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Comparative estimation models ,Bayesian and iterative on The effect of consumption indicators on inflation in Algeria

التقدير المقارن، لنموذجي التحليل البيزي والتكراري لأثر مؤشرات الاستهلاك على التضخم في الجزائر

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Abstract:

The estimation of parameters in iterative models is affected by the probabilistic event, while Bayesian estimation is based on conditional probability theory that explains the phenomenon according to the theory of random states and Markov chains. As the aim of the study is to identify the difference between the iterative and Bayesian analysis model of the impact of price indicators in Algeria on inflation, relying on the descriptive analytical. Which revealed the correlation between inflation and the food consumption index as a single indicator using iterative inference, while it was associated with a more overlapping relationship using Bayesian inference. making it a significant models.

Keywords: estimation; iterative; Bayesian; Markov chains; inflation .

JEL Classification Codes: C13, C16, C11,C02, E13.

ملخص:

يتأثر تقدير المعلمات في النماذج التكرارية بالحدث الاحتمالي ، بينما يستند التقدير البيزي على نظرية الاحتمال الشرطي التي تفسر الظاهرة وفقًا لنظرية الحالات العشوائية وسلاسل ماركوف. حيث ان الهدف من الدراسة هو التعرف على الفرق بين نموذج التحليل التكراري والبيزي لأثر مؤشرات الأسعار في الجزائر على التضخم، معتمدين على المنهج الوصفي التحليلي. والتي كشفت عن الارتباط بين التضخم ومؤشر استهلاك الغذاء كمؤشر وحيد باستخدام الاستدلال التكراري ، بينما ارتبطت بعلاقة أكثر تداخلًا باستخدام الاستدلال البايزي .بما يجعل منها نماذج اكثر دلالة في فسير الظاهر القياسية .

تصنيفات JEL : C13، C16، C11، C02 ، E13.

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1. INTRODUCTION:

The parameters estimation models according to the iterative inference theory is a standard method affected by the size of the sample and the number of the experiment, It is theory that assumes the stability of the conditions of the experiment. Where The researcher finds a different results with a different number of repetitions related at the same data, which drop the conditions of serious analysis related to a dynamic nature data, and it will not be able to the conditions of probability with machine learning and deep learning model,. Therefore, Bayesian inference is considered a powerful alternative, as it replaces the principle of stillness that is assumed by iterative analysis with logical updating according to the abundance and accuracy of information, which varies from one researcher to another. Throwing a dice is determined by the information we have. Where, through what was mentioned above. It has possibility of including stronger levels of uncertainty and then estimating the parameters of the model on their basis, which made it a reliable and accurate method. especially when it comes to artificial intelligence algorithms that reject the hypothesis of the stability of the phenomenon and address problems Prediction within the probabilities of stochastic random transfer according to the theory of Markov chains (Al-Akari, no date).

1.1. Problematic of the study:

Inflation is considered one of the biggest economic problems for the mother, but studying the phenomenon or predicting it within the approved standard models often fails to describe it accurately. Therefore, what this research paper is concerned with is the comparative analysis of the phenomenon and its relationship to some consumer price indicators, in order to determine the ability of those standard models in describing the phenomenon. Accordingly, the problematic of the main paper is concerned with the study of the difference in the comparative statistical estimate between the iterative and Bayesian inference models, and the practical results that may result from them related to the characterization of the phenomenon of inflation in Algeria.

Is there a fundamental difference in analyzing the impact of consumption indicators on inflation, depending on, iterative and Bayesian methods?

1.2. objectives of the study:

The importance and objectives of the research lie in the fact that it is concerned with:

- Introduction to the theoretical foundations of Bayesian analysis,
- Comparing the results of the analysis of a relationship to the effect of consumption indicators on inflation in Algeria between the iterative and Bayesian inference models,

1.3. hypotheses:

The hypotheses are related to the main problem of it, which deals with two main objectives, one of which relates to analyzing the relationship of inflation with consumption indicators that were included in the statistical model, and then comparing the results of the two measurement models. So, the hypotheses of the paper are:

- The first hypothesis:

H1:The various indicators of consumer prices affect the inflation rate in Algeria.

- The second hypothesis:

H1:There is no difference between iterative and Bayesian statistical estimation models in the results of analyzing the relationship of inflation with various indicators.

1.4.Previous studies :

- kheder Alakkari's (The Use Bayesian Inference to Study The determinants of Inflation in Syria during the period 2011-2017), 2019, the study aimed to analyze the development of the inflation rate and its components, using Bayesian analysis due to its ability to include real factors for calculating the rate Inflation, and concluded that there is an increasing gap between the official and unofficial exchange rate that explains the ineffectiveness of the Syrian Central Bank's financial tools to combat inflation, in addition to its link to food consumption prices affected by the high cost of it in their countries of origin.
- Tariq Kaddouri's study entitled (The Contribution of Rationalizing Government Expenditure to Achieving Economic Development in Algeria for the Period 1990-2014),where is aimed to link government spending policies with levels of rationalization and economic development. In terms of the existence of a theoretical relationship between the change in spending helps to explain the changes in the gross domestic product, and concluded that there is a formal relation is not strong between the increase in government expenditures on development, due to the presence of several factors, including, the rise in the general level of prices, the effect of population increase on Spending amount.

2. Conditional Probability and Bayesian Inference

The conditional probability theory go back to the British priest Biz Simon Laplace, who published its first formula in the year 1812. Where the conditional probability theory does not equate between cases for the purpose of prediction, but rather works to include criteria called conditional criteria, when it is assumed that team x beat team Y in the season three times, it is easy to predict his victory over the fourth times. But if there is new information related to the absence of the most prominent strikers of Team X in the fourth match. The probability of winning for team x according to will be affected as much as the additional information received (Alakari, 2019, pp.: 37-38). Therefore the proponents of Bayesian inference argue that it is a method that is incompatible with the principles of interpretation of ordinary probabilities that equate probabilistic cases. On this basis, the Bayesian probability constitutes a statistical estimate that varies according to what provides the strength and accuracy of the information. It is also an approach based on the possibility of automatic modification of data, in addition to being a method that elicits new knowledge based on previous information and the degree of its updating (Alakari, 2019, pp:39).

2.1.The Mathematical Foundations of Conditional Probability Theory

The conditional probability theory assumes that there are two events in the sample space, where the first event is known as p(A) and the second event is known as p(B) As for the formula P(A/B), it indicates the probability that event A will occur on condition that event B will occur. Therefore, the conditional probability theory of Bayes can be defined as a mathematical procedure that allows access to new results based on previous knowledge and wrote its equation as the form:

$$P(A/B) = \frac{P(A) \times P(B/A)}{P(B)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (01)$$

An important part in Bayesian analysis is also formed by the parameters and models that must be created, and the models form the mathematical formulas of the observed events, while the parameters constitute the factors in the models that affect the observed data. This means that reaching the formation of correct equations requires two mathematical models before starting any analysis process. , the first of which is called the probability function, while the second model is called the priority distribution model, which will allow what is known as the posterior distribution, whose equation is written as:

$$Posterior = \frac{prior * likelihood}{Normalization} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(02)$$

- Prior: is an initial probability obtained before any additional information, and is indicated by the formula P(A). It should also be noted that there are two types of Prior, a type called Conjugat Prior, in which the subsequent allocation is in the same form as the post allocation. Another one called uninformative Prior is used when we have little information about the previous distribution.
- Posterior: It expresses the subsequent probability, that is, the probability that has been modified according to what was obtained from additional information, and it is referred to as P (A/B).

The essence of the difference between the recursive and Bayesian probability models lies in the amount and value of information, which may differ from one researcher to another, which highlights the importance of conditional analysis according to Bayesian theory compared to iterative inference in describing the relationship of variables.

2.2. Bayesian Regression and Macrov Series

Within this element, we will have to refer to how the parameters of the Bayesian model are estimated, and then to the mathematical distribution accompanying the strength of the estimated parameters, in addition to the overall inferential power of the good fit of the model.(Siham Kamel Muhammad, and other., nd., p. 07)

2.3. Parameters of the model in Bayesian inference:

The parameter βi is referred to in iterative inference as a fixed value in regression models, while it is different if it is related to the Bayesian model, where it is considered as a random value measured according to probability distributions. Therefore, the goal of Bayesian analysis is not to find the best value for the parameters in the model, but rather to determine the subsequent distribution of each parameter.

2.4. **The mathematical distribution associated with the power of the parameter:**

in 1946 Jeffry proposed two mathematical formulas to deal with the unknown parameters of the model, where he mentioned that if the value of the parameter complies with the field (-∞,+∞),then the previous probability distribution is taken as a normal distribution whose function is given as)Yomnr ،Roula و ،Khder(2019 ،:

$$f(\beta i) = \frac{1}{\sigma.\sqrt{2\pi}} e^{-1/2\left(\frac{\beta_{i-\mu}}{\sigma}\right)2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(03)$$

But if it is known that the parameter to be estimated takes the domain (0,∞ +), the previous probability distribution is treated as a log-normal distribution with the following equation:

$$f(\beta i) = \frac{1}{\sigma.\sqrt{2\pi}} \boldsymbol{e}^{\boldsymbol{-1/2\left(ln\frac{\beta_{i-\mu}}{\sigma}\right)2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(04\ \boldsymbol{)}$$

2.5. The inferential significance of the Bayesian model (Andrew, and other, 2021p: 11-14)

After the determination of the initial distribution, we must estimate the optimal subsequent distribution, which is not based on the P-Value reference, but rather on what is known as the Bayes Factors (BF), which expresses the probability of a particular hypothesis in relation to the reference of another hypothesis, and is determined by:

- π_0=p(H_0) : represents the initial probability of the null hypothesis,
- π_1=p(H_0): represents the initial probability of the alternative hypothesis,

Prior=π_0/π_1: represents the subsequent distribution of the null hypothesis

Posterior=p_0/p_1 and represents the post-distribution of the alternative hypothesis.

On this basis, the Bayes coefficient BF is given by the following equation:

$$BF = \frac{p(\ x_i/H_0)}{p(\ x_i/H_1)} = \frac{priore}{posterior} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (05)$$

It explains the value of the factor in which the probability value is doubled in favor of one of the hypotheses, if it is:

- BF>1: This indicates that the data raised the relative probability value of the null hypothesis,
- BF<1: This indicates that the data reduced the probability in favor of the alternative hypothesis

Thus, it becomes clear that the Bayes coefficient does not depend on the value of the distribution of parameters, but rather on the probability that the data allow.

3. **Markov Chains for Post-distribution Estimation Markov Chain**

Marcov series took the name of its Russian creator, it is based on a stochastic process concept ,that explains the phenomenon in random cases and is based on the laws of probability in the temporal and spatial space that are completely subject to the laws of probability. Whether it is related to a continuous or discontinuous space. We describe the stochastic process in a Marcov series if the event in time n+1 for any of its states depends only on the state in time n, according to the following equation(YEHIA, 2018, p. 1238).

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (06) \text{prob}\left(X_{n+1} = \frac{j}{X_n} = i\right) = p_{ij}$$

The Definitions of Marcov processes were also provided, including: It is a stochastic, stochastic process with certain characteristics, in which the system of events occurs in relation to time or space according to the laws of probability (YEHIA, 2018, p: 1238). It was also defined as a method by which past changes and fluctuations are analyzed in order to predict future changes and take appropriate decisions (YEHIA, 2018, p: 1238).

3.1. Markov Probability Matrix (Siham Kamel et al., p.: 08)

The Markov Matrix expresses the probabilistic transition of the Markov series within the conditions of stochasticity and randomness, that is, the transition from one state to another during the time period. As the system of events is formed in consideration of time or place according to the laws of probability. These transition states are based on the classification of the phenomenon, and let us have, for example, the phenomenon y, which is classified within n

states and is symbolized by writing the general state equation of the probabilistic transition according to Markov's theory

$$p_{ij}^{m} = p(X_{m+n} = j/X_n = i)$$

.i=1,2,3,…n ……(07)

i,j ,=1,2,….n ……..(08)

Since the transition from state (i) to state (j) is one step for the observed time period, whereas :

p_{ij}^{m}: represent the transitional probabilities during (m) steps,

p_{ij}^{m+n} :Represents the Markov chain transition probability matrix after (m+n).

We may witness some special cases in Markov chains, such as the homogeneity expressed by stability or stability, which results when the probabilistic characteristics of the stochastic process do not change over time. .

3.2. Estimating transitional probabilities using maximum Likelihood method (hocine babtine2016 ,p:91)

Suppose there is a sample consisting of observations in the form of chains, and assuming that (n) represents these states in time (t = 0), this will enable us to write a Markov function in the steady state as follows

$pr(x_0, x_1, \dots \dots x_t) = \Pr(x_0) \prod \Pr(x_t/x_{t-i})$……(10)

Assuming that $n_{ij}(t)$ represents the number of observed values, then the previous probability can be written as:

……..(11)$pr(x_0, x_1, \dots \dots x_t) = \Pr(x_0) \prod pij^{nij}$

Then we can write the probability density function as :

…… …(12).$pr\left(\sum_j nij\right), n_{12}\left(\sum_j nij\right), \dots \dots ./\text{n}(0)p_{11}, \dots) = [\prod(ni(t-1)!/\prod \text{nij(t)!}]\ [\prod pij^{nij}]$

taking the logarithm of both sides of the equation and using the Langrangian Multipliers, we will get

ij……(12)$\sum_j nij = \hat{\lambda} j \sum_j \hat{p}$

If $\sum_i pij = 1$

i$\sum_j nij = \hat{\lambda}$ .....(13)

$p\imath\jmath = \widehat{n\imath\jmath} \sum_\jmath n\imath\jmath$ .....(14).

Markov chains, in terms of being a mathematical method, will help us in predicting the subsequent distribution of the probability phenomenon, taking into account that the parameter ((x) β), which represents a random variable of the probability state p(x) in the sample space, which follows the conditional probability distribution

p (xn+1/xn). Which is called the step-by-step of the probabilistic process, which makes this method of prediction not related to the full knowledge of the history of the process of prediction of the phenomenon.

And the estimation of the subsequent distribution based on previous information will be the essence of the difference in predicting Markov chains for random phenomena based on the mathematical basis of the random transition matrix and not on the logic of the recurrence of the probability phenomenon. And we will rely on this, as it comes to analyzing according to the R software, on MCMC function also called Markov chain Monte Carlo ,testing the

relationship and the random path draw for the parameters estimated model based on its current value (Andrew, and other, 2021p: 258).

4. Inflation:

Inflation is defined as a quantitative measure of the rise in prices above the average value of a basket of goods and services in the economy during a certain period, as it refers to a decrease in the purchasing power of the country's currency, which is related to the imbalances that occur at the price level, which in turn affects the purchasing value or the cost of production (Rice, 2017 , p.: 82). Therefore, it expresses a proportional or non-proportional relationship between the quantity of money and the general level of prices (Ben Issa and Ben Yesho, 2015, p. 47). Any case of discrepancy between monetary development and the evolution of prices. As for its origin, it can be a local or external source. As for its reasons, it is due to the Central Bank not enjoying the independence of the monetary decision, or the absence of transparency associated with its decisions, and it can also be due to the Central Bank's reliance on incorrect tools to assess the gap between the monetary mass and consumer prices (Amna and Ice, 2020, p.: 705).

4.1. Types of inflation:

Determining the reasons for the gap between the amount of money in circulation and the amount of products and commodities in the markets will be related to the originating source of the phenomenon, in terms of it being a phenomenon of internal or external origin, which will be related to its type in terms of being commodity or capitalist inflation (Suwaih and Bin Thabet, 2020, p.: 102).

 Domestic Inflation: It results from the imbalance between the quantity of money and price levels at the level of the national economy, which includes:

• Inflation of demand, which occurs when the total demand for goods and services rises in a way that exceeds production capacity, which leads to a rise in their prices. In addition to cost inflation, which is linked to higher production costs leading to higher commodity prices. It may also be linked to higher labor costs or other costs (Suwaih and Bin Thabet, 2020, p: 102).

Imported inflation: It arises as a result of the country's dependence on imports in the dynamism of its economy, as the prices of its goods are affected by foreign economies (Suwaih and Bin Thabet, 2020, p.: 102).

4.2. the inflation rate:

4.*.2.1* The method of calculating the inflation rate depends on several indicators:

- Consumer Price Index (CPI): which expresses a measure of the weighted average prices of a basket of goods or services measured to a reference basket, which constitutes a criterion for its relative weight for a certain period.
- Producer Price Index (PPI): It is an indicator that measures the imbalances in the average prices of productive goods for local producers, linked to time, and mathematically, it can be described by the Laspeyres index where :

q_{i0}: is the quantities of the base period and

p_{ti}represents the prices of the continent period

$$\text{Laspeyres} = \frac{\sum_i^n p_{ti} q_{0i}}{\sum_i^n p_{0i} q_{0i}}$$

4.2.2.GDP deflator :

It is used to calculate all the prices of goods included in the composition of the GDP (consumption, investment and net exports) by comparing the nominal GDP (measured to the prices of the current year) with the real GDP measured to the prices of the base year. Mathematically, its rate is described as:

GDP deflator =Nominal GDP (for the current year) / Real GDP (for the base year).

4.3. The problems associated into Algeria measurement in of Inflation rates:

It is usually resorted to evaluating the consumer price index or the cost of production prices for a basket of goods to calculate inflation, but in Algeria there are some structural problems in the way it is calculated, which can be summarized in the following points:

- The absence of a unified behavior in the method of calculating the indicator, which made the data of the National Bureau of Statistics distinguished by the great difference,
- Focusing on linking inflation rates to consumer prices without linking them to the cost of production.
- The approval of the Bank of Algeria to calculate the inflation rate within the reference region of Algiers,
- Incentives related to the national economy due to its link to rent, whose data do not qualify for regulating the phenomenon of inflation.

The unregulated framework of the money market, which does not allow the study or analysis of the imbalance between monetary development and price development.

5. Applied study:

Because of the extension of the study objective to analyze the difference between the two Bayesian iterative measurement models, we have to analyze the difference in the results obtained in assessing the inflation rate, and then compare the two inference models to arrive at identifying the essential differences between the two measurement models.

Well we record the following criteria's :

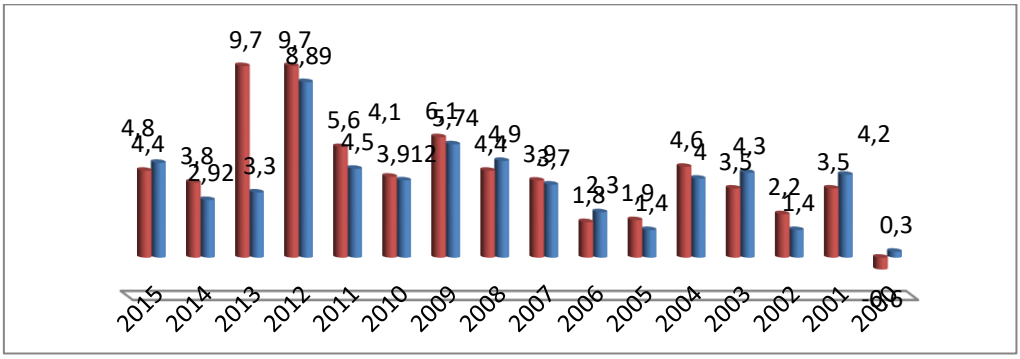
- The difference in the consumption index between the capital city and the rest of the country, indicates the error of the central bank’s adoption of the capital city price index as a reference for measuring the inflation rate.
- The general consumer price index was associated with a heterogeneous relationship between the capital city and the rest of the country - especially in the year 2013.

5.1. Study the relationship of measurement indicators to inflation :

Where we will present the values in a descriptive manner to identify the nature of the distribution of indicators.

- **.Description of consumption indicators and inflation rates :**

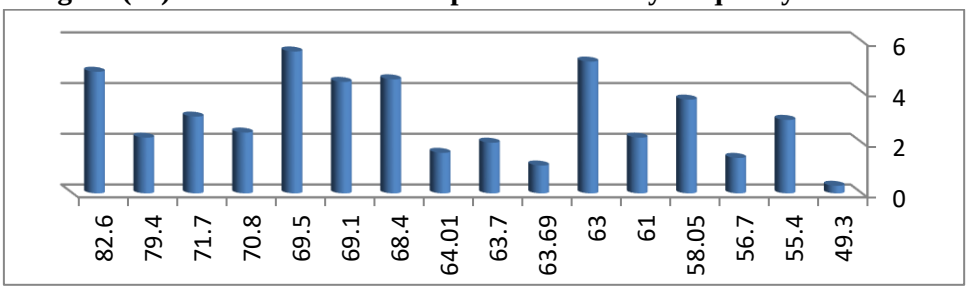
Figure (01): shows the difference in the overall inflation rate and the capital city



Source: Prepared by the researcher based on Excel

The highest years that recorded significant inflation rates were 2011, 2012 and 2013, as they were different between what was recorded at the level of the capital city and the rest of the country .The economy's liquidity index includes net assets and monetary transactions, but what we notice is the absence of a strong correlation between the economy's liquidity and inflation rates.

Figure (02): shows the relationship of the economy's liquidity to inflation



Source: Prepared by the researcher based on Excel

- **the relationship of consumption indicators to inflation:**

We have already indicated that the aim of the study is related to comparing the linear and Bayesian measurement models. Therefore, we will adopt a phase that begins with measuring the relationship within the linear method, and then interviewing it with the Bayesian model later.

Correlation matrix between inflation and consumption indicators:

```
> cor.test(inf,liq)
        Pearson's product-moment correlation
data:  inf and liq
t = 1.9637, df = 14, p-value = 0.06974
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.0402701  0.7805984
sample estimates:
      cor
0.464711
```

Source: Prepared by the researcher based on R_stedio

Matrix of total correlation between the variables of the study:

```
> round(cor(data[,-1]),2)
       con  hurb   meu  sant  tran  educ ind.A ind.N   LIQ  INF
con   1.00 -0.18  0.40  0.29 -0.14  0.51  0.93  0.67  0.40 0.59
hurb -0.18  1.00 -0.26 -0.19  0.46 -0.11 -0.13 -0.12 -0.34 0.04
meu   0.40 -0.26  1.00  0.79 -0.39  0.33  0.48  0.53  0.74 0.67
sant  0.29 -0.19  0.79  1.00 -0.34  0.15  0.33  0.31  0.43 0.47
```

```
tran  -0.14  0.46 -0.39 -0.34  1.00 -0.27  0.08  0.15 -0.24 0.09
educ   0.51 -0.11  0.33  0.15 -0.27  1.00  0.43  0.19  0.64 0.33
ind.A  0.93 -0.13  0.48  0.33  0.08  0.43  1.00  0.77  0.48 0.69
ind.N  0.67 -0.12  0.53  0.31  0.15  0.19  0.77  1.00  0.57 0.59
LIQ    0.40 -0.34  0.74  0.43 -0.24  0.64  0.48  0.57  1.00 0.46
INF    0.59  0.04  0.67  0.47  0.09  0.33  0.69  0.59  0.46 1.00
```

Source: Prepared by the researcher based on R_stedio

Table (01): shows the moral significance of the relationship of inflation with price indicators

Index	inf	inf	inf	inf	inf
variables	Inde.n	Index.A	liq	con	hurb
p-value	0.01628	0.00289	0.0697	0.0163	0.8831
variables	meub	sant	tran	educ	/
p-value	0.0045	0.0675	0.7359	0.2157	/

Source: Prepared by the researcher based on R_stedio

- The presence of different parameters in their direction and degree of strength,
- The overall consumption price index (Inde.n) explained its relationship to inflation with a coefficient of D that reached about 60%, while the CPI for the city of Algiers was associated with a more significant coefficient that reached about 70%.
- The difference in the moral significance of the relationship of inflation with total consumption prices and consumption prices for the city of Algiers, shows the defect in the leverage approved by the Bank of Algeria,
- Correlation coefficient recorded a significant relationship between the food and furniture consumption price index without other indicators.

5.2.Linear analysis of the relationship of inflation with consumption indicators

Estimating the parameters of the model by the linear regression method is based on a probabilistic value that explains the type of relationship between the variables, as it is a method that assumes the homogeneity of the behavior of the variables as it is affected in a way by the number of repetitions of the experiment, i.e. the size of the sample, where we will adopt the input method to measure the potential relationship, direct total and then phased within a method that differentiates Interpret statistical models using the AIC standard based on the lm package and then the steep linéaire régression package in the R_stedio software.

- **Relationship of inflation and total consumption rates using Linear. Model**

Before proceeding to the study of the regression relationship, we must identify the nature of the distribution of the study variable.

```
> shapiro.test(INFL)
        Shapiro-Wilk normality test
data:  INFL
W = 0.95957, p-value = 0.65
```

Source: Prepared by the researcher based on R_stedio

Table (02): the results of the Shapiro_.test test for the study variables

Variables	inf	con	edu	meu	TLEC	tran	hard	Sant
Shapiro. Test p-value	0.65	0.2407	0.3799	0.0988	0.9411	0.078	1.216e-05	0.4465

Source: Prepared by the researcher based on R_Stedio

The data included in the model follows a moderate distribution, with the exception of the (hard) housing price index data.

- **Multiple regression model of the inflation into price indicators:**

```
> lmmodel<-lm(INFL~con+educ+harb+meu+tran+TELEC+sant)
> summary(lmmodel)
Call:
lm(formula = INFL ~ con + educ)
Residuals:
    Min      1Q  Median      3Q     Max
-1.6938 -1.2150  0.1261  1.3430  1.7089
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.71868    0.59092   2.908   0.0122 *
con          0.27482    0.12430   2.211   0.0456 *
educ         0.01648    0.12265   0.134   0.8952
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Residual standard error: 1.373 on 13 degrees of freedom
Multiple R-squared:  0.3478,      Adjusted R-squared:  0.2475
F-statistic: 3.466 on 2 and 13 DF,  p-value: 0.06215
```

Source: Prepared by the researcher based on R_Stedio

Multiple regression analysis of the relationship of inflation with the indicators of the study, showed the existence of a significant relationship for the food consumption index, which is constant on inflation, without other indicators, explaining the strength of the relationship, which reached 60%.

- **Incremental Inclusion:**

It is a statistical method that allows the adoption of incremental input, and then a comparison between several models with the AIC standard.

```
> summary(stepmode1)
Call:
lm(formula = INFL ~ con + harb + meu + TLEC + tran)
Residuals:
    Min      1Q  Median      3Q     Max
-0.9338 -0.3380 -0.1723  0.2251  1.6276
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercepte)  6.32504    3.04365   2.078  0.06440 .
con           0.33627    0.10457   3.216  0.00924 **
harb         -0.76109    0.38952  -1.954  0.07923 .
meu           1.35034    0.36071   3.744  0.00382 **
TLEC         -0.10850    0.05305  -2.045  0.06803 .
tran          0.22820    0.07999   2.853  0.01717 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Residual standard error: 0.8532 on 10 degrees of freedom
Multiple R-squared:  0.8063,      Adjusted R-squared:  0.7094
F-statistic: 8.325 on 5 and 10 DF,  p-value: 0.002457
```

Source: Prepared by the researcher based on R_Stedio

The results of the study differed by using the two methods of direct linear regression and steep linear regression, which depends on the comparison between the standard models within the AIC standard. Steep linear on the existence of a significant relationship with each of the price index of consumption of food, furniture and transport (con-meu-tran), which is a result that differed when the sample size changed or the conditions of the experiment changed.In general, we record within this first type of direct or gradual inference the existence of a significant relationship between a single indicator of the inflation rate and then with three different indicators under its assumptions. Although it is a statistical method widely spread in Arab studies, it does not enable the researcher to include updates related to the data, as well as the possibility of standard comparison between several models.Which we will remedy in the

following through the use of Bayesian analysis, which is based on the theory of conditional probability, through which we will search for the results in light of the availability of the ability to include new data or information, thus raising the level of standard studies according to the strength of the data and its availability.

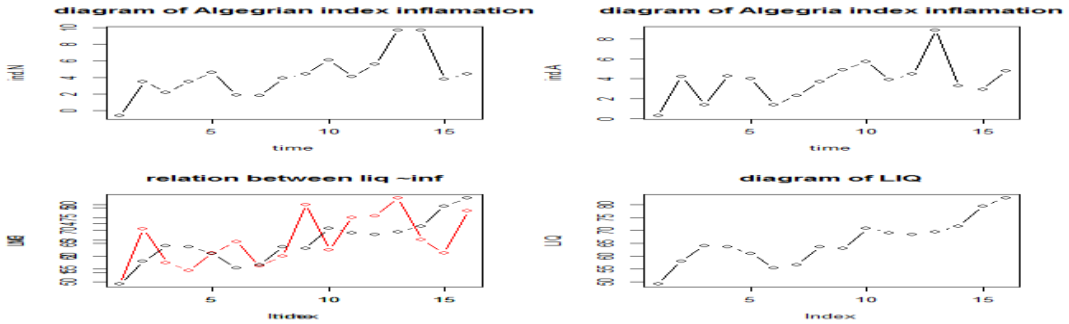
5.3. Relationship of the inflation index with the liquidity of the economy:

The inflation rate was associated with an insignificant average coefficient (cor=0.4647, p-value=0.0697) with the economy's liquidity rate .

- There is no integration between cash transactions and net assets to the inflation rate,
- The volume of cash transactions and net assets that know a continuous increase over time, that does not reflect the same trend with the rate of inflation**.**

Figure (03): Relationship of the inflation rate to the liquidity of the economy

```
plot(ind.N,xlab = "time",type = "b",main = "diagram of Algegrian index inflamation")
par(mfrow=c(3,3))
plot(ind.A,type = "b",main = "diagram of Algegria index inflamation",xlab = "time")
plot(INF,type = "b",main = "diagram of Algegria index inflamation",xlab = "time")
plot(LIQ,type = "b",main = "monetry liquid")
plot(INF,type = "b",col="red")
par(new=TRUE)
plot(LIQ,xlab = "time",type = "b", main = "relation between liq ~inf")
```



Source: Prepared by the researcher based on R_Stedio

6. Bayesian analysis of the relationship of inflation with consumption indicators :

We have already referred to the different nature of Bayesian analysis, which goes beyond the usual analysis in that it does not study the relationship of variables within the hypothesis of the stability of the conditions of the experiment, but rather discusses them analogously within their most probable cases, so it is a method characterized by:

- The parameters of the model are considered as random variables that are measured according to probability distributions and not fixed parameters, as is the case in recurring regression.
- The aim of Bayesian regression is not to find the individual best value of the model parameters, but to determine the subsequent .

- The explanatory power of the model is determined by the strength of its parameters through a standard comparison based on reading the behavior of the series for the data SE with the standard deviation SD. Which symbolizes the standard deviation of the post-experimental distribution from the simulation in each parameter. As for the percentages in the second table of outputs, they express the quantities and form of the subsequent distribution for each parameter. It is expressed in Naive SE as the probable simple standard error. The Time-series SE expresses the potential standard error of the series for the mcmc scale to estimate the later expected value of the parameter, which is compared with the standard deviation of the subsequent distribution of the same parameter. In the event that its value is less than the standard error of SD, this means that the estimation of the expected value of the parameter has an arithmetic error that can be ignored, in addition to the possibility of inferring the nature of its moderate distribution. In light of these data, we will test the relationship of inflation to several consumption indicators, and then read the results of the analysis in light of the aforementioned determinants.

6.1. Divide the models:

The first model includes the relationship of the index of food consumption prices, transportation, education, and public health on the inflation rate.

6.1.1. The first model: the relationship of inference indicators to inflation :

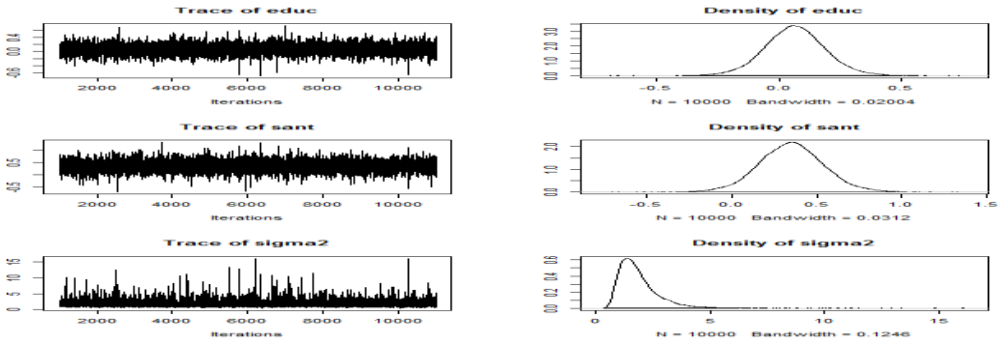
```
>model1<-MCMCregress(INFL~con+tran+educ+sant,data = reg1,mcmc = 10000,b0=0,B0=0.1,C
0=2,d0=0.11,marginal.likelihood = "Chib95")
> summary(bay1)
Iterations = 1001:11000
Thinning interval = 1
Number of chains = 1
Sample size per chain = 10000

1. Empirical mean and standard deviation for each variable,
   plus standard error of the mean:
             Mean    SD Naive SE Time-series    SE
(Intercept) 0.18914 1.0050    0.010050       0.010050
con         0.21361 0.1315    0.001315       0.001315
tran        0.18181 0.1318    0.001318       0.001318
educ        0.06459 0.1269    0.001269       0.001269
sant        0.34794 0.1996    0.001996       0.001996
sigma2      1.91855 1.0718    0.010718       0.016169

2. Quantiles for each variable:
                2.5%      25%     50%    75%   97.5%
(Intercept) -1.83537 -0.44294 0.19508  0.8142  2.2179
con         -0.04504  0.13119 0.21282  0.2957  0.4756
tran        -0.08215  0.09909 0.18134  0.2652  0.4429
educ        -0.18579 -0.01654 0.06362  0.1440  0.3200
sant        -0.04938  0.21993 0.34812  0.4733  0.7471
sigma2       0.79165  1.25300 1.66594  2.2588  4.5748
```

Source: Prepared by the researcher based on R_Stedio

Figure (04): the graph of the outputs of the first model



Source: Prepared by the researcher based on R_Stedio

- All the variables that were included in the model indicated the existence of a direct relationship with inflation, where all its parameters were positive, but in terms of their strength, the public health index was more distinguished in its impact on the inflation rate, followed in importance by the food consumption price index and then transportation. As for the education price index. It came late in its importance and interpretation of the inflation rate in Algeria. Which explains that

  the high demand for these services will raise their production costs and the logistical costs arranged with them, especially in light of a regressive policy to support such industries, which will lead to an increase in the rate of inflation.
- The existence of a limited effect of the education indicator on the inflation rate explains the spending policy related to the sector.
- The MCMC error scale was smaller than the standard error SD for all variables, and therefore it can be inferred that the estimation of the expected value of the subsequent distribution of the coefficient has a standard error that can be ignored, and that the experimental distribution approaches the normal distribution, which is shown in the attached figure with the outputs.

6.1.2.The second model: the relationship of the education and health index to inflation:

We will work within this second model to include both the public health price index and education as two indicators that explain the extent to which the government and the state in general care about its citizens, as it can be considered a measure of urbanization among nations.

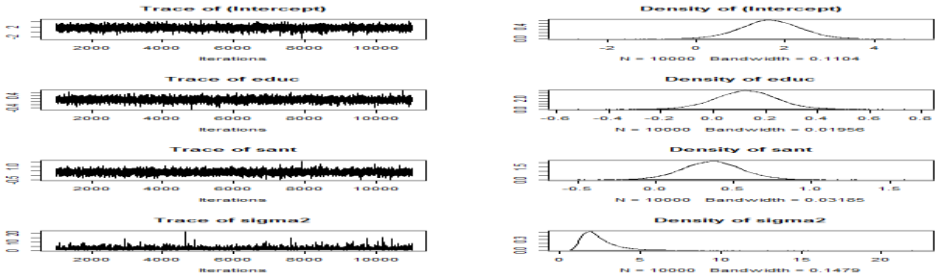
```
> bayes2<-MCMCregress(INFL~educ+sant,data = reg1 )
> summary(bayes2)
Iterations = 1001:11000
Thinning interval = 1
Number of chains = 1
Sample size per chain = 10000
1. Empirical mean and standard deviation for each variable,
   plus standard error of the mean:
              Mean    SD    Naive SE   Time-seriesSE
(Intercept) 1.7402 0.7115   0.007115       0.007115
educ        0.1232 0.1222   0.001222       0.001222
sant        0.3456 0.2017   0.002017       0.002058
sigma2      2.4270 1.1798   0.011798       0.014525

2. Quantiles for each variable:
               2.5%     25%    50%    75%  97.5%
(Intercept)  0.34754 1.29128 1.7360 2.1938 3.1629
educ        -0.12079 0.04479 0.1233 0.2010 0.3686
```

```
sant         -0.05677 0.21639 0.3467 0.4753 0.7479
sigma2        1.08511 1.66272 2.1477 2.8488 5.4890
```

Source: Prepared by the researcher based on R_Stedio

Figure (05) the graph of the outputs of the second model



Source: Prepared by the researcher based on R_Stedio

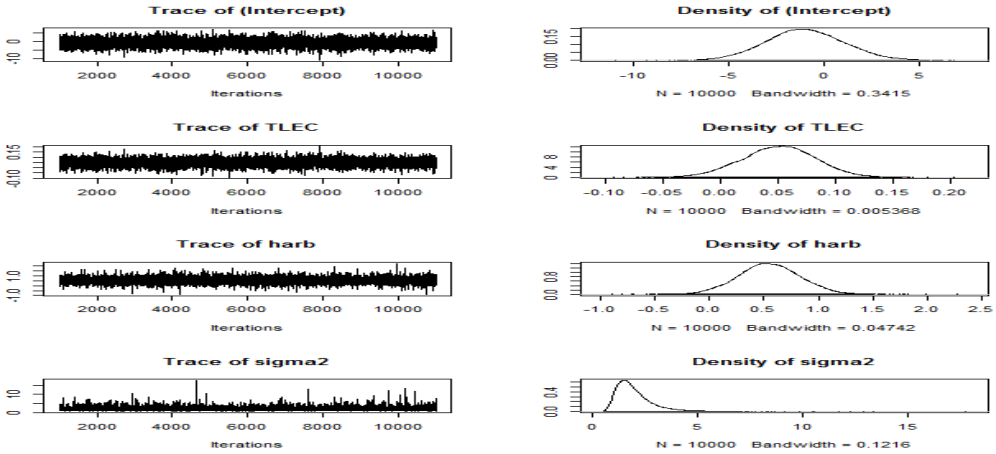
- The model explained the direct relationship of the Education and Public Health Index on inflation, as its coefficients were positive,
- The measure of error MCMC came smaller than the standard error sd for the variables (edu, sant), and therefore the expected value estimate for the subsequent distribution of the parameters has a standard error that can be ignored, meaning that the experimental distribution approaches the normal distribution, which is shown in the attached figure of the outputs .

6.1.3 The third model: the relationship of the housing and communications index to inflation:

```
> bayes3<-MCMCregress(INFL~TLEC+harb,data = reg1 )
> summary(bayes3)
Iterations = 1001:11000
Thinning interval = 1
Number of chains = 1
Sample size per chain = 10000
1. Empirical mean and standard deviation for each variable,
  plus standard error of the mean:
                Mean     SD       Naive SE       Time-series SE
(Intercept) -1.72609  2.85498  0.0285498      0.0285498
TLEC         0.06127  0.04463  0.0004463      0.0004463
harb         0.54012  0.30295  0.0030295      0.0030295
sigma2       2.07718  1.00973  0.0100973      0.0124312
2. Quantiles for each variable:
                2.5%     25%      50%      75%      97.5%
(Intercept) -7.31383 -3.52715 -1.74295 0.09425   3.9826
TLEC        -0.02765 0.03338  0.06168  0.08975   0.1482
harb        -0.04559 0.34581  0.53585  0.73384   1.1325
sigma2       0.92871 1.42306  1.83813  2.43818   4.6978
```

Source: Prepared by the researcher based on R_Stedio

Figure (06): Outputs of the third model



Source: Prepared by the researcher based on R_Stedio

- The model explained the direct relationship of the housing index (hard) and communications (TLEC) on inflation within positive coefficients, where the impact factor of the housing index reached 54%, explaining its strong impact on inflation compared to the communications index, which did not exceed 6%.
- The (mcmc) error scale was smaller than the standard error sd for the variables (edu, sant), and therefore the estimation of the expected value of the subsequent distribution of the parameters has a standard error that can be ignored, meaning that the experimental distribution approaches the normal distribution, which is shown in the attached figure for the outputs.

6.1.4 Comparison between model1,model2,model3

The previous models indicate the extent to which the variables they contain affect the rate of inflation. But what concerns us in our study also is to identify the variable most affecting the rate of inflation, which is the essence of the scientific value that we need to highlight by adopting a comparison between the standard models with the aim of adopting them later as a scientific and practical value to control Inflation rate. This requires us to compare the previous models using Factor Bayes, which weights between the standard models to discover which models were more appropriate in explaining the relationship.

6.2.Results of the BF factor to test the most influential change in the inflation rate

```
model1<-MCMCregress(INFL~con+tran+educ+sant,data = reg1,mcmc = 10000,b0=0,B
0=0.1,C0=2,d0=0.11,marginal.likelihood = "Chib95")
> model2<-MCMCregress(INFL~educ+sant,data = reg1,,mcmc = 10000,b0=0,B0=0.1,
C0=2,d0=0.11,marginal.likelihood = "Chib95" )
> model3<-MCMCregress(INFL~TLEC+harb,data = reg1,,mcmc = 10000,b0=>
> summary(BF)
The matrix of Bayes Factors is:
       model1 model2  model3
model1    1.0  0.027 0.0197
model2   37.0  1.000 0.7304
model3   50.7  1.369 1.0000
The matrix of the natural log Bayes Factors is:
       model1 model2 model3
model1   0.00 -3.611 -3.925
model2   3.61  0.000 -0.314
```

```
model3   3.93  0.314  0.000
The evidence to support model3 over all
other models considered is worth no more
 than a bare mention.
Strength of Evidence Guidelines
(from Kass and Raftery, 1995, JASA)
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
2log(BF[i,j])       BF[i,j]        Evidence Against Model j
------------------------------------------------------------
  0 to 2             1 to 3          Not worth more than a
                                          bare mention
  2 to 6             3 to 20         Positive
  6 to 10            20 to 150       Strong
>10                >150            Very Strong
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
model1 :
   call =
MCMCregress(formula = INFL ~ con + tran + educ + sant, data = reg1,
mcmc = 10000, b0 = 0, B0 = 0.1, d0 = 0.11, marginal.likelihood = "Chib95",
    c0 = 2)
   log marginal likelihood =  -46.74848
model2 :
   call =
MCMCregress(formula = INFL ~ educ + sant, data = reg1, mcmc = 10000,
    b0 = 0, B0 = 0.1, d0 = 0.11, marginal.likelihood = "Chib95",
    c0 = 2)
   log marginal likelihood =  -43.13723
model3 :
   call =
MCMCregress(formula = INFL ~ TLEC + harb, data = reg1, mcmc = 10000,
    b0 = 0, B0 = 0.1, d0 = 0.11, marginal.likelihood = "Chib95",
    c0 = 2)
   log marginal likelihood =  -42.823
```

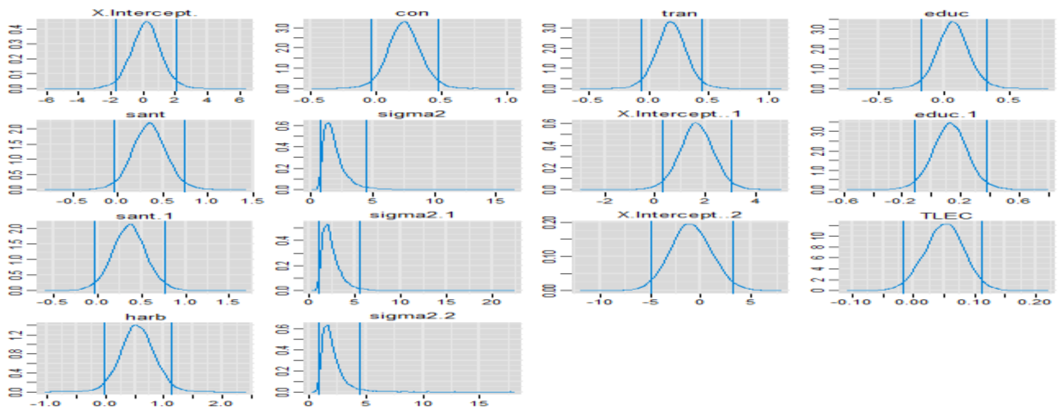
Source: Prepared by the researcher based on R_Stedio

According to the Biz factor, the best positive evidence was in favor of the third model, which linked the inflation rate and the price index

Housing and communications. Since the bass factor in the third model is greater than the right one BF > 1, this means that.

Figure :(07) Density function of the three models

```
library(mcmcplots(
D<-data.frame(model1,model2,model3(
  denplot(D, collapse=TRUE, greek=TRUE, ci=0.95(
```



Source: Prepared by the researcher based on R_Stedio

Figure (07) indicates the extent to which price indices contributed to raising the potential value of inflation, as the housing index (hard) ranked first in terms of importance, followed by the communications price index (TLEC) and then the public health index (sant). As for the two nutrition indicators (con).) and transport (tran) recorded similar transactions in effect, while the education indicator (edu) recorded a regressive value in its indication of inflation.

6.3. Results interpretation:

The study revolved around two main hypotheses, the first of which aimed to analyze the impact of consumer price indicators on the inflation rate, where the study revealed the existence of a partial significant relationship that differed in its strength according to the different applied statistical models. A greater possibility of Bayesian analysis, in terms of being a method that allows controlling the conditions of the experiment, and also allows the researcher to include deeper levels of data and information, within which the hypothesis of the stability of the study conditions falls. According to the Bayes Matrix (The Matrix of Bayes Factors), the positive evidence for Bayes Factor BF was better in favor of the third model in explaining the inflation rate, which included the housing price index (harb) and communication prices (TLEC). In terms of explanatory power in interpreting inflation rates, it was The housing index scored the highest importance. The following points can also be recorded in detail .

- The association of the high rate of inflation with public health prices, 34.7%, is justified in light of the significant decline in the health sector in general in Algeria, which led to the emergence of new traditions represented in the reluctance of many Algerians from health services in Algeria and the preference for other destinations for treatment (Tunisia in particular), Where some studies mentioned that the number of medical tourism in favor of Tunisian private clinics in Tunisia recorded the attraction of 3 million Algerians for the year 2017 only, with incomes exceeding 800 million dollars,
- The importance of consumer prices for foodstuffs in their impact on inflation was declining compared to public health prices. This indicates two things. The fact that food consumption prices were significant in relation to inflation of 21% was linked to some extent with the effect of the transport index within a coefficient of 18%, which indirectly indicates the link between the cost of food production and transport costs.
- The limited impact of education prices reflects the type of policy associated with the sector,
- Bayes factor BF analysis indicated that the third model, which is related to the analysis of the impact of housing prices, was the most important in explaining inflation rates. The rise in housing prices affects, within a strong factor, the inflation rate in Algeria.

6.4.Comparison estimated models in linear and Bayesian analysis:

The limitation of the cumulative effect of the relationship of variables within the multi-linear method, as the explanatory power of the model did not exceed 35%

The linear analysis revealed a direct relationship between the food consumption price index (con=33.6%), the furniture price index (meu=1.35%) and transportation (trans=22.8%) on inflation, meaning that the rise in those related costs raises the rate of inflation. Inflation, it

also revealed a negative effect between inflation and the housing index (hard=-0.76%), in contradiction with the economic counterpart.

- The food consumption index (con) is linked in the same direction with the transportation index, and it positively affects the rate of inflation, meaning that the increase in their prices leads to a rise in the rate of inflation.
- The use of Bayesian analysis revealed different outputs that came within three models:

✓ Where the first model revealed the existence of a direct relationship for all indicators of the inflation rate. The values were recorded in succession with (con=21%) (tran=18%) (educ=6%) (sant=34.7%). Where the model retained the importance of consumer prices Food has an effect on inflation rates, but it ranks relatively late compared to public health prices (21% versus 34%).

✓ The second model also revealed the relationship between the public health index on inflation with almost the same coefficient (sant = 34%), while it only indicated that it was linked to the education index with a coefficient of (educ = 12%).

✓ the third model, it revealed the strong relationship of the housing index to inflation (hard =54%), meaning that the rise in housing prices and the related moods affect very significantly on inflation rates in Algeria.

- Differentiating models using Bayesian analysis, revealing the importance of the third model, that is, to the extent to which price indicators have contributed to raising the probabilistic value of inflation in Algeria.
- using Bayesian model, revealed the relation between inflation, thus dropping the utmost importance of food consumption prices in their impact on inflation rates in Algeria.

▪ **Recommendations:**

✓ The special nature of the Algerian economy makes the explanation of the gap between the monetary mass and purchasing power related to several axes:

✓ The correlation of inflation with public health prices and within a relatively strong coefficient that is linked to the decline in the competitiveness of the health sector, so controlling the rate of inflation requires raising the efficiency of the performance of the public and private health bottom.

✓ The correlation of the inflation rate with production costs imposes a reassessment of tax policies, especially with regard to food industries, which would affect production costs and then negatively affect inflation levels.

✓ The correlation of the trend of the food consumption price index with the transportation index has its significance in the strong relationship between the two variables, as the rise in transportation prices directly affects the cost of producing food commodities and then the inflation levels.

✓ The correlation of the housing index with a strong coefficient of the inflation rate requires the introduction of a work policy directed to keep housing prices within the levels of purchasing power and thus control the inflation rate.

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-Appendices

years	core inflatio	Economy rate/liquidit	i./consumption /national	consumption index for the capital city	Educat	Transp	healt	Furnit	Livin	Food
2000	0.3	49.3	-0.6	0.3	-4.4	2.3	3.6	0.9	1.7	0.8-
2001	3.7	58.05	3.5	4.2	0.6	3.3	6.8	2	2.4	5.5
2002	1.6	64.01	2.2	1.4	1	2.9	0.6	0.4	0.0	0.3
2003	1.1	63.69	3.5	4.3	0.2	5.6	1	-0.4	1.7	3.9
2004	2.2	61	4.6	4	0.8	10.6	0.0	-0.4	1.7	3.7
2005	2.9	55.4	1.9	1.4	0.3	9.8	1.1	-0.2	13.4	-0.7
2006	1.4	56.7	1.8	2.3	0.5	-0.1	1.0	0.1	4.1	4.2
2007	2	63.7	3.9	3.7	2.1	2.2	1.8	0.4	2.1	6.4
2008	5.2	63	4.4	4.9	5.2	4.0	1.8	1.1	1.1	7.5
2009	2.4	70.8	6.1	5.74	6.0	3.6	3.4	1.8	2.7	8.2
2010	4.4	69.1	4.1	3.912	-0.1	2.5	2.8	3.5	1.9	4.2
2011	4.5	68.4	5.6	4.5	0.6	3	4.4	3.5	1.4	4.2
2012	5.6	69.5	9.7	8.89	2.9	4.5	4.3	3.9	4.5	12.2
2013	3.03	71.7	9.7	3.3	-2.9	5.1	4.1	2.7	1.6	3.2
2014	2.2	79.4	3.8	2.92	8.9	-1.1	4.1	3.6	1.3	3.9
2015	4.8	82.6	4.4	4.8	4.9	3.7	6.1	4.4	1.3	4.7

Source: RAPPORTS:2015, 2012, 2009 2008, 2007, 2006, 2005, 2004, EVOLUTION ECONOMIQUE ET MONETAIRE EN ALGERIE, Bank of Algeria , https://www.bank-of-algeria.dz/html/communicat