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Estimating Market Power in Iranian Dairy Processing Industry with Dynamic Imperfect Competition Model

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ABSTRACT

The purpose of this study was to investigate dairy processors market power in Iran. For this purpose, the dynamic imperfect competition model, in which processors are allowed to exert market power in both downstream (selling dairy products) and upstream (buying raw milk from dairy farmers) was applied. Market power parameters, dairy products demand, and raw milk supply elasticities were jointly estimated in a system of equations including market margin, dairy demand, and raw milk supply equations by none linear estimation technique. Data for the period 1992 to 2012 on the industry level were used for estimating an empirical version of the model. The result indicated that conjectural elasticities values were a departure from zero, which reflected non-competitive behavior in dairy market and in raw milk market specifically. Among three dairy products including pasteurized milk, yogurt, and cheese, the conjectural elasticity was the highest for the pasteurized market and the lowest for yogurt .The result suggests that dairy industries processors exercise marketing power in the downstream and upstream market in the dairy products supply chain. Therefore, policymakers must make appropriate policy for facilitating entrance conditions for new dairy processors and improve farmers' marketing cooperative so as to have more competitive raw milk price.

Keywords: Conjectural elasticity, Dairy products, Dynamic oligopoly and oligopsony, Dynamic imperfect competition model, market structure.

INTRODUCTION

Dairy farming is much more industrialized today than in the past in terms of resource, technology, and organizational structures and is one of the most important sectors of Iran's agriculture food economy. Values added of milk and dairy processing industries were about 9200 billion Rial which was about 22 percent of value added of food industries sector in Iran during 2012 (Ministry of Industry, Mine, and Trade).

In the 1980s, dairy farming in Iran was undergoing dramatic change, driven by both supply and demand factors. Consumption was shifting from raw milk, which was generally produced for local markets, toward manufactured products such as all kinds of pasteurized milk, cheese, butter, and yogurt. Innovations in breeding and feeding systems led to large increases in the amount of milk that a cow produced. Milk production in 2012 was over 5.9 million tons, which was double the 2.8 million tons produced in 1992. That means raw milk production had increased 5 percent annually. The increase in raw milk and dairy production led to a decline in imports of dairy products such as cheese and yogurt dramatically. The production trend of three products including pasteurized milk, cheese and yogurt are depicted in Figure 1.

About 85 percent of the raw milk is allocated to produce different types of

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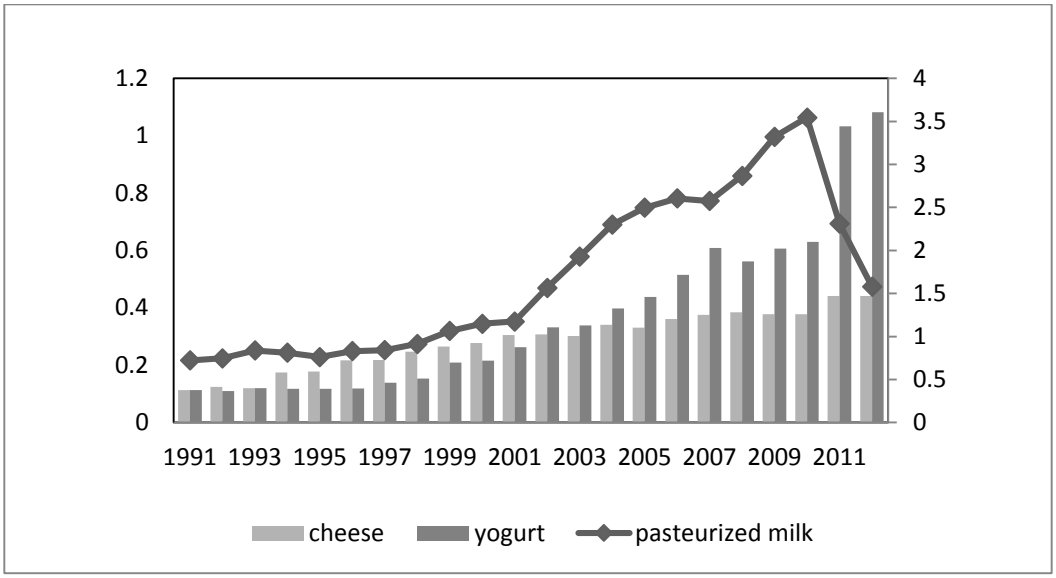

Figure 1. The production trends of three products include pasteurized milk, cheese, and yogurt.

pasteurized milk, yogurt, and cheese by dairy industry in Iran. During 1992 to 2012, the average annual production of pasteurized milk was about 2.1 million tonnes which was about 40 percent of total raw milk production. Average annual production of all different kinds of cheese and yogurt are, respectively, 0.36 and 0.47 billion tonnes and their shares from total raw milk are 35 and 9 percents, respectively. It is clear that from 1992 to 2010 three dairy products had increasing production trends. However, in the last two years, following the decline in demand, pasteurized milk supply has fallen sharply due to increased price following the decrease in pasteurized milk subsidies by the government.

According to Ministry of Industry, Mine, and Trade report, more than 600 private dairy companies are producing dairy products. More than 60% of dairy market share belongs to less than 10 large dairy companies. For example, Pegah Company has about 30 percent of dairy products market share by daily receiving 6,000 tons raw milk from different dairy farmers. In addition, about 70% of raw milk is bought by less than 9 percent of total dairy processing factories, while the National Agriculture Statistics Service has reported that raw milk is produced in almost all provinces in Iran and about 17,000 dairy farm produce raw milk. Consequently, each farmer has a very small share of raw milk marketing. In these circumstances, the existence of market power in upstream (toward farmer) and downstream (toward farmer) of dairy industries is possible in Iran. Therefore, the objective of this study was to estimate market power in Iranian dairy processing industry with dynamic imperfect competition model.

Economic theories and empirical results demonstrate that economic performance of dairy industries, and also social welfare, is influenced by the market mechanism. In other words, there is a causal relation between market power and social welfare in economics. This is because market structure in dairy industries can affect market outcomes by influencing the market participants incentives and their decision-making process. Market power arises when a company is manipulating price above marginal cost to gain more profits. In this situation, market structure departs from perfect competition and firms gain more profits from lower production. The existence of market power may be due to the low number of buyers or sellers, cost structure, brand entrance barriers, patent advantages, and etc.

To investigate market power, two common approaches have been applied in literature: The Structure-Conduct-Performance (SCP) and New Empirical Industrial Organization

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(NEIO). SCP approach draws a positive relation between market concentration and the economic performance in terms of profits. This positive relation is usually interpreted as the exercise of market power (Schmalensee, 1989). In the beginning of the 1970s, progress made in game theory led to extensive research in the context of firm competition, marketing channel, and various advertising strategies (Moorthy, 1993). Also, it was found that market outcomes and profitability are not only a function of the structural characteristics used in SCP studies. Rather, they are affected by industry and firm-specific demand and cost characteristics that are difficult to model within the SCP framework (Bresnahan, 1989). A consequence of these insights has led to development of the NEIO literature. This approach has utilized more detailed data of demand, cost, and competition feature in analyzing firms' marketing mixture and profitability relation. NEIO approach has frequently been used to investigate market power in food sector in the US, Australia and Canada (Schroeter, 1988; Schroeter and Azzam, 1990; Azzam and Pagoulatos, 1990; Azzam, 1997; Bhuyan and Lopez, 1997; O'Donnell *et al*., 2007; Bunte and Peerlings, 2003; Tostao *et al*., 2011).

The common feature of most NEIO literature is that firms engage in a sequence of static games assumption for optimizing their profit. Therefore, by changing economic conditions, the firm could be able to react immediately (Williams and Isham, 1999). Also, by this assumption, a firm maximizes its current profit given its belief about how its rivals behave and assuming that actions in other periods do not affect behavior in this period. But, some researchers indicate that the traditional static measures of market power are misleading when firms play a dynamic game (Dockner, 1992; Slade, 1995; Corts, 1999). Fundamental and strategic reasons may cause the firms to play the dynamic games rather than the static games. When the firm's current decisions alter the rivals' future behavior, there is a strategic reason. If the firm's current decision changes stock variables and its profit, there is a fundamental reason for solving the dynamic problem by the firms (Perloff *et al*., 2007).

In the dairy industries supply chain, processors deal with the dairy farmers for producing raw milk and retailers for selling dairy products i.e. most of the dairy factories in Iran have a distribution system and sell their products to the retailer directly, therefore, wholesalers are eliminated. Producing raw milk directly is dependent on herd size and the number of livestock as quasi-fixed input which leads to dynamics in milk supply. In other words, farmers could not immediately react to the changes of economic situations and processors' dynamic profit function comes from dynamic milk supply.

Thus, in this study, we aimed to use dynamic imperfect competition model for investigating dairy processors market power given the presence of both oligopoly and oligopsony power at the same time. While in most studies oligopoly or oligopsony power are separately investigated in the dynamic framework (Dockner, 1992; Karp and Perloff, 1993a, b; Deadhar and Sheldon, 1996; Hunnicut and Aadland, 2003; Richard *et al*., 2001). Notable exceptions are Steen and Salvanes (1999), Shabbar *et al*. (2003) and Sckokai *et al*. (2013) who used the dynamic imperfect competition model in which processors were allowed to exert oligopsony and oligopoly power simultaneously. Also, to our knowledge, this study is unique in assessment of market power in a dynamic framework in Iran.

MATERIALS AND METHODS

Theoretical Model

The market power of dairy industry is analyzed in the context of a dynamic imperfect competition model of the supply chain using a conjectural variations approach based on the Perloff *et al*. (2007) model. As described previously, dairy products supply chain consists of three main components. In this supply chain, processors dealing with the farmer for buying raw milk and retailers for selling dairy products.

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According to the description of dairy industry status in the previous section, the price taker assumption of farmers and retailers and the ability of dairy processors to exert downstream and upstream market power could be reasonable. Raw milk is a perishable good and the number of dairy farmers and retailers are numerous, therefore, in this study, it was assumed that dairy farmers and retailers are a price taker and dairy processors could potentially exert downstream and upstream market power. We also assumed that the supply of processors coincides with the demand of retailers in the same time. In addition, we assumed retailers demand elasticities were the same with households dairy demand elasticities. Since dairy products including milk, cheese, and yogurt are not storable by retailers, for buying raw milk and selling dairy products, dairy processors face with raw milk supply and dairy products demand.

The consumer demand for dairy products is assumed to be obtained by consumer utility maximization problem subject to a budget constraint. Thus, at time t, the inverse market demand of jth dairy products takes the following general form:

$$P_{jt}^{c} = P_{jt}^{c}\left(Q^{c}{}_{jt}, e_{jt}\right) \qquad j = 1,2,3 \quad (1)$$

Where, $Q^{c}{}_{jt}$ is the vector of market quantities of milk, cheese, and yogurt, P_{jt}^{c} is jth dairy product consumer price, and e_{jt} is demand shifter.

As mentioned before, raw milk production by farmers is directly dependent on herd size and the number of livestock as quasi-fixed input, and this property leads to dynamics in milk supply. Therefore, the corresponding inverse raw milk supply is:

$$P_{t}^{m} = P_{t}^{m}(Q_{t}^{m}, Q_{t-1}^{m}, s_{t}) \quad (2)$$

Where, P_{t}^{m} is raw milk price, Q_{t}^{m} and Q_{t-1}^{m} are the raw milk supply in period t and t-1, and s_{t} is raw milk supply shifter. The processor's profit at time t can be written as:

$$\pi_{i} = \sum_{j=1}^{3} P_{jt}^{c}\left(Q^{c}{}_{jt}, e_{jt}\right) q_{jt}^{c} - P_{t}^{m}(Q_{t}^{m}, Q_{t-1}^{m}, s_{t}) q_{t}^{m} - C_{t}\left(\sum_{j} q_{j}^{c}, f_{t}\right) \qquad j = 1,2,3 \quad (3)$$

Where, q_{jt}^{c} is the quantity of *j*th dairy product production in period *t*, q_{t}^{m} is raw milk quantity, C_{t} is dairy products processing cost, and f_{t} is processing cost shifter.

If there is a constant return to scale and similar production technology in producing dairy products, dairy products production function is:

$$q_{jt}^{c} = \alpha_{j}\gamma_{j} q_{t}^{m} \quad (4)$$

Where, α_{j} is the raw milk conversion factor to *j*th dairy products, γ_{j} is the share of raw milk for production of jth dairy product into total consumed raw milk by the ith processor.

By substituting production function in Equation (3), the *i*th processor profit function could be rewritten as a follow:

$$\pi_{i} = \sum_{j=1}^{3} \alpha_{j}\gamma_{j} P_{jt}^{c}\left(Q^{c}{}_{jt}, e_{jt}\right) q_{t}^{m} - P_{t}^{m}(Q_{t}^{m}, Q_{t-1}^{m}) q_{t}^{m} - C_{t}(q_{t}^{m}, f_{t}) \qquad j = 1,2,3 \quad (5)$$

As mentioned before, processors profit function is dynamic because of the existence of dynamic raw milk supply. The processor does not know the exact future price and quantity of supply milk or the marginal effect of current actions on these variables or on the variance of the price. Therefore, processor's objective is to maximize the present discounted value of its expected profits:

$$E_{t}[\sum_{\tau=0}^{T} \delta^{T} \pi_{t+\tau}] \quad (6)$$

Where, δ is the discount rate. This problem can be written as a form of Bellman equation with two discrete periods. Thus, the firm's dynamic programming equation can be written as:

$$J\left(Q^{m}{}_{t-1}, M_{t}\right) = \max E_{t}\left[\pi_{t} + \delta J(Q_{t}^{m}, M_{t+1})\right] \quad (7)$$

Where, $J(.)$ is processor's value function, which represents the equilibrium value of its pay off. This value function depends on the state variable (the level of raw milk supply

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at time t-1) and on the exogenous variables at time t (M_t) (dairy products price, processing cost and supply, demand and cost shifters). The value function on the left side of the equation equals the maximized value of the expectation of the sum of current profits (π_t) and discounted continuation profits. Assuming there is an interior solution (q_t^m), the first order condition for maximizing the value function is:

$$E_t\left[\partial\pi_t/\partial q_t^m + \delta\left(J_{Q^m}(t+1).\partial Q_t^m/\partial q_t^m\right)\right] = 0 \quad (8)$$

In Equation (8), $J_{Q^m}(t+1)$ is the partial derivative of value function with respect to the state variable$Q^m{}_t$, at time *t* and denotes the shadow value. In other words, it equals the expected change in the present discounted value of the firm's payoff due to a small change in the lagged raw milk supply quantity at time *t*.

Our objective was to obtain an estimable equation for estimating necessary parameters (market power parameter and unknown parameter in cost and demand function). That is, the endogenous and unknown shadow value should be eliminated.

If the optimum solution for first order condition is q^{*m}_t, then the maximized dynamic programming is:

$$J(Q_{t-1}^m, M_t) = \left[\pi_t(q^{*m}_t) + \delta J(Q_t^m, M_t)\right] \quad (9)$$

Then, by using the envelope theorem and the open-loop assumption, the derivative of both sides of Equation (9) is taken with respect to Q_{t-1}^m. In the open-loop, the assumption is that changes in the firm's state variables do not affect the rivals' controls.

$$J_{Q^m}(t) = \left[\partial\pi_t/\partial Q^m{}_{t-1} + \delta E_t J_{Q^m}(t+1).\partial Q_{it}^m/\partial P_{it}^m . \partial P_{it}^m/\partial Q_{it-1}^m\right] \quad (10)$$

By advancing Equation (10) by one period and taking expectation conditional on the current information, we have the fallowing equation:

$$E_t\left[J_{Q^m}(t+1)\right] = E_t\left[\partial\pi_{t+1}/\partial Q^m{}_t + \delta E_t J_{Q^m}(t+2).\partial Q_{it+1}^m/\partial P_{it+1}^m . \partial P_{it+1}^m/\partial Q_{it}^m\right] \quad (11)$$

By arranging Equation (8), the function $E_t J_{Q^m}(t+1)$ is obtained.

$$E_t J_{Q^m}(t+1) = -1/\delta . \partial\pi_t/\partial q_t^m . \partial q_t^m/\partial Q_t^m \quad (12)$$

And combining Equations (11) and (12), the below equation results:

$$-1/\delta . \partial\pi_t/\partial q_t^m . \partial q_t^m/\partial Q_t^m = E_t\left[\partial\pi_{t+1}/\partial Q_t^m \left(\partial\pi_{t+1}/\partial q_{t+1}^m . \partial q_{t+1}^m/\partial Q_{t+1}^m . \partial Q_{t+1}^m/\partial P_{t+1}^m . \partial P_{t+1}^m/\partial Q_t^m\right)\right] \quad (13)$$

Equation (13) could be written in inestimable and tabloid form in Equation (14) by differentiating from firm's profit with respect to q_t^m and q_{t+1}^m as fallow:

$$m = \varepsilon^m\theta^m\left(\beta P_{t+1}^m - 1/\delta P_t^m\right) - \sum_j \varepsilon_j\theta_j\alpha_j\left(\gamma_{jt+1}\beta P_{jt+1}^c - 1/\delta\,\gamma_{jt}P_{jt}^c\right) + \beta/\delta\, MC_{jt} + \rho Q_{t+1}^m \quad j = 1,..,3 \quad (14)$$

Where:

$$m = -1/\delta\left(\sum_j P_{jt}^c\,\alpha_j\gamma_j - P_t^m\right) + \beta\left(\sum_j P_{jt+1}^c\,\alpha_j\gamma_j - P_{t+1}^m\right)$$

$$\theta_j = \frac{\partial Q_{jt}^c}{\partial q_{jt}^c}\frac{q_{jt}^c}{Q_{jt}^c} = \frac{\partial Q_{jt+1}^c}{\partial q_{jt+1}^c}\frac{q_{jt+1}^c}{Q_{jt+1}^c},$$

$$\theta^m = \frac{\partial Q_t^m}{\partial q_t^m}\frac{q_t^m}{Q_t^m} = \frac{\partial Q_{t+1}^m}{\partial q_{t+1}^m}\frac{q_{t+1}^m}{Q_{t+1}^m}$$

$$\varepsilon_j = \frac{\partial Q_{jt}^c}{\partial P_{jt}^c}\frac{P_{jt}^c}{Q_{jt}^c} = \frac{\partial Q_{jt+1}^c}{\partial P_{jt+1}^c}\frac{P_{jt+1}^c}{Q_{jt+1}^c},$$

$$\varepsilon^m = \frac{\partial Q_t^m}{\partial q_t^m}\frac{q_t^m}{Q_t^m} = \frac{\partial Q_{t+1}^m}{\partial q_{t+1}^m}\frac{q_{t+1}^m}{Q_{t+1}^m}$$

In this equation, m is the present value of the expected market margin changes that depends on the dairy products price (hereafter, we refer to this equation as a "market margin equation"), raw milk price and processing marginal cost. Moreover,

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$\beta = {\partial Q_{t+1}^{m}}/{\partial Q_{t}^{m}}$ and θ_j and φ are, respectively, conjectural elasticity's for *j*th dairy product and raw milk markets. Also, ε_j and ε^m are, respectively, *j*th demand own price elasticity and raw milk supply elasticity.

Similar to most of this type of studies, in order to obtain an estimable form of Equation (14), we worked with aggregate data. This means aggregation over processors is done. Thus, in each period, q_j^c , q^m were replaced by corresponding market quantities Q_j^c , Q^m. Also, we assumed linear aggregation of industry output.

In order to obtain the empirical version of our model, it was necessary to specify the functional forms for the demand functions, the supply functions, and the marginal cost of processing.

The demand side of our model considers households consumption of dairy products. To model final consumption, we used the Almost Ideal Demand System (AIDS) specification. The AIDS model has some advantages that make it popular. For example, this model is compatible with aggregation over consumers and the liner version of ADIS is easy to estimate and interpret (Eales and Unnevehr, 1988; Alston and Chalfant, 1993). The AIDS model can be defined as:

$$w_{it} = \alpha_i + \sum_{j=1}^{3} \gamma_{ij} \ln P_{jt} + \beta_i \ln\left(\frac{X_t}{P_t}\right) \qquad i = 1,2,3,4 \qquad (15)$$

Where, w_{it} is the budget share of ith dairy products, X_t is the total household expenditure on milk, cheese, yogurt, and butter, P_t is the Stone price index, and , μ_{ij}, and τ_i are parameters to be estimated. The theoretical properties of homogeneity, symmetry, and adding-up are maintained through some restrictions on demand parameters. It is worth mentioning that more than 85% of Iranian butter consumption needs are satisfied by imports. Therefore, we don't analyze its market power. But, consumers consume the butter in breakfast with milk and cheese and it is on the dairy products group for consumers. For this reason, in estimating dairy demand, butter demand is estimated by the other three dairy products for reasonable estimation. Marshallian (uncompensated) elasticity for the demand equations at the mean point of the sample was estimated by using the formulas reported by Jung and Koo (2000)

$$\varepsilon_{ij}^{M} = -\delta_{ij} + \gamma_{ij} w_{it} - \beta_i \left({w_{jt}}/{w_{it}}\right) \qquad (16)$$

Where, δij= 1 for *i*= *j* and δij= 0 for *i*≠ *j* and expenditure elasticity can be calculated as follows:

$$\eta_{it} = 1 + {\beta_i}/{w_{it}} \qquad (17)$$

We employed a standard (quantity dependent) linear supply function for raw milk. It means that raw milk supply can be written as:

$$\mathrm{Q_t^{rm}} = \sigma_0 + \sigma_1 Q_{t-1}^{rm} + \sigma_2 P_t^{rm} + \sigma_3 P_t^{fd} + \sigma_4 Q_{t-1}^{dm} \qquad (18)$$

Where, Q_{t-1}^{dm} is the volume of imports of dry milk at t-1 and P_t^{fd} is the concentrate price as a proxy of dairy cow feed price. Q_{t-1}^{rm}, $\mathrm{Q_t^{rm}}$ and P_t^{rm} are introduced previously. Dairy processor can substitute fresh dairy milk with raw milk in processing and producing some dairy products. But, this substitution depends on price ratio, though in some cases it is expected to reduce demand of fresh raw milk.

Also, we assumed marginal cost of dairy products were the same and a linear function of wage index (P_{wi}), capital price (P_{cp}) and packing price (P_{pk}) in dairy processing industry:

$$mc = \vartheta_1 P_{wi} + \vartheta_2 P_{pk} + \vartheta_3 P_{cp} \qquad (19)$$

Capital market price of dairy industry calculated from the summation of capital return ratio (capital return ratio was equivalent to official long run interest rate and it is independent of kind of capital assets) and rate of depreciation minus capital gain (capital gain and rate of depreciation were calculated for two kinds of capital assets including machinery and building, because the machinery and building stocks are, respectively, about 60 and 20% of the capital stock in Iranian dairy industry). Also, the packing price was calculated from 12% of consumer price for every dairy product and

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then we used weighted average according to the value of dairy products production in each year.

Given estimates of the conjectural elasticities, the useful measures of the degree of exertion of market power in each product can be developed from Equation (20) (Schroeter and Azzam, 1990):

$$L_i = \frac{p_j - p^m - mc}{p_j - p^m} \quad (20)$$

Where, $p_j = \alpha_j . P_j^c$ is the price of a unit of processed raw milk and other variables are introduced in the previous section.

Data and Estimation

Yearly frequency data for the period 1992 to 2012 is used for estimating an empirical version of the model. Unfortunately, the divided information about different types of production, consumption or price of milk, cheese or yogurt isn't available. In this study because of insufficient data, we used aggregate production and consumption of different types of liquid milk, cheese, and yogurt. Information on the households' dairy consumption both in value and in quantity has been retrieved from the Households Income and Expenditure Survey (HIES), which this information are published by Statistical Center of Iran every year. The required data for estimating raw milk supply include raw milk production, its price and concentrate price are received from Ministry of Agriculture-Jahad for case studying period. Also, the volume of dry milk import is available on the FAO Stat site. Data on the wage index and capital stocks of different types of assets (machinery and building) in Iran's dairy industry are available from Statistical Center of Iran. In market margin equation, the dairy producer price is applied. But, for estimating demand and calculating price elasticity, dairy consumer price was used.

The system of equation is estimated using nonlinear maximum likelihood estimator by Shazam software. The system includes five equations, one market margin (14), one raw milk supply (18) and three demand equations (15). Starting values for estimating this system have been constructed by OLS separate estimation of equations. It should be noted that marginal cost equation is placed in the market margin equation when the system of equations is estimated.

RESULTS AND DISCUSSION

The parameter estimates of the system of five equations (14, 15, and 18) are reported in Table 1. The results show that statistically significant parameters are present in all equations, and this is a signal that the estimation technique performed well. Thus, the goodness of fit such as R^2 statistics shows that for all equations, the value is above 70 percent for the system of equation. The stationary of residuals is tested by Augmented Dickey-Fuller test. The null hypothesis of non-stationarity (unit roots) was rejected at the 1% significance level. The residuals from five equations were found to be stationary. Normality test of residuals was performed under the assumption that the errors were normally distributed and we couldn't reject the null hypothesis at the 1% significance level. To test residuals autocorrelation, LM test and correlogram diagram were checked out. The statistics and diagram showed autocorrelations at various lags hover around zero. The problem of heteroskedasticity is likely to be more common in cross-sectional than in time series data (Gujrati, 2004), but we tested it by Park test and accepted the assumption of homoscedasticity. Also, multicollinearity among explanatory variables of the system equations was accomplished by inspection of the eigenvectors and eigenvalues. However, multicollinearity between milk and yogurt prices were not detected. Therefore, the yogurt demand function was eliminated and parameters were obtained by adding up condition.

Homogeneity and symmetry conditions were imposed to the demand equations. For a better explanation of demand parameters, analysis of dairy demand can be done by calculating elasticities. Table 2 shows the Marshallian (uncompensated) price elasticity (17) and expenditure elasticity estimates for the demand equations at the sample mean.

The demand functions are well behaved and both own-price and expenditure elasticities have the expected signs. This result suggests

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Table 1. Estimated parameters of the system of equations.

	Variable	Parameter	Coefficient	*T*-stat	Coefficient	*T*-stat	Coefficient	T-stat
Demand			**Milk**		**Cheese**		**Butter**	
Constant		π_{i0}	-0.91	-2.15	1.60	6.80	-0.48	-2.65
Milk price	P_{1t}	μ_{i1}	0.04	0.85	-0.03	-1.5	-0.04	-2.15
Yogurt price	P_{2t}	μ_{i2}	0.04	-	-0.10	-	-0.03	-
Cheese price	P_{3t}	μ_{i3}	-0.03	-1.5	0.12	2.71	0.02	1.6
Butter price	P_{4t}	μ_{i4}	-0.04	-2.15	0.02	1.6	0.06	3.5
Total expenditure	$ln\left(\frac{X_t}{P_t}\right)$	τ_i	0.25	3.45	-0.25	-7.34	0.07	2.42
R^2			0.80		0.95		0.77	
Raw milk supply								
Constant		σ_0	994.07	5.32				
Raw milk supply at *t*-1	Q_{t-1}^m	σ_1	0.53	3.98				
Raw milk price	P_t^m	σ_2	1.36	3.36				
Concentrate price	P_t^f	σ_3	-1.05	-2.96				
Dry milk imports at *t*-1	Q_{t-1}^{dm}	σ_4	-0.04	-1.86				
R^2			0.90					
Marginal cost								
Wage index	P_l	ϑ_1	0.06	1.07				
Capital price	P_k	ϑ_2	-533.29	-2.83				
Packing price	P_p	ϑ_3	1.50	7.30				
R^2			0.92					

that these commodity groups satisfy the demand law. The own price elasticities are lower than unity, indicating that demand is inelastic in all cases. However, the results show that pasteurized milk demand is more sensitive to the own price changes with respect to the other dairy products. What it means is that with rising prices of dairy products, the reduction of pasteurized milk consumption will be greater than other products. Evidence of this result can be seen in Figure 1 in 2010 when reduction in consumption was accompanied by a reduction in dairy consumption subsidies and rise in prices of dairy products. Looking at cross-price effects between milk and cheese represent the degree of substitutability. This could be due to the pattern of pasteurized milk and cheese consumption in Iran. Because these two products are often consumed together in breakfast. Also, yogurt and pasteurized milk are complementary. The last column of Table 2, shows the income elasticity of cheese is lower than the other products. This means that demand for pasteurized milk, yogurt, and butter are relatively more sensitive to the amount spent by consumers with respect to the cheese. In fact, cheese demand is inelastic with respect to total expenditure, thus, it can be classified as necessity goods. This could be due to the cheese being the main food for Iranian households' breakfast.

The supply of raw milk (18) by the dairy farmer is well behaved and the elasticities are shown in Table 3. The explanatory variables have expected signs. By increasing dry milk imports, the dairy factories can replace some part of fresh raw milk usage by imported dry milk and it leads to the decrease in the raw milk price in the market and, consequently, causes decrease in the supply of raw milk by dairy farmers. Also, increases in concentrate price for dairy farmer cause increase in raw milk production cost, thereby decreasing supply of raw milk. The positive sign of raw milk price, in addition to being consistent with supply theory, shows positive own price supply elasticity of raw milk. The most interesting economic parameters for policy analysis are elasticities. Table 3 summarizes the estimated supply elasticities computed at sample means based on the estimated parameters. Inelastic supply price of raw milk implies disability of farmers to react to the price changes immediately. If the price of milk increases one percent, the milk supply is increased 0.62 percent. Also, the significant parameter of Q_{t-1}^{m} in raw milk supply equation reflects the dynamics of the raw milk supply function. Negative elasticities of concentrate price and dry milk imports indicate that one percent increase in them would lead to, respectively, 0.31% and 0.1 percent reduction in raw milk supply.

Marginal costs of dairy processors are positively related with packing cost and labor cost in dairy processor companies, while they are negatively related to capital price. Marginal cost parameters significantly differ from zero.

Without a doubt, the most important part of the results is about the conjectural elasticities in dairy products and raw milk supply markets. After estimating a system of equation and calculating dairy demand and raw milk supply elasticities, the conjectural elasticities were calculated in both downstream (selling dairy product) and upstream (buying raw milk from the dairy farmer) for dairy processors in Iran. The results of these elasticities are illustrated in Table 4.

Table 2. Demand elasticities at the mean point.

	Milk price	Yogurt price	Cheese price	Butter price	Income
Milk quantity	-0.84	0.01	-0.62	-0.3	1.9
Yogurt quantity	0.19	-0.46	-0.33	-0.24	1.26
Cheese quantity	0.08	-0.11	-0.76	0.1	0.42
Butter quantity	-0.67	-0.40	-0.15	-0.4	1.7

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Table 3. Raw milk supply elasticities at the mean point.

	Raw milk price	Raw milk quantity in (t-1)	Concentrate price	Dry milk imports
Raw milk quantity	0.62	0.51	-0.31	-0.1

The conjectural elasticity values are a departure from zero. These results would suggest that there is a deviation from price taking behavior in either of the output sectors or the input sector.

Among three dairy products including pasteurized milk, yogurt, and cheese, conjectural elasticities of pasteurized milk was the highest and the yogurt was the lowest. Households' consumption statistics show that yogurt consumption in the period under review has increasing trend. During 2010, 2011, and 2012, pasteurized milk and cheese consumption suddenly decreased because of fundamental changes in dairy price and production subsidies, but household yogurt consumption was increased. In addition, comparing the demand elasticities for dairy products show that yogurt has the lowest demand elasticity. The existence of these consumption conditions could be due to the fairer price of yogurt compared to pasteurized milk and cheese. In the raw milk market, the conjectural elasticity is 0.78, which that represents the existence of intensive market power in upstream (toward dairy farmers). Raw milk departure from the competitive market can be due to the large number of farmers against the dairy processors, raw milk high spoilage and inability to maintain the quality of the milk produced by farmers.

Wald test on these market power parameters was applied. At first, the perfect competition, in general, was tested. The null hypothesis that all market power parameters are equal to zero ($\theta_1 = \theta_2 = \theta_3 = \varphi = 0$) was rejected at the 1% level of significance with 375.09 test statistic. Second, the market power toward consumers in all three markets was checked. The test statistic was equal to 287.8, rejecting the null hypothesis of $\theta_1 = \theta_2 = \theta_3 = 0$ at the 1% level of significance. These results showed the existence of market power toward the dairy consumers.

The market of dairy products is a departure from competitive according to the results of conjectural elasticity in Table 4. Therefore, the prices of these products are not equal to the marginal costs. The price distortion (Lerner) indices were calculated and the average values of L_i over the sample period were 0.42, 0.32, and 0.46 for milk, yogurt, and cheese, respectively, with decreasing trend. Therefore, the price distortion decreased over the time for dairy products. The price of dairy products can be decreased by about 40% averagely, if the structure of dairy markets become competitive.

CONCLUSIONS

In this study, the role of market power by processors was evaluated within the supply chain of dairy products in Iran. We focused on the role of processors because a small number of dairy companies owned more than 60% of dairy market share, the number of dairy farmers and retailers was large compared to the dairy processors, raw milk high spoilage, impossibility of quality maintenance of raw milk by farmers, and the rise in dairy consumption. We analyzed market power in

Table 4. Marketing power (Conjectural elasticities) in downstream and upstream for dairy processors in Iran.

	Milk	Yogurt	Cheese	Raw milk
Parameter	θ_1	θ_2	θ_3	φ
	0.70^{***}	0.48^{***}	0.62^{***}	0.78^{***}

*** Indicate significant at the 1% level

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the context of a dynamic imperfect competition model, under a quantity setting approach as presented in Perloff *et al*. (2007). The model was extended to which processors are allowed to exert market power in both downstream (selling dairy products) and upstream (buying raw milk from dairy farmers). For this purpose, a system of 5 equations including market margin and demand and supply equations was estimated by nonlinear maximum likelihood estimator on the industry level data and market power parameters, demand and supply elasticities were calculated.

The results showed that the price elasticity of pasteurized milk was more than the other dairy products and consumption was sensitive to the consumers' income. Since the per capita consumption of this essential food is very low in Iran, promoting consumption by advertising and more attention by government and policymakers to the raw milk price variations are necessary.

We found evidence of market power in dairy products and raw milk market. The existence of a noncompetitive market in dairy products leads to decrease in consumer welfare. Also, price and income elasticities of dairy products show that every action in increasing dairy market efficiency and decreasing dairy products price can increase consumption of dairy products in Iran. On this basis, policy makers must pay more attention to the dairy supply chain structure, make appropriate policy for facilitating entrance conditions of new dairy processors, and prepare market condition for efficient price in the competitive market. Raw milk in Iran is supplied by numerous farmer, i.e. more than 17,000, thus, improving farmers' bargaining power and, consequently, raw milk price can improve dairy farmers' livelihood and increase their welfare. Also, improving farmers' marketing cooperative can help in having more competitive raw milk price.

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بررسی قدرت بازار در صنعت لبنیات ایران با کاربرد الگوی رقابت ناقص پویا

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چکیده

هدف از این مطالعه بررسی قدرت بازاری فراوری کنندگان لبنی در ایران است. برای این منظور الگوی رقابت ناقص پویا به کار گرفته شد که در آن امکان وجود قدرت بازاری فرآوری کنندگان در پایین دست (فروش فرآورده‌های لبنی) و بالادست (خرید شیرخام از دامداران) فراهم شد. پارامترهای قدرت بازار، کشش‌های عرضه و تقاضای شیر و فرآورده‌های لبنی در یک سیستم معادلات شامل معادله حاشیه بازار، تقاضای محصولات لبنی و عرضه شیرخام، به طور همزمان به وسیله روش تخمین غیرخطی برآورد شد. داده‌های به کار رفته به صورت سالیانه در بازه زمانی ۱۳۷۱ تا ۱۳۹۱ در سطح صنعت می‌باشد. نتایج نشان می‌دهد که مقادیر کشش انتظاری از صفر فاصله دارد. بنابراین رفتار فرآوری کنندگان در بازار شیر و فرآورده‌های لبنی از رقابتی فاصله دارد. در میان سه محصول لبنی شامل شیرپاستوریزه، ماست و پنیر، شیرپاستوریزه دارای بیشترین و ماست دارای کمترین کشش انتظاری است. نتایج نشان می‌دهد که فرآوری کنندگان صنعت لبنیات در زنجیره تأمین فرآورده‌های لبنی دارای قدرت بازاری هستند. بنابراین سیاست‌گذاران بایستی سیاست‌های مناسب در جهت تسهیل ورود بنگاه‌های جدید در صنعت لبنیات و بهبود فعالیت تعاونی‌های بازاریابی شیرخام را اتخاذ نمایند.

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