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Economic Effects of Environmental Pollution Tax on the Wheat Market

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ABSTRACT

Control of environmental impacts which remain from agricultural activities is always a concern for communities. In Iran, wheat transportation takes place on roads that are dependent on fossil fuels and results in the release of a large amount of carbon dioxide. Accordingly, applying control policies for internalization of the external effects of releasing these pollutants seems necessary. One way to control this type of pollution is the use of tax instruments. Therefore, the aim of this study was to evaluate the economic effects of pollution tax on wheat market actors. This tax is proportional to the shadow value of pollution that happens due to energy consumption in the distribution sector. For this purpose, a Dynamic Spatial Equilibrium Model has been used to model the wheat market and Input Distance Function has been used to estimate carbon dioxide emission tax. The results showed that application of the tax payment policy would reduce wheat trade in the country by about 24 percent, while only 16.2 percent of the wheat price was considered as tax. Therefore, carbon dioxide emission will be significantly reduced. On the other hand, due to increased transportation costs, economic surplus for customer declined and economic surplus for producers and government revenues increased. Hence, internalization of the external effects of carbon dioxide emission will increase the welfare of the society.

Keywords: Dynamic spatial price equilibrium, Environmental tax, Input distance function, Wheat Market.

INTRODUCTION

The significant distances between the areas of consumption and trade, and distribution across different regions results in the imbalance of supply and demand for food products. Road transport requires high fossil fuel consumption and causes external effects (Santos, 2017), one of which is the greenhouse gases emission (Edwards-Jones, 2010). Energy consumption in Iranian transportation sector increased 1.86 times during 2000 and 2014, while carbon dioxide emission increased by 2.04 times. Accordingly, the CO_2 emission has increased per unit of fuel consumption (Iran Energy Balance Sheet, 2016). Therefore, traditional transportation systems are not able to achieve environmental goals in the products supply chain (Aghazadeh, 2004). Hence, the Green Supply Chain Management Strategy (GSCM) must be used in order to improve sustainability in transportation (Sharma *et al.*, 2015; Kirilova and Gr Vaklieva-Bancheva, 2018). Sustainable food distribution systems must meet the benefits of society, the economy, and the environment simultaneously (Ilbery and Maye, 2005).

One of the ways that Green Supply Chain Management works is the use of environmental regulations. Decision-makers are always looking for regulations to increase the effectiveness of environmental policies (Gouldson *et al.*, 2009; Taylor *et al.*, 2012; Sabzali Parikhani *et al.*, 2018). Economic instruments, which are used to control and reduce emissions, include input based instruments or emissions based instruments (Esteban and Albiac, 2016). Therefore, environmental policies can be divided into variety of "*direct command and control*

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regulation", "*economic instruments*", "*information-based instruments,*" "*co-regulation and self-regulation*" and "*support mechanisms and capacity building*" (Gouldson *et al.,* 2009; Taylor *et al.,* 2012). In the meantime, economic instruments that are considered for environmental issues change the calculations of the beneficiaries in making a decision (Perman *et al.,* 2003). One of the economic instruments is environmental tax-subsidies (Gouldson *et al.,* 2009), which can also be considered as *Ad Valorem* (James and Nobes, 2011). Environmental economist believe that market based mechanisms are the best way to implement environmental policies (Pearce and Barbier, 2000; Pearce and Turner, 1990; Alamdarlo *et al.,* 2014; Majidi *et al.,* 2017). Hence, the adoption of environmental taxes will reduce product supply (Sukanya, 2012), so, consumer prices will be increased (Sloman, 2006) and finally it will change distribution of society welfare (Fullerton and Metcalf, 2002).

To assess the effects of environmental taxes, the general equilibrium methods (Beausejour *et al.,* 1995; Zhang, 1998; O'Ryan *et al.,* 2003; Benavente, 2016; Coxhead *et al.,* 2013; Orlov, 2015; Reynolds *et al.,* 2015)) and partial equilibrium methods (Sacchelli *et al.,* 2014; Ignaciuk *et al.,* 2006; Johansson and Azar, 2007; Chalmers *et al.,* 2014) can be used. On this basis since 1920, various studies have been done on the effects of environmental taxes on various issues including water pollution (Helfand *et al.,* 2003). Griffin and Bromley (1982) showed that input tax is considered as appropriate policy instruments for non-point pollutions control. Gardner and Young (1988) have considered tax instruments as the most reliable methods to control pollution emissions. The study carried out by Wu and Dunn (1995) is one of the first studies that have emphasized on environmental management in the products distribution. Nagurney and Toyasaki (2003) also used environmental concerns in a supply chain model, and used the spatial equilibrium model to optimize the chain. Bosona and Gebresenbet (2011) have made their best effort to design a supply chain that, while reducing environmental impacts, will lead to an increase in the number of potential markets. Asgari *et al.* (2013) have also tried to optimize the wheat distribution system in Iran using the storage and transport costs minimization method. Validi *et al.* (2014), minimizes CO_2 production in a multi-objective programming model to consider environmental impacts in Ireland Milk Industry supply chain. Sall and Gren (2015) have studied the effects of environmental taxation at a rate of 8.9 to 33.3% of the price of milk and meat on their consumption in Sweden. The study concluded that adopting environmental taxes reduces pollution caused by the milk and meat industry. Bonnet *et al.* (2016) believe that adopting environmental taxes could lead to more stable consumption of meat and seafood in France. Chen and Nie (2016) believe that applying environmental taxes (for example, carbon taxes) will lead to deadweight loss in the consumption and distribution sector, but its low level will increase welfare in the manufacturing sector. Choi *et al.* (2016) report that applying environmental taxes, if accompanied by environmental incentives, will lead to better results for ecosystem.

Carling *et al.* (2017) assess the effects of transportation taxes in Sweden, and predict that applying this policy will have a positive impact on carbon dioxide control. Kirilova and Vaklieva-Bancheva (2018) examined the effects of GSCM on the Bulgarian milk industry by combining three models of production, supply chain, and environmental impacts. Mogale *et al.* (2017) provided a model to examine wheat supply chain management in India and optimized wheat distribution and storage systems based on transport minimizing inventory and operational costs.

Wheat Supply Chain in Iran: Wheat is considered as the most important good in the Iranian food basket (Khalilian *et al.,* 2014), and its cultivation area in 2015-2016 was 5.92 million hectares, which has led to 14.6 million tons' production (Ministry of Agriculture Statistics Yearbook, 2017). Wheat in Iran is often supplied using domestic productions and import sources and is transported to silos, which are dispersed throughout the country. Then, they are

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transferred to the final-user markets through the distribution mechanism. Some wheat, which is not consumed in a period, is added to the wheat stock in the next period. Therefore, there is a dynamic mechanism in the wheat supply chain, as shown in Figure 1. In this chain, the highest energy consumption is related to the wheat distribution sector. Therefore, the distribution sector is the best place to apply environmental policies in order to control the emission of pollution. Figure 1 shows how to apply the environmental tax. The wheat transportation constitutes a significant part of the transportation of goods. All wheat transportation takes place through the road in Iran, and this sector is often dependent on fossil fuel consumption. For this reason, transportation is considered as the second-largest energy consumer sector in Iran, such that its consumption has increased from 183.5 million barrels of crude oil in 2000 to 341.3 million barrels of crude oil in 2014. It is the second sector in the CO_2 emission in Iran, and its share decreased from 25.1 percent in 2000 to 24.93 percent in 2014, with no significant change in this period (Iran Energy Balance Sheet, 2015).

Considering the characteristics of the wheat supply chain in Iran, adopting environmental policies seems essential to reduce environmental damages. By reviewing the research literature in this area, most studies on the cereals supply chain have emphasized on the cost minimization, but this study was aimed to maximize the welfare of the wheat market actors, so that there are also storage and transportation costs in the objective function. In addition, in this model, the amount of carbon dioxide emission by the product distribution system is internalized. Therefore, this study aimed to examine the effects of taxation on transportation, to control energy consumption and carbon dioxide emission. The research's innovation was that the amount of

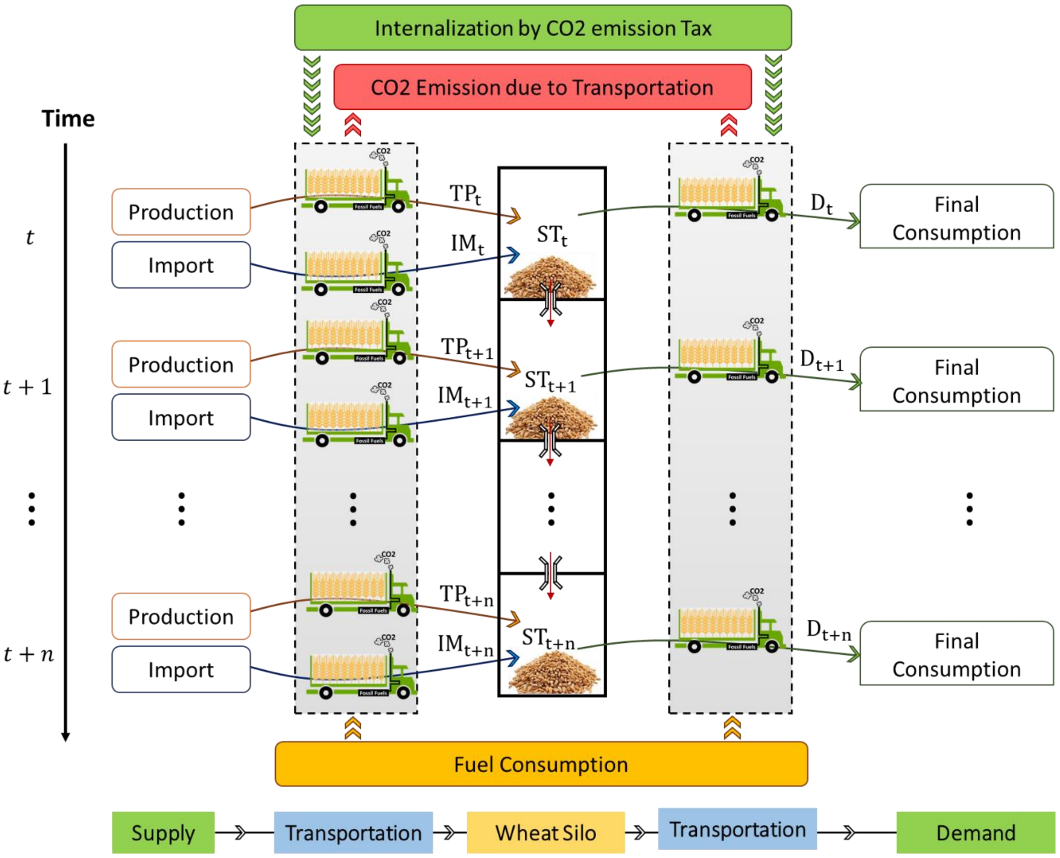

Figure 1. Wheat transportation network in Iran and applying the environmental tax in distribution system.

environmental tax was considered based on the type of goods transported.

MATERIALS AND METHODS

In the first step, the shadow value of the pollutant was obtained using an Input Distant Function and then using a Dynamic Spatial Price Equilibrium model, the effects of the adoption of environmental tax for transportation on wheat market indicator was evaluated.

Data

In this research, 30 provinces of Iran were considered as areas of production and consumption, and 6 provinces as import areas. Various types of data have been collected in each province and over a period in this study. Wheat production cost statistics was used in order to estimate the value of the shadow of wheat contamination (Statistics of the Ministry of Agriculture, 2016). The amount of energy consumption in the wheat transport sector was derived from the road transportation statistics and carbon dioxide emissions in each area by the emission factor (Road Transportation Statistics, 2016; Iran Energy Balance Sheet, 2016). Statistics on inventory and transportation costs have been obtained from the Ministry of Agriculture Jihad (2015) and the price and quantity of wheat production and consumption have been obtained from the Iranian Statistics Center (2015). Table 1 shows information used in this study in terms of province.

In this study, the methodology consisted of two parts. In the first step, the shadow value of CO2 emission due to wheat transport was estimated using an input distant model. Then, using a dynamic spatial equilibrium model, the welfare impacts of external effects internalization for the CO2 emission in the wheat market was investigated.

Internalization of External Effects of CO_2 Emission

The shadow price must be obtained in order to internalize the external effects of contamination (Färe *et al.*, 1993, 1989). Estimation of the distance function in which the relationship between desirable and undesirable outputs is determined is one of the ways to obtain this shadow value (Shephard, 1970; Färe and Primont, 1995; Rečka, 2011, Mosavi *et al.*, 2017; Najafi Alamdarlo, 2018). The input distance function can be written using the Translog approach as Equation (1).

In Equation (1), the symmetry and homogeneity conditions are satisfied. In Equation (1), D_{it} is the value of the input distance function, X represents the inputs used in the wheat production (chemical pesticides, fertilizers, machinery costs, seeds, energy and labor). desirable output in this model is the amount of wheat produced and the undesirable output is the amount of CO2 released due to wheat distribution. In this approach, the shadow value of the shadow of contamination is obtained through the following equation (Färe *et al.*, 1993):

$$\begin{aligned} Ln\, D_{it} = {} & \beta_0 + \sum_{k=1} \beta_k \cdot lnX_{kit} + 0.5 \sum_{k=1}\sum_{j=1} \beta_{kj} lnX_{kit} \cdot lnX_{jit} + \alpha_1 \cdot t + 0.5 \cdot \alpha_{11} t^2 + \sum_{k=1} \alpha_{1k} \cdot t \cdot lnX_{kit} \\ & + \sum_{b=1} \alpha_{1b} \cdot t \cdot lnY_{bit} + \sum_{g=1} \gamma_g \cdot lnY_{git} + 0.5 \sum_{g=1} \gamma_{gg} \cdot \left(lnY_{git}\right)^2 + \sum_{b=1} \gamma_b \cdot lnY_{bit} \\ & + 0.5 \sum_{b=1} \gamma_{bb} \cdot (lnY_{bit})^2 + \sum_{g=1}\sum_{b=1} \gamma_{bg} \cdot lnY_{git} \cdot lnY_{bit} + \sum_{k=1}\sum_{g=1} \theta_{kg} \cdot lnX_{kit} \cdot lnY_{git} \\ & + \sum_{k=1}\sum_{b=1} \theta_{kb} \cdot lnX_{kit} \cdot lnY_{bit} + \varepsilon_{it} \end{aligned} \qquad (1)$$

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Table 1. Summary of data (average of 2014-2015). [a]

Provinces	Price (Rials) Rials/kg	Supply (1000 ton)	Demand (1000 ton)	Inventory cost (Rials)	Silo capacity (100 Ton)	Production cost (1000 Rials)	Seed (kg ha^{-1})	Toxin (L ha^{-1})	Labor (Person per day)	Fertilizer (kg ha^{-1})	Machinery cost (1000 Rials)	Energy (L hr^{-1})	CO2 emission from transportation(Ton hr^{-1})
ARDB	5832	471.1	224.5	207	188	578.0	179	0.94	11.0	197	175.0	489.5	0.234
AZGH	5839	466.7	560.1	207	239	476.5	169	0.96	14.8	146	230.9	638.4	0.517
AZSH	6135	441.3	671.9	207	225	472.5	163	1.16	24.6	171	188.9	559.0	0.522
BOSH	5715	65.0	191.6	207	8	338.9	155	0.41	10.5	162	82.1	227.5	0.727
CHAH	5919	102.6	161.8	207	28	552.1	210	0.91	31.1	226	216.6	644.8	0.714
ESFH	5940	233.4	886.8	207	324	706.8	178	0.95	37.7	305	264.9	787.1	2.699
FARS	5849	1093.5	833.6	207	542	610.3	219	1.09	22.5	294	292.7	620.3	0.568
GILA	6932	6.1	447.4	207	103	431.6	131	0.12	35.2	142	172.9	473.3	7.236
GOLE	5683	648.8	324.9	207	222	688.8	206	3.21	19.5	270	170.0	433.0	0.280
HAME	5809	561.4	317.1	207	261	571.0	190	1.13	18.5	225	196.1	551.9	0.261
HORM	5199	43.0	290.1	207	120	864.3	277	2.13	30.3	483	175.3	455.5	11.079
ILAM	5888	188.3	100.4	207	20	398.9	207	0.98	11.9	230	122.1	350.3	0.303
KERM	5930	247.0	538.4	207	336	774.5	230	1.14	30.2	385	259.5	695.4	1.764
KESH	5918	650.4	351.0	207	206	515.7	183	1.43	13.9	229	137.6	352.8	0.294
KHOZ	5992	1147.6	821.9	207	35	403.2	175	0.86	10.8	212	129.1	313.5	0.635
KHRJ	5675	51.3	119.7	207	484	387.3	120	0.32	26.2	177	148.0	434.5	0.888
KHRR	5781	612.8	1089.8	207	516	458.5	146	0.45	17.9	202	203.3	512.5	0.867
KHRS	5750	181.7	157.7	207	55	476.8	176	0.56	19.0	198	179.7	509.8	0.333
KOHK	5796	110.5	118.9	207	28	446.6	144	0.66	21.2	207	139.1	361.4	0.362
KORD	5900	564.6	269.6	207	138	492.9	184	1.11	18.7	170	158.7	382.2	0.185
LORE	5833	392.0	315.7	207	190	452.4	188	1.15	20.8	199	186.0	520.7	0.356
MARK	5941	334.1	255.7	207	161	464.2	167	1.03	16.6	219	200.8	491.4	0.369
MAZA	5661	109.2	556.6	207	103	567.1	196	2.02	29.7	227	220.1	607.0	3.125
QAZV	5694	261.1	217.5	207	105	590.1	162	1.02	19.1	229	239.6	650.3	0.521
QOOM	5710	30.1	210.6	207	128	769.8	253	2.67	29.3	454	196.4	516.3	4.804
SEMN	5758	96.9	114.7	207	128	561.7	226	1.02	26.5	262	229.0	534.5	0.881
SIST	5527	141.5	459.0	207	119	473.2	171	0.31	37.4	245	213.1	596.3	3.135
TEHR	5860	233.8	2662.2	207	814	655.3	145	1.60	23.1	264	302.3	732.5	14.535
YAZD	5914	59.0	195.8	207	98	1041.1	199	1.07	83.5	537	338.5	976.3	2.394
ZANJ	5823	359.0	184.0	207	123	489.9	142	0.75	19.7	184	175.3	456.1	0.171
GTEH	5282	6.4											
GKHR	5478	120.7											
GKHO	5490	1424.0											
GSIS	5439	89.3											
GGIL	5413	97.6											
GMAZ	5478	331.4											
GHOR	5451	786.7											
AVARAGE	5763	344.9	455.0	207	202	557.0	183	1.11	24.4	248	198.1	529.1	2.025

[a] Source: Energy Balance Sheet, Ministry of Agriculture Jihad, Iran Statistical Center, Environmental Organization Protection.

$$P_b = P_g \cdot \frac{\partial D_{it}(x,y)/\partial y_b}{\partial D_{it}(x,y)/\partial y_g} \qquad (2)$$

In Equation 2, P_b is the shadow value of undesirable output, and P_g is desirable output shadow price. The amount of shadow value of carbon dioxide emissions can be used as a measure to internalize it in a wheat market model. Hence, the shadow price is equivalent to the tax that the pollutant must pay for every kilogram of wheat displacement.

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Dynamic Spatial Equilibrium Model for Wheat Market

Takayama and Judge (1964, 1971) solved the spatial prices equilibrium within the framework of the Quadratic Programming Model. According to this framework, a variety of policies, including tariffs, transport taxes, etc. can be evaluated (Arndt *et al*., 2001). Nonlinear programming approach should be used in order to apply these policies in the model (Rutherford, 1995; Harker, 1986). Therefore, according to studies, the following model is designed to examine the environmental impacts of the environmental tax for wheat market (Arndt *et al*., 2001; Devadoss *et al*., 2005; Mosavi, 2014; Macarll and Spreen, 1996):

$$Max\ W=\left(\frac{1}{1+r}\right)^{t}\left[\sum_{t}\sum_{i}\left(\int_{0}^{D_{it}}p_{dit}dQ_{dit}-\int_{0}^{S_{it}}p_{sit}dQ_{sit}-\int_{0}^{M_{it}}p_{mit}dQ_{mit}\right)-\left(\sum_{t}\sum_{i}\sum_{j}c_{ijt}T_{ijt}\right)-\left(\sum_{t}\sum_{i}\sum_{j}\tau_{ijt}T_{ijt}\right)-\sum_{t}\sum_{i}\omega_{it}IN_{it}\right] \tag{3}$$

s.t.

$$Q_{dit}-\sum_{t}\sum_{i}T_{ijt}-IN_{it-1}+IN_{it}\leq 0 \qquad \forall i,t \tag{3-1}$$

$$IN_{it}\leq \text{Capacity}_{it} \qquad \forall i,t \tag{3-2}$$

$$-Q_{sit}-\sum_{t}\sum_{i}T_{ijt}\leq 0 \qquad \forall i,t \tag{3-3}$$

$$Q_{dt},Q_{st},T_{ijt}\geq 0 \qquad \forall i,t \tag{3-4}$$

The above objective function (Equation 3) is a quasi-welfare function that is maximized over a five-year period (2010-2014). This function actually reflects the present value of the welfare in the wheat market. In the above equations, the parameters and their values are listed in Table 2:

The first constraint (Equation 3-1) is the model's dynamic conditions. Therefore, changes in inventory will depend on supply (import+domestic production), demand and transportation for wheat. The second constraint (Equation 3-2) shows that the inventory level in each area should be equal or less than the storage capacity. The third constraint (Equation 3-3) shows that the goods which are transported from a region should be less than or equal to the supply in that area. The fourth limitation (Equation 3-4) also reflects that the values of supply, demand, and trade are positive. This model was solved for the wheat market in Iran during the period 2010-2014 in the GAMS program and the CONPT3. The price elasticity used for supply and demand in each province was obtained from the study of Najafi Alamdarlo *et al.* (2016).

RESULTS AND DISCUSSION

In this section, In this section, first, the results of the estimation of the distance function are indicated, then, the effects of applying the pollution tax scenario on wheat trade patterns in Iran were identified. Finally, evaluation of welfare effects of this policy on wheat market was studied.

CO_2 Emission Taxation Scenario

As mentioned above, the consumption of fossil fuels in the transportation sector leads to CO2 emission. In order to internalize this pollution in the distribution system, the cost imposed on the environment can be received from the distribution system actors by tax. An increase in energy price is one of the ways to apply this policy, which will increase transportation costs. One way to estimate the input distance function is to use the Aigner and Chu (1968) mathematical programming

Table 2. Model parameters definition and characteristic.

Parameter	Definition	Description	Parameter	Definition
W	Objective function		T_{ijt}	Transported goods from i to j
r	Interest rate	$r = 14.17$ %	ρ_{djt}	Demand market price
t	Time period	$t = 2010, 2011, \dots, 2014$	ρ_{sit}	Supply market price
i and j	Regions	$i,j = 1, 2, \dots, 30$	τ_{ijt}	Tax rate
Q_{dit}	Domestic demand	$Q_d = \alpha - \beta P$	ω_{it}	Inventory cost
Q_{sit}	Domestic supply	$Q_s = \delta + \varepsilon P$	IN_{it}	Inventory stock
Q_{mit}	Import demand	$Q_m = \epsilon - \theta P$	Capacity_{it}	Capacity of inventory in region i
c_{ijt}	Transportation cost			

approach. In this method, the sum of the deviations of the function from an unknown boundary is minimized and does not require statistical scale. In this method, the performance of desirable and undesirable outputs can be considered (Färe, *et al.*, 1989). According to the distance function estimation (Equation 1) and obtaining the shadow value of the pollutant price (Equation 2), the cost imposed on the environment per kilogram of transportation of wheat can be determined. These values as a percentage of wheat price for each province are shown in Table 3. The average for this tax is 0.162. Hence, the shadow value of the pollution caused by wheat transportation is equal to 16.2% of the wheat price. This tax can be considered as the basis to internalize the external effects due to wheat transportation and can be added to the transportation cost.

Wheat Distribution Pattern in the Regions

The spatial modeling of the wheat market requires the price elasticity of supply and demand function in each province. These elasticities are taken from the study of Najafi *et al.* (2016). According to the optimization carried out over a five-year period, trade pattern of wheat can be determined. Figure 2 shows how wheat, from both internal and external sources, is transported in Iran's provinces. The red lines indicate the wheat transportation from the domestic production site and yellow lines show transportation from the wheat import location. The largest export origin is Khozestan Province and the largest import destination is the Province of Tehran. This has caused wheat transit in these

Table 3. The average of shadow value of CO2 in wheat transportation in each province of Iran.

Province	CO2 shadow price (% Wheat price)	Province	CO2 shadow Price (% Wheat price)	Province	CO2 shadow price (% Wheat price)
ARDE	16.7	KHRS	0.195	KESH	0.242
ESFE	0.054	KHOZ	0.205	KOHK	0.266
ILAM	0.214	ZANJ	0.309	GOLE	0.234
AZSH	0.268	SEMN	0.114	GILA	0.040
AZGH	0.246	SIST	0.073	LORE	0.275
BOSH	0.246	FARS	0.101	MAZA	0.066
TEHR	0.017	QAZV	0.160	MARK	0.214
CHAH	0.157	QOOM	0.031	HORM	0.019
KHRJ	0.189	KORD	0.319	HAME	0.197
KHRR	0.132	KERM	0.065	YAZD	0.041

[a] Source: Research Finding.

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two provinces to be higher than the others. The focus of wheat transportation in the country's western side is more, because consumer and producer markets are located in the area.

The optimal wheat distribution pattern after applying the internal taxation policy is shown in Figure 3. Applying the tax scenario in the wheat distribution system can reduce the amount of wheat transportation (Carling *et al.*, 2017). According to the results of comparison of Figures 2 and 3, the amount of wheat trade in Iran will be lower after applying the tax policy. In fact, in this case, the amount of wheat transportation is more expensive and some transport routes are eliminated from the distribution system. On the other hand, demand for the product decreases due to increased price for the consumer as a result of increased energy costs. For both of these reasons, the amount of trade between the regions is reduced and this can largely prevent the spread of pollutions from transportation.

The amount of wheat transported before and after applying the policy of internal taxation is shown in Figure 4. The amount of wheat trade has increased from 2.65 million tons in 2010 to 8.25 million tons in 2014. The reason for this increase, which often occurs in 2011, is a sudden increase in imports because of Iran's sanctions. From 2012 on, wheat trade reached a steady state. By applying the tax scenario, domestic trade of wheat will have decreased dramatically and its declining trend starts from 2012. For example, in the case of applying this policy, wheat trade between regions will be reduced by 2 million tons in 2014. Reduced domestic trade, in addition to decrease in energy consumption, will reduce the CO_2 emissions. Also, if 16.2 percent of the wheat price is considered tax, then the total trade is reduced by an average of 24 percent. This means transportation elasticity in the face of rising transportation costs. The reduction in CO_2 emission is also shown in Figure 4. According to the trend observed in Figure 4, Implementing the tax policy will reduce carbon dioxide emissions. This can show the effectiveness of applying this policy in the wheat transportation sector.

Welfare Effects of Tax Collection on Wheat Market Actors

The changes in economic indicators in the wheat market, including the consumer surplus, producer surplus, tax revenue, and total surplus are shown in Table 5. This table

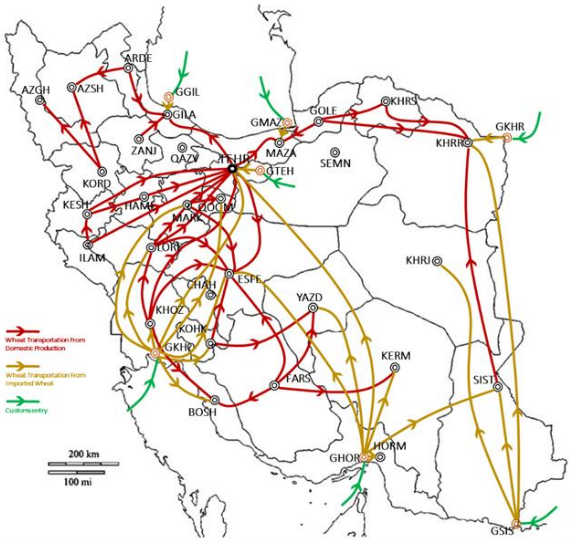

Figure 2. Wheat transportation network after model optimization (Average of period 2010-2014).

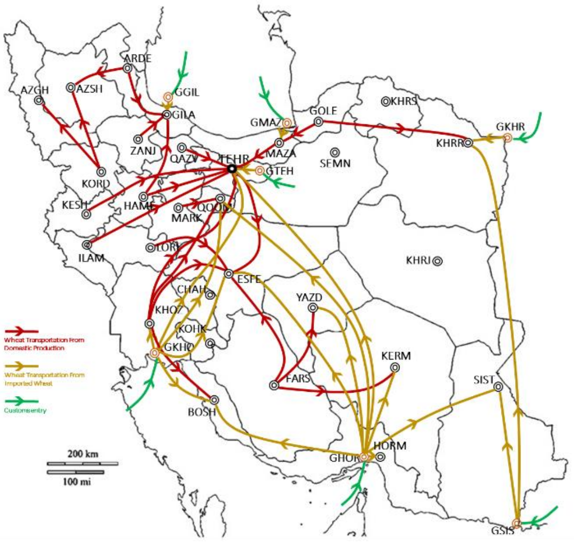

Figure 3. Wheat transportation network after applying the tax policy scenario (Average of period 2010-2014).

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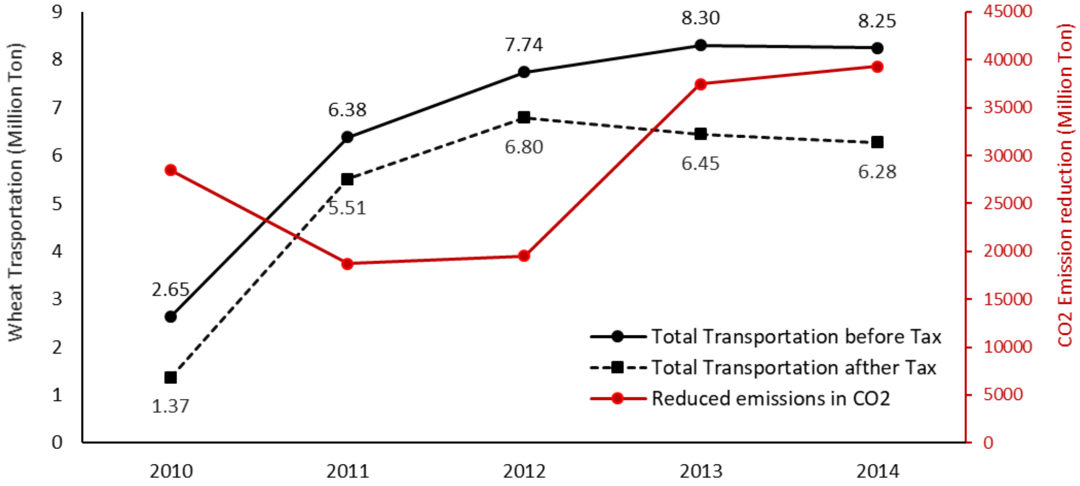

Figure 4. Total transportation of wheat before and after applying tax policy and reducing CO_2 emission.

actually reflects the status of these indices after applying the tax collection policy in 2013 and 2014.

As shown in Table 4, the surplus for producer has increased in some wheat-exporting provinces, but has been decreasing in some others. For example, KHOZ and FARS are both exporters of wheat to the rest of the region, but applying this policy has led to an increase in the producer's surplus for Khozestan Province and its decline for Fars Province. Of course, the amount of this reduction in the producer surplus is negligible. In general, the producer surplus has increased for the whole country (Chen and Nei, 2016).

Applying the tax policy caused deadweight loss in the demand sector. The economy mechanism is such that by increasing costs, usually the final users must pay the price. In this case, when the tax policy is applied (an increase in energy price and consequently an increase in transportation costs), the final users must bear this increased price. Hence, an increase in the product price will reduce their surplus. Of course, in some of the wheat exporting provinces, the increase in transportation costs will reduce their exports. This creates a demand excess in the market of the province and leads to a decrease in prices, consequently, the consumer surplus will be increased in these provinces.

Given that the government is considered as the tax collector, applying internalization policies lead to higher government revenues. Thus, despite a decline in consumer surplus, the producers' surplus and government revenues will increase, and may increase the welfare of the society.

CONCLUSIONS

In Iran, transportation is one of the largest sectors that consume energy, often in the form of fossil fuels. These fossil fuels lead to carbon dioxide release and cause the spread of climate change phenomenon. On the other hand, transportation between consumption and production areas has become inevitable due to the inequality of supply and demand for food products. Therefore, this study aimed to investigate the effects of applying the environmental tax policy on carbon dioxide emissions in Iran's wheat market using a dynamic spatial equilibrium model. It should be noted that applying environmental policies is associated with problems in developing countries, and sometimes cannot achieve satisfactory results, hence it must be implemented carefully.

Therefore, in this study, the tax considered for collection was proportional to the type of goods being transported. The amount of tax was estimated by the input distance function.

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Table 4. Changes in welfare indexes in wheat market after applying the tax policy scenario.

Provinces	2013				2014			
	PS (Producer surplus $)	CS (Consumer surplus $)	TAX (Government revenue $)	TW (Society welfare $)	PS (Producer surplus $)	CS (Consumer surplus $)	TAX (Government revenue $)	TW (Society welfare $)
ARDB	19.8	10.2	27.1	57.1	20.0	6.2	36.1	62.3
AZGH	-42.8	-48.4		-91.1	-56.7	-42.2		-98.8
AZSH	-37.9	-58.7		-96.6	-52.4	-50.1		-102.5
BOSH	-6.6	-16.9		-23.5	-14.2	-15.0		-29.2
CHAH	-9.8	-15.9		-25.7	-15.9	-12.1		-28.0
ESFH	-19.7	-77.5		-97.2	-25.1	-66.9		-91.9
FARS	-5.0	-4.2	11.9	2.6	-12.4	-6.4	24.1	5.2
GILA	-0.5	-39.6		-40.0	-1.0	-33.7		-34.6
GOLE	56.9	30.0	50.7	137.7	96.3	24.8	100.9	222.1
HAME	38.8	22.2	35.9	96.8	42.8	14.6	52.3	109.8
HORM	-3.1	-21.1	0.6	-23.6	-5.6	-18.0	0.8	-22.8
ILAM	12.6	7.5	10.6	30.7	26.1	6.0	33.6	65.7
KERM	-23.0	-46.5		-69.4	-31.2	-38.4		-69.6
KESH	56.5	34.7	38.3	129.5	89.5	27.1	104.3	220.9
KHOZ	93.5	65.9	54.2	213.6	82.6	46.4	41.0	170.0
KHRJ	-4.8	-10.1		-14.9	-6.6	-8.3		-15.0
KHRR	-52.3	-93.5		-145.8	-67.1	-78.2		-145.3
KHRS	10.2	9.1	2.3	21.6	16.9	8.0	7.4	32.3
KOHK	-8.0	-10.2		-18.2	25.0	10.6	12.5	48.1
KORD	97.9	47.3	72.1	217.3	129.4	32.9	119.2	281.6
LORE	46.7	42.0	6.3	95.0	59.8	30.1	15.1	105.0
MARK	25.5	20.5	9.7	55.8	40.2	15.6	27.4	83.2
MAZA	-3.8	-21.0	4.9	-19.9	-20.8	-39.7		-60.5
QAZV	8.7	7.5	3.9	20.0	11.5	5.1	11.7	28.4
QOOM	-2.6	-18.3	33.2	12.3	-4.1	-16.0		-20.1
SEMN	-8.7	-9.9		-18.6	-11.8	-8.6		-20.5
SIST	-12.9	-38.4		-51.4	-22.0	-32.5		-54.5
TEHR	-19.4	-232.6		-252.0	-19.7	-202.0		-221.7
YAZD	-4.8	-17.2		-21.9	-5.5	-14.1		-19.7
ZANJ	53.2	30.2		83.4	72.6	21.3	56.2	150.1
SUM	254.8	-453.0	361.7	163.5	340.6	-433.5	642.7	549.8

Source: Research findings.

Simulation and optimization of this study was done for a five-year period on the wheat market in Iran. Also, considering the role of inventory in balancing Iran's wheat market, a dynamic mechanism must be used to analyze the effects of policies on this market. Therefore, the welfare effects of internalizing costs of emissions of wheat transport pollution were examined in the form of a dynamic green supply chain. CO2 emission shadow price due to wheat transportation was equivalent to 16.2% of its price. Now, if the same rate is considered as tax on the wheat distribution, it will increase transportation costs and change the inter-regional trade pattern of wheat crops. As expected, applying tax collection policy has significantly removed some of the trade routes for wheat. Consequently, the amount of wheat transport will be about 24 percent lower on average as a result of this policy and given that the tax rate of 16.2 percent, it can be expected that this policy will play an important role in controlling the carbon dioxide emission (Hariga *et al.*, 2017). The reduction in carbon dioxide after applying tax collection policy follows an increasing trend. Also, applying the tax collection scenario will reduce the demand for wheat (Mosavi, 2014), because the cost price will increase for consumers. Reduced demand can play an important role in reducing the import of this product and, as a result, the consumption and trade pattern will improve. On the other hand, producers' surplus increases, but consumers suffer losses (Lechtenbohmer *et al.*, 2010), while tax revenues will increase. The outcome of these factors will lead to an increase in the welfare of the wheat market actors. However, changes in the consumer surplus in each region are also significant. Regional differences can reflect the benefits of each region in the production and export of wheat. Therefore, the regions that have positive changes in the producers and consumers' surplus after applying the tax policy have a high potential for the production and trade of this product. It should be noted that in order to prevent consumer losses, complementary policies must be applied (Mosavi, 2014). Hence, compensatory payments to consumers are proposed as a viable suggestion. Another point that must be considered is that regional distribution and well-being changes are also significant after applying the policy.

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آثار اقتصادی دریافت مالیات آلودگی زیست محیطی بر روی بازار گندم

ح. نجفی علمدارلو

چکیده

کنترل آثار مخرب زیست محیطی که از فعالیت‌های کشاورزی به جا می‌ماند، همواره یکی از دغدغه‌های جوامع به شمار می‌رود. حمل و نقل گندم در ایران از طریق جاده‌ای صورت می‌گیرد که وابسته به سوخت‌های فسیلی است و منجر به انتشار حجم زیادی از دی‌اکسیدکربن شده است. بر این اساس، اعمال سیاست‌های کنترلی برای درونی‌سازی آثار جانبی انتشار این آلاینده‌ها ضروری به نظر می‌رسد. یکی از راه‌های کنترل این نوع از آلودگی‌ها استفاده از ابزار مالیات است. بنابراین هدف این مطالعه بررسی آثار اقتصادی دریافت مالیات آلودگی بر روی فعالین بازار گندم می‌باشد. این مالیات متناسب با ارزش سایه ای آلودگی است که در نتیجه مصرف انرژی در بخش توزیع محصول اتفاق می‌افتد. برای این منظور از یک مدل تعادل فضایی پویا برای مدلسازی سازی بازار گندم و از تابع مسافت نهاده برای برآورد مالیات انتشار دی‌اکسیدکربن استفاده شده است. نتایج تحلیل حاکی از این است که اعمال سیاست دریافت مالیات، مقدار تجارت گندم در کشور در حدود ۲۴ درصد کاهش خواهد یافت، در صورتی که تنها ۱۶,۲ درصد از قیمت گندم به عنوان مالیات در نظر گرفته شده است. همین پدیده منجر به حذف بعضی از مسیرهای تجاری از شبکه توزیع گندم می‌شود. در نتیجه مقدار انتشار دی‌اکسیدکربن به مقدار قابل توجهی کاهش خواهد یافت. از طرف دیگر، به علت افزایش هزینه‌های حمل و نقل، مازاد رفاه تقاضاکنندگان کاهش می‌یابد، اما مازاد رفاه برای تولیدکنندگان و درآمد های دولت افزایش خواهد یافت. در نهایت درونی‌سازی آثار جانبی انتشار دی‌اکسیدکربن، منجر به افزایش رفاه جامعه خواهد شد.

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