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ESTIMATING OPTIMAL FUEL TAX RATE ON GASOLINE VEHICLES IN IRAN

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Abstract: *The study of the external effects of the transport sector and also the costscreated byvehicles requires detailed analysis, so that one can devise a mechanism to reduce these costs. Considering un-priced pollution, congestion, accident externalities, and interactions with the broader fiscal system, the currentpaper usesan analytical framework to estimate the second-best optimal level of gasoline taxation. Calculations are provided under various scenarios and the sensitivity of the optimal tax rate with changing parameters has also been investigated. Giventhe central values used in the paper, the second-best optimal gasoline tax was 475 cents/ gal, also the VMT optimal tax obtained was 57 cents/mile. For the comparison to the optimal gasoline tax, we convertedthe resulton a per gallon basis which equals to 1396 cents/gal. Due to inelastic demand of gasoline in Iran, the Ramsey component was assigned to large values of optimal tax which is supposedly an efficient methodfor raising revenues without causing a lot of change in economic behavior.*

Keywords: *Gasoline tax, elasticity, fiscal interaction, Iran.*

Jel classification: *D63, G18, E62, H23*

INTRODUCTION

Transport sectorpossesses a major share of gasoline consumption in Iran. The significant consumption in the sectoron one hand and the growth of car purchase on the other causes concerns about external effects on society and costs associated with itregardlessof the benefit the carshave for manufactures and consumers. Since cars are the main sources of negative external effects including the environmental pollution, heavy traffics, road accident, etc. the prolonged use of the product makes policy makers adopt policies to reduce these effects. One way to reduce external effects is imposing proper taxation on the cars. Such a tax system is implemented in order to modify and optimize the consumption and production of these products. Iran is a country with

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high rate of gasoline consumption in the transport sector and suffers from high instances of accidents and heavy traffics in the big cities[3](Endnotes)[3]. In the World Health Organization's 2011 report on air quality and health, three of Iran's provincial towns are ranked in the list of the world's 10 most-polluted cities. "According to the report, Tehran has roughly four times as many polluting particles per cubic meter as Los Angeles." This has led to need for revising the gasoline prices as a deterrent to prevent negative outcomes arising from the consumption of these products in order to encourage car manufacturers to comply with higher fuel-economy standards.

The policies for imposing fuel taxes do not follow similar patterns in various countries, and each country must implement its own appropriate tax system to take into consideration its local and environmental conditions and also economic factors.In light of these objectives, it is important to apply an optimal tax system which can cover at least all the external costs each car impose on the society in order to create revenues for government, and shift toward suitable patterns of consumption and production.

In this research, we intend to use a formula in order to estimate optimal gasoline tax in Iran. The formula was first used by Parry-Small (2006) to estimate the optimal tax rate in Britain andthe United States. It included congestion costs and pollution costs arising from fuel consumption, costs related to the accidents (in terms of the distance driven, and not thefuel consumed) and price and income elasticity of gasoline. They estimated tax rate considering external costs as much as possible. We also use a tax on vehicle per miles system (VMT), which better represents distance related externalities.

There are several other researches which have studied the taxation on car and fuel consumption. Giblin and McNabola (2009), studied changes from vehicles tax policy in Ireland. They reported that imposing this tax system resulted in 3.6-3.8% reduction in CO_2 emission and an increase in the annual tax revenues. Mc Mullen, Zhang and Nakahara (2010), have studiedthe results of switching from a fuel tax system to a VMT one. They found that VMT tax is more regressive than fuel tax making it a more suitable taxing system for rural households. They suggest tow alternative VMT tax systemsto be used instead of the general flat VMT tax mechanism and point out that those alternatives are more regressive. Hammar and Jagers(2006)have examined emission reduction in transport sector. They argue that fairness does matter in policy-making and consumers who are persuaded about the fairness of a policy are more inclined to accept the increase in the co_2 tax. They also show that importance of fairness principles dependson whether one uses a car and does have personal gains and interestsin using private cars.Bureau (2010), investigate distributional effect of carbon tax on car fuels. They used panel data from 2003 to 2006, showing that carbon taxation is regressive before revenue recycling occurs. He also shows that recycling additional revenues from the carbon tax strengthens poorest households. Blackman, Osakwe and Alpizar (2009) investigated fuel tax incidence in Costa Rica. They showed that increase on fuel tax thorough spending on gasoline is a progressive one while spending on diesel results in a regressive one. Lin and Prince (2009), calculate the optimal gasoline tax for the state of California. Their analysis shows that optimal gasoline tax is $1.37/gal which is three times the current tax system.Grabowski and Morissey (2005), find that increase in state gasoline taxes are associated with fewer traffic fatalities.Johnstone and Karousakis (1999)argue that a vehicle characteristic tax in conjunction with a fuel tax can be more efficient.

The rest of the paper is organized as follows. Section 2 describes analytical model and a formula for imposing the optimal tax. Section 3 presents the data used in the paper. Section 4 lays out our calculation of the optimal gasoline tax and section 5is dedicated to the concluding remarks.

THE MODEL

In the current paper, we use the Parry and Small model (Parry and Small 2006) with emphasis on our country-specific characteristicsto reach an optimal gasoline tax.

In this model we assume a static-closed economy with many agents, with the representative agent having the following utility function:

$$U = u(\varphi(C, M, G, T), N) - \phi(\mathrm{P}) - \delta(A)$$

Functions $u(\cdot)$ and $\Psi(\cdot)$ are quasi-concave. $\Phi(\cdot)$, $\theta(\cdot)$ are weakly convex functions representing disutility from pollution and accident risk. All variables are in per capita terms and defined as follows:

- *C* Quantity of numeraire consumption good
- *M* Travel measured in vehicles miles
- *T* Time spent for driving
- *G* Government spending
- *N* Leisure on non- market time
- *P* Quantity of (local and global) pollution
- *A* Severity-adjusted traffic accidents

G, *P* and *A* are perceived as exogenous. *M* is vehicles miles traveled (VMT), and are produced by a homogenous function:

$M = M(F, H)$, where *F* is fuel consumption and *H* is money expenditure on driving. In this function, there is a trade-off between vehicles cost and fuel efficiency, so that when gasoline prices or taxes increase, agents buy more fuel-efficient cars and driveshorter distances.

T, is driving time and demonstrated by $T = \pi(M)M$

M fixed aggregate miles driven per capita and π is the inverse average travel speed. π will be fixed, because M is considered fixed, implying that drivers don't take into account their contribution to congestion. If $\pi' > 0$, it means that an increase in VMT leads to more congested roads.

There are two types of pollution: P_F and $P_M \cdot P_F$ is carbon-dioxide type of pollution, and relates to the use of fuel and results in climate change.dependson miles driven and provide distance-related pollution damage, resulting in local air pollution. It is clear that $P_F' > 0$, $P_M' > 0$. $A = (\bar{M}) = a(\bar{M})\bar{M}$, the cost of accidents such as the risk of an accident is internal and considered implicitly in the utility function or money cost (H). Other costs are external and included in è('"), so disutility from accident is considered independent from amount of individual's own driving.

On the production side, the assumption is, firms are competitive and goods in market are produced with constant returns to scale. Producer prices and wage rate are exogenously fixed. Budget constraint of agent is:

$$C + (q_F + t_F)F + H = I = (1 - t_L)L$$

Where

I = disposable income, q_F = gasoline price, t_F = tax on gasoline, t_L = tax on labor, L = labor supply.

The time constraint on labor, leisure and driving are given as:

$$L + N + T = \bar{L}$$

The government expenditure is financed by taxes and budget constraint of government which is:

$$t_L L + t_F F = G$$

We assume that government spending is exogenous then this relationship is a trade-off between gasoline revenues and labor tax revenues.

Optimal Gasoline Tax

If we take the derivative of the utility with respect to gasoline tax and set this equal to zero, after some manipulation, we have formula of optimal gasoline tax. We go straight to the key equation of optimal tax. Details are mentioned in Parry and Small paper (see Parry and Small, 2004).

$$t_F = \frac{MEC_F}{1 + MEB_L} + \frac{(1 - \eta_{MI})\varepsilon_{LL}^c}{\eta_{FF}} \frac{t_L(q_F + t_F)}{1 - t_L} + \frac{\beta}{\alpha_{FM}} E^C \left\{ \varepsilon_{LL} - (1 - \eta_{MI})\varepsilon_{LL}^c \right\} \frac{t_L}{1 - t_L}$$

Where

$$MEC_F \equiv E^{P_F} + (\beta / \alpha_{FM})(E^C + E^A + E^{P_M})$$

$$\beta = \frac{dM / dt_F}{dF / dt_F}\frac{F}{M} = \frac{\eta_{MF}}{\eta_{FF}}, \eta_{FF} = \eta_{MF} + \eta_{FF}^{\overline{M}}, \alpha_{FM} = F / M$$

$$MEB_L \equiv \frac{-t_L \frac{\partial L}{\partial t_L}}{L + t_L \frac{\partial L}{\partial t_L}} = \frac{\frac{t_L}{1-t_L}\varepsilon_{LL}}{1 - \frac{t_L}{1-t_L}\varepsilon_{LL}} = \frac{t_L \varepsilon_{LL}}{1 - t_L(1+\varepsilon_{LL})}$$

Where η_{MI} is the expenditure elasticity of demand for VMT, and $1/\alpha_{FM}$ is fuel efficiency, η_{FF} is gasoline demand elasticity. It is worth noting that $\eta_{FF} = \eta_{MF} + \eta_{FF}^{\overline{M}}$ and μ_{MF} is elasticity of VMT with respect to the consumer fuel price and $\eta_{FF}^{\overline{M}}$ is the elasticity of fuel efficiency with respect to the price of fuel.and are uncompensated and compensated labor supply elasticity. α_{FM} and t_L are determined as following:

$$\alpha_{FM} = \alpha_{FM}^0 \left(\frac{q_F + t_F}{q_F + t_F^0}\right)^{-\eta_{FF}^{\overline{M}}}, t_L = \alpha_G - \frac{t_F}{q_F}\alpha_F$$

α_G and α_F are the shares of government spending and gasoline production in the national output.

The first component indicates the adjusted Pigovian tax and is proportional to the sum of all marginal externalities, MEC_F, and is inversely proportional to the marginal excess burden associated with the labor tax, $MEB_L \cdot MEC_F$ is adjusted by $\frac{1}{1+MEB_L}$, where MEB_L is welfare cost in labor market from an incremental increase in the tax on labor divided by the marginal revenues. This adjustment is the result of interaction between tax on gasoline and other pre-existing taxes such as labor tax.

The second effect is Ramsey tax. Ramsey (1927), posed that in order to minimize dead-weight loss and maximize revenue of government, inelastic goods should be taxed higher than elastic goods.So as vehicle travel becomes a stronger substitute for leisure, then gasoline demand becomes more inelastic than the compensated demand for leisure.

The third component represents the positive feedback effect of reduced congestion on the labor supply in a world where labor supply is distorted by the labor tax. We see that the reduction in congestion here is due to gasoline taxation.This reduction, apart from being a welfare-improvement, increases time available for both labor and leisure.

VMT TAX

To calculate the optimal fuel equivalent VMT tax rate, $t_F^{v^*}$, we set $\beta = 1, \eta_{MF} = \eta_{FF}$ and α_{FM} to its zero-fuel tax value.

Data Source for Iran-specific Parameter Values

Initial motor fuel efficiency: we have considered average fuel efficiency at 23 miles/gallon for passenger and private cars[4].

Distance-related pollution damage: E^{P_M} 4 cent/mile, with range of 1-8.

Global climate change pollution damage: E^{P_F} 6 cent/gallon, range from 1 to 10.

Fuel-related pollution damage: This is taken from Parry and Small's estimate for Britain and the US and also from Eduardo and Boccardo for a large number of countries such as Brazil, Mexico, Turkey and so on.

A number of studies have been conducted by Iran's Ministry of Energyleading to estimation that social cost of transport sector in Iran in 2009 was $4972 million. After dividing this number by vehicle miles traveled and then updating it to 2012 prices, we have 3.4 cents/mile. However, this number doesn't include congestion costs and it is only the air pollution parameter which is included. Given the fact that there is nodistinguished estimate for congestion costs in Iran, we consider 4 cents/mile as a central value for with range of 1-8.These are damages from global climate change and local air pollution, respectively.

External Congestion Cost: E^C

Using studies by Pormoalem and Nadali (2005),and considering external cost imposed on major cities of Iran, we choose a central value of 6 cent/mile with range of 3.5-10.0 cent/mile.

External accident cost: Ayati et al (2006) estimate marginal external cost of accidents on Iran's road sector at about 0.8-2.7 percent of GDP. This numbers are multiplied by GDP and then divided by average driven miles in Iran. We then updated the data to that of 2012which includes the prices andthe number of vehicle in the fleet, resulting in 2 cents/mile as the external accident cost.

Gasoline Price Elasticity: –0.07 with range of –0.04, –0.11

A large number of researches in the literatures[5]have estimated the demand function for gasoline using regressions and various parameters.These calculated numbers vary between 0.04 and 0.11. We chose central value of 0.07 for which ranges between 0.04-0.11.

Elasticity of VMT with respect to gasoline price and income: η_{MF}, –0.03, with range of –0.03, –0.7 and 0.5 with range of 0.08-0.7.

In order to obtain value of η_{MF} and η_{MF}, we have used the data of miles traveled, price of gasoline and household income.We then applied ARC elasticity formula to calculateand. The value of these parameters are varied between 0.03-0.7 and 0.08-0.7, we chose 0.4 as a central value for η_{MF} and 0.5 for η_{MI}.

Uncompensated labor supply elasticity: ε_{LL}, *compensated labor supply elasticity:* ε^{c}_{LL}.

We use the number of .045 for ε_{LL} based on Taee research about labor function in Iran[4], same parameter value for compensated labor supply elasticity is taken into consideration because we didn't have any estimated number for η^{c}_{LL} but in the sensitivity analysis we use the range that is close to those countries that have labor market similar to Iran. Therefore we chose 0.45 as a central value and the range of 0.2-0.9 for these tow parameters. These degrees of elasticity are averaged across males and females.

Producer price of gasoline: q_F 60 cents/gal

We need the producer cost of gasoline for the quantity of q_F which means the opportunity cost to Iran's economy of supplying a gallon of gasoline. If gasoline could be sold on world markets, the opportunity cost would be the world price, because that is what must be given up to consume a liter in the domestic market.Crude oil is about $100 per barrel, with 42 gallon per barrel that is $2.38/gallon[7]. So gasoline in world markets must trade at some level above that because it includes refining costs.Since, according to official statistics, more than 60% of gasoline consumption in Iran is imported from abroad,the cost to Iran's economy of importing each liter of gasoline is about 4 to 5 times the domestic prices that consumers[8]pay in Iran. Current consumer price of gasoline(60 cents/gallon)includes a subsidy. The current subsidy would be $p_F - q_F$, where p_F is the actual domestic price and q_F is the opportunity cost. Thus, we consider 250 cents/gallon as an opportunity cost of gasoline use in Iran and difference between p_F and q_F as a negative initial tax.

Total government spending over GDP: 0.4 with range of 0.3-0.7.

Based on data ofIran's Economic Time Series Database and researches by Chaeshmi and Bazmohamadi[9], we averaged government expenditure at 0.4 with range of 0.3-90.7.

Fuel production shares: 0.03, with range of 0.01-0.04.

Gasoline production share of national production are obtained from gasoline consumption multiplied by gasoline price and then divided by national production. These data are taken from Iran's Economic Time Series Database and Statistical Research Center.

Empirical Results and Sensitivity Analysis

4-1-optimal gasoline tax

Using all parameter at their benchmark values, optimal tax rate is estimated at 475cents/gallon. Component of tax rate is shown in table 1. According to this table, marginal external cost is 128 cents/gallon, showing great values of external cost such as E^{P_F} and E^{C}. Also Ramsey component is too large (365 cents/gallon of optimal tax), which is due to small price elasticity of demand for gasoline in Iran. Finally congestion feedback adds 12 cents/gallon.

Mehregan and Ghorbani (2010), estimate short and long run price elasticity of demand for gasoline in Iran. They show that long run elasticity is meaningless because of consecutive fixing of nominal gasoline prices and lack of suitable alternative sources for gasoline. It means that gasoline elasticity in Iran is very low resulting in higher component of Ramsey tax. The lower η_{FF} the larger the Ramsey component.

The most important component of the optimal tax we have calculated is the Ramsey tax component. To make it understandable, some details of the parts of the formula are shown in table 2. It is clear that is large and leads to large Ramsey component.This implies that it is a very efficient way to raise revenue, without causing a lot of changes in economic behavior.

On the VMT tax, we need to make clear that the tax is (by definition) per mile, not per gallon. We convert it to a per gallon basis for comparison to the optimal gasoline tax[10].

The results for optimal VMT tax show 1396 cents/gallonwhich is far above the optimal fuel tax rate. The VMT tax rate is less than triple the optimal fuel tax, and, as can be seen in table 4, the Ramsey componentis very largebecause of small elasticity of gasoline. But due to political reasons, VMT tax rate,which is listed in Table 3, is not the actual rate that would be charged for consumers if this tax system is implemented.

The following figuresshow the sensitivity analysis with respect to variation in most important parameters within the ranges we offer. Cross-mark represents the optimal tax in the central values. Figure 1 shows analysis for ε_{LL} and ε^{c}_{LL}. The Optimal tax increases by ε^{c}_{LL}. However, the decrease by increasing ε_{LL} reflects the fact that gasoline taxes have a narrow base relative to the labor taxes, and in this respect are less efficient for raising revenues. Figure 2 and 3 represent the results of sensitivity analysis of optimal gasoline tax to parameters.

As fuel production share increases, the Pigovian component increases while Ramsey and congestion components decrease. Ramsey component increases by rise in α_F, but gradually decrease as far as Ramsey component becomes negative and afterward this negative component decrease to t^*_F which is sum of three components. But this process does not repeat in high values of η_{FF} and η_{MF}.We noted that η_{MF} and η_{FF} has been changed so that β remains between 0 and 1.

According to the Fifth Five-Year Development Plan, Iran must reach to Persian Gulf FOB prices. With respect to fluctuation of exchange rate, Iran will not be able to comply with Fifth Development Plan. As a result, government needs more accurate mechanism in gasoline pricing. FOB price criteria must be changed so that consumers will not be affected by increase or decrease in exchange rate. Ending subsidies as a first step toward improving economic performance is recommended, and in the second step, consumers-based costs imposed on society should be charged.

CONCLUSION

We have estimated optimal gasoline tax with respect to parameters specific to Iran. Using a theoretical model we obtained 475 cents/mile for optimal fuel tax and 1396 for optimal VMT tax.

Calculations have been carried out in MATLAB, using linear search algorithm to estimate optimal rate and performance sensitivity analysis. Ramsey component compared to Pigovian component is very large. This is due to small price elasticity of gasoline. As a result, government can receive significant revenues originated form gasoline tax if this taxation is implemented. We note that this type of taxation must be accompanied byredistributive policies to help poor people. We also believe that in Iran the tax is actually progressive, *i.e.*, it would be paid as a higher proportion of income by rich people than by poor people. This is quite logical, since we expect most poor people do not own cars.

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Notes

1 In the World Health Organization's 2011 report on air quality and health, three of Iran's provincial towns are ranked in the list of the world's 10 most-polluted cities. "According to the report, Tehran has roughly four times as many polluting particles per cubic meter as Los Angeles."

The rate of road accidents in Iran is twenty times more than the world's average and Globally, road traffics accidents kill 1.2 million people every year and leave 20-50 million people injured and disabled.http://www.unicef.org

2 http://www.ifco.ir/transportation/standards/leveling_vehicles.asp

3 Khataei and Eghdamie (2004), Chitnis(2006), Mehregan and Ghorbanie(2010)

4. This research has been done for Ministry of labor and social security, Taee use social and economic characteristics of households and calculate his estimate by combining time series and cross sectional data.

5. http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RCLC1&f=D

6. http://aftabnews.ir/vdcfcjdj.w6dttagiiw.html

7. Department of Studies and Economic policies

8. Fuel tax rate (cents/gallon)* α_{FM} (gallon/mile)= VMT tax rate(cents/mile)

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