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Energy Consumption and Food Price: A Quantile Regression Approach on Iranian Data

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ABSTRACT

Energy and agriculture sectors play a key role in Iran's economy as the former provides considerable share of the public budget and the latter contributes significantly to employment, non-oil exports, and food self-sufficiency. Iranian government is following an energy subsidy targeting policy to increase energy (especially exhaustible ones) efficiency. Obviously, this will influence, among others, energy price and consumption, cost of production and, finally, food price. Therefore, the current study focused on the nexus between energy consumption and food price in Iranian agriculture. Since such relationships may differ as food consumption varies, the quantile regression model was applied and estimated using data for the period 1966-2017. Main findings revealed the direct and significant impact of energy consumption and globalization index on food price in the 0.75th quantile, while exchange rate showed the same effect in 0.25th and 0.75th quantiles. Furthermore, money supply was explored as another driver for food price in all quantiles.

Keywords: Energy and food price nexus, Globalization index, Iranian economy, Iran.

INTRODUCTION

Agriculture is of great importance to the Iranian economy due to its significant capabilities as well as to the role it plays in providing raw materials for some industries and providing food for the society (Khorami and Pierof, 2013). The importance of this sector is well understood when its multifunctional characteristics and its effect on providing rural development are also taken into consideration. On the other hand, meeting the Iranian government policies to get rid of the oil-dependent economy and promote non-oil exports require more efficient use of natural resources especially non-renewable ones including energy (Sassoli and Saleh, 2007).

Because of its strong backward and forward linkages with other economic sectors, agriculture in developing countries acts as the primary driving force for economic growth. From the economic development perspective, this sector plays important role in the country's growth and development (Hosseini *et al*., 2011).

Food price instability directly influences farmers' income and consumers' cost of living. Since food expenditure accounts for a significant share of the low-income households' budget, these fluctuations have a bigger effect on households in developing countries than in developed nations. Therefore, examining food price changes and their influential factors seems necessary (Kohansal and Hezareh, 2016).

This has been the topic of many studies. For example, Alem (2011) studied the effect of rising food prices on the welfare of Ethiopian urban consumers during 2004-2009. The results indicated that households in urban areas had lost 15% of their annual food budget due to an unexpected rise in food prices. This impact was reported to be

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more for poor households. Vu and Glewwe (2011) studied the welfare change of Vietnamese households due to increased prices for cereals during the 1980-2007 and showed that the consumers' welfare loss was less than the welfare gained by producers. Ferreira *et al*. (2013) studied the distributive welfare effects of food price inflation among Brazilian households and argued that households with average income were more vulnerable than poor households, since poor families enjoyed government social security programs. In the Indian context, Weber (2015) has reported, respectively, 6% and 4% decrease in urban and rural households' welfare due to food price increase. These studies indicate that food prices play a vital role in social welfare; therefore, determination of the influential factors on price should be taken into consideration.

Based on the different studies on this subject, different variables could cause food price changes. Many studies in this area articulate that energy is a vital input in the production of agricultural commodities (Thaghizadeh-Hesary *et al.*, 2018). Ortiz *et al*. (2011) pointed out that energy, among others, played a key role in shaping food price soar. The simultaneous increase in energy price and agricultural commodities suggests that energy is an effective factor in food price increase (Sayyadi and Moghaddasi, 2015). Energy prices have direct and indirect influences on the agricultural commodity price (Radmehr and Rastegari Henneberry, 2020). On one hand, agricultural production, especially in the production of field crops, consume a significant amount of energy. Therefore, an increase in energy price could cause an increase in production cost and, consequently, lead to higher food prices (USDA, 2011), which is the direct impact of energy price. From another viewpoint, agriculture, as an energy-intensive sector, was traditionally linked to the energy industry through its input channels. Between these inputs, fertilizer and pesticides are the two most prominent indirect energy inputs (Janda and Kristoufek, 2018); therefore, energy price increase leads to input price rise which, in turn, affects commodity price.

Moreover, in energy producers countries such as Iran, the government budget is heavily dependent on energy resources and their international prices (Radmehr and Rastegari Henneberry, 2020). Therefore, in these countries, monetary policies, such as money supply and exchange rate, and fiscal policies, such as government expenditures, are affected by the energy prices.

Besides energy price, macro variables are the other important determinants of agricultural commodity prices. Because of the importance of these macro variables, some studies investigate the impact of money supply on food prices. These studies find a strong and significant relationship between money supply and commodity prices. Following theoretical background on the effect of money supply on overall inflation and the co-movement tendency among different price series, many researchers have reported some evidence supporting such relationship (Hua, 1996; Peng and Marchont, 2004; Kargbo, 2005; Ghetmiri and Harati, 2005; Akbari and Rankaduwa, 2005; Azamzadeh Shuraki and Khalilian, 2010; Moghaddasi *et al*., 2010; Hemmati, 2011; Mushtaq *et al*., 2011; Central Band of Iran, 2013; Pishbahar and Javdan, 2015).

The positive association between exchange rate and food prices has also been notified in some works (Kargbo, 2000; Frank and Garcia, 2010; Ranjpour *et al*, 2014; Radmehr and Rastegari Henneberry, 2020). They believed that any increase in exchange rate results in higher economy-wide inflation and this, in turn, causes a rise in food prices, following the same tend as money supply.

Finally, trade openness seems to influence agricultural food price variations through different channels (FAO, 2004). In the short run, improvement in trade openness index increases the availability of the agricultural commodities via import, as it allows products to be produced in most efficient areas. Therefore, the price of commodities

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will drop (Fusco *et al.*, 2020). On the other hand, globalization increases the dependence of local food market on international markets; therefore, price fluctuation in the international market can be transmited to the domestic market and create price instability (García-Dorado *et al.*, 2019; Daneshvar *et al.*, 2019) In the long run, trade openness motivates an improvement in the production technology through technology diffusion. Implementation of the new technologies usually reduces the production costs and, as a result, the price of agricultural commodities will decrease (Gygli *et al.*, 2019). Based on these studies, globalization index has a complex influence on commodity prices. Therefore, its impact should be taken into consideration in a different situation.

Considering the critical role of agriculture in Iran's national development plans, policymakers allocate a high energy subsidy to this sector (for instance 0.1 \$ L^{-1} for gasoline in Iran *versus* 2.45 \$ L^{-1} in other countries of the region) to decrease the share of energy in production cost and avoid high food price. However, many believe that cheap energy has led to overuse of this valuable input, lower efficiency, and higher cost of production in Iranian agriculture, which, in turn, results in lower competitive advantage in world markets (Hosseini *et al*., 2011; Kohansal and Hezareh, 2016; Ghaderi *et al*., 2005; Institute of Agricultural Research Planning and Economics, 2007; Abbasian and Moradpour Oladi, 2008)). Analyzing the food price trend in recent years indicates that government policy does not meet the expectation (Radmehr and Rastegari Henneberry, 2020) and it seems that high energy subsidy leads to efficiency reduction and higher cost of production. Because of this noncompliance between policy goals and its results, it seems of great importance to investigate the association between fossil-based energy consumption and food price to evaluate the consequences of policy implication.

The contribution of the current study is twofold. In an international view, it is among rare works dealing with the effect of energy consumption (not oil price) on food price in a developing oil-dependent economy. Besides, in the Iranian context, this study can be regarded as the first empirical attempt in examining the nonlinearity in the nexus between energy use and food price.

MATERIALS AND METHODS

Data and Evolution of Variables

In this study, time-series data for the period 1966-2017 were derived from different sources used to investigate the impact of energy consumption on agricultural food prices. Data of real food price index, money supply, and market exchange rate were collected from the central bank of Iran, energy consumption in the agricultural sector was gathered from Iran's Ministry of Energy, and finally, globalization index for Iran was obtained from World Bank.

The trend of the agricultural food price index, money supply, and energy consumption in the agricultural sector are presented in Figures 1, 2, and 3. Food price followed an increasing trend during the study period. Figure 1 depicts the evolution of three variables of interest. Real food price index, deflated by Consumer Price Index (CPI) in Figure 1, clearly shows steeper growth in the last decade. This is mainly due to the transmission of world food prices soar into the domestic markets on one hand and increased amount of money supply in the economy on the other hand (Figure 2). Meanwhile, agricultural energy consumption experienced a relatively smoother path (Figure 3) implying a gradual increase, which can be attributed to a moderate rate of increase in agricultural activities expansion.

The description of variables, along with the sample mean, standard deviation, and variables normality test are presented in Table 1. The estimated Jarque-Bera

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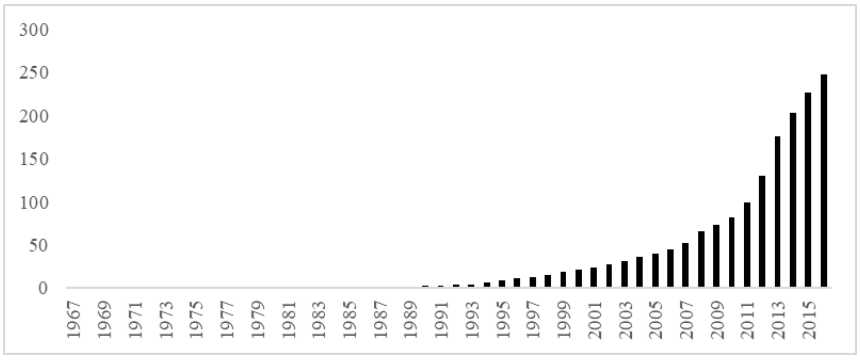

Figure 1. Real food price index (Percent)**.** Source: Central Bank of Iran.

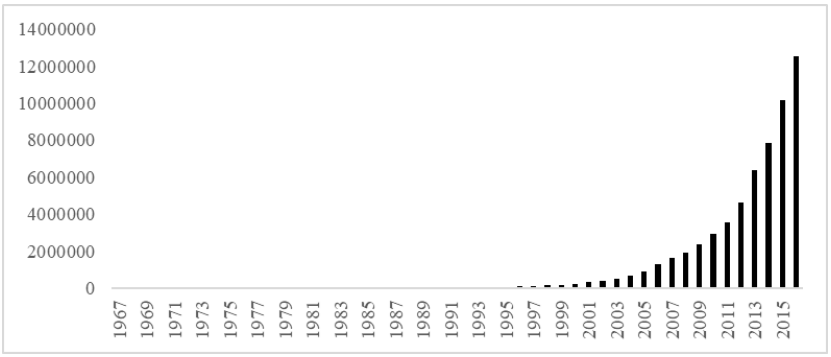

Figure 2. Money Supply (Billion Rials, Iranian National Currency). Source: Central Bank of Iran.

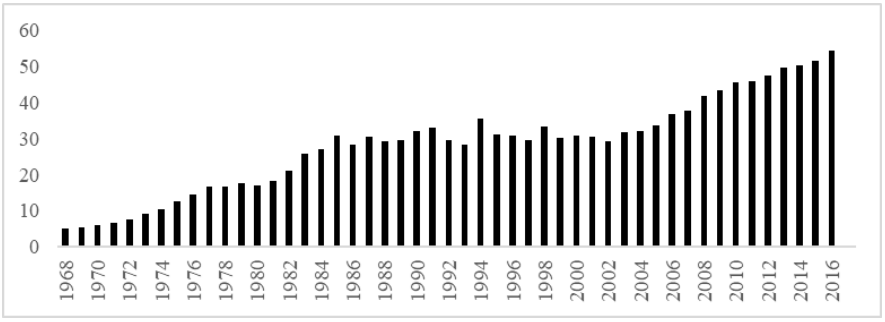

Figure 3. Agricultural energy consumption (Million barrels of oil equivalent). Source: Iran's Ministry of Energy.

Table 1. Summary statistics and description of variables.

Variables	Description (Unit)	Data source	Mean	Standard deviation	Jarque–Bera (P-Values)
FP	Real Food Price index	Central Bank of Iran	33.67	61.24	80.8 (0.00)
E	Energy consumption in agriculture (Million barrels of oil equivalent)	Iran's Ministry of Energy	6374.81	13.36	0.93 (0.63)
M	Money supply (Billion Rials)	Central Bank of Iran	11865516	9.38	1.05 (0.59)
KOF	Globalization index	World Bank	31.19	2673873	187.24 (0.00)
MER	Market Exchange Rate (Rials per USD)	Central Bank of Iran	27.93	9619.7	54.8 (0.00)

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coefficient for food Price Index (FP) rejects normal distribution of the variable and, as can be seen in Figure 4, most of the observations are concentrated on the left side of the distribution, in fact, more than 80 percent of food price index observations are less than 50. This visual inspection of the data along with the abnormal distribution of dependent and independent variables and the mentioned theoretical background convinced us that the usual ordinary least squares (OLS) econometrics base model leads to invalid estimated coefficients. Therefore, a robust alternative such as quantile regression can be considered as a proper tool for investigating variables' association.

Empirical Model

In this study, a regression analysis was used to identify the impact of effective factors on food prices. In this model, food price, as a dependent variable, was regressed on certain explanatory variables, using the basic model presented below:

$$FP_t = \beta_1^{(\tau)} KOF_t + \beta_2^{(\tau)} MER_t + \beta_3^{(\tau)} M_t + \beta_4^{(\tau)} E_t + \varepsilon_t^{(\tau)} \quad (1)$$

Where, FP stands for Food Prices, KOF, MER, M, and E are globalization index, market exchange rate, money supply, and agricultural energy consumption, respectively. Also, ε is residual term.

Quantile Regression

In order to examine the variables' association, the quantile regression model, which has been frequently applied by economists during the last decade, was used in this study. The unique feature of this model, introduced by Koenker and Bassett in (1978), is the capability to model-dependent variable's variation in all segments of its statistical distribution (and not only its center, as in common regression models). Moreover, quantile regressions are more robust against the presence of outliers in the dependent variable. For mathematical representation, consider the following equation:

$$Y_i = \beta_\tau x_i + \varepsilon_{\tau i} \; i = 1,2,\dots,n \quad (2)$$

Eq. 2 relates the dependent variable (Y) to a set of explanatory variables ($x_i = (1, x_{i1}, \dots, x_{ik})$) in the τ-th quantile and $\tau \in (0,1)$. Besides, $\beta_\tau = (\beta_0, \beta_1, \dots, \beta_k)$ is a

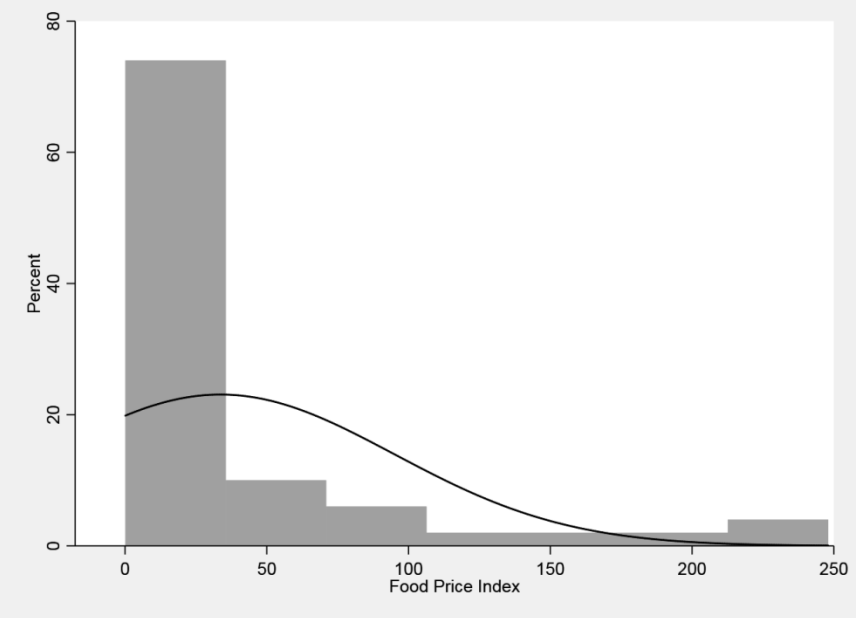

Figure 4. Distribution of agricultural food price index.

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vector of unknown parameters to be estimated. The above equation is called the linear regression model of τ-th quantile. The slope coefficients ($\beta_\tau s$) are estimated by minimizing the following equation, which is a weighted sum of positive and negative errors:

$$\hat{\beta}(\tau) = \min_{\beta \in R^p}\left(\sum_{i\in\{i:y_i\geq x_i\beta\}} \tau|y_i - x_i\beta| + \sum_{i\in\{i:y_i<x_i\beta\}}(1-\tau)|y_i - x_i\beta|\right) \quad (3)$$

RESULTS AND DISCUSSION

In the economic modeling of time series, the first step is examination of the stationarity of variables. In a long-run time series, because of the existence of probable structural breaks, the results of common unit root tests such as Generalized Dickey-Fuller (1979) and Phillips-Peron (1988) may be misleading. Here, the tests are biased towards the non-rejection of the null hypothesis (existence of unit root) (Perron, 1997). Considering the occurrence of such breaks in the Iranian economy (Islamic revolution, imposed war, sanctions), the proper unit root tests must also be applied. Therefore, we adopted the test proposed by Lee and Strazicich (2003) for investigating the presence of unit root in our data. The null hypothesis of the LS test is the existence of a unit root test and the alternative hypothesis is stationarity of the variables.

The results of a Lee and Strazicich (LS) unit root test, which takes into account the effect of breakpoints in the data, for all the variables are presented in Table 2. The results indicate that all the variables are stationary in the level. It should be noted that results of the LS unit root test with considering the structural brakes and without considering the break do not change significantly.

After checking for stationarity of variables and finding empirical support for suitability of the chosen model, the quantile regression was estimated. Table 3 presents the estimated results for three different quantiles.

According to Table 3, money supply positively affects food price in all quantiles. This, of course, is in line with theoretical expectations because, based on macroeconomic principles, a greater money supply leads to an increase in total demand which, in turn, causes higher inflation in all commodity groups including food items. This result was reported by Sassoli and Saleh (2007), Hua (1996), and Aazamzadeh Shuraki and Khalilian (2010). It should be noted that the money supply has a greater positive impact on food prices. However, the overall impact of the money supply is not considerable. These results might be caused by the government policies about the food price, which does not let the price of these commodities be determined freely in the market.

As Table 3 shows, only in the third quantile (0.75^{th}) all explanatory variables show a statistically significant impact. In other words, for higher values of FP, we found a significant association among variables. The third quantile (0.75^{th}) includes the highest food prices, which arise in the last years. Therefore, it can be concluded that the impact of government policies diminished during the time because of the high budgetary cost of policy

Table 2. Result of LS unit root test.

Variables	Lag	t-Statistic	Critical value			Null hypothesis
			1%	5%	10%	
FP	5	-9.51	-4.88	-4.31	-4.03	Rejected
E	8	-4.85	-4.90	-4.34	-4.06	Rejected
KOF	0	-4.86	-4.75	-4.18	-3.89	Rejected
M	5	-9.77	-4.86	-4.30	-4.02	Rejected
MER	3	-4.93	-4.88	-4.31	-4.03	Rejected

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Table 3. Result of quantile regression model estimation.

	Quantile	Coefficient	Std error	t-Statistic	Prob
C	0.25	-21.57	19.16	-1.12	0.26
	0.50	-13.95	16.31	-0.85	0.39
	0.75	-17.16***	3.56	-4.82	0.00
KOF	0.25	0.48	0.35	1.37	0.17
	0.50	0.37	0.35	1.05	0.29
	0.75	0.53***	0.10	5.27	0.00
M	0.25	$1.43\times 10^{-5***}$	1.08×10^{-6}	13.20	0.00
	0.50	$1.55\times 10^{-5**}$	7.80×10^{-6}	1.98	0.05
	0.75	$1.82\times 10^{-5***}$	9.77×10^{-7}	18.58	0.00
E	0.25	0.31	0.41	0.75	0.45
	0.50	0.17	0.31	0.54	0.59
	0.75	0.19**	0.08	2.36	0.02
MER	0.25	0.002**	6.97×10^{-4}	2.67	0.02
	0.50	0.002	0.001	1.65	0.10
	0.75	0.001***	2.32×10^{-4}	6.00	0.00

** and ***: Denote statistically significance at 5 and 1% levels, respectively.

implementation, and reduction in the government's ability to allocate financial resources, due to budgetary limitation. In the other words, policymakers do not choose a sustainable approach for food price management.

Moreover, in the third quantile, the largest effect goes to the KOF index of globalization. This clearly reveals the susceptibility of domestic food prices to world food price variation. Hence, it is anticipated that more integration of the Iranian economy into the world economy leads to stronger linkage between world and domestic commodity prices.

The variable of interest, namely, energy consumption exerts a significant impact in the third quantile. In terms of magnitude, it follows KOF. Therefore, energy consumption in agriculture can be regarded as a driver for food prices. This result confirms the assumption of Hosseini *et al.* (2011), Kohansal and Hezareh (2016), Ghaderi *et al.* (2005), Institute of Agricultural Research Planning and Economics (2007), and Abbasian and Moradpour Oladi (2008) results, which indicate that policy of energy subsidies not only help the producers to decrease the production cost but also causes a food price increase due to the reduction in production efficiency and rise in production costs. As presented in Table 3, impact of energy consumption in the first quantile is more noticeable. It seems that energy scarcity in the rural area from 1960 to 1990 has led to higher energy price and cost of production.

Moreover, exchange rate variations directly influence food prices. This is also in line with prior expectations. Higher exchange rates for foreign currency raises the price of imported food, which positively affects the food price index, while price of imported production inputs such as some fertilizers, most herbicides, and pesticides would also increase. Kohansal and Hezareh (2016) and Radmehr and Rastegari Henneberry (2020) have reported the same finding. It should be noted that the modest impact of the exchange rate on the food price is due to the allocation of the preferential exchange rate by the government for the import of essential food and production inputs.

After estimating different quantiles, it is necessary to investigate their dissimilarity. This is commonly done by using the slope equality test proposed by Koenker and

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Table 4. Quantile slope equality test.

	Test summary	Chi-square statistic	Chi-square df	Prob
	Wald test	25.38	8	0.00
Restriction detail: b(tau_ h) – b(tau_ k) = 0				
Quantiles	Variable	Restr value	Std error	Prob
0.25, 0.50	KOF	0.11	0.32	0.73
	M	-1.21×10^{-6}	7.44×10^{-6}	0.87
	E	0.13	0.35	0.69
	MER	-3.37×10^{-5}	0.00	0.97
0.50, 0.75	KOF	-0.16	0.31	0.60
	M	-2.66×10^{-6}	7.34×10^{-6}	0.71
	E	-0.02	0.28	0.91
	MER	5×10^{-4}	0.002	0.62

Bassett (1978). Table 4 presents the test result. The estimated Wald statistic is significant at a 1% level, confirming the dissimilarity of the three estimated quantiles. This implies that the relationship among variables should not be studied through an overall regression. In other words, the size of impact differs in separate parts of the dependent variable distribution.

CONCLUSIONS

This study aimed at investigating the effect of agricultural energy consumption on food prices in Iran. A regression model was used based on relevant literature that considers energy consumption, money supply, globalization, and exchange rate as influential factors on food price. Due to the high degree of government intervention in agriculture, we supposed quantile regression to be the best model to fit our data. This model was estimated using time series data for the period 1966-2017. The suitability of the applied model was confirmed through different statistical and econometric tests. In other words, our findings strongly suggest the estimation of different regressions for separate parts of the food price statistical distribution. Furthermore, only in the 0.75^{th} quantile a positive and significant relationship between the food price index and all considered covariates was identified. It means that at higher levels of food price, the selected covariates can better explain food price variations.

Moreover, in terms of impact size, the KOF index of globalization was found to have the greatest effect on food price. From the policy-making point of view, this is an important finding implying high sensitivity of domestic food price to the world food price variations. Also, agricultural energy consumption showed a significant and positive impact on food prices. This could be attributed to the low efficiency of energy use in Iranian agriculture, which, of course, is due to the highly subsidized fuel price. In other words, more use of energy brings less output and leads to a higher cost of production. Therefore, policies aiming at the enhancement of energy efficiency in agriculture including pricing strategy reform are recommended.

Meanwhile, the estimated effect of the exchange rate was in accordance with prior expectations, as more expensive foreign currency results in a higher price of imported food and, consequently, a rise in food price. Hence, strengthening of domestic production, at least for staple foods, and keeping adequate buffer stock to manage the market where foreign currency and food imports become more expensive, can be suggested.

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Finally, other findings revealed a direct association between food price and money supply (as expected). Therefore, the government should follow rigorous fiscal discipline in its budget to reduce both budget deficit and reliance on central bank reserves.

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مصرف انرژی و قیمت غذا: رهیافت رگرسیون کوانتایل در کشاورزی ایران

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چکیده

بخش انرژی یکی از مهم ترین بخش های زیربنایی است که دارای اثرات مستقیم و غیرمستقیمی در زمینه‌ی اقتصادی، سیاسی و اجتماعی می‌باشد. ایران نیز دارای منابع غنی انرژی است. مدیریت اقتصادی مناسب انرژی‌های پایان پذیر دارای اهمیت زیادی است. لذا می بایست مصرف منابع انرژی به خصوص میزان استفاده از منابع پایان‌پذیر کنترل شود. بنابراین افزایش قیمت یا کاهش یارانه حامل های انرژی گامی موثر در جهت کنترل مصرف و افزایش بهره وری انرژی می باشد.در این میان با افزایش قیمت انرژی، بخش کشاورزی از آن اثر گرفته و هزینه تولید آن افزایش می یابد و به دنبال آن قیمت مواد غذایی افزایش می یابد. از آنجایی که بسیاری از خانوارها به شدت به محصولات ضروری به منظور تأمین کالری غذایی روزانه خود وابسته هستند، توجه به این روابط ضرورت می یابد. لذا این پژوهش به بررسی اثرگذاری مصرف انرژی در بخش کشاورزی بر شاخص قیمت مواد غذایی در ایران با استفاده از داده های سری زمانی 1346-1395 پرداخته است. برای این منظور مدل تحقیق با استفاده از رگرسیون چندک تخمین زده شد. نتایج نشان داد که مصرف انرژی و شاخص جهانی سازی در چندک 75 ام و متغیر نرخ ارز در چندک 25 ام و 75 ام بر شاخص قیمت مواد غذایی اثرگذار است. همچنین حجم نقدینگی در همه ی چندک های مورد بررسی اثری مثبت و معناداری بر قیمت مواد غذایی دارد.

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