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Demand Estimation and Forecasting of Wheat in Iran: Using Econometric and dynamic systems approaches

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ABSTRACT

The aim of this research is the estimation of wheat demand function and forecasting required amount of wheat in future years for Iran. Wheat has been recognized as a strategic commodity and now has a substantial position in consumption basket and food pattern in Iran too. Investigations indicate per capita consumption of bread as the main product of wheat in Iran is much higher than the world average. Hence study and modification of wheat consumption pattern, as one of principal commodities used in Iran, is an inevitable necessity. For this purpose the combination of econometric and dynamic systems methods have been applied. The results show that wheat price and GDP per capita have a negative and significant effect and the price of substitute commodities (such as rice and meat) and population growth have a positive and significant effect in wheat demand. Meanwhile if this condition continues per capita consumption of Iran and world average will be 102 and 54 kilograms respectively in 2025; however, we can put this difference in least by using different strategies and scenarios.

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INTRODUCTION

Due to the increasing trend of world population and scarcity of existing resources in agriculture sector such as farmlands and water resources, it is predictable that global competition instruments for domination over others will not just confined to the development of military weapons in the future. Food will play a major role in changes of political regimes and geographical lines. In not too distant future, food and required facilities for achieving it will be the main factor in demarcation between rich and poor, developed and underdeveloped communities, and the most fundamental means for global dominance(FAO).

The aim of this research is to study effective factors in wheat demand in Iran and world average. In this regard this paper is organized as follows. Firstly research hypothesis would be presented and they are: “wheat demand will reduce in the future” and “existing gap between wheat consumption in Iran and world average will decrease”. Then theoretical Basis and literature review, studying the trend of per capita consumption of wheat in Iran and some selected countries, explanation and estimation of pattern by dynamic system and econometric methods with different scenarios and best strategies for reducing per capita consumption are presented and finally results and suggestions of this research are stated.

Theoretical basis and literature review:

Wheat demand function can be analyzed within microeconomic theories and is obtained by maximizing utility function relative to income restriction. These functions can be inferred by studying maximization of utility. Firstly a special utility function usually should be determined then with this assumption that consumer is seeking to maximize his utility, estimated demand function is concluded.(Mohamad Nariman, Microeconomics)

The law of demand by assuming given other factors sentences: demand changes adversely with price, i.e. except some special cases (Giffen commodity), if solitary consumers intend to maximize their satisfaction considering their limited monetary income, their solitary demand will move in reverse.

Changes in price usually disturb cost pattern of consumer. To find out the effect of price change and income in consumer’s purchase, all variables should have been changed simultaneously.(Ferguson, Microeconomic Theory)

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Wisely Leontief, Russian American economist in 1929 in a research whose subject was "An attempt in statistical analysis of demand and supply" completed the presented studies in this field. Other economists such as R.Stone and von seeliski have also conducted appropriate studies.

Schultz estimated wheat demand function based on statistical data relating to the years 1920-1934. In this study he divided the demand function into two parts. At the first part demand changes are due to the price changes and at the second part demand changes are due to the factors like taste which occur over time.

Moreover Schultz estimated beef demand function based on the statistical observations over the period 1923-1933. He concluded that annual payment of wages has a close relationship to national income, and composes part of the income that largely affects consuming commodities like beef. In addition, as studies have shown, demand for beef depends not only to its price but also to the pork's price.

Moore calculated corn demand curve based on the annual statistical observations of corn in the period 1866-1911 by dependent variable $\frac{\Delta p}{p}$ and independent variable $\frac{\Delta x}{x}$.

Mukhtar et al. at the paper "cointegration and error correction in the modeling of wheat consumption" have estimated elasticity of wheat demand of Pakistan in short and long terms. They estimated elasticity of wheat demand by Cointegration and Vector Error Correction Methods. According to their findings, income is the most important and effective factor in the elasticity of wheat demand in long term, and price is the most important factor in the wheat consumption in short term. They also showed wheat demand elasticity in the food and consumption products basket, is proportional to security policies. Reduction in the flexibility of wheat demand elasticity in short and long terms indicates most likely by liberalization of agricultural trade and increase in wheat price, poor households suffer.

Kumar et al. in a research whose subject was "demand and supply of sugar cereals" forecasted supply and demand of two important grains (rice and wheat) in India by QUAIDS method until 2025. The results of this study are indicating that demand elasticity considering food costs for rice, wheat and cereals in India is negative which this is acceptable according to observed reduction in the consumption of these commodities (rice, wheat and cereals) for a relatively long period, even when income level has increased in the country. In this study in a scenario of income growth, per capita consumption of rice and wheat are forecasted 4.1 and 5.5 respectively in 2025 which have reduced in relation to per capita consumption of rice and wheat 4.4 and 6.1 in 2005. Comparison of predicted values with real values for 1993 and 2008 indicates errors in predicting are less than three percent that it shows the validity of the model.

Torkamani in his research for investigating removing bread subsidy estimated the demand and Engle equations of bread for urban and rural households. According to estimated income elasticity, demand function is fitted by the correction of dependant variable. Price elasticity of bread is 54 percent for urban households and 65 percent for rural communities.

Hashemi et al. in a study targeted estimation and forecasting of wheat demand. Instead of direct expression of the demand function for wheat which wheat consumption would be predicted based on that, demand function is planned for special derived products of this product such as bread, biscuit, cookie and etc. and then with estimation of consumption of any of these, requested consumption has been calculated through known coefficients.

Moghaddam has estimated supply and demand of wheat using data of 1957 to 1969 by *2SLS* method. By putting different variables in function (about 8 variables), two variables were significant which one of them was weighted average rainfall per hectare of five provinces with 65 percentage of total wheat production in Iran, and another was wheat price at the previous year.

Investigating the trend of wheat consumption in Iran and some other selected countries:

On average the mean of per capita consumption of wheat in the world has meager fluctuations during the discussed period. On average per capita consumption of world equals to 65 kilograms per year per person. The amount of wheat consumption is greater than the value predicted by FAO and the highest consumption was in food industry so that the consumption of wheat has grown from 59.5 kg in 2008 to 60 kg in 2010.

Per capita consumption of wheat in Iran is 148 kg per year which is more than two or three times with that of European countries. According to the field survey has been carried out in Tehran and some provincial capitals about 33 percent of bread are wasted. In other words, a third of all bread that is produced is discarded. Given that more than half of the required annual bread production wheat is imported, therefore the issue is more than ever before.

The Model:

The research methodology is a micro and macro economic analysis which wheat consumption is designed based on a wheat demand function. Product demand is obtained from the utility maximization over the budget restriction. Given that we are going to observe the macroeconomic effects of per capita consumption of wheat, sum of that should be used as the total wheat demand. It should be mentioned that due to the lack of information

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on bread prices, the price of wheat and wheat consumption are substituted as proxies. Model is estimated by econometric methods and for simulation SD method is used.

Dynamic System is a methodology because dynamic system theory, which puts the behavior of system as a basis, is determined by the interaction of feedback loops. In this regard and by definition of the methodology, it can be seen that dynamic system is not merely a method to test hypotheses but it has its own specific methodology; however, computer solving of model can be used as a method to test hypotheses, future predictions and simulation real world. This section expresses the major subsystems. Generally designed system model contains four subdivisions. The first section is about economy that includes per capita consumption in Iran and the world average per capita consumption of wheat which their impact on agricultural sector is observed. Agricultural sector includes production, consumption and etc. which its influence on economic and social sectors is investigated. Social sector includes population growth and its impact on domestic agricultural and social sectors is studied and finally is the foreign agricultural sector which its effect on domestic agricultural and economic sectors is observed.

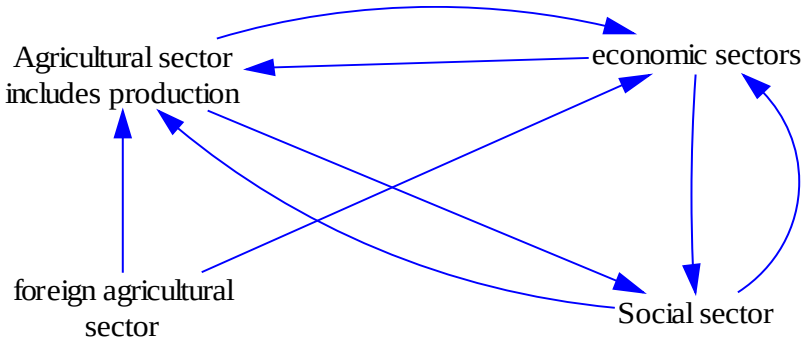

Fig. 1: The original graph of system model

Causal-Spiral diagrams:

Causal-Spiral diagrams while expressing causal relationships between two or more variables also specify the direction of their effect. This effect on the variable can be direct or indirectly through intermediate variable.

In terms of Causal-Spiral diagrams it can be expressed whatever wheat consumption in Iran that has a large gap with the world average decreases then existing gap would decrease thus create an adverse relationship which this cause a negative loop.

In relation to the subsystem of per capita consumption of wheat in Iran, price of domestic wheat has a negative effect on per capita consumption. The prices of rice and meat as the substitute commodities have a positive effect on per capita consumption. Per capita income has a negative effect on per capita consumption which indicates this point that whatever the household welfare increases the per capita consumption of wheat would decrease. There its income elasticity is less than zero. However population growth has a positive effect on per capita consumption and finally the process of taste changes reveals itself by a negative sign indicating taste changes in consumers are in direction of the reduction of per capita consumption of wheat in Iran.

About the average per capita consumption in the world, it should be noted as it was true in the case of Iran the price has negative effect, rice price as substitute commodity has a positive effect and per capita income has a negative effect on average per capita consumption in the world which suggests whatever the household welfare increases the consumption of wheat would decrease therefore income elasticity is smaller than zero. About the population growth it should be cited that its growth cause consumption increase.

In below chart the detailed final Causal-Spiral diagram with effective variables is shown.

Wheat demand (per capita consumption) in Iran:

To evaluate the effect of each factor on the per capita consumption of wheat, we estimate the model by the Generalized Method of Moments (GMM). It is a new method which is suitable when the term distributions or specifications are unknown. The period is 1991-2011 and forecast is up to horizon in 2025. Thus according to above points the equation of domestic wheat demand is estimated as following:

$$\begin{aligned}&\mathrm{LOG(CP)} = 17.01 - 0.7 * \mathrm{LOG(GNI)} - 0.1 * \mathrm{LOG(PW)} + 0.14 * \mathrm{LOG(POP)} + 0.035 \\ &\qquad * \mathrm{LOG(PR)} + 0.05 * \mathrm{LOG(PB)} + 0.02 * \mathrm{TR} \\ &\text{t: } (10.81) \quad (-7.37) \quad (-3.01) \quad (3.36) \quad (2.66) \quad (6.95) \quad (6.92) \quad (-10.16) \\ &\text{se: } (1.573) \quad (0.107) \quad (0.033) \quad (0.039) \quad (0.013) \quad (0.007) \quad (0.002) \quad (0.071) \\ &R^2 = 0.85 \qquad DW = 2.17 \qquad JS = 0.07\end{aligned}$$

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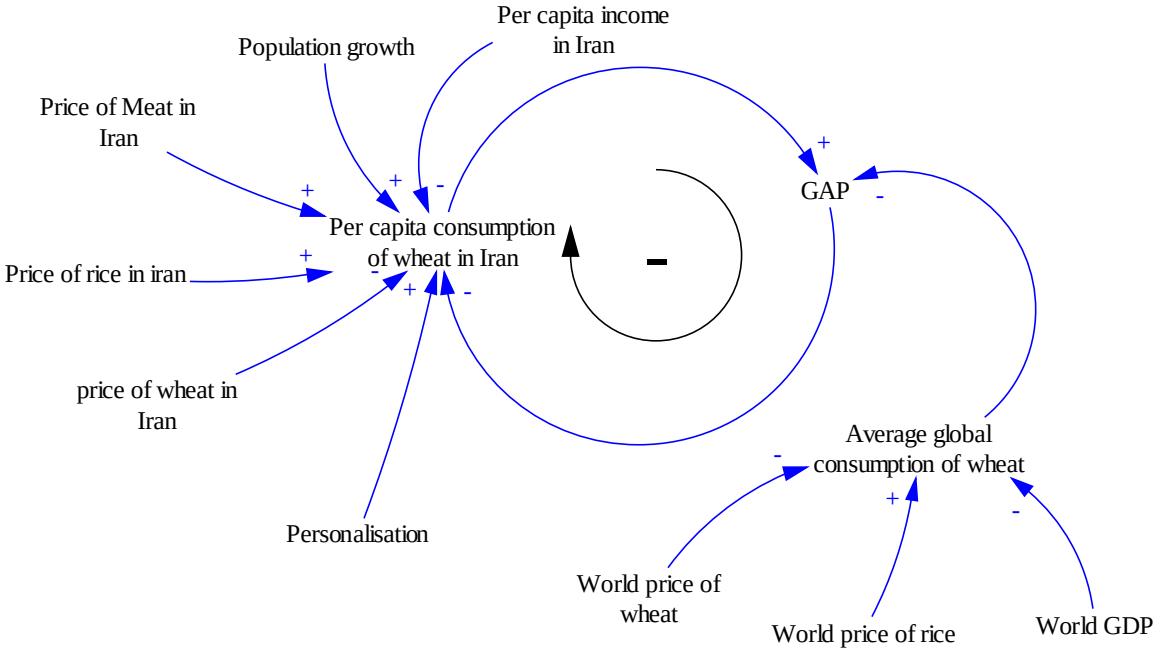

Fig. 2: Causal-Spiral diagram of per capita consumption of wheat model

As it can be seen the explaining power of the regression is high and applied model describes consumption changes quite well. J-statistic has a few numbers and is smaller than χ^2 distribution thus the accuracy of the GMM instruments is approved. Sign of all coefficients of the rewritten explanatory variables confirm the initial assumptions. This means that the wheat price coefficient has a negative sign indicating the demand curve has a negative slope.

Per capita income is in constant 2000 Iranian Rial and the coefficient is (-0.7) that indicates if per capita income increase one percent, consumption of wheat will decrease 7 percent. This confirms our primary forecast about a negative relationship between per capita income and per capita consumption of wheat. It shows by increase in household income the demand for wheat is also reduced.

The real price coefficient (Rial) of wheat in Iran is (-0.1) which is the same price elasticity of domestic wheat demand. This coefficient suggests if wheat price increase 1 percent, wheat consumption will reduce 10 percent. This also corroborates our initial prediction on the negative relationship between growth of wheat price and its consumption.

Considering that the price elasticity is less than 1 percent, it can be interpreted that wheat is an inelastic commodity and consumers react weak against prices and have little sensitivity to its changes. This could be due to low wheat prices, consumer tastes, the high gap between the prices of wheat and substitutes such as rice and meat. In other words, it can be concluded that although by increase in price consumption decreases, this reduction will be much less than the increase in wheat prices. Thus wheat is considered a staple in the consumption basket of Iranian households.

Real price coefficient (RLS) for rice and meat in Iran is (0.035) and (0.052) respectively. This coefficient represents if 1 percent increase in the price of rice and meat occur, assuming other things being equal, (3%) and (5%) increase in the demand for wheat will be happened respectively. Thus the substitutions hypothesis of the rice and meat is verified. According to the fact that the price elasticity is less than one, it can be interpreted that wheat toward prices of substitute goods as is approximately inelastic.

Population growth coefficient is (0.14). This coefficient shows if population growth increases 1 percent, wheat consumption will increase 14 percent that this confirms our initial prediction of a positive relationship between population growth and per capita consumption of wheat.

With regard to the comparison of coefficients it can be concluded that per capita income relatively has more effect on wheat demand in comparison to wheat price, rice and meat prices and population growth in Iran.

Wheat demand (per capita consumption) in the world:

To evaluate the effect of each factor on the per capita consumption of wheat, we estimate the following function by the Generalized Method of Moments (GMM).

Given the above points, wheat demand equation is estimated as follows:

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$$\begin{array}{lccccc} \text{Lncpw} = 5.3 - & 0.12 * \text{LnGDP} - & 0.024 * \text{LnPW} + & 0.041 * \text{LnPR} + & 0.021 * \text{LnTR} \\ \text{t: } (48.83) & (-14.47) & (-3.41) & (10.56) & (6.14) \\ \text{se: } (0.10) & (0.008) & (0.007) & (0.004) & (0.003) \end{array}$$

$$R^2 = 0.94 \qquad DW = 2.37 \qquad JS = 0.05$$

As it can be seen the explaining power of the regression is high and applied model describes consumption changes quite well.

Per capita income is in constant 2000 and the coefficient is (-0.12) that indicates if per capita income increase one percent, consumption of wheat will decrease 12 percent. This confirms our primary forecast about a negative relationship between per capita income and per capita consumption of wheat.

The real price coefficient of wheat in world demand function is (-0.024) which is the same price elasticity of wheat demand. This coefficient suggests if wheat price increase 1 percent, wheat consumption will reduce 0.024 percent. This also corroborates our initial prediction on the negative relationship between growth of wheat price and its consumption.

Considering that the price elasticity is less than 1 percent, it can be interpreted that wheat is an inelastic commodity and consumers react weak against prices and have little sensitivity to its changes.

Real price coefficient for rice is (0.04) This coefficient represents if 1 percent increase in the price of rice and meat occur, assuming other things being equal, (4%) increase in the demand for wheat will be happened. Thus the substitutions hypothesis of the rice is verified. According to the fact that the price elasticity is less than one, it can be interpreted that wheat toward prices of substitute goods as is approximately inelastic.

With regard to the comparison of coefficients it can be concluded that per capita income relatively has more effect on wheat demand in comparison to wheat and rice prices.

Dynamic System Model:

The first scenario, the step to the wheat price and forecasting wheat consumption in Iran:

As it is observed a positive step on the variable wheat price was imposed. This step causes the price of wheat has a growth rate by 20 percent over 2012 to 2025 and the value of about 74 kilograms can be gained which about 70 percent of the gap is moderated. As you can see with the step to the value of 6.5 units the results of below table are achieved:

Table 1: The values of step and prediction of per capita consumption

Price growth (percent)	step	Price at 2025	Per capita consumption in Iran at 2025	Per capita consumption In the world at 2025
20	6.5	93.2	75	52

After imposing the positive step to price, this variable moves as the same former trend which indicates the model is valid since the impact of a variable onto another variable can be observed in dynamic systems according to relationship between the variables. This shows that the system is validated if by imposing a step to a variable of the system, it is not getting out of control.

The above arguments suggests that for achieving desired per capita consumption in addition to price increases, other effective variables for adjusting existing gap should change at the right direction to get optimum point which various scenarios are expressed in the following.

The second scenario, the step to the domestic wheat, rice and meat prices and forecasting wheat consumption:

As it is observed a positive step on wheat, rice and meat prices was imposed. This step causes the price of wheat has a growth rate by 20 percent and the prices of rice and meat have a growth rate of 15 percent over 2012 to 2025 and in that case the value of about 86.8 kilograms for per capita consumption can be gained which about 60 percent of the gap is moderated. As it can be seen with the mentioned steps the results of below table are achieved:

Table 2: The values of steps and prediction of per capita consumption

Price growth of wheat (percent)	Price at 2025	Price growth of rice and meat	Per capita consumption in Iran at 2025	Per capita consumption In the world at 2025
20	93.2	0.15	86.8	51.9

After imposing the positive step to the prices of wheat, rice and meat domestic per capita consumption moves as the same former trend.

The third scenario, the step to the domestic wheat price and per capita income forecasting wheat consumption:

As it is observed a positive step on the variables wheat price and per capita income was imposed. This step causes the price of wheat has a growth rate by 20 percent over 2012 to 2025 and in this case the value of about

60 kilograms can be gained which about 87 percent of the gap is moderated. In this case the highest adjustment is carried out and this can be more considered in policy making for optimal consumption of wheat in Iran and by reducing the consumption of domestic wheat, the context for exporting this strategic product will be provided. As you can see with the mentioned steps the results of below table are achieved:

Table 3: The values of steps and prediction of per capita consumption

Price growth (percent)	Price at 2025	Growth of per capita income	Per capita income at 2025	Per capita consumption in Iran	Per capita consumption In the world
20	93.22	0.5	1.64E+07	60	51.92

After imposing the positive step to price, cited variables moves as the same former trend. After imposing the step on wheat price and per capita income, domestic per capita consumption moves as the same former trend.

The fourth scenario, the step to the domestic wheat price, per capita income, and rice and meat prices and forecasting wheat consumption:

As it is observed a positive step on wheat, rice and meat prices and per capita income was imposed. This causes the price of wheat has a growth rate by 20 percent and the prices of rice and meat have a growth rate of 15 percent and per capita income has a growth rate of 5 percent over 2012 to 2025 and in that case the value of about 69 kilograms for per capita consumption can be gained which about 75 percent of the gap is moderated. As it can be seen with the mentioned s the results of below table are achieved:

Table 4: The values of s and prediction of per capita consumption

Price growth of wheat (percent)	Price at 2025	Growth of per capita income	Price growth of rice and meat	Per capita consumption in Iran	Per capita consumption In the world
20	93.22	0. 5	0.15	69.62	51.92

After imposing the positive to the prices of wheat, per capita income, and rice and meat prices, domestic per capita consumption moves as the same former trend.

The fifth scenario, the to the domestic and foreign wheat prices simultaneously:

As it is observed a positive step on wheat price in Iran and average world price was imposed. This step causes the price of wheat has a growth rate by 20 percent and the average world price has a growth rate of 3 percent and in that case the value of about 74 kilograms for per capita consumption in Iran and the value of about 41 kilograms for per capita consumption of average per capita consumption of the world can be gained which about 60 percent of the gap is moderated. As it can be seen with the mentioned steps the results of below table are achieved:

Table 5: The values of steps and prediction of per capita consumption

Price growth of wheat (percent)	Price at 2025	Price growth of the world	Per capita consumption in Iran	Per capita consumption In the world
20	93.22	0.03	74.97	41.59

After imposing the positive step to the mentioned variables, average per capita consumption of the world moves as the same former trend.

Above scenarios indicate that consumption patterns in this section cannot be modified singly by using the price mechanism. Bread is an essential commodity which provides bulk of the required food and energy of low-income classes. Thus removal of subsidies and increasing its price by itself can enter additional economic pressure to vulnerable groups and disadvantaged communities. As well in case of direct payment of subsidies to vulnerable groups in the society, increase in the price of bread does not influence its demand, because bread is an essential commodity and absolutely inelastic.

RESULTS AND DISCUSSION

In this paper the effective factors on wheat demand (per capita consumption) is investigated in Iran that results show per capita income and wheat price do not have significant effects and rice and meat prices have a positive effect and moreover among factors effective on wheat demand (average per capita consumption) in the world, per capita income and wheat price do not have significant effect and price elasticity for rice is estimated -0.05 and price elasticity for wheat is estimated -0.44.

The fact is that per capita consumption of wheat is higher than the world average and this strategic product in case of droughts can cause serious problems in terms of economic, social, and political. Thus per capita consumption of wheat should be pursued as a policy that *targeted subsidies* has also followed this policy and with the increase in price of bread has attempted to reduce consumption and wastes.

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Given that wheat is a strategic commodity and Iran has imported it approximately in the most of investigated years except a few years, the consumption should be reduced as planned with appropriate policy strategies such as increases in wheat prices so that the lower classes of society not to be harmed.

For this purpose we can prepare the context for modification of consumption patterns through paying subsidies to lower declines and increasing their income and also arranging appropriate policies for replacing substitute commodities such as rice and meat.

Considering that production and imports is spent on consumption we can create a surplus by reducing consumption and provide a context for exporting of this strategic product or by reducing the under cultivation lands, provide a context for production of other strategic commodities.

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