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Determining the Welfare Effects of Sugar Beet Mechanization

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Abstract

Sugar beet is a by-product of industrial agriculture which plays an important role in providing the required domestic sugar. Given the high proportion of imported sugar in sugar consumption, one way to provide the required sugar is to use a support tool. One of these tools is mechanization. In order to assess the impact of mechanization on the welfare of producers and consumers, supply and demand equations for sugar beet for the period 1971-2012 are developed using two-stage least squares (2SLS). The effect of mechanization on welfare and the welfare of producers' and consumers' communities is then analysed in three scenarios: 1%, 4% and 10% reduction in price. The results show that price elasticity of demand is -0.02 and price elasticity of supply 0.013. Additionally, in all scenarios, according to the proportion of total consumer welfare surplus in total social welfare surplus, implementation of this policy is supported by consumers.

Keywords: support tools- social welfare- supply and demand- two-stage least- sugar beet

Introduction

Sugar beet is a by-product of industrial agriculture, which has an important role in providing the country's sugar requirements. Forage beet molasses is used for animal feed. Thus, sugar plays an important role in the household diet, in the processing industries and in livestock. The product and its related policies are therefore taken very seriously by policymakers. Government policies of intervention reducing the price of sugar lead to importation to meet the needs of consumers (Najafi, 2002). The government's constant determination of sugar price for the factories is proportional to the increase in the cost of production; on the other hand, impolitic importing of sugar is one of the main issues of sugar beet producers in the country. We can say that the government's policy on basic products such as sugar is mainly to the detriment of producers and manufacturers (Najafi, 2001; Mahmudi, 2002). We should note that sugar production will also be affected. Generally, governments are using three types of tool, price, technological and institutional, to affect decisions over whether to cultivate a crop, and rate of input or a combination of inputs to affect the amount of production and production growth rate over the years (Salami and Eshraghi, 2001). On sugar beet and government intervention in its market, several studies have been conducted. Kohansal and Hoseyni (2007) studied price support policies, production control, cultivated level control and price support associated with sugar beet in Khorasan province using a simulation model. The results indicated that strengthening motives for sugar beet production, price-support policies without cultivated area control will be a powerful tool. Najafi (2002) also examined the effect of producer's price support policies and the sugar beet domestic supply rate. In this study, the nominal protection rate for sugar beet was entered. The results showed that the nominal protection rates were negative.

This means that implicit tax would be taken from producers. Some studies predict the effects of reformed distributive EU sugar welfare, and conclude that over 1996-2000 global welfare would increase by 1.1 billion pounds. The European Union producers' contribution was 26%, that of the global seed industry 24% and that of farmers and consumers in other countries 50% of total universal welfare (Demont, 2006; Demont et al., 2008; Demont and Tollens, 2004; Demont et al., 2004). The effects of agricultural policies have also been investigated. Tavali (1982) evaluated rice-pricing policies in Korea. Kruger et al. (1988) studied the economic motivation for production in developing countries, and concluded that agricultural producers are damaged not by any single policy, but also through macroeconomic policies and trade. Fuglie (1990) estimated the effect of potato-storage technology in Tanzania on welfare benefits for producers' and consumers' storage losses. Moridi (1993) worked on the pricing experience in Iran. Najafi (2000) evaluated government policies and their effects on the growth of wheat, rice, sugar and cotton. Yavari (2001) also investigated the welfare effects of wheat-pricing policies during 1971-1998. Nuri (2005) investigated Iran's rice policies. Ahmadian (2005) also developed a theoretical model to evaluate the cost of government support, investigating the guaranteed price of wheat on the effects of government welfare cost components in Iran. Hoseyni pur and Ahmadian (2008) investigated the welfare effects of technology growth on cotton production in Iran.

Surveying Iran`s sugar beet and sugar production

During the years 1971-2012, the cultivated area for sugar beet decreased from 160,210 acres, with an average annual growth rate of - 9/7%, to 96,350 acres in 2012. Evaluation of the production of sugar beet shows that 3988 tons was produced in 1971 with an average annual growth rate of 0/29%, while 4069 tons were produced in 2011. Table 1 shows average cultivated area, production rate and growth rate.

Table 1: Average cultivated area, sugar beet production rate and annual growth rate during different periods in Iran (acre – thousand tons – per cent)

Time Period	1971-2011	2006-2011	1998-05	1990-97	1984-89	1979-83	1971-78
Average Production Quantity	4460	4371	5167	4934	4001	3621	4249
Average Annual Growth Rate	0.29%	-15.18%	1.55%	6.29%	0.49%	1.76%	-0.48%
Average Harvest Area	166726	119666	173752	186688	154457	155801	172603
Average Annual Growth Rate	-1.37%	-23.7%	-1.7%	3.5%	-0.1%	2%	-0.47%

Ref: Iran Sugar Industries Association

As Figure 1 shows, the sugar beet production in the study period, like cultivated-area growth, fluctuated. However, agricultural mechanization improved, which improved relative arable performance.

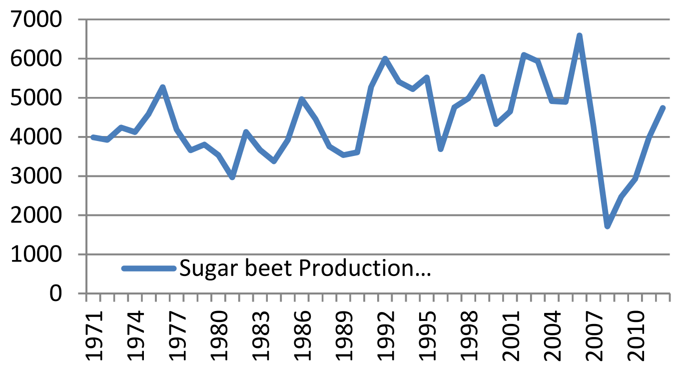

Figure 1: Sugar production growth during 1971-2012

Evaluation of sugar production in the country shows that the average sugar produced from beet sugar was 71/9% in the study period. In other words, only 18/1% was produced from sugar cane. Investigating the amount of sugar produced from sugar beet shows 532,000 tons in the year 1971, with average annual growth rate of 0/22% to 551,000 tons per year. It should be noted that this rate faced an average decrease of 43% in 2007 and 2008.

Sugar imports amounted to 87,000 tons in 1971, with average annual growth rate of 13/9% to 1/6 million tons in 2012. The proportions of total imports of sugar and sugar production in the country show fluctuating growth of 62/78% in 1971, with an average annual growth rate of 85/4% that reached 149% in 2012. Average sugar imports during the study period amounted to 681000 tons. Average imports of sugar and sugar production are presented in Table 2. Figure 2 shows the processes of importing sugar and sugar production during the study period.

Table 2: The average rate of sugar production and imports of sugar, and annual growth rate during different periods (ton – per cent)

Time Period	1971-78	1979-83	1984-89	1990-97	1998-05	2006-11	1971-2011
Average Sugar Produced from Sugar beet	539787	464748	483523	598692	636920	464673	555838
Average Annual Growth Rate	-69.1%	1.14%	-0.01%	6.08%	2.92%	-0.01%	0.12%
Average share of Sugar produced from Sugar beet from Total Sugar production	68.35%	75.28%	75.07%	76.51%	66.03%	56%	74.37%
Average Quantity of Sugar Imported	286203	489024	455527	645616	703838	1496333	598752
Average Annual Growth Rate	40.26%	69.3%	3.7%	20.8%	25.04%	62.8%	32.6%
Average portion of sugar imported from total sugars production	45.23%	80.14%	71.05%	87.2%	77.74%	153.34%	78.12%

Ref: Iran Sugar Industries Association

This study is consistent with other studies on sugar beet and sugar production and welfare effects caused by sugar beet production mechanization in Iran during 1971-2012.

Materials and methods

The effect of mechanization on welfare

Figure 2 shows the effect of mechanization on the supply and demand of sugar beet. As expected from other constant factors, the mechanization of the supply curve effect (S_0) is in parallel to the right ($s_1$curve), and the balance point shifted from the initial point (P_0Q_0) to the second balance point (P_1Q_1). In other words, as shown in Figure 2, the balance point shifted to point b, and as a result of this price balance transfer P_0 reduced to P_1 and the balance amount increased from Q_0 to Q_1. Per cent decrease in the market equilibrium price is given by Z, which is defined as follows:

$$Z = -\frac{p_0 - p_1}{p_0} \tag{1}$$

The supply curve transfer rate is shown with the parameter k. If K = k/P0, it establishes the $Z = K\varepsilon / \eta + \varepsilon$ relationship between K and Z. ε represents the price elasticity of supply and η the absolute value of the price elasticity of demand (Alston et al., 1997).

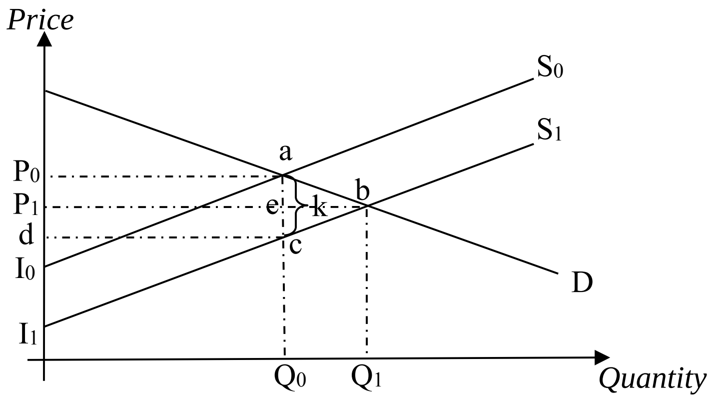

Figure 2: Change in the balance point and in welfare due to mechanization

Mechanization effect on consumer welfare

At the primary balance point a, consumer welfare surplus is equal to p_0af area. After transferring the supply curve due to the mechanization, production to the right (secondary balance point b) and the consumer welfare surplus will be p_1bf. Because of this change, the size of p_0abp_1 consumer welfare has increased. Alston et al. (1997) showed that the change in consumer welfare can be written as:

$$\Delta CS = P_0 Q_0 Z\,(1 + 0.5\eta) \quad (2)$$

Mechanization effect on producer welfare

As shown in Figure 3, in primary balance point (a) the producers' welfare surplus is equal to the area of p_0ai_0 after mechanization and the transfer of the supply curve to the right; for secondary balance point (b), the producers' welfare surplus will be p_1bi_1. Because the two triangles dci_1 and p_0ai_0 are equal, it can be concluded that the change in producer surplus is equal to p_1bcd. Alston et al. (1997) showed that the change in producers' welfare can be written as follows:

$$\Delta PS = P_0 Q_0 (K - Z)(1 + 0.5\eta) \quad (3)$$

Production mechanization's effect on society's welfare

Because society consists of producer and consumer, in order to study the welfare of society, a total of the consumer and producer welfare surplus must be found. Therefore, the society's welfare will be the size of the area p_0abcd. Alston et al. (1997) demonstrated that, considering Figure 3, the change in social welfare can be written as:

$$\Delta SC = P_0 Q_0 K (1 + 0.5\eta) \quad (4)$$

In order to investigate the effect of mechanization on consumer and producer welfare and the social welfare net, firstly domestic sugar supply and demand functions are estimated and the price elasticity of supply and demand is calculated. The functions of supply and demand have been fitted in this study. As in the studies by Yavari (2001) and Hoseyni poor and Ahmadian (2008), the linear logarithmic forms were as follows:

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

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

where Q^d_t is domestic demand for sugar beet (ton), and Q^s_t is domestic production of sugar beet (tons) in Iran, P^d_t is sugar beet price (ton to rial), I_t is sales income of sugar produced by factories, P_t is the price of produced sugar, P^s_t is sugar beet price, and A_t indicates sugar beet cultivated area . U_{1t}

and U_{2t} represent model-disturbing parts. During the study period, a significant proportion of the total domestic demand for sugar beet was met by sugar factories. However, most of the domestic demand for sugar was met by sugar imports. The rate of sugar beet production plus imports divided by the grade of the sugar beet shows the amount of domestic sugar beet demand. Because part of the demand was met by sugar factories, the income of these factories affects the demand.

In an ultra-recognition equation, where the number of unapplied predetermined variables is more than the number of endogenous descriptive variables we can use any combination of unapplied variables as a tool variable. However, if none of the predetermined variables are used, it is possible that one will make inefficient estimates (Sedighi et al., 2000). The two-stage least squares method uses all the predetermined variables as tool variables to achieve consistent and efficient estimates. Taking the following equation, which has a predetermined variable k where g is an endogenous variable (Sedighi et al., 2000):

$$y_1 = Y_1\gamma_1 + X_1\beta_1 + \varepsilon_1 = Z_1\delta_1 + \varepsilon_1 \quad (7)$$

where

$$Z_1 = [Y_1 \;\; X_1] \;\;,\;\; \delta_1^{'} = [\gamma_1 \;\; \beta_1]$$
$$Y_1 = [Y_2\, Y_3 \cdots Y_g] \;\;,\;\; X_1 = [X_1\, X_2 \cdots X_k] \quad (8)$$
$$X = [X_1\, X_{k+1}\;\; X_{k+2} \cdots X_k]$$

If d1 estimates δ_1, the two-stage least squares method consists of two stages (Sediqi et al., 2000):

Step 1: conventional least squares method for the following unconstrained summary equations:

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

to obtain the coefficients summary $p_i = (X'X)^{-1}X'y_1$ where pi is the estimate of π_i. Then they are used to calculate yi predicted values in the $\hat{y}_i = Xp_i = X(X'X)^{-1}X'y_1$ sample.

Step 2: The yi predicted values in the sample of constituting matrix $\hat{Z}_i = [\hat{Y}_1 \;\; X_1]$,

where $\hat{Y}_1 = [\hat{Y}_2\, \hat{Y}_3 \cdots \hat{Y}_g]$

were used with the ordinary least squares method in the following equation:

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

where η represents the component error, used to access estimates of the two-stage least squares.

This is calculated by the following equation:

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

Two-stage least squares estimates of the relation number 10, according to the original variables amount for the i Th equation as follows:

$$d_{1,2SLS} = \left(\hat{Z}_1^{'}\hat{Z}_1\right)^{-1}\hat{Z}_1^{'}y_1 = \left[\left(Z_1^{'}X\right)\left(X'X\right)^{-1}\left(X'Z_i\right)\right]^{-1}\left(Z_i^{'}X\right)^{-1}X'y_i \quad (12)$$

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

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

One of the basic assumptions of the above model is that the structural error terms are not correlated with each other.

Due to the time series data used in this study, to investigate the static variables model the Phillips-Peron test is used. After estimating the sugar beet demand and supply equations, the production mechanization can affect in three scenarios, 1%, 4% and 10% reduction in price due to mechanization, is investigated.

The study method was a library method. The required data were obtained from the Iran Association of Sugar Industry website. To analyse the data and estimate the model, Eviews 5 software was used.

Results and discussion

Due to the use of time series data, the first step in estimating functions of sugar beet supply and demand is to study static variables used in the model in the Phillips-Peron test; a generalized Dickey-Fuller test is used. Table 3 shows that all the variables used in this study become stationary by one differentiate.

Table 3: Results of stationary in variables affecting supply and demand of sugar beet during 1971-2012

Variable	Band Width or Lags	Null Hypothesis	PP Statistics	ADF Statistics
LQ^s_t	3	Unit root	-1.7	-1.19
$D(LQ^s_t)$	6	Unit root	-3.6*	-3.8*
LQ^d_t	4	Unit root	-2.5	1.4-
$D(LQ^d_t)$	9	Unit root	-11.5*	-4.7*
LA	1	Unit root	-0.5	-1.1
D(LA)	2	Unit root	-3.9*	-3.8*
LI_t	2	Unit root	-1.2	-2.2
D(LIt)	1	Unit root	-3.8*	-3.9*
LP_t	3	Unit root	-1.7	-2.9
$D(LP_t)$	3	Unit root	-3.56*	-4.9*
LP^s_t	0	Unit root	-2.55	-2.3
$D(LP^s_t)$	2	Unit root	-5.9*	-6.8*
	1% level	5% Level *	10% Level	
Critical Value For PP test	-4.22	-3.5	-3.2	
Critical Value For ADF test	-4.23	-3.54	-3.2	

Ref: Author's Calculation

After examining the static model variables, the sugar beet supply and demand equations using simultaneous equations and the two-stage least squares method have been estimated as follows (numbers in parentheses indicate the standard deviation):

$$LnQ_t^d = 14/06 - 0/027 \ln P_t^d + 0/13 \ln I_t \quad (15)$$
$$(0/36) \quad (0/14) \quad (0/12)$$
$$\bar{R}^2 = 0/4 \qquad D.W = 1/6$$

$$LnQ_t^s = 3/46 + 0/013 \ln P_t^s + 0/035 \ln P_t + 0/46 \ln A_t \quad (16)$$
$$(0/9) \quad (0/008) \quad (0/029) \quad (0/066)$$
$$\bar{R}^2 = 0/86 \qquad D.W = 1/8$$

According to the above equations, we can conclude that the sugar beet price elasticity of demand is equal to -0.027, and maize price elasticity of supply is 0.013 (ε = +0.013 and η=-0,027).

The Durbin-Watson test shows that supply and demand equations do not have a problem of autocorrelation. The demand function price coefficient variable of certainty level 95% and the income coefficient variable of certainty level 90% were significant. The signs obtained for the parameters are consistent with the theoretical catechism. A negative relationship between demand quantity and price and a positive relationship between demand quantity and income are evidence of this adaptation. The supply function of the coefficient supply price variable was positive and significant. Hoseyni pur and Ahmadian (2008) and Yavari (2001) obtained similar results in their studies. Elasticity of demand and supply is also in accordance with theoretical studies.

Table 4 presents welfare effects of mechanization in three price scenarios. According to the first scenario, mechanization of sugar beet production reduces the price to 1%. In the second scenario, mechanization reduces the price level to 4%. Finally, in the third scenario it is assumed that the mechanization leads to a decline in the price level to 10%. In Table 4, we can observe the change amount of consumer and producer welfare surplus and eventually the whole community in terms of RLS. In all three scenarios producer benefits were greater than consumer benefits. The average consumer surplus welfare of 2.07 was equal to producer welfare surplus.

Table 4: Results of mechanization – welfare impacts of sugar beet production Source: study findings

	Z	K	ΔCS	ΔPS	ΔSC
First Scenario	0.01	0.014	18229539	37861349	19631810
Second Scenario	0.04	0.044	72888619	151384054	78495435
Third Scenario	0.1	0.107	182073868	378153418	196079550

Ref: Author's Calculation

Agriculture is one of the supported divisions. But, the choice of an efficient support tool is one of the challenges facing policymakers. Sugar beet introduced as an industrial product has, in addition to human use, an important role in providing molasses for livestock feeding. However, to provide the required sugar, although we can cultivate sugar cane, because of the special conditions it requires we cannot cultivate much area. Rates of sugar beet produced in plants generally do not suffice to meet factories' demand, and hence in order to respond to market demands every year a large amount of raw sugar is imported. The sugar import process causes the withdrawal of much of the country's currency and the closure of sugar production units, and also reduces employment. Closure of sugar production units reduces sugar beet cultivation. If the mechanization of sugar beet production improves, productivity and transit supply increase and the curve moves to the right. Changes in producer and consumer welfare are only one of the supply-curve transition effects. The effects of mechanization on production, waste reduction and even poverty are just some of the positive effects of mechanization in society.

However, other government policies like increasing cultivated area, paying food subsidies, and increasing guaranteed prices, as well as other tools, could move the supply curve down; the direct and indirect positive effects of mechanization distinguishes this tool from other tools. The results indicate that consumers' gains from factories producing sugar at 1% price reduction due to mechanization are 2/7 times greater than producers' gains. So, sugar factories, by providing required capital for mechanized growth of production, ultimately earn more interest. Considering the mechanization benefits for society, we suggest that some resources should be allocated to preserve and increase production capacity. Hoseyni pur and Ahmadian (2008) found similar results in the case of cotton. The reason for putting sugar beet and sugar cane into one group and making them analogous is because they are used as first production materials of other products. Hoseyni pur and

Ahmadian (2008) showed that the net income for consumers of mechanization implementation was double that of manufacturers' net return. Cotton factories as product consumers must invest to improve production technology. Yavari (2001) also showed that through wheat-pricing policy, the welfare of consumers and producers increases. Of course, again consumers will experience the greater increase.

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