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Structural Break Analysis in Beef Production of Turkey

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ABSTRACT
Although Turkey has significantly increased beef production in the last fifty years via livestock protection and domestic support policies, self-sufficiency and price stability has not been sufficiently achieved. Forecasting is essential to analyse the structure of the beef market and evaluate the sector. This study aimed to forecast beef production of Turkey by considering structural breaks. The data of the study was time series of beef production for the period 1961-2019 and it was obtained from the Turkish Statistical Institute and, Food and Agriculture Organization. Data was analysed and forecasted using ARIMA Model. The results indicated that ARIMA (1, 1, 0) is the best-fitted model and beef production would regularly increase in four years period and reach 1,133,687 tons in 2023. This research concluded that despite two structural breaks of beef production in 1983 and 2009, imports and domestic support policies substantially shaped the trend of beef time series in the last decade in Turkey.

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Türkiye'nin Sığır Eti Üretiminde Yapısal Kırılma Analizi

ÖZET
Türkiye hayvancılığı koruma ve destekleme politikaları ile son elli yılda sığır eti üretimini önemli ölçüde artırmış olmasına rağmen, kendi kendine yeterlilik ve fiyat istikrarı konusunda yeterince başarı sağlayamamıştır. Sığır etinin tahmin edilmesi, sığır eti pazarının yapısını analiz etmek ve sektörü değerlendirmek için gereklidir. Bu çalışmada yapısal kırılmalar dikkate alınarak Türkiye'deki sığır eti üretiminin tahmin edilmesi amaçlanmıştır. Araştırmanın verileri Türkiye İstatistik Kurumu ve FAO'dan alınan 1961-2019 dönemi sığır eti üretim verileridir. Verilerin analizi ve tahmini ARIMA Modeli kullanılarak yapılmıştır. Sonuçlara göre ARIMA (1, 1, 0) modelinin en uygun model olduğu, sığır eti üretiminin dört yıllık dönemde düzenli olarak artacağı ve üretimin 2023'te 1,133,687 tona ulaşacağı öngörülmektedir. Türkiye'de sığır eti üretiminde 1983 ve 2009 yıllarındaki iki yapısal kırılmaya rağmen, ithalat ve yurtiçi destek politikalarının son on yılda üretimi önemli ölçüde şekillendirdiği ortaya konmuştur.

Araştırma Makalesi

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INTRODUCTION
Although Turkey has great potential in agriculture, livestock production has always been of secondary importance concerning crop production. The livestock sector has further supported since 2000 and the share of livestock supports in the total agricultural supports was increased from 0.5% to 31% by 2019 (MoFAL, 2015; Anonymous, 2018). Meanwhile, with the support provided to the livestock producers due to the problems encountered, the share of the livestock sector in the total agricultural production value increased from 22% to 29% in the period 2000-2016 (FAO, 2020a). In the last two decades, the share of beef production in total meat production has increased almost two times (TurkStat, 2014; 2020a). However, a 13% decrease in real producer price of beef with a perpetual increase in consumer price in the same period indicated that beef producers could not get use from increasing of

consumer prices (TurkStat, 2020b). However, there has been an increasing trend in the main production cost items such as concentrated feed and breeding materials constituted of a large part of the production costs (Gözener and Sayılı, 2015; Çelik and Sarıözkan, 2017; Alhas Eroglu and Bozoglu, 2019).

The last sixty years period of beef production series indicated that there has been an increasing trend despite two essential structural breaks (Figure 1). The first structural break was caused only by an increase in the level and maintained its almost constant slope level until the world food crisis of 2009. The second break is quite significant than the first one because the impacts of policies due to the meat crisis in Turkey at the beginning of 2009 and these are very effective on this change and the government has started to import a large number of cattle and beef along with supporting the producers since then. For this reason, examining and forecasting are inevitable by researchers to evaluate the appropriateness of such beef production policies and obtain sound forward-looking insight.

In the literature, few studies have forecasted different research areas of the livestock sector in Turkey such as farm animals, production, consumption, etc. Cenan and Gürcan (2011) examined some farm animals, whereas Yavuz and Zulauf (2004), Çelik (2012), Akgül and Yıldız (2016), Çelik (2017) and Ordu and Zengin (2020) forecasted amount of meat production. Alhas Eroglu et al. (2019) also forecasted amount of production but beef production data contain two structural breaks. In this study, structural breaks are taken in consideration. Not only meat but other livestock products were also forecasted in Turkey (Karkacıer, 2000; Kaygısız and Sezgin, 2017; Koşum et al., 2019; Yıldırım and Altunç, 2020). On the other hand, Özen et al. (2019) forecasted meat consumption whereas Yavuz et al. (2013), Ayyıldız and Çiçek (2018) and Küçükoflaz et al. (2019) forecasted yield and price of meat sector. Although the livestock sector and especially beef production are of vital importance, there has been a scant number of studies in Turkey. This scarcity could be resulted not only from the uncertainty of the sector as a result of livestock policies but also from the nature of the sector that depends on living beings. Also, the meat sector is a controversial subject in the country due to the lack of a detailed understanding of the sector as well as the existence of distinct dynamics, policy implications, and structural problems. Since beef is the main part of meat production, the forecasting of the meat production is indispensable for developing more effective support policies in the red meat market. Consequently, this study aimed to forecast beef production of Turkey by considering structural breaks and evaluate sectoral developments in the light of policies and practices in Turkey.

This paper is structured as follows: The second section describes material and method and the third section presents model results and discussion. The fourth section introduces the conclusion with recommendations.

MATERIAL and METHOD

In this study, 59 years of time-series data (1961-2019) of Turkey were examined to forecast beef production over the period 2020 to 2023 in the light of endogenously determined structural breaks. Data were obtained from the TurkStat and, Food and Agriculture Organization (FAO) (TurkStat, 2020a; FAO, 2020b).

Auto-Regressive Integrated Moving Average Model (ARIMA) is one of the approaches used to forecast time series which was formulated in the context of Box-Jenkins methodology (Box and Jenkins, 1976). This methodology consists of four steps: i) model identification, ii) estimation of parameters, iii) diagnostic tests and, iv) forecasting. The model is denoted by ARIMA (p, d, q) where p is the number of autoregressive terms indicating the dependent relationship between the observations and some number of lagged observations; d is the differencing levels of series to make the time series stationary and q is the number of moving average terms keeping the dependency between observation and residual errors. The general form of the model can be shown as:

$$(1 - \phi_1 L - \phi_2 L^2 - \cdots - \phi_p L^p)\Delta^d Y_t = \delta + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{q-1} \quad (1)$$

In classical time series analysis, the Augmented Dickey-Fuller (ADF) test has extensively been used to determine the unit root. One important issue regarding ADF type endogenous break unit root tests is that they omit the possibility of a unit root with a break. If a break exists under the unit root null, two undesirable results can follow: i) These endogenous break unit root tests will exhibit size distortions such that unit root null hypothesis is rejected too often. When utilizing such tests, researchers may incorrectly conclude that a time series is stationary with a break when in fact the series is nonstationary with the break. ii) ADF type endogenous break unit root tests incorrectly estimate breakpoint (Lee and Strazicich, 2001; 2003; 2004).

First of all, the data generating process based on the unobserved component model could be attained as follows:

$$y_t = \delta Z_t + X_t \quad , \quad X_t = \beta X_{t-1} + \varepsilon_t \quad (2)$$

In the formula, Z_t contains exogenous variables and the unit root null hypothesis is described by β=1. Lee and Strazicich defined two models of structural change: i) The first model is a crash model that allows for a one-time change in intercept under the alternative hypothesis. ii) The other one allows for a shift in intercept and change in trend slope under the

alternative hypothesis. Then, unit root statistics can be obtained from;

$$\Delta y_t = \delta' \Delta Z_t + \emptyset \tilde{S}_{t-1} + u_t \quad (3)$$

Unit root null hypothesis is described by $\emptyset = 0$ and the LM t-test statistic can be formulated as follows:

$\tilde{\tau}$ = t statistic testing the null hypothesis $\emptyset = 0$ (4)

Autocorrelated errors could be corrected with augmented terms $\Delta\tilde{S}_{t-j}$ and j = 1,..., k as in the standard ADF test. The location of the break (TB) is determined by searching all possible breakpoints for the minimum (i.e., the most negative) unit root test t-test statistic as follows (Lee and Strazicich, 2001; 2004):

$$Inf\tilde{\tau}(\tilde{\lambda}) = Inf\tilde{\tau}(\lambda) \quad \text{where} \quad (5)$$
$$\lambda = T_B/T$$

This study used ARIMA ML methodology to forecast and Lee-Strazicich method to analyze structural breaks. Data analysis and forecasted amount of beef production were obtained via R statistical programming.

RESULTS and DISCUSSION

Figure 1 reported the actual and first difference of beef production of Turkey for the period 1961-2019 and revealed some significant points. i) The amount of beef production has distributed through mean with constant variance and has constant slope during the 1961-1983 period. ii) In 1983, the amount of beef production has increased almost 2.5 times in comparison with the former period. Therefore, beef production had an essential break in the level and it has continued with a constant mean until 2009. iii) Since 2009, beef production has an upward trend as a result of imports and supports. Especially after 2009, the increasing slope has indicated that beef production would not have constant mean and variance as a result of import and support policies. Therefore, the time series of beef production would be non-stationary at level but would be stationary at the first difference (Figure 1).

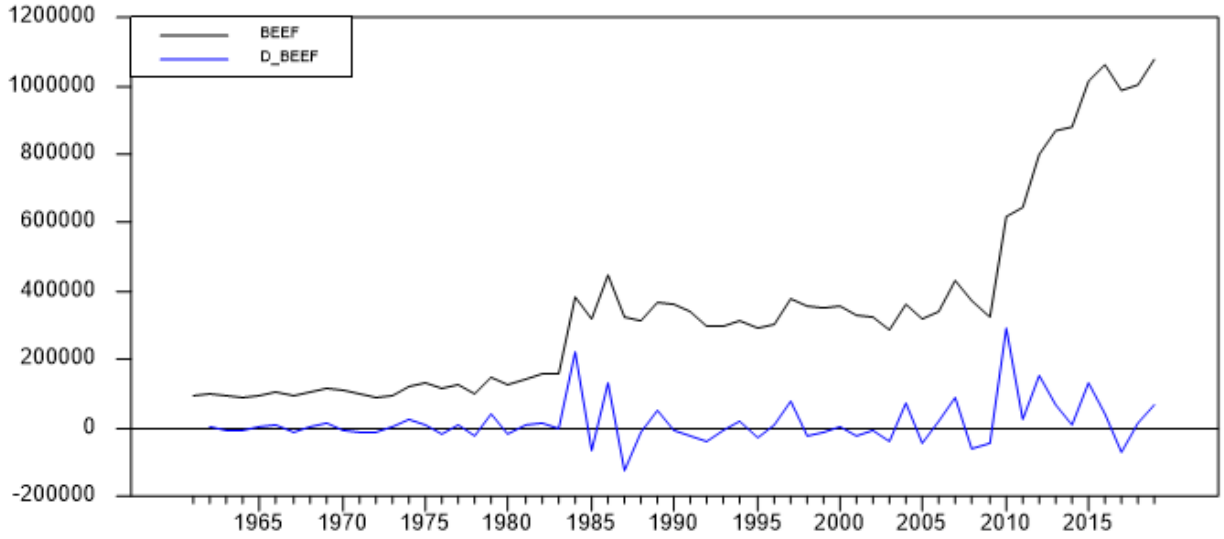

Figure 1. Actual and first differenced beef production of Turkey for 1961-2019
Şekil 1. Türkiye'de 1961-2019 yılı için gerçek ve birinci farklı alınmış sığır eti üretimi

In this context, the time series of beef production should be examined to decide whether the series have unit root or not. First of all, the number of lags should be determined and unit root tests should be applied with considering these lags. Table 1 presented information criteria for ADF lag lengths of beef production and indicated that lag length would be 1 for AIC whereas 0 for BIC and HQ.

Lee-Strazicich unit root test which considers structural breaks was applied within 2 different scenarios of lag lengths. Table 2 presents Lee-Strazicich unit root test results and indicates that we cannot reject the null hypothesis of a unit root in the time series of beef production and it is non-stationary despite two different lag analyses. Therefore, the first difference should be applied but primarily structural breaks should be examined. The results indicated that two structural breaks have observed in 1983 and 2009. On the other hand, the non-stationary structure of time series of beef production probably resulted from the rise of production after 2008.

Dickey-Fuller unit root test has applied to decide whether the series have unit root or not. The results highlighted that beef production is stationary in the first difference and the null of a unit root in the first difference could be rejected at a 5% significance level both for with and without constant (Table 3). Therefore, beef production is stationary at the first

difference and it constituted a basis for Box-Jenkins ARIMA models. In ARIMA (p, d, q) combination, d=1 and then p and q would be examined via BIC and AIC, respectively.

AIC analysis indicated that AIC would be smallest in p=1 and q=0 combination and Box-Jenkins ARIMA model (1, 1, 0) best fitted (Table 4).

Table 1. Information criteria for ADF lag lengths for beef production
Çizelge 1. Sığır eti üretiminde ADF gecikme uzunlukları için bilgi kriterleri

Lags	AIC	BIC	HQ	MAIC	ADF
0	22.447	22.564*	22.491*	22.386	-1.200
1	22.442*	22.598	22.501	22.343*	-0.719
2	22.479	22.674	22.553	22.391	-0.816
3	22.469	22.703	22.557	22.472	-1.366
4	22.508	22.781	22.612	22.548	-1.307
5	22.531	22.843	22.649	22.717	-1.561
6	22.542	22.893	22.675	23.087	-1.911
7	22.584	22.974	22.731	23.143	-1.473
8	22.624	23.053	22.786	23.026	-1.058
9	22.638	23.106	22.815	23.987	-1.436
10	22.677	23.184	22.869	24.296	-1.439

Table 2. Lee-Strazicich unit root test results
Çizelge 2. Lee-Strazicich birim kök testi sonuçları

Lag length	Variable	Coefficient	T-Stat	0.01	0.05	0.10
0	S{1}	-0.6855	-5.2075	-7.0040	-6.1850	-5.8280
	Constant	-5770.8162	-0.6948			
	D (1983:01)	235201.5779	6.0400			
	DT (1983:01)	-5197.7617	-0.4661			
	D (2009:01)	-205609.1875	5.0352			
	DT (2009:01)	98657.3904	5.7313			
1	S{1}	-0.6875	-5.1724	-7.0040	-6.1850	-5.8280
	Constant	-6389.5972	-0.7444			
	D (1983:01)	235226.4655	5.9887			
	DT (1983:01)	-4603.8683	-0.4042			
	D (2009:01)	205502.1889	4.9892			
	DT (2009:01)	98789.2766	5.6881			

Table 3. Dickey-Fuller Unit Root Test Results for First Difference
Çizelge 3. Birinci farkta Dickey-Fuller birim kök testi sonuçları

	Without constant	With constant
Significance Level	Critical Value	Critical Value
0.01 (**)	-2.60328	-3.54775
0.05 (*)	-1.94628	-2.91271
0.10	-1.61878	-2.59371
T-Statistic	-4.57515**	-5.07107**

Table 4. AIC analysis of models for beef production
Çizelge 4. Sığır eti üretimi için modellerin AIC analizi

AR/MA	0	1	2	3	4	5
0	1453.2038	1453.4536	1453.2654	1454.4251	1456.3812	1456.5633
1	1452.9500*	1454.7685	1454.1984	1456.3942	1467.4033	1458.5525
2	1454.3817	1458.0244	1456.1237	1460.4975	1459.8501	1457.5893
3	1453.7948	1455.7816	1457.7058	1459.2965	1460.7169	1459.0296
4	1455.7882	1457.7692	1460.6272	1466.4068	1467.4703	1467.1843
5	1457.5751	1464.5476	1460.2238	1461.5382	1473.0750	1464.0345

Table 5. Final estimates of parameters
Çizelge 5. Parametrelerin son tahminleri

Parameters	Coefficient	Std error	T-Stat	P-value
Constant	16783.17692	7338.09593	2.28713	0.02598
AR 1	-0.19470	0.13174	-1.47790	0.14503

The parameters of the beef model were estimated and presented in Table 5. Accordingly, it was determined that the estimation of parameters in the constant model is statistically significant ($p<0.05$).

Table 6 and Figure 2 reports the forecasted amount of beef production of Turkey for the period 2020-2023 period. The results highlighted that beef production would reach 1,081,585.524 tons in 2020 and 1,133,687.858 tons in 2023. Therefore, increasing the trend of beef production in Turkey would continue in the near future. The results of the study are compatible with Çelik (2012) and Akgül and Yıldız (2016) who revealed that production of meat would increase from 2014 to 2020 and red meat production would increase up to 2023, respectively. On the other hand, the results of the model highlighted that structural breaks are not as essential as the increasing trend of the last ten years. Therefore, the forecasted amount of this study is quite similar to the results of Alhas Eroglu et al. (2019) who did not consider the structural breaks. In this sense, the time series trend of Turkish beef production has considerably shaped in the last ten years period and there are some reasons for this change. i) The impacts of the support policies in this period are more serious concerning former periods. The government imported a high amount of cattle since 2011 and it has increased year by year. Although the government has supported producers to alleviate the costs and to increase beef production, the level of production could not reach the desired level and prices of beef meat have perpetually risen. ii) The methodological change of TurkStat in the computation of beef production is also of vital importance. Until 2010, the amount of beef production was calculated as the sum of two components in Turkey: Slaughtering at the slaughterhouses and slaughtering during Festival of Sacrifice which is taken from Turkish Air Association as hides collected by them. The beef production covers slaughterings inside and outside of slaughterhouses starting from 2010 (TurkStat, 2019a).

Table 6. Forecasted amount of beef production for Turkey in the 2020-2023 period (tons)
Çizelge 6. Türkiye'de 2020-2023 döneminde öngörülen sığır eti üretim miktarı (ton)

	2020	2021	2022	2023
Production forecast	1,081,585.524	1,100,447.431	1,116,825.882	1,133,687.858
Std. error	(66600.242)	(85510.993)	((102302.647)	(116467.063)

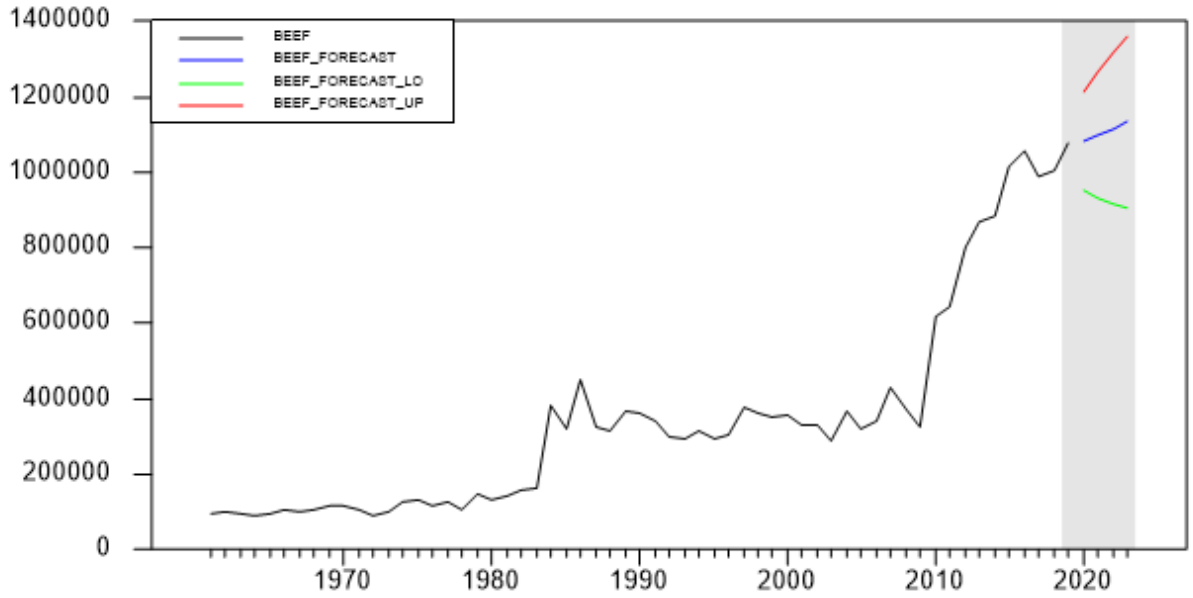

Figure 2. Forecasted amount of beef production in the period 2020-2023
Şekil 2. 2020-2023 döneminde tahmini sığır eti üretim miktarı

iii) The change of population has also affected beef production in Turkey. Until 2000, population has determined via census and total population of Turkey was 67.8 million. Since 2007, population has been calculated at the end of every year and the population of Turkey was 70.5 million by 2007. The number of population has increased 1.37% on average in the period 2007-2019 (TurkStat, 2020c). iv) Lastly, since 2000, the number of visitors has substantially increased year by year. For example, almost 13.5 million departing visitors have visited Turkey in 2001 but this number has risen to 32 million by 2009 (TurkStat, 2020d). Therefore, consumption has also increased with tourism. For these reasons, the rise of beef production should be assessed with all of these impacts, and policies should be regulated to increase productivity and efficiency.

Table 7 and Figure 3 revealed the residuals for ARIMA. According to the fluctuations in the previous years, we can observe that, even after the world food and financial crisis in 2008, there were high swings around zero in residuals of the forecasted ARIMA model as expected, but they were damped in the following periods. Meanwhile, the test statistics indicated that there is no autocorrelation in residuals ((Ljung-Box Q (10)) and even in squared residuals (McLeod-Li (10)). On the other hand, a zero-mean of residuals is also examined by the t-test. Therefore, it is indicated that Box – Jenkins ARIMA (1, 1, 0) is the best model for forecasting of beef production.

Table 7. Autocorrelation analysis of the model for residuals
Çizelge 7. Model kalıntıları için otokorelasyon analizi

Test	Statistic	P-Value
Ljung-Box Q(10)	6.8282	0.7416
McLeod-Li(10)	5.8025	0.8316
Turning Points	-0.1054	0.9160
Difference Sign	0.2254	0.8216
Rank Test	0.7848	0.4326

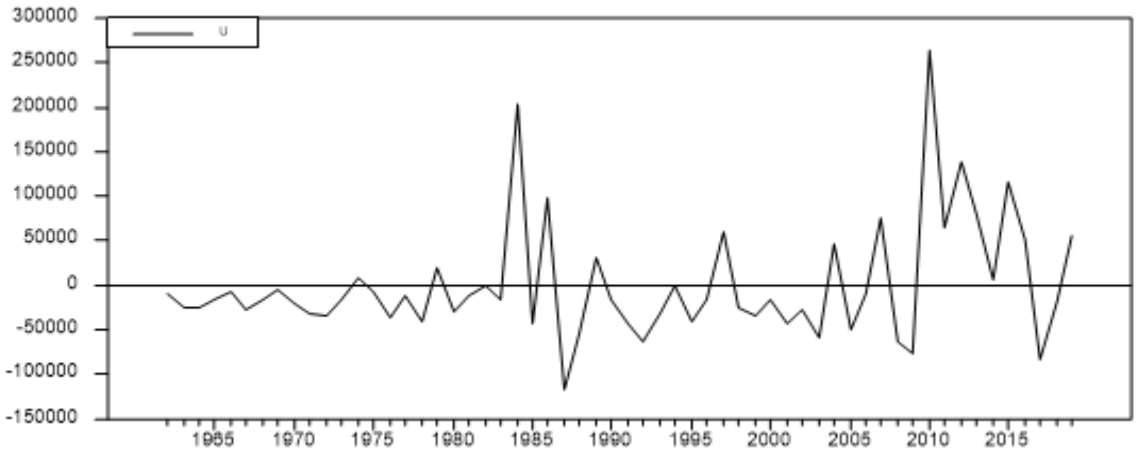

Figure 3. Residuals from ARIMA (1, 1, 0)
Şekil 3. ARIMA (1, 1, 0)'dan kalıntılar

CONCLUSION

This study examined to forecast beef production of Turkey from 2020 to 2023 via Box-Jenkins methodology by considering structural breaks. The results of the study highlighted that in the next four-year period, beef production would increase without any interruptions. Model results revealed that future beef production has been substantially formed thanks to the last ten-year production. We can highlight that the prohibition of the slaughter of pregnant and high breeding female animals during the Feast of Sacrifice, the opening of import permission for breeding animals from abroad and the grants and incentives for breeding heifers were effective in these increases. Therefore, two structural breaks are not as significant as times series of the last ten years and this period has been mainly dominated by policy applications named imports and supports. Unfortunately, imports are much more efficient on beef production than supports and both producers and consumers have been poorly affected by this policy. Therefore, market regulation through imports should not be an agricultural policy for the livestock sector and the government should take necessary precautions to increase the amount of beef production via support and grants towards breeding heifers in particular. In this way, the sustainability of the sector and market balance could be achieved in favour of both producers and consumers. In future studies, with the help of the dummy variable, it can be shown how the import plays a role in the meat production estimations and whether it is compatible with the Central Bank monetary policies in the country.

Contribution of the Authors as Summary

Authors declares the contribution of the authors is equal.

Statement of Conflict of Interest

Authors have declared no conflict of interest.

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