Forecasting Inflation using the ARIMA Approach (Case of Albania)

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Abstract: Traditionally, macroeconomic statistics have played a major role in creating the framework for analyzing economic phenomena. Price changes are one of the most worrying situations where individuals, firms, and government tend to keep in control as much as possible. Even if the economic effect could be negligible, the psychological effect could be more considerable. Inflation creates a touchable impact in the vast majority of economic sectors. Meanwhile, empirical studies of inflation have shown a very correlative relationship between inflation and other macroeconomic indicators such as unemployment, GDP growth, net exports, etc. Albanian economy has suffered from time to time from inflation consequences. Simultaneously, inflation in Albania has created a cyclical form and a significant trend. Due to these conditions, simple econometric models such as ARMA or ARIMA can be used to forecast future inflation, especially at the moment when inflation is the focus of the Albanian economy. This paper aims to create an ARIMA econometric model of inflation in the time frame from 2009-2022. It also creates a quantitative approach for forecasting inflation in the Republic of Albania. Furthermore, this paper tries to explain some phenomena linked with inflation giving some qualitative data. ARIMA model will be used to forecast future inflation in Albania. Lastly, as explained in the paper, it is shown that the ARIMA model should be taken under consideration in policymaking processes.

Keywords: - Inflation, ARIMA model, forecasting

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1 Introduction

Macroeconomic statistics have historically been crucial in developing the foundation for examining economic phenomena. Due to their significance in the overall economy, macro indicators (including unemployment, inflation, economic growth, imports, and exports) have been at the core of economic theories. One of the most unsettling circumstances is when prices change, and people, businesses, and the government all try to maintain as much control as they can. The psychological impact of inflation could be greater even if the economic impact can be minimal.

In the vast majority of economic sectors, inflation has a palpable effect. Price fluctuations can occasionally turn deadly as a result of the domino effect they generate. Prices of final goods increase as a result of rising costs of production in the industries and sectors they affect. A very strong correlation has been found between inflation and other macroeconomic indicators including unemployment, GDP growth, net exports, etc. in empirical studies of inflation.

Occasionally, the effects of inflation have impacted the Albanian economy. In the previous three decades, the focus of fiscal policy and the macroeconomic framework have included inflation as a key indicator. Additionally, the central bank of Albania's key monetary policy goals has been price stability and targeted inflation. Prices rose by double digits in the first decade of the 1990s, taking into consideration the structural change in the Albanian economy. Meanwhile, they started to normalize in the second decade after previous fluctuations and shocks. This normalization was accompanied by the

intervention of central government institutions, the central bank, and the improvement of other macroeconomic indicators.

Albanian inflation seems to be a useful indicator to examine in terms of its trend and form. Some industries are largely responsible for inflation, while other economic sectors maintain more stable pricing. Recent years show high inflation in developing sectors like construction, and food and beverage industry, etc. In Albania, inflation has simultaneously resulted in a strong trend and a cyclical form. These factors make it possible to predict future inflation using straightforward econometric models like ARMA or ARIMA, particularly currently when inflation is a key concern for the Albanian economy.

The purpose of this study is to develop an ARIMA econometric model of inflation for the period from 2009 to 2021. Furthermore, it develops a quantitative technique for forecasting inflation in the Republic of Albania. There are no recent papers or studies that forecast inflation in Albania with econometric models that analyze the process of inflation forecasting in Albania and explain its cyclical trend. Besides that, by providing some qualitative data, this research attempts to explain several occurrences connected to inflation. The ARIMA model will be employed to estimate Albanian inflation in the future. Additionally, this study extends to the ongoing discussion on inflation and its consequences for the Albanian economy. Literature suggests that ARIMA models are one of the best and most practical methods for explaining the economic phenomenon of inflation.

2 Literature Review

The focus of economists has always been on inflation, just like it is with all macroeconomic measures. Some theoretical frameworks make an effort to explain how inflation affects the economy and how prices affect supply and demand. Other economists have developed streamlined models to describe the roots of inflation and predict their effects. In general, inflation takes into consideration the stable growth of the prices in a certain economy, [5], [6].

One of the major concerns about inflation is how it affects economic growth. The ability to measure how inflation affects economic growth can be somewhat limited at times. Due to the additional effects of inflation, it is very hard to quantify the real impact. Inflation affects all equilibrium sides. Due to changes in the cost of the end products themselves as well as the production factors, demand and supply chains experience significant volatility. Hernando and Andrés have examined how inflation affects economic growth, [1], [8], [4]. They concluded that inflation typically forces the economy to contract because higher prices constrain both supply and demand. Controversially, the first economic theories sought a positive correlation between growth and inflation [7], [15].

Numerous studies examine how inflation affects investments. "*Price inflation is associated with increased price volatility, and it can lead to future investment insecurities*", [12], [13]. As investments are frequently associated with significant cash flow, inflation may be detrimental to the climate for investments. In the meanwhile, inflation is being targeted at concerns about future cash flows. The inflation rate has a greater impact on the general equilibrium than unemployment or the other macro indices.

Different perspectives on the economic structure resulted in various solutions. Monetarists have examined the crucial part that monetary expansion plays in determining the rate of inflation. Other schools of economic thinking, such as the Neoclassicals, have developed ideas that attempt to explain how inflation affects capital accumulation and investment, which in turn influences how it affects growth, [6], [9]. Since the economy is temporarily transitioning into a new stable potential growth level, the short-term inflation brought on by an increase in aggregate demand is seen as beneficial for the economy. While Keynesians define long-term inflation as a troubling phenomenon in the long run. A "lazy dog" could best describe inflation; it stays at a certain level until there is a disturbance.

One of the most important questions regarding inflation is linked with the level of inflation that causes economic growth to be negative. What level of inflation is harmful to economic growth? Various studies have made a lot of empirical reviews of different levels of inflation in different stages of growth. In addition, cross-data about different countries have been analyzed together. Authors like Ghosh and Philips, Khan, and Senhadji concluded that reducing inflation by 1 percent could raise output by between 0.5 and 2.5 percent. They also found that

there is a nonlinear relationship between inflation and economic growth, [15], [19], [11].
The econometric modeling of inflation has been the subject of many recent studies. We may use these measures to design an inflation forecasting framework by taking into account new models of auto-regressive vectors and the concepts of moving averages. According to mathematical reasoning, we can clearly describe inflation as one of the self-explanatory phenomena that can "repeat itself". We can accurately anticipate future inflation utilizing econometric tools in addition to analyzing the historical time series of inflation. In light of the above, this paper's goal is to examine Albania's inflation rate and predict future inflation using ARIMA models, [2], [14], [17], [20].

The first discussion linked with the level of inflation determines which type of inflation should be considered. Other countries with similar economic typologies as the Albanian economy suggest that the *core inflation* should be the right level to be considered, [4], [10]. The inflation rate taken into consideration in this paper will be the inflation rate measured in the Republic of Albania by the Consuming Price Index (Core-CPI) (monthly data), [19], [16].

3 Methodology

This section outlines an ARIMA modeling and forecasting framework. The rigorous collection and assessment of data serve as the foundation for the ARIMA forecasting process, [18]. The generalized ARIMA model can be used as a tool to predict future inflation rates if it is developed under theoretical assumptions. Figure 1 serves as a synopsis of the general process and the key steps.

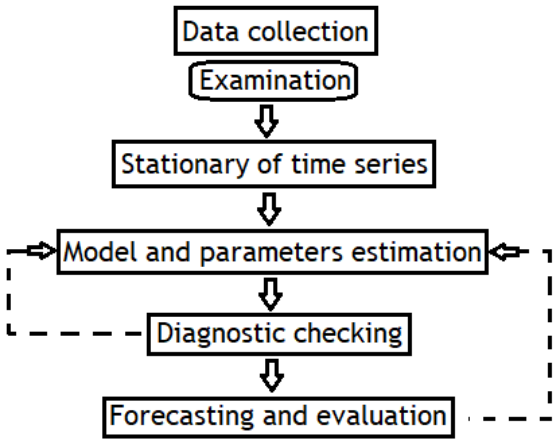

Fig. 1: Arima forecasting steps

3.1 Data Collection and Examination

This paper examines the Republic of Albania's inflation data over the last 13 years (2009 – 2022). The inflation rates data are collected from the Bank of Albania[1] and show monthly data about the core inflation of a time series with 166 data rows. We can see some inflation shocks from time to time by taking a quick look at the data (Figure 2) Meanwhile, the inflation rate has become more stable and less volatile in recent years. As can be seen, by the figure below, the core inflation in Albania has been under the targeted level of 4% for more than 12 years. Meanwhile, the highest inflation before 2022 has been in 2011 as the world crisis began to affect the Albanian economy. Continuously, for approximately three years (2013 – 2016), the economy of Albania was accompanied by deflation and then it stabilized between the interval 2% - 4%. Nowadays, the core inflation has peaked at almost 10%. In addition, the last months have shown a new trend of rising inflation in almost all the important economic sectors of Albania. Moreover, the Russo – Ukrainian war and the energetic crisis have been the main contributors to inflation. Foods and beverages, input prices, transportation, and real estate sectors have been the most affected by inflation.

[1] Bank of Albania is the official central bank of the Republic of Albania.

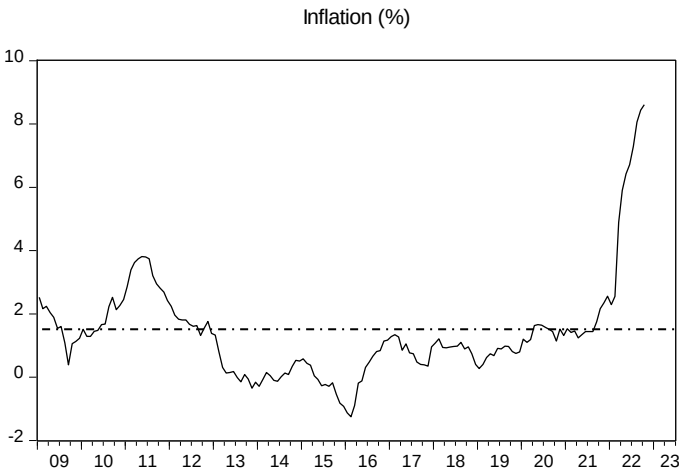

Fig. 2: Monthly core inflation data (%)
(2009 -10M2022) Generated by: EViews 10

3.2 Stationarity of Time Series

In the autoregressive models and regressive models in general which create time series, econometric diagnosis, and tests must be in consideration to assess the effectiveness and relevance of these models. Stationarity of the time series is one of the most important initial points to complete, and it serves as a pre-test for creating the autoregressive models. A stationary process has the property that the mean, variance, and autocorrelation structure do not change over time. Stationarity can be defined in precise mathematical terms. Still, for our purpose, we mean a flat-looking series, without trend, constant variance over time, a constant autocorrelation structure over time, and no periodic fluctuations. If the time series is not stationarity, usually the data of the time series can be different (in the first or second level). That is, given the series L_t we create the new series $Y_i = \Delta L_t = L_i - L_{i-1}$. The differenced data will contain one less point than the original data. Although we can differentiate the data more than once, one difference is usually sufficient.

Before evaluating the stationarity of data collected, the general form of the ARIMA model is a simple ARMA model (autoregressive moving average model). If the time series is root stationary, then we can create an ARMA model. Whereas the time series fail to be originally stationary, we differentiate (usually at the first level) data and take into consideration an ARIMA model. A generalized *ARMA (p; q)* model can be described below:

$$Y_t = \sum_{i=1}^{p} \varphi_i \, y_{t-i} + \sum_{i=1}^{q} \theta_i \, y_{t-i} + \varepsilon_i$$

Generally, an ARIMA (*p,d,q)* is a nonseasonal model where:

- **p** is the number of autoregressive terms,
- **d** is the number of nonseasonal differences needed for stationarity, and
- **q** is the number of lagged forecast errors in the prediction equation.

Let *y* denote the d^{th} difference of Y, which means if time series are stationary at the first difference (as our model explained below), then $y_t = Y_t - Y_{t-1}$. The primary ARIMA model should now be as:

$$\Delta y_t = \sum_{i=1}^{p} \varphi_i \, y_{t-i} + \sum_{i=1}^{q} \theta_i \, y_{t-i} + \varepsilon_i$$

Analyzing inflation rate data (on monthly basis) we conclude that they are not unit root stationary, and they are being converted into stationary ones at the first level.

The augmented Dickey-Fuller test for stationarity of time series is presented in Table 1.

Table 1. Augmented Dickey-Fuller test for stationarity of time series

Null Hypothesis: D(INF) has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.759156	**0.0000**
Test critical values:	1% level	-3.470427	
	5% level	-2.879045	
	10% level	-2.576182	

Evaluating the probability coefficient [0.00] ($p < 0.05$), we conclude that the data are now stationarity in the first difference. The Augmented Dickey-Fuller is one of the most used tests for stationarity, so the model passes the stationarity test, [3], [21]. Inflation data series can now be used to create an Arima model.

4 Model Parameters and Estimation

The evaluation of the Arima models begins with determining the terms *p* and *q*. To determine the autoregressive order and the level of moving average terms, the correlogram of the data series must be analyzed. We must determine the correct order of autoregressive terms by checking whether any of the autoregressive terms exceeds the limits of partial correlations. The same logic is used to determine the best moving average terms. The autocorrelation and partial correlation of the inflation time series are shown in Figure 3.

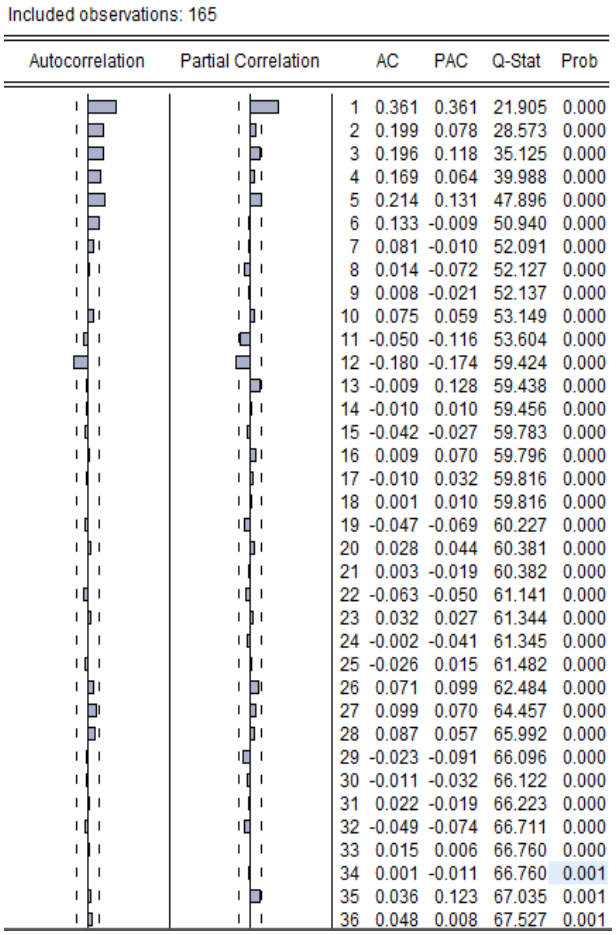

Fig. 3: Autocorrelation and partial correlation of inflation time series

The partial autocorrelation defines the AR terms of the ARIMA model, so it is determined that is it suggestable to use AR (1). Meanwhile, the autocorrelation test tells us that the right terms of moving average should be MA (12). In conclusion, the full ARIMA model used in this paper will be ARIMA (1,1,12).

Let's take into consideration the general ARIMA (1,1,12). The equation should be as it follows:

$$\Delta y_t = c + \varphi_1 \Delta y_{t-1} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots + \theta_{11} \varepsilon_{t-11} + \theta_{12} \varepsilon_{t-12} \quad (1)$$

4.1 ARIMA Equation Estimation

As it is shown by the estimation of the model, all the variables are statistically significant and have statistical importance [for AR (1), MA (12)] because the p. value < 0.05. Meanwhile, the whole model is statistically important, and this is proved by the fact that *p.(F-stat) < 0.05*. As a first step to model estimation, the ARIMA (1,1,12) can now be tested for other econometrical proofs.

The ARIMA inflation model used is presented in Table 2.

Table 2. ARIMA inflation model Generated by EViews10

Dependent Variable: D(INF)

Method: ARMA Maximum Likelihood

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.019538	0.027534	0.709597	0.4790
AR (1)	0.410206	0.096172	4.265347	**0.0000**
MA (12)	-0.516693	0.148626	-3.476462	**0.0007**
SIGMASQ	0.076603	0.003759	20.37674	**0.0000**
R-squared	0.240867	Mean dependent var		0.036909
Adjusted R-squared	0.226722	S.D. dependent var		0.318628
S.E. of regression	0.280190	Akaike info criterion		0.340947
Sum squared residuals.	12.63951	Schwarz criterion		0.416243
Log-likelihood	-24.12816	Hannan-Quinn		0.371512
F-statistic	17.02801	Durbin-Watson stat		2.122275
Prob(F-statistic)	**0.000000**			

4.2 White Noise Test

The ARIMA model can be used only if it passes some econometric tests. One of the most important tests is the White Noise Test (Ljung – Box Q Statistic). A time series is white noise if the variables are independent and identically distributed with a mean of zero. This means that all variables have the same variance (σ^2) and each value has a zero correlation with all other values in the series. Our monthly data shows that the white noise test is passed successfully (as all the values of probability are greater than 5%) [p > 0.05], affirming that the residuals of the model (ε_i terms) are white noised. As all the tests have been completed, the model estimation continues with the evaluation of covariance stationarity and invertibility. The next analysis consists of analyzing the ARMA roots covariance and invertibility.

4.3 ARMA Covariance Stationarity and Invertibility

Conducting the ARMA roots test about the covariance stationarity shows us that AR roots should be inside the circle graph (as presented below). This confirms the covariance stationarity. At the same time, the invertibility test shows that also the MA root is inside the ARMA structure circle, so the model can now be used normally. The ARMA roots are illustrated in Figure 4

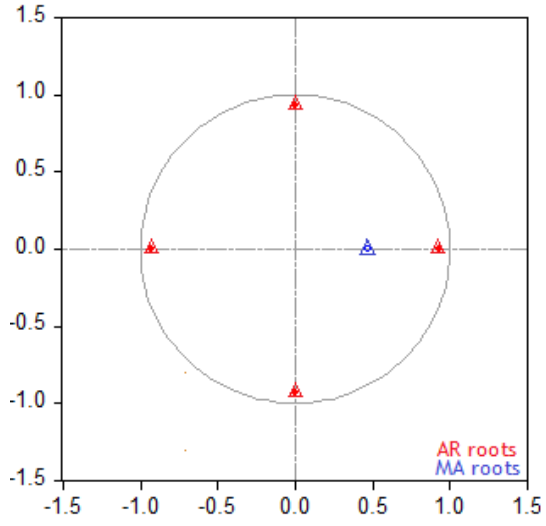

Fig. 4: ARMA roots

In conclusion, after testing the stationarity of the time series, white noise test (Q-correlogram), and ARMA structure, *the model can be used to forecast future inflation.*

4.4 Forecasting the Inflation in Albania

Regarding the model used in this paper, the final ARIMA model is described below:

$$\Delta y_t = 0.019 + 0.41\, y_{t-1} - 0.517\, \varepsilon_{t-12} + \varepsilon_t \qquad (2)$$

Equation (2) shows the correlative relationship between autoregressive terms and moving average terms with the inflation defined by the equation.

- Theoretically, there will be a 0.019% level of inflation, ceteris paribus.
- If the previous monthly inflation changes by 1%, we can expect a 0.41% change in the monthly actual inflation (this is shown by the auto-regressive (AR) part of the equation).
- A change in the moving average part (MA) contributes to the hammering of the effects of the previous year's inflation into the actual monthly inflation with 0.517%. This is explained by the effects of the moving average concept as the previous inflation caused in any sector is expected to impact less in previous months (periods) due to the intervention of the central bank and other institutions.

The forecasting process shows the result of future foreseen inflation in Albania for the end of the year 2022 and the first half year of 2023. Figure 5 below shows the tendency and trend of a dynamic forecast of the actual time series (M11-2022 – M6-2023):

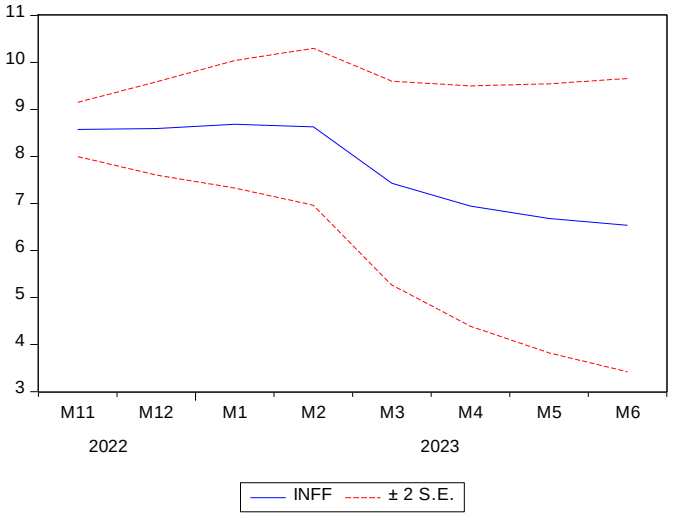

Fig. 5: Forecasted inflation in Albania

As it is forecasted by the model, the core inflation rate in Albania will increase for the next four months and then gradually decrease in the other next months. In addition, the inflation will stay stable at the level of 8% - 9%, due to the stabilization instruments used all these months. Furthermore, other macroeconomic indexes like GDP growth and unemployment also indicate a decline in the level of inflation. In the same logic as above, nominal shocks are also expected during these months.

5 Conclusions

Due to its major role in the economy, inflation does impact not only the general level of prices but almost all the other macro indexes like economic growth, unemployment, trade balance, current account, etc. Inflation is neither a reason nor a consequence. It is a complex indicator that measures the oscillation of prices in the economic situation overall. It must not be studied as an isolated index but concerning inflation and other macro indicators.

Regarding the econometric model, we can conclude that the econometric model of ARIMA is one of the models that can create a satisfactory framework to predict inflation and to create forecasting models for phenomena like inflation. ARIMA models work especially for time series of data in developing countries due to the lack of stationarity of their data in the unit roots. So, inflation in Albania can be forecasted and used as a policymaking tool. As a matter of fact, the next three years are expected to be with more stable inflation, but most of the time below the expected inflation rate defined by the Bank of Albania.

The last recent years show data on high levels of inflation due to covid-19 effects on the Albanian economy. Henceforth the econometric models (especially the models that use autoregressive terms) may be used accompanied by some qualitative data and explanations. Some *"unusual shocks"* of inflation can derive from some situations that are hard to explain just by quantitative data and statistical models.

Consequently logically, we recommend that the Bank of Albania and other government institutions involved in policymaking should be more aware of the consequences coming from an unpredictable inflation rate in the Albanian economy. Moreover, the objective of the central bank for core inflation can be revised in adaption to the changes caused by the earthquake and Covid-19 pandemic situation. The central bank of Albania should intervene in the Albanian economy with direct and indirect instruments in case of hyperinflation during the next months. The Bank of Albania (BoA) has increased the level of treasury bonds sold in the Albanian financial market as a measure to decrease the level of cash in the economy. In addition, BoA has increased the level of interest rate to 2.75% as a direct operative instrument.

While the inflation level is a very important topic nowadays in Albania, the analysis should go deeper into understanding the changes in core inflation. At the same time, it is recommended to focus on the main sectors and industries that cause inflation. A deeper analysis may be concentrated into sectors like construction, real estate, or some parts of the food supply chain due to their importance in the Albanian economy.

A sustainable economy and the challenges posed by solutions require modern approaches to study the impact of important indicators like inflation. Additional studies should be made to create a full framework of studies for typical indexes like inflation in Albania. This paper suggests that for important macro topics, these studies should be conducted from time to time to affirm or change some viewpoints or to enrich the studies file as frequently as possible. Structural autoregressive models can be very useful in determining the importance of nominal and real shocks in the economy. Throughout this model, additional interpretations can be made to understand specific consequences of inflation in the overall economic performance. We also invite other authors to improve the theoretical and practical framework with valuable studies.

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-Ingrid Konomi has worked on the literature review and economic analysis of the data's statistical processing results.

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The authors have no conflict of interest to declare that is relevant to the content of this article.