does not accept it and prefers to spend the cost of the penalty. The reason for this is that the reduction of fuel consumption will increase its purchasing by the costumers and in this way the cost of reducing fuel consumption is multiplied in more cars which makes this action damaging. In this case, the other results can be obtained by setting the specific rate for the penalty and deprivation the government's authority for its adjusting.

Finally, people will achieve the conclusion that to purchase 18 million and 268 thousand light-duty vehicles in the specific period of time.

It is essential to analyze the sensitivity of variables for determining the behavior of different players towards their actions and others. Also, the ways to reduce the fuel consumption can be determined by assessing the impact of different policies on each player.

4.1. Fuel price

Fuel price does not considerably influence people's utility. By fixed parameters in equilibrium state, changing the fuel price from 0 to 6000 Rials causes 2.6% reduction in people's utility, 6.2% reduction in the number of vehicle purchase, and 6.2% reduction in gasoline consumption. Due to fuel price changes from 0 to 6000 Rials, the government's utility will increase 1%.

It seems that gasoline does not have effective role on determining the player's utility because of its cheap price. Thus, gasoline price leverage can be used for positive effects in other cases with higher influence, because it would bring low side effects for the major players of transportation section.

4.2. Annually car charges

Assuming that all variables are fixed in their equilibrium values, thus increasing annual car charges from 0 to 1% will have 1.68% higher utility for the government. Using this leverage and designing similar leverages can be accompanied by negative effects on car industry and people's welfare. Therefore, it seems that using political tools, which can manage fuel consumption rather than number of vehicles, is more useful. Reduction the people's utility and number of existing vehicles with changing charges from 0 to 1% percent per year is respectively 3.4 and 8.5%.

The car manufacturer also gains utility by changes of car charges, which is originated from charges in people's willingness to buy cars. Changing car charges from 0 to 1% will reduce the car manufacturer's utility by 8.5 percent. Hence, changing amount of car charges in different values does not change the outcome of the game.

4.3. Tax

Tax here means the same tax received from car manufacturer by the government, and it is defined specifically for the vehicle market and transportation management. Increase or decrease of this tax does not influence the people, because the car manufacturer choice regarding

Table 2
The game balance in the situation that the penalty option is not available to the government.

Player	choice	amount
government	fuel price	0 Rials
government	car charges	1% of car price
government	tax	50%
government	penalty	15 million Rials
government	loan	0
car manufacturer	car price	100 million Rials
car manufacturer	average consumption of the vehicles	7.93
people	car quantity	27,273,000

the car price is the highest price and no cost is paid for car engine modifications. Thus, there is no more space for maneuver for adjusting governmental tax effect, and itself utility will be reduced just by increasing tax.

According to the car manufacturer's utility function, to increase the tax from 0 to 50% will reduce the firm's utility 47%. While the car manufacturer sets the highest car prices and does not reduce fuel consumption of the vehicles, to use this tool by the government is useless and even harmful. Because it would have devastating effects on the economy and car industry. In the game's equilibrium, it is also observed that the government has set the amount of tax at zero, with complete information about the utility functions of other players.

4.4. Penalty

The amount of penalty chosen by the government is 15 million Rials, equal to the cost of reducing the fuel consumption of motor vehicles that the car manufacturer should spend. Between these two options, spending the penalty will be chosen. In the situation that the penalty option is not available to the government, the game balance is according to Table 2.

According to Equation (9), the daily fuel consumption is equal to 126 million and 230 thousand liters per day. This is 49.9% higher than the main game's equilibrium state. Thus, it seems that adding authority of taking penalty to the government's authorities considerably helps the management of the fuel consumption. Of course, the car manufacturer loses 273 trillion Rials in the equilibrium state, while it takes advantages of 136 trillion Rials in this case. Now, we have to find out the amount of penalty which neither harms the car manufacturer nor increases fuel consumption.

The car manufacturer does not show any reaction against various penalties up to the ceiling for the cost of reducing fuel consumption. Nevertheless, as soon as the amount of penalty goes higher than that ceiling, the car manufacturer will do its best to reduce consumption and will achieve the lowest consumption in the game's equilibrium. In a state of equilibrium, it is enough to add another 140,000 Rials to the amount of the penalty imposed by the government, so that the car manufacturer will behave in exactly the opposite way as its current behavior.

The basic question is that why the government does not determine this level of penalty, and why its utility results from fuel consumption reduction. The fixed parameters and to increase the penalty rate will certainly increase the government's utility, however, in the dynamic state, increasing penalty to levels higher than the firm's optimization costs will cause that the payment does not be given to the government anymore, and the car manufacturer spend it to enhance the engine efficiency. Therefore, instead of imposing an effective penalty for improving car fuel consumption, the government uses it as a source of income. It seems that taking the government's authority to determine the penalty is an effective step for improving fuel consumption. If the penalty would be increased by 140,000 Rials, then the results of the game will be changed as shown in Table 3.

Table 3
The game balance in the situation that the penalty is setting by the organization except the government.

Player	choice	amount
government	fuel price	6000 Rials
government	car charges	1% of car price
government	tax	50%
government	penalty	15.14 million Rials
government	loan	15 million
car manufacturer	car price	100 million Rials
car manufacturer	average consumption of the vehicles	5
people	car quantity	25,764,000

In addition, according to Equation (9), the daily fuel consumption is equal to 75 million and 147 thousand liters per day. As observed, with a little change in the penalty, utility rate of the government reaches to 3775 trillion Rials from 4434 trillion Rials, the utility rate of the car manufacturer reaches to 519 trillion Rials from 273 trillion Rials, and the people's utility reaches to 8195 trillion Rials from 7164 trillion Rials. Thus, because the government is starter of a game with perfect information, it measures all dimensions for maximizing its benefits, and to increase its benefits by 17%, causes a bankruptcy of the car manufacturer and 13% reduction in people's utility.

On the other hand, increasing fines by 140,000 Rials, providing loans by the government will increase its utility. In addition, if fine increase is up to one million Rials or higher, amount of the loan that will most benefit the government will be reduced to 10 million Rials, while other variables will not change much.

4.5. Loan

The government's interests require not to allocate any loans for enhancing the efficiency of the motor vehicles. Now, the result of the game will change if an organization ratifies that the government should lend a loan to the car manufacturer. By raising the loan from zero to 2 million Rials no change will be made in the balance of the game unless, the government reduces the amount of the penalty as same as the amount of the loan which it has to lend. By changing the amount of forced loan from 2 to 12.6 million Rials the balance of the game will be according to Table 4.

Also, according to Equation (9), the daily fuel consumption is equal to 126 million and 230 thousand liters per day. But, by changing the amount of forced loan from 12.6 to 15 million Rials which is equal to the all of costs for reducing the fuel consumption, the balance of the game will be according to Table 5.

According to Equation (9), the daily fuel consumption is equal to 75 million and 147 thousand liters per day which is 10.8% less than the amount of consumption in the main balance of the game.

4.6. Car price

Depending on the change in car price, the car manufacturer's benefit

Table 4
The game balance in the situation that the penalty is setting by the organization except the government.

Player	choice	amount
government	fuel price	0 Rials
government	car charges	1% of car price
government	tax	50%
government	penalty	0
government	loan	2–12.6 million
car manufacturer	car price	100 million Rials
car manufacturer	average consumption of the vehicles	7.93
people	car quantity	2,727,300

Table 5
The game balance in the situation that the penalty is setting by the organization except the government.

Player	choice	amount
government	fuel price	0 Rials
government	car charges	1% of car price
government	tax	50%
government	penalty	0-4 million Rials
government	loan	12.6–15 million
car manufacturer	car price	100 million Rials
car manufacturer	average consumption of the vehicles	5
people	car quantity	25,764,000

will go up or down. In the main balance of the game, the car manufacturer has chosen the maximum level of price. If the ceiling price changes from 140 to 100 million Rials which is the minimum price, the results of the game will not change unless, by choosing the new ceiling price, the firm loses much more and the car quantity and subsequently the fuel consumption rise.

4.7. Average of the fuel consumption

By reducing the average fuel consumption of vehicle's engine, it is expected that fuel consumption will decrease in the country. But, reducing fuel costs will have a recursive effect for people, so they will buy more cars. The calculations show that the recursive effect of reducing the average fuel consumption is not remarkable and equals to 1.8%, because the fuel price does not have a significant effect on the people's utility concerning the car price. The reduce of fuel consumption in the country by changing the average fuel consumption of the vehicle's engine is 10,181,063 Lit/d per Lit/100 Km.

So, the average fuel consumption of vehicles is an effective parameter in fuel consumption. Changing the standard by the government from 6 to 5 or even 4 L per 100 km will not change the average fuel consumption of producing vehicles, while the car manufacturer will lose more and the government will benefit more. So, if the authority to set the standard falls under the responsibility of the government, it will set the standard at the low level to gain more profit. Therefore, because the balance of the game not to change, it is better not to set a very strict standard for the car manufacturer to prevent the bankruptcy.

On the other hand, if the standard of the average fuel consumption of vehicles is 7.1 or higher, the balance of the game will be according to Table 6.

The fuel consumption is changing between 75 million and 983 thousand per day and 84 million and 206 thousand per day. Consequently, by the correct setting of the standard, fuel consumption can be reduced to 9.8% compared to the main balance of the game. The standards will be improved in the future. Ultimately, the exertion of the foreign technology on the car manufacturer by the government cannot lead to the advancement of the technology in domestic firms.

Table 6
The game balance in the situation that the standard for fuel consumption is between 7.1 and 7.93 L per 100 km.

Player	choice	amount
government	fuel price	6000 Rials
government	car charges	1% of car price
government	tax	50%
government	penalty	20 million Rials
government	loan	0
car manufacturer	car price	140 million Rials
car manufacturer	average consumption of the vehicles	Standard
people	car quantity	18,268,000–18,388,000

5. Conclusion and policy implications

Considering the modeling and the results obtained from game equilibrium, also by looking at the sensitivity analysis of different parameters relative to each other, some suggestions on the proper management of the conjunct collection of transportation of light-duty vehicles can be provided.

The rise of fuel price from zero to 6000 Rials i.e. the export price has a small influence on the rate of people's utility and fuel consumption. As a result, it is not possible to use fuel price as an effective factor to manage the fuel consumption. Thus, the government involved will be able to develop the economic justice among lower classes, by means of equalizing the price of fuel sold in the country with the international prices, and omitting subsides and opportunity cost for its export. On the other hand, the government can provide the expenses for developing alternative fuels via allocating the subsidies saved from gasoline. In this way the difference between the supply and demand of gasoline would be resolved by means of other fuels such as CNG, liquefied gas, biofuels, and electricity.

In various scenarios, the government has always tended to raise the annual tax to its highest level. Increasing the rate of the car charges from the current level of 0.15%–1% will increase the government's utility by 1.5%, while the people's utility and the car manufacturer's utility will respectively have been fallen by 1.5 and 8%. The government must forget the benefit from increasing the car charges and do not harm the car manufacturer. The results of the sensitivity analysis have also shown that the change in the annual rate of car charges do not affect the outcome of the game. So, setting the annual tax must be done by an organization except for the government, e.g. the parliament.

As a result of dispossessing the government's authority for setting the rate of penalty for the car manufacturer, the reduction in fuel consumption, the rise in the people's utility, and the suitable marginal profit for the firms could have been expected. Of course, changing the penalty level from the government's optimal point to the level favored by the whole country causes considerable changes in the game's balance. Its useful outcomes were mentioned in the penalty sensitivity analysis section. One of the important results was the 17% reduction in the government's utility in which implies that the process of dispossessing the government's authority for setting the penalty will be difficult and encounters serious obstacles.

In the main game's balance state, the government decides not to provide loans for the car manufacturer in order to improve its vehicles' fuel consumption. In the loan sensitivity analysis section, it was observed that the game's balance is biased toward fuel consumption reduction by lending more than 12.6 million F. However, by forcing the government to lend loans as great as 12.6–15 million Rials per vehicle, not only exorbitant costs are imposed on the government, but will also be deprived of the penalty for the average difference in fuel consumption of vehicles with standard rates. While, by increasing the tax from zero percent in the original balance state to 50 percent in the new balance, some of these costs are adjusted. Finally, it can be said that by setting a mandatory loan rate for the government through other institutions, the government will lose 11.52 percent of its utility, but the public utility will rise by 14.5 percent, and the car industry will be rescued from a loss of 500 trillion Rials. It will even have net profit of 120 trillion Rials.

Improvement of average vehicle fuel consumption has low recursive effect on increasing public fuel consumption, and can be an effective tool in fuel consumption management. Thus, the strategies leading to improvement of fuel consumption in vehicles outperform in consumption management.

Setting a standard level for average fuel consumption in manufactured vehicles is beneficial for the government. Therefore, if the authority for its determination is relegated to the government, it would make decision much strictly. However, in sensitivity analysis of standard level it was specified that the standards close to reality and the

existing conditions of the car industry reduce fuel consumption. Thus, setting step standards for achieving proper fuel consumption management in the country by an institution other than the government, such as the parliament, can be an effective and efficient way.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2019.02.052.

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