



Determining welfare effects of technological improvement policy for sugar beet

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ABSTRACT

As an industrial crop, sugar beet plays an important role in meeting domestic demand for sugar. Given the higher level of imported sugar in Iran, the application of protectionist policies is an approach for supplying required sugar. One of these policies is technological improvement. In order to study the effect of this policy, sugar beet supply and demand equations in 1971-2008 were fitted by two-stage least squares method and then, the impact of technological improvement on the welfare of producers, customers and finally, on social welfare was examined under three scenarios of 1, 4 and 10% reduction of prices resulting from technological improvement. Results show that price elasticity of demand is -0.02 and of supply is 0.013. Furthermore, we found that this policy provides more protection for the consumers under all studied scenarios given the share of consumers' welfare surplus from total social welfare surplus.

Keywords: Protectionist policy, Social welfare, Sugar beet, Supply and demand, Two-stage least squares

INTRODUCTION

As an industrial crop, sugar beet plays an important role in meeting the demand for sugar in Iran. Forage sugar beet and molasses are used for feeding animals. Therefore, it plays an important role both in family food basket and in processing and livestock industries in Iran. So, policy-makers have been interested in this crop and its related policies. Sugar beet-related policies of the government have been based on extensive intervention to control sugar price on one hand and to meet consumers' demand through imports on the other hand (Najafi, 2001). Given that sugar beet purchase price is determined by the government and is declared to the factories, the lack of the increase in its price in proportion to the increase in production costs on one hand and the unstructured sugar beet imports on the other hand are the main issues of sugar beet producers in Iran.

Accordingly, it can be said that the orientation of the government about staple crops has been mainly against producers and processing industries (Najafi, 2001; Mahmoudi, 2002). It should be noted that the prejudices to sugar beet production will adversely affect sugar factories and in turn, sugar production. Governments usually influence farmers' decision about the cultivation of a certain crop by price, and technological and institutional policies which in turn, allow them to control the application of an input or a combination of inputs and finally, influence production growth rate from one year to another (Salami and Eshraghi, 2001). Some studies have been conducted on sugar beet crop and the relevant policies. Kohansal and Hosseini (2007) studied the policies of price support, production control, cultivation area control, and price support in combination with cultivation area control of sugar beet by simulation pattern in Khorasan province, Iran. They found that a combination of price support policy

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Table 1. Mean cultivation area, production and annual growth rate of sugar beet at different periods in Iran

	Period						
	1971-1978	1979-1983	1984-1989	1990-1997	1998-2005	2006-2008	1971-2008
Mean production (×1000 t)	4248	3621	4001	4934	5167	4371	4460
Mean annual growth rate (%)	-0.48	1.76	0.49	6.29	1.55	-15.18	0.29
Mean cultivation area (ha)	172603	155801	154457	186688	173752	119666	166726
Mean annual growth rate of whole period (%)	-0.47	2.00	-0.1	3.5	-1.7	-23.7	-1.37

Table 2. Mean sugar production and importation and their annual growth rate at different periods in Iran

	Period						
	1971-1978	1979-1983	1984-1989	1990-1997	1998-2005	2006-2008	1971-2008
Mean sugar extracted from sugar beets (t)	5397.57	464748	483523	598692	636920	564673	555838
Mean annual growth rate (%)	-1.69	1.14	-0.01	6.08	2.92	-0.01	0.12
Mean share of sugar beet-extracted sugar in total sugar production (%)	86.35	75.28	75.07	76.51	66.03	56	74.37
Mean sugar importation (t)	286203	489024	455527	645616	703838	1496333	598752
Mean annual growth rate (%)	40.26	69.3	3.7	20.8	25.04	62.8	32.6
Mean ratio of sugar importation to total sugar production (%)	45.23	80.14	71.05	87.22	77.74	153.34	78.12

without controlling cultivation area would be a strong tool for increasing the incentives to sugar beet production. Also, Najafi (2002) examined the effect of price support policy on sugar beet producers and its domestic supply. He included nominal rate of protection in sugar beet supply function, too. The results showed that nominal rate of protection was negative which meant collecting implicit tax from producers. In some studies, the effect of distributing improved varieties of sugar beet in the EU on welfare was studied and it was concluded that they increased global welfare by 1.1 billion £ in 1996-2000 in which the contribution of the EU, global seed industry, and the farmers and consumers of other countries was 26, 24 and 50%, respectively (Demont *et al.*, 2004; Demont and Tollens, 2004; Demont, 2006; Demont *et al.*, 2008). Moreover, the outcomes of agricultural protectionist policies were studied in some studies. Tolly (1982) evaluated the price policy for rice in Korea. Kruger *et al.* (1988) studied the economical incentives for production in developing countries and concluded that agricultural producers are severely damaged by large-scale economical policies rather than by single-sector policies. Fuglie (1990) estimated the effect of potato storage technology on producers' welfare and the decrease in storage losses for consumers in Tanzania. In a study on price policy as a development means, Moridi (1993) focused on Iran's experience in pricing. Najafi (2000) evaluated the effect of public protectionist policies on the growth rate of wheat, rice, sugar beet and cotton. Also, Yavari (2001) studied the effects of wheat price policy on welfare during 1971-1998. Nouri

(2005) examined rice protectionist policies in Iran. Ahmadian (2005) designed a theoretical paradigm for studying public protectionist expenses and studied the effect of guaranteed price of wheat on the components of public welfare expenses in Iran. In addition, Hosseinipour and Ahmadian (2008) considered the welfare outcomes of the growth of cotton production technology.

The study of sugar beet cultivation area in Iran during 1971-2008 revealed that it has decreased from 160210 hectares in 1971 to 51040 hectares in 2008 with an annual growth rate of -1.37%. But, its trend was variable. The highest mean growth rate of cultivation area was 3.5% in 1997-2000 and the lowest one was -23.7% in 2006-2008. Also, the study of sugar beet production showed that it was 3988 Mt in 1971 which reached to 1713 Mt in 2008 with an annual growth rate of -0.29%. However, 6593 Mt sugar beet was produced in 2006 which decreased to 1713 Mt in 2008 with a growth rate of -47%. Table 2 presents mean cultivation area, production rate and growth rate in different periods.

As can be seen in Fig. 1, like the trend of its cultivation area changes, sugar beet production trend over this period was variable, although technology growth relatively improved its agronomic yield.

The study of the status of sugar production in Iran shows that sugar beets have, on average, contributed 74.3% of produced sugar in Iran over the studied period. In other words, only 25.6% of produced sugar has been extracted from other sources. The study of the sugar extracted from sugar beets reveals that its produced sugar has

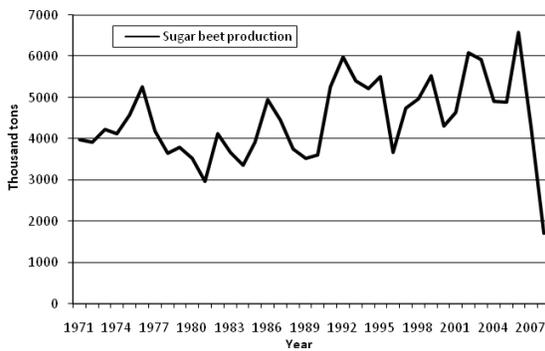


Fig. 1. Trend of the variation of sugar beet production in 1971-2008

decreased from 532000 t in 1971 to 233000 t in 2008 with an annual growth rate of -0.12%. Nonetheless, it should be noted that its growth rate was -43% in 2007 and 2008.

The study of sugar importation indicates that it has increased from 87000 t in 1971 to 839000 t in 2008 with an annual growth rate of 32.59%. The study of the ratio of imported sugar to the total domestically produced sugar shows that it has variably increased from 62.87% in 1971 to 151.8% in 2008 with an annual growth rate of 72.12%. Mean sugar importation was 598000 t over the studied period. Table 2 summarizes mean sugar imports, sugar extracted from sugar beets and its share. Also, Fig. 2 illustrates the trend of sugar importations and domestic extraction from sugar beets over the studied period.

Along with similar studies, the current study was conducted to examine the status of sugar beet and sugar production and to investigate the welfare outcomes of technological improvement of sugar beet production in Iran during 1971-2008.

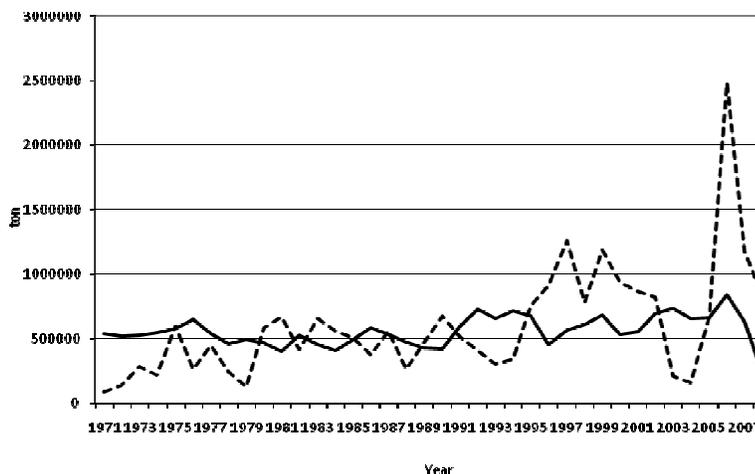


Fig. 2. The trend of the variation of sugar produced from sugar beet (solid line) vs. imported sugar (dotted line) in 1971-2007

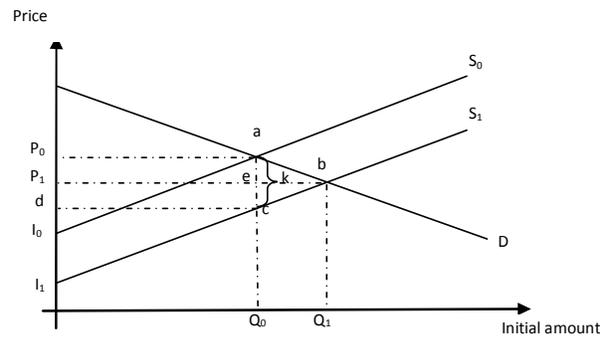


Fig. 3. Technological improvement-induced shift in equilibrium point and change in welfare

MATERIALS AND METHODS

Impact of technological improvement on welfare

Fig. 3 depicts the impact of technological progress on sugar beet supply and demand. Supposing the other factors to be constant, it is expected that as a result of technological progress, supply curve (S_0) is transferred to the right (S_1 curve) in a parallel manner and that the equilibrium point is shifted from the initial point (P_0Q_0) to the secondary point (P_1Q_1). In other words, as can be seen in Fig. 3, the equilibrium point is shifted from a to b and as a result of this shift, equilibrium price will be decreased from P_0 to P_1 and equilibrium amount will be increased from Q_0 to Q_1 . The percentage of the decrease in market equilibrium price is depicted with Z which is defined as follows:

$$Z = -\frac{P_0 - P_1}{P_0} \tag{1}$$

On the other hand, the extent of the rightward

and downward shift of demand curve is depicted with parameter k and if $K=k/P_0$, then the relation between K and Z will be as $Z=K_{\epsilon}/\eta+\epsilon$, where ϵ shows price elasticity of supply and η shows the modular of price elasticity of demand (Alston *et al.*, 1997).

Impact of technological improvement on consumers' welfare

Consumers' welfare surplus is the area of P_0aF sector at initial equilibrium point a . After the rightward shift of supply curve due to the improvement of production technology (secondary equilibrium point, b), consumers' welfare surplus will be the area of P_1bF sector. Technological improvement will result in the increase in consumers' welfare by P_0abP_1 . Alston *et al.* (1997) showed that the change in consumers' welfare can be written as follows:

$$\Delta CS = P_0Q_0Z(1+0.5\eta) \quad (2)$$

Impact of technological improvement on producers' welfare

As can be seen in Fig. 1, producers' welfare surplus equals the area of P_0al_0 region at initial equilibrium point a . But after technological improvement and the rightward shift of supply curve, it will be equal to P_1bl_1 at secondary equilibrium point b . Given the fact that the two triangles P_0al_0 and dcl_1 are equal, it can be concluded that the change in producers' surplus will be equal to P_1bcd . Alston *et al.* (1997) showed that the change in producers' welfare can be written as follows:

$$\Delta PS = P_0Q_0(K-Z)(1+0.5\eta) \quad (3)$$

Impact of technological improvement on social welfare

Since society consists of producers and consumers, examination of social welfare needs the examination of the sum of producers' and consumers' welfare. Therefore, social welfare will be equal to the area of P_0abcd . Alston *et al.* (1997) indicated that as Fig. 1 shows, the change in community welfare can be written as follows:

$$\Delta SC = P_0Q_0K(1+0.5\eta) \quad (4)$$

In order to study the effect of technological improvement on producers' and consumers' welfare and the net social welfare, firstly the functions of domestic sugar beet supply and demand

were estimated and then, the price elasticity of supply and demand was calculated. Consistent with Yavari (2001) and Hosseinipour and Ahmadian (2008), the functions of fitted supply and demand were linear logarithmic in the current study as follows:

$$\ln Q_t^d = \alpha_0 + \alpha_1 \ln P_t^d + \alpha_2 \ln I_t + \ln U_{1t} \quad (5)$$

$$\ln Q_t^s = \alpha_0 + \alpha_1 \ln P_t^s + \alpha_2 \ln P_t + \alpha_3 \ln A_t + \ln U_{2t} \quad (6)$$

where, Q_t^d depicted domestic demand for sugar beet (t) and Q_t^s depicted domestic production of sugar beet (t) in Iran. Also, P_t^d was sugar beet price (expressed in Rial), I_t was the revenue of the purchase of sugar produced by factories, P_t was the price of produced sugar, P_t^s was sugar beet price, A_t was sugar beet cultivation area, and U_{1t} and U_{2t} were the components of model dissonance. We found that during the studied period, a great part of domestic demand for sugar beet was from the side of sugar factories. Furthermore, domestic demand for sugar was mostly met by sugar importations. Hence, domestic demand for sugar beet is depicted by the sum of domestic sugar production and importations divided by sugar content. Since a part of domestic demand has been put forward by sugar factories, the revenue of these factories influenced the demand.

In a post-identification equation in which predetermined unapplied descriptive variables outnumber endogenous descriptive variables, any combination of predetermined unapplied variables can be used as institutional variable. Though if all predetermined variables are not used, then the estimation may become inefficient (Seddighi *et al.*, 2000). Two-stage least squares method is an example of the methods which use all predetermined variables as institutional variables in order to gain efficient and consistent estimations. Suppose that the following equation, which includes k predetermined variables and g endogenous variables, is a post-identification equation in a structured pattern with G endogenous variables and k predetermined variables (Seddighi *et al.*, 2000):

$$y_1 = \gamma_1 y_1 + X_1 \beta_1 + \epsilon_1 = Z_1 \delta_1 + \epsilon_1 \quad (7)$$

where,

$$\begin{aligned} Z_1 &= [\gamma_1 \ X_1] \ , \ \delta_1 = [\gamma_1 \ \beta_1] \\ Y_1 &= [y_1 \ y_2 \ \dots \ y_g] \ , \ X_1 = [X_1 \ X_2 \ \dots \ X_k] \\ X &= [X_1 \ X_{k+1} \ X_{k+2} \ \dots \ X_k] \end{aligned} \quad (8)$$

Table 3. Results of the study of statics of variables affecting sugar beet supply and demand in 1971-2008

Variable	Band wide	Null hypothesis	Test statistic	Test statistic
LQ_t^s	3	Presence of single root	-1.7	-1.9
$D(LQ_t^s)$	6	Presence of single root	-3.6*	-3.8*
LQ_t^d	4	Presence of single root	-2.5	-1.4
$D(LQ_t^d)$	9	Presence of single root	-11.5*	-4.7*
LA	1	Presence of single root	-0.5	-1.1
$D(LA)$	2	Presence of single root	-3.9*	-3.8*
Ll_t	2	Presence of single root	-1.2	-2.2
$D(Ll_t)$	1	Presence of single root	-3.8*	-3.9*
LP_t	3	Presence of single root	-1.7	-2.9
$D(LP_t)$	3	Presence of single root	-3.56*	-4.9*
$LP_t^d = LP_t^s$	0	Presence of single root	-2.55	-2.3
$D(LP_t^d) = D(LP_t^s)$	2	Presence of single root	-5.9*	-6.8*
	1% level	5% level*	10% level	
Critical values of PP test	-4.22	-3.5	-3.2	
Critical values of ADF test	-4.23	-3.54	-3.2	

If d_1 is the estimator of δ_1 , then the two stages of two-stage least squares method are (Seddighi *et al.*, 2000):

Stage 1 Normal least squares method for the following abridged equations:

$$y_1 = X\pi_i + v_i \quad i = 1, 2, 3, \dots, g \quad (9)$$

is used for estimating abridged coefficients of $p_i = (X'X)^{-1}X'y_1$ where, p_i is the estimation of π_i . Then, they were exploited for calculating predicted values of y_i in the sample, i.e. $\hat{y}_i = Xp_i = X(X'X)^{-1}X'y_1$.

Stage 2 The predicted values of y_i in the sample were used to create the matrix $\hat{z}_i = [\hat{y}_1 \ X_1]$ where $\hat{y}_1 = [\hat{y}_2 \ \hat{y}_3 \ \dots \ \hat{y}_g]$ and, the following normal least squares method

$$y_1 = \hat{y}_1\gamma_1 + X_1\beta_1 + \eta = \hat{z}_1\delta_1 + \eta_1 \quad (10)$$

was used for finding the estimations of two-stage least squares where η depicted error component. Then, the following equation was calculated:

$$d_{1,2SLS} = (\hat{z}_1' \hat{z}_1)^{-1} \hat{z}_1' y_1 \quad (11)$$

The estimations of two-stage least squares in Eq. 10 in terms of main values of variables and for i th equation are

$$d_{1,2SLS} = (\hat{z}_1' \hat{z}_1)^{-1} \hat{z}_1' y_1 = [(z_1' X)(X'X)^{-1}(X'z_1)]^{-1} (z_1' X)^{-1} X' y_1 \quad (12)$$

$$Var - Cov(d_{1,2SLS}) = s_i^2 (\hat{z}_1' \hat{z}_1)^{-1} \quad (13)$$

$$s_i^2 = \frac{(y_i - z_i d_{1,2SLS})(y_i - z_i d_{1,2SLS})}{n - g - k + 1} \quad (14)$$

Indeed, an essential assumption of the foregoing model is that the structural error terms are not

correlated with each other.

Given that the data used in this study were a sort of time series, extended Phillips-Perron and Dickey-Fuller tests were used for studying the statics of the variables of the model. After estimating sugar beet supply and demand functions, the impact of the improvement of production technology was examined in three scenarios of 1, 4 and 10% price reduction.

The current study was a library research. The required data were collected from the homepage of Iranian Sugar Factories Syndicate (www.isfs.ir). Eviews 5 software was used for analyzing the data and estimating the model.

RESULTS AND DISCUSSION

Results of estimation of sugar beet supply and demand functions by extended Phillips-Perron and Dickey-Fuller tests are presented in Table 3. They show that all variables used in the current study were statics with differentiation of the first order.

After examining the staticity of the model variables, sugar beet supply and demand equations were fitted by two-stage least squares method using simultaneous equation system as follows (figures in parenthesis are standard deviations):

$$\ln Q_t^d = 14/06 - 0/027 \ln P_t^d + 0/13 \ln I_t \quad (0/36) \quad (0/14) \quad (0/12) \quad (15)$$

$$\bar{R}^2 = 0/4 \quad D.W = 1/6$$

$$\ln Q_t^s = 3/46 + 0/013 \ln P_t^s + 0/035 \ln P_t + 0/46 \ln A_t \quad (0/9) \quad (0/008) \quad (0/029) \quad (0/066) \quad (16)$$

$$\bar{R}^2 = 0/86 \quad D.W = 1/8$$

On the basis of these equations, it can be concluded that price elasticity of sugar beet demand is -0.027 and price elasticity of corn supply is 0.013

($\eta = -0.027$, $\varepsilon = +0.013$). Also, the magnitude of Durbin-Watson statistic showed that supply and demand equations were not self-correlated. For demand function, coefficient on price variable was significant at confidence level of 95% and coefficient on revenue variable was significant at confidence level of 90%. The signs obtained for variables were consistent with theoretical basis, too. The negative relation between demand and its price and the positive relations between demand and revenue are proofs of this consistency. In demand function too, the coefficient on commodity supply price variable was positive and significant. Hosseinipour and Ahmadian (2008) and Yavari (2001) reported similar results. They found elasticity of demand and supply consistent with theoretical basis, too.

The impact of technological improvement on welfare was studied under three price scenarios in Table 4. According to the first scenario, the technological improvement of sugar beet production decreased price by 1%. In the second scenario, it decreased price by 4%. Finally, it was supposed in the third scenario that technological improvement decreased price by 10%. The extent of the changes in welfare surplus of consumers, producers and finally, whole society expressed in Rial can be seen in Table 4. In all three scenarios, the benefits for producers were greater than for consumers. On average, the welfare surplus of consumers was 2.07 times as great as that of producers.

Agriculture sector has been protected in Iran due to its production nature and its prior and post communications with other sectors. But, selecting an efficient protectionist policy is a challenge for policy-makers. Sugar beet is known as an industrial crop in Iran which plays an important role in supplying sugar needed by people and its remaining molass is used for feeding animals. In addition, it can be directly used by people. Although sugar demand can be met by growing sugar cane, its cultivation is possible only in southern Iran due to its special required climatic conditions. The produced sugar beets do not usually meet the demand of sugar factories. So, a great deal of sugar is annually imported in the raw form to meet demand surplus of the market. The importation of sugar means the exit of a great deal of foreign exchange from the country. Furthermore, sugar production units are closed and many people lose their jobs. If sugar production technology is developed, efficiency will be improved, production will be increased and finally, supply curve will shift to the right side. A consequence of this shift is the

Table 4. Results of the study of the impact of technological improvement of sugar beet production on welfare

	Z	K	ΔCS	ΔPS	ΔSC
Scenario 1	0.01	0.014	18229539	3786349	19631810
Scenario 2	0.04	0.044	72888619	151384054	78495435
Scenario 3	0.1	0.107	182073868	378153418	196079550

improvement of the welfare of producers and consumers. The impact of technological improvement on production, the reduction of wastes and even, poverty is only a part of its positive consequences. Although the position of supply curve can be shifted by other policies like increasing cultivation area, subsidizing, increasing guaranteed prices and other governmental tools and policies, the direct and indirect influences of technological improvement are its distinguishing advantages. The results of the current study indicate that the benefits of 10% price reduction caused by technological improvement for consumers – who are the sugar factories – are 2.7 times as great as those for producers. Therefore, sugar factories can collaborate in investing on technological improvement of the production and finally, gain more benefits. Moreover, given the benefits of technological improvement for society, it is recommended that a part of sources which are dedicated to maintaining and increasing production capacity is invested on technological improvement. In their study on cotton, Hosseinipour and Ahmadian (2008) reported similar results. The fact that puts cotton and sugar beet in one category and makes them comparable is that both are industrial crops and are used as raw material for other products. Hosseinipour and Ahmadian (2008) found that the benefits of fulfilling technological improvement policy for consumers (factories) were twice as great as those for producers (farmers). Therefore, as the customers of cotton, fiber factories producing fibers from cotton bolls should invest on technological improvement of cotton production. Also, Yavari (2001) showed that wheat pricing policy enhanced consumers' and producers' welfare. However, consumers enjoyed greater increase in their welfare.

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