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# Demand for Natural Gas in Food and Beverage Industries of Iran

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**ABSTRACT**

Food and beverage industries play crucial roles in satisfying food requirements. They rely on various kinds of energy to prepare and process foodstuff. The relative prices, technology level, sector growth and machinery status determine use of energy carriers in these enterprises. This paper examines the relationships among natural gas use, value-added and energy prices in food and beverage industries of Iran during 1978-2014. The decision unit is food-manufacturing workplace. By considering microeconomic basics and applying co-integration approach, demand for natural gas is estimated. Due to the long-run nature of co-integrating relationships, the long run own- and cross- price elasticities and income elasticity are estimated. Our findings show that natural gas is a luxury input in food industry, it is highly elastic to its price; and electricity and oil products are substitutes for natural gas. In a growing food sector, we would expect natural gas use to increase more rapidly.

**Keywords:** Natural Gas, Food Industry, Price Elasticity
**JEL Classifications:** D21, Q13, Q41

## 1. INTRODUCTION

The rapid economic growth of societies has resulted in formation new eating habits, so that the diversity in foodstuffs has been increased and traditional foods have been evolved into the ready and conserved foods. The expansion of food and beverage industries, on one hand, has raised the access to different kinds of foods, and on the other hand, it has created new threats for health due to changes in nature of foods amid conservation, processing and packaging. As a result, in order to reduce the negative effects of ready and processed foods, food standardization schemes such as hazard analysis and critical control points have been introduced.

The urban lives and activities have declined share of home foods and have driven people to consume the ready foods. Food and beverage industries encompass a wide range of activities from materials preparation, production, processing, conservation and transportation. They include all operations, which transform raw materials originating from catching and harvesting farm and animal products to consumable foods.

The main food and beverage industries in Iran consist of dairy industry, cereals, meat, edible oils, sweets and candies, vegetables, fruits and beverages. Currently, about 2900 food producers are operating across the country in the following food groups: Hamburger, spaghetti, wafer and biscuits, beverages, meat, saffron, honey, cake, dates, bread, flour, protein, fish, ice cream, tomato sausage, tomato and so on. According to official data of Statistical Center of Iran, these firms employ 230 thousands workers totally.

With an arid and semi-arid weather and a population over than 79 million people, Iran is planning to secure food for its citizens. The specific ideological view of the political system, in particular, self-sufficiency in agricultural sector, triggers the provision of safe and sufficient food in Iran. More specifically, article 2 of general policies of agriculture in Iran, which is approved by the Expediency Discernment Council of the System points to meet food security with an emphasis on production by domestic resources, to achieve self-sufficiency in basic products and to improve health of foodstuffs through reforms in consumption and production patterns (Offered General Policies: NO. 24-20-10-1391). In addition, article 7 refers to upgrade the quality of food.

As indicated by Maslow's hierarchy of needs, food is one of the basic needs for humans (Maslow, 1943). Everyday life is dependent on food along with water and air. In a normal environment, food supply is met by interaction of farmers, food businessmen and government. However, critical conditions such as war, natural disasters and trade sanctions result in lack of food. Food and beverage industries as connectors of farmers to consumers are responsible for providing healthy and standard foodstuffs for human beings and animals. These industries play crucial roles in food security for all nations, too. Various inputs are used to produce and to process the foods. Besides crude corps and grains, manpower, energy and machinery are vital inputs in the food processing and manufacturing.

Due to vital shares of energy carriers in completing production chain, this paper investigates the factors affecting demand for natural gas use in food and beverage industries in Iran during 1978-2014.

This paper includes 5 sections. Section 2 reviews pertinent literature. Section 3 devotes to materials and methods. In this section, the mathematical function is shaped in accordance with microeconomic demand theory. Section 4 contains discussion and results. Because of using annual time series, all variables are tested against unit root. Then, the co-integration approach was applied to derive long-run relationships among natural gas consumption and its main determinants such as value-added, own and cross prices of natural gas at firm level. Finally, Section 5 concludes.

## 2. REVIEW OF LITERATURE

The most of studies on food have focused on economic analysis of household behavior, public policies, pricing and marketing, and food trade. For example, Attanasio et al. (2013) analyzed the welfare consequences of increases in food prices in Mexico using micro-level data and concluded that the poor have been affected by the increases in relative prices of foods.

Manrique and Jensen (1997) found that the value of women's time, income, and household demographic variables are main determinants of expenditures on convenience meat goods, especially across the large and high-income families in Spain.

Arndt et al. (2016) studied the relationship between shifts in food prices and child nutrition status in a low income setting and concluded that food penury, driven by the food and fuel price crisis combined with a short agricultural production year, increases the malnutrition amongst under-five children in Mozambique.

Agheli and Emamgholipour (2016) explained fast food consumption pattern among the Iranian urban households over the 2008-2013 period and indicated that the relative expenditure on fast foods and snacks is significantly linked with non-wage incomes, total income, and relative food prices.

Ferrière and Suwa-Eisenmann (2015) examined the impact of food aid on households' marketing behavior, based on a panel of households followed during 1994-2009 in 15 villages of Ethiopia. They found that food aid reduces the probability of being a producer.

Bilgic and Yen (2013) estimated demands for sixteen food products using data from the Turkish Household Expenditure Survey by the linear approximate almost ideal demand system. They obtained a mix of gross substitutes and complements, while net substitution is the dominant pattern.

A number of researches have devoted to energy issues in food sector. For instance, Ogunjuyigbe et al. (2015) presented electrical energy conservation strategy in Nigerian food and beverage industries with the view of devising means to reduce their energy consumption. They studied the electrical energy consumption trends in the industry using a walk-through energy audit of four food and beverages industries. They found that replacing standard motors with super-efficient motors would save considerable energy per annum for industries, which in turn reduces the energy bill significantly.

Using monthly data between 1970 and 2013, De Nicola et al. (2016) provide a comprehensive analysis of the extent of co-movement among the nominal price returns of 11 major energy, agricultural, and food commodities. They study the degree and the time evolution of unconditional and conditional correlations using a uniform-spacing estimation, multivariate dynamic conditional correlation models, and a rolling regression procedure. They find that (1) the price returns of energy and agricultural commodities are highly correlated; (2) the overall level of co-movement among commodities increased, especially between energy and agricultural commodities; and (3) the stock market volatility is positively associated with the co-movement of price returns across markets, especially after 2007.

With regard to the food prices and food security in Finland, Irz et al. (2013) estimated a vector error-correction (VEC) model to investigate the short-term and long-term dynamics of food price formation using monthly series of price indices from 1995 to 2010. The results indicated that a statistically significant long-run equilibrium relationship exists between the prices of food and those of agricultural commodities, labour, and energy. In addition, farm prices represent the main determinant of food prices, followed by wages in food retail and the price of energy.

Gardebroek and Hernandez (2013) examined volatility transmission in oil, ethanol and corn prices in the United States between 1997 and 2011. Using a multivariate generalized autoregressive conditional heteroskedasticity approach, they evaluated the level of interdependence and the dynamics of volatility across these markets. The estimation results indicated a higher interaction between ethanol and corn markets, particularly after 2006 when ethanol became the sole alternative oxygenate for gasoline. They observed significant volatility spillovers from corn to ethanol prices. They also did not find major cross-volatility effects from oil to corn markets.

In a research on relationship between biofuel, as a substitute for fossil fuel in the energy market, and food, Bahel et al. (2013), found a positive linkage between energy and food prices. They concluded that the equilibrium price of food will be growing as long as the oil stock is being depleted, and beyond if demand is growing.

Lin and Lei (2015) evaluated the changes in carbon dioxide emissions from energy consumption in China's food industry

**Table 1: Descriptive statistics of main variables (period: 1978-2014)**

| Var. | Measurement unit | Mean | Median | SD | JB stat.[P] |
|---|---|---|---|---|---|
| *PG* | IRR/$m^3$ | 59.41 | 59.31 | 15.59 | 0.63[0.73] |
| *PE* | IRR/kWh | 48.07 | 41.78 | 23.35 | 3.03[0.22] |
| *PO* | IRR/Liter | 53.74 | 40.48 | 44.97 | 106.18[0.00] |
| GAS | Million $m^3$ | 551.12 | 299.35 | 577.06 | 21.09[0.00] |
| VAL | Billion IRR, 1997=100 | 4569.43 | 4226.34 | 2004.94 | 2.28[0.32] |
| n | Number of workplaces | 1829.70 | 1872.00 | 814.05 | 3.31[0.19] |

Var. and SD represent variable and standard deviation. *PG, PE* and *PO* denote real prices of natural gas, electricity and oil products, respectively. GAS is a symbol for natural gas consumption in food industry, VAL indicates value added of food industry, and n refers to number of food producing workplaces. JB stat is acronym of Jarque-Bera statistic. SD: Standard deviation

from 1986 to 2010 based on the logarithmic mean Divisia index method. They found that energy intensity and industrial activity are the main determinants of the changes in carbon dioxide. Lin and Xie (2015) estimated the system of cost share equations in China's food industry and analyzed the substitution relationship between factors. They found that there exist substitution relationships between energy and other input factors, among which the substitution elasticity between energy and labor is the biggest, and the substitution of energy for capital dominates that of capital for energy.

In a study on food industry in Taiwan, Ma et al. (2012) found that food industry in Taiwan is labor intensive, the cost of raw materials is high, and there is much product diversification. In addition, this industry is a large user of electricity in Taiwan's manufacturing sector. In addition, they estimated the energy saving potential of 76 food firms.

Following a review of literature related to energy consumption, energy efficiency measures and energy indicators in the food industry, Nunes et al. (2016) studied the production process and the energy consumption of sausages processing industry in Portugal (20 industries). They concluded that electricity with a share of 82% is the main type of energy used in these industries. They also estimated electricity savings up to 24%.

Biglia et al. (2015) analyzed using multi-energy systems to produce hot water for processes and space heating in a chocolate factory in Italy and developed a thermal model to examine the hot water production system during the summer season considering the options of the heat recovery and of the solar thermal exploitation. Results showed that solar integration becomes profitable, from the energy point of view, only if the collector's area is increased. However, this leads to high investment costs.

Alves et al. (2014) applied a mathematical methodology to estimate energy savings resulting from the application of energy efficiency measures in cold chambers from the dairy industry in Portugal. They obtained substantial reductions in the consumption of energy of 67% with a return of investment in the defined measures of 4 years.

Tassou et al. (2011) provided energy consumption data of a sample of 2570 retail food stores from a number of major retail food chains in the UK. The data showed a wide variability of energy intensity even within stores of the same retail chain. They found that if the electrical intensity of the stores above the average is reduced to the average by energy conservation measures, annual energy savings of the order of 10% can be achieved representing 355,000 tones annual reduction in $CO_2$ emissions.

## 3. MATERIALS AND METHODS

Data on natural gas consumption, value added and number of manufacturing workplaces is extracted from Statistical Center of Iran. Data on prices of natural gas, electricity and oil products is gathered from Iran's Energy Balance Sheets (Iran's Ministry of Energy). The descriptive statistics of variables under study is given in Table 1. The averages of prices of all energy carriers consumed in food and beverage industries seem very low in comparison with international prices. With an official exchange rate of 26509 Iranian Rial (IRR) per US dollar in 2014[1], real natural gas price is on average 0.22 cent/$m^3$, while one kWh of electricity costs 0.18 cent, and one liter of oil products amounts to 0.2 cent in real terms. Standard deviations indicate higher changes in prices of oil products rather than those of electricity and natural gas prices. According to the Jarque-Bera statistic, prices of natural gas and electricity, value-added and number of workplaces are normally distributed, but the other variables do not have normal distribution.

The mean of natural gas consumption is about 551 million/$m^3$, while average value-added is nearly 4569 billion IRR, or 172 million US dollars. The descriptive statistics on the number of food workplaces is interpreted in similar manner. The median statistics show that half of observed natural gas prices are >59.31 IRR/$m^3$, and 50% of them are smaller than 59.31 IRR/$m^3$. Similar interpretations are applicable for other variables.

The main variable in this research is natural gas used in food-related workplaces. The share of natural gas in Iranian economy was low before implementing the first national economic development plan (1989-1993). In fact, most of natural gas extracted from the oil and gas wells was burned; however, gas delivery to industries and residential units increased the importance of natural gas in the fossil fuels basket. A glance to the natural gas consumption trend in food manufacturing workplaces indicates the similar orientation in food industry. As shown in Figure 1, the annual natural gas use has been always lower than 500 million/$m^3$ during 1978-1997. In addition, the natural gas use is relatively low-sloped until 1996, but a significant upward shift is observed from 1997 to date.

1 Economic Indicators, No. 82, 3rd Quarter, 2015/16, Central Bank of Iran.

In Iran, plenty natural gas reserves have been led to charge low prices to different sectors. In nominal terms, the natural gas prices were under 5.63 IRR, (or 7.3 cent) per/m$^3$ during 1978-1990, but gradual liberalization of fuel prices and implementation of the Iranian targeted subsidy plan in 2010 have fundamentally led to increasing natural gas prices.

In line with microeconomic basics, the absolute prices may be misleading in allocation of scarce resources among various needs, so the relative prices are commonly used to analyze the demand for goods and services. This tradition is valid in determining the demand for natural gas.

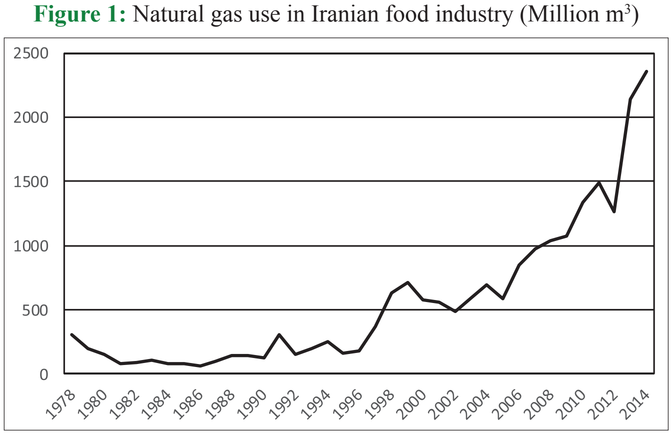
For foods and services, the well-behaved demand functions are generally derived from utility maximization behavior of individuals, however demand for inputs are often resulted from profit maximization by producing firms. In brief, if we maximize a profit function through partial differentiation with respect to inputs such as capital, labor, energy and materials, and set the partial derivatives equal to zero, the demands for inputs are obtained as functions of quantity of output and prices of inputs. Due to heterogeneity of food products, the aggregation of food produced and processed is too hard, so researchers appeal routinely to value added. This variable summarizes the quantities and prices of foods.

Contrasting to customary per capita demand for the households, the per capita consumption has no clear meaning among workplaces, thus the approach of this paper is to consider the natural gas use per workplace (*GPW*). Hence, the aggregate natural gas use is divided into number of workplaces in order to derive equivalent per capita consumption. This approach is repeated, when manufacturing value added is taken into account. In addition, all variables under study are included in logarithmic form to get price and income elasticities. As a result, this paper considers the following functional form to estimate demand for natural gas in food and beverage industries.

$$Log(GPW_t)=a_0+a_1Log(VPW_t)+a_2Log(PG_t)+a_3Log(PE_t)+a_4Log(PO_t)+u_t \quad (1)$$

Where *GPW* represents natural *GPW*, *VPW* gives value added per workplace, *PG, PE*, and *PO* denote natural gas price, electricity price and mean of oil products prices, respectively. In calculating

**Figure 1:** Natural gas use in Iranian food industry (Million m$^3$)




*PO*, we account for diesel, fuel oil and kerosene, which are mainly used in heating processes., $a_i$=1, 2, 3, 4 denotes coefficients, *t* is a symbol of time and *u* is disturbance term of the model. Except for number of workplaces and natural gas uses, the remainder of variables is in real terms considering 1997 as base year. More accurately, the prices of all fuels are adjusted with respect to consumer price index (CPI), but value added is adjusted using industrial sector price deflator.

## 4. RESULTS AND DISCUSSION

Testing for unit root in order to avoid spurious regression is essential before estimating a time series model. Currently, econometric software including Eviews.8 report numerous unit root tests, however augmented Dickey-Fuller (ADF) test, developed by Said and Dickey (1984), is a commonly accepted test among researchers. The null hypothesis of this test indicates unit root in time series. Table 2 gives the results of ADF test. When the absolute value of ADF statistic is greater than MacKinnon (1996) critical values, the time series under study will be stationary. The results of the unit root tests show that all variables have unit root in the level; however, they turn into stationary by the first differencing.

Since all variables are I(1), the estimation of model 1 through ordinary least squares will result in a spurious regression. Thus, we have to consider non-stationary time series analysis. A linear combination of two or more I(1) series may be stationary(Engle and Granger, 1987). Existence of such stationary combination indicates co-integration. As a result, the so-called co-integrating equation is interpreted as a long-run equilibrium relationship among the variables. In non-panel samples, the Johansen–Juselius (1990) co-integration approach is suitable when there are three or more time series, however Engle–Granger (1987) or Phillips–Ouliaris (1990) residual based test is applied where we have two variables.

The presence of a co-integrating relation forms the basis of the VEC specification. The VAR-based co-integration tests use Johansen (1995) methodology.

Suppose a VAR of order *P*:

$$Z_t=\alpha_1 Z_{t-1}+\alpha_2 Z_{t-2}+\ldots+\alpha_p Z_{t-p}+\omega_{xt}+\eta_t \quad (2)$$

Where $Z_t$ is a *k*-vector of non-stationary I(1) variables, $x_t$ is an *m*-vector of deterministic variables, and $\eta_t$ denotes residual terms. By rewriting (2) as,

**Table 2: Unit root tests**

| Variables | Level: Constant and trend | | First difference: Constant and trend | | Result |
|---|---|---|---|---|---|
| | ADF test Stat. | P | ADF test Stat. | P | |
| Log(GPW) | −2.207 | 0.4720 | −5.423 | 0.0004 | I (1) |
| Log(VPW) | −3.161 | 0.108 | −8.305 | 0.0000 | I (1) |
| Log(*PG*) | −3.324 | 0.078 | −5.908 | 0.0001 | I (1) |
| Log(*PE*) | −4.227 | 0.935 | −7.146 | 0.0000 | I (1) |
| Log(*PO*) | −1.305 | 0.871 | −6.046 | 0.0003 | I (1) |

ADF: Augmented Dickey-Fuller

$$\Delta z_t = \Omega z_{t-1} + \sum_{i=1}^{p-1} \Pi_i \Delta z_{t-i} + ... + \alpha_p z_{t-p} + \omega x_t + \eta_t \quad (3)$$

Where,

$$\Omega = \sum_{i=1}^{p} \alpha_i - I, \Pi_i = -\sum_{j=1}^{p} \alpha_j \quad (4)$$

According to the Granger's representation theorem, if the rank of coefficient matrix is $r$ ($r < k$), then there will exist $k \times r$ matrices $\Theta$ and $\lambda$ with ranks $r$ such that $\Omega = \Theta\lambda'$ and $\lambda' z_t$ is I(0). $r$ is the co-integrating rank and each column of $\lambda$ is the co-integrating vector. The elements of $\Theta$ are adjustment parameters in the *VEC* model. Johansen $\Omega$ estimates the matrix from an unrestricted *VAR* to test whether he can reject the restrictions resulting from reduced rank of $\Omega$.

Johansen and Juselius (1990) method gives two trace and the maximum eigenvalue statistics. If the number of co-integrating vectors is not same by these statistics, then vectors will be selected in terms of the interpretability of the co-integrating relations. Table 3 indicates three co-integrating relationships based on trace statistic and one co-integrating vector according to maximum eigenvalue statistic at the 0.05 level, so we continue our analysis with the first co-integrating equation.

The normalized co-integrating vector is reported as follows:

$$\underset{}{Log(GPW_t)} = -\underset{(1.64)}{2.375} + \underset{(0.438)}{3.018}Log(VPW_t) - \underset{(0.355)}{1.440}Log(PG_t) + \underset{(0.186)}{0.543}Log(PE_t) + \underset{(0.172)}{0.491}Log(PO_t) \quad (5)$$

In Equation 5, the standard errors are in parentheses, so in the significance level of 1%, the coefficients of right-handed variables are statistically significant. The signs of all coefficients are consistent with theoretical expectations, too. Hence, there is a long-run relation among variables under consideration.

According to the results, one unit increase in value added per workplace (*VPW*) increases the natural *GPW* by 3.02%, other things being equal. Because of logarithmic form of Equation 5, the income elasticity of demand for natural gas is >1. In other words, natural gas is counted as luxury input in food and beverage industries. Relative low price of natural gas, cleanliness and easy access to natural gas in food industry may justify this reality. Our findings are compatible with those of Andersen et al. (2011). They estimate the long-run income elasticity of natural gas in food and tobacco sector of Finland and Italy as much as 2.47 and 1.25, respectively.

In the long-run, we find that demand for natural gas is highly own price elastic in food and beverage industries. When other factors are kept constant, 1% increase in natural gas price reduces the natural gas use by 1.44%. The magnitude of long-run own-price elasticity reaffirms the luxury nature of natural gas in this industry. In Andersen et al. (2011) study, the food and tobacco industry exhibited a relatively high own-price elasticity of natural gas demand.

The coefficients of *Log(PE)* and *Log(PO)* show that electricity and oil products play substitute roles for natural gas. If electricity price increases by 1%, then demand for natural gas per workplace will increase by 0.54%. Of course, fuel switching depends on relative prices, assembly line and technological possibilities.

Furthermore, 1% increase in price of oil products can increase the natural gas use by 0.49%, ceteris paribus. The relative position of oil products has been weakened within food and beverage industries in Iran. This phenomenon originates from relative abundance of natural gas, structural changes in food and beverage industries, manufacturing structure and technological processes, and environment-friendly policies in food and beverage industries.

## 5. CONCLUSION

This article specified and estimated demand for natural gas in food and beverage industries of Iran regarding energy carriers and economic growth in this sector. Using annual data over the period 1978-2014, a micro-founded function of natural gas demand was estimated after checking for unit root in time-series. The integrity of order one, I(1), for all variables under study was accepted and the co-integration approach was applied to estimate long-run linkages among them. Based on maximum eigenvalue statistic, the existence of one co-integrating vector was confirmed.

The co-integration analysis showed that natural gas is a luxury input in food and beverage industries in Iran. This fact is consistent with higher elastic demand for natural gas considering own-price elasticity. These elasticities have meaningful policy interpretations. The natural gas use in food and beverage industries responses quickly and highly to changes in food manufacturing and real natural gas price. So, we expect natural gas consumption to response to economic cycles. Thus, economic boom results in intensive use of natural gas, and stagnation affects it adversely. In addition, natural gas pricing should be taken into account when food manufacturers decide how to use energy carriers. If nominal natural gas price grows with a higher rate than CPI, then a decline in natural gas use will be inevitable. As we shown, electricity and

**Table 3: Unrestricted co-integration rank tests (period: 1978-2014)**

| Hypothesized number of CE (s) | Trace test | | | Maximum eigenvalue test | |
|---|---|---|---|---|---|
| | Eigenvalue | Trace statistic | P* | Maximum-eigenvalue statistic | P** |
| None | 0.631 | 99.924 | 0.0003 | 146.961 | 0.0281 |
| At most 1 | 0.478 | 63.076 | 0.0064 | 68.269 | 0.1693 |
| At most 2 | 0.445 | 38.988 | 0.0186 | 37.626 | 0.0589 |
| At most 3 | 0.298 | 17.202 | 0.1251 | 17.749 | 0.1297 |
| At most 4 | 0.104 | 4.077 | 0.4007 | 7.288 | 0.4007 |

*Rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) P values, CE refers to co-integrating equation oil products can be replaced for natural gas in food and beverage industries, provided that technology let to make such substitution. The multi-fuel and fuel-switching systems are recommended to reduce the adverse effects of increasing real natural gas prices.

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