Inflation forecast with Artificial Intelligence

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INTRODUCTION

Inflation is the continuous and generalized increase in prices in an economy. Small inflation rates are natural and associated with a healthy growth of an economy, however, uncertainties related to inflation volatility and predictability bring issues to maintain purchasing power and, at the macroeconomic level, in monetary policy design. Recently, because of the pandemic event of the COVID-19, central banks once again are concerned about the increase of inflation worldwide. To observe the trend of the inflation, several central banks use core inflation to decompose the inflation in persistent and transient components [1, 2]. In Brazil, inflation targets are defined using the Extended National Consumer Price Index (IPCA), which is sensitive to seasonal behaviour and demand shocks. Such effects add adversities to the analysis of the inflation, which in turn, impose extra difficulties to the design of monetary policies. In this sense, the use of core inflation as a target would allow the design of less rigid monetary policies. Thus, in this work, we propose a wavelet approach to calculate the core inflation using Daubechies families, which allow exclusion of transient components of the inflation without the need of additional hypothesis. To compute wavelet core inflations, we use the IPCA time series, between July 2006 and November 2022. We consider, additionally, a few brazilian macroeconomics indexes to increase idiosyncrasy of the economic context, such as production index, variation of trade balance and market expectation. For the forecast, artificial intelligence techniques are adopted, such as neural networks. We point out that the use of neural networks make it possible to study highly complex problems that cannot always be described by analytical models [3]. We analyse confidence intervals to estimate bounds for inflation forecast probable values. Among the main conclusions, our inflation forecast generated smoothed signals, allowing to identify the trend of inflation up to twelve months.

METHODOLOGY

We collected data on the Time Series Management System, on the Central Bank of Brazil website, including IPCA, monthly Gross Domestic Product (GDP), production index, trade balance and market expectation between July 2006 and November 2022. First, we construct a wavelet core inflation index based on IPCA: we decompose IPCA using Daubechies wavelet in five scales and, for reconstruction, we maintain just three detail levels; this procedure assures a smooth signal. The obtained wavelet core inflation index is presented in Figure 1.

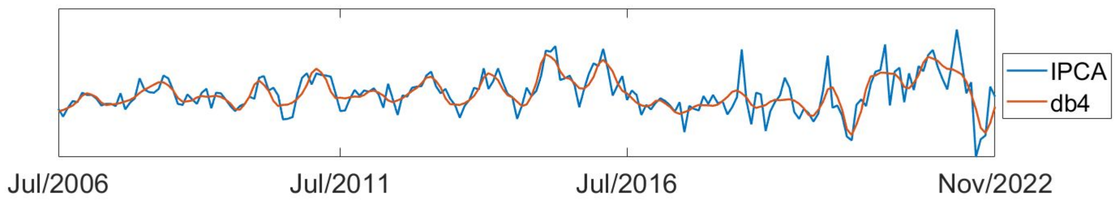

Figure 1. Wavelet core inflation based on IPCA using Daubechies 4.

To incorporate macroeconomic data, we use Principal Component Analysis (PCA) to reduce dimensionality. This data was divided into three sets: train (60%), validation (10%) and test (30%); input data; and forecast data. The neural network has three layers: an input layer, one hidden layer with neurons varying between 1 and 50 and hyperbolic tangent activation function, and an output layer. We use Scaled Conjugate Gradient (SCG) and Mean Square Error (MSE) as performance criteria. The output is a smoothed forecast to the IPCA.

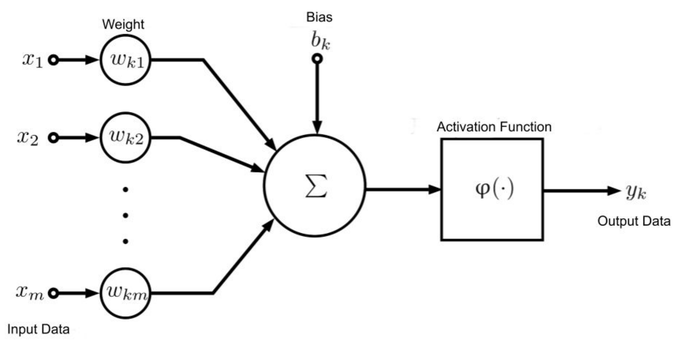

Figure 2. Mathematical model for a neuron k

Finally, we calculate the confidence intervals of our forecast: we use bootstrap perturbation to generate different sets through permutation. The confidence intervals are generated in 250 simulations as described before.

RESULTS

The first test aims to describe the set of neural networks that generates the inflation forecast. We analyse the median of the number of neurons and the MSE to describe the performance of the neural networks using Daubechies 6 and the previous macroeconomics index presented. On the number of neurons, we observe that the median was 36 neurons, indicating the necessity of a number of neurons close to the maximum number of neurons allowed (50), which, in turn, require additional computational time. For the MSE, we observe that the obtained values range between 0.1347 and 0.5852, with a median value of 0.2781. We emphasize that we do not consider outliers in this analysis.

In the second test, we generate the inflation forecast and the 95% confidence interval to compare with the IPCA data, as presented in Figure 3. As expected, the signal generated is a smoothed version of IPCA and represents the trend of inflation between December 2021 and November 2022. In this forecast, six of the twelve months are located in the confidence interval; this fact suggests that the IPCA data outside confidence interval were impacted by transitory effects. Among those effects, we may cite some abnormal climate events, fuel price increase worldwide and the brazilian election, without forgetting residuals effects from COVID-19 pandemic.

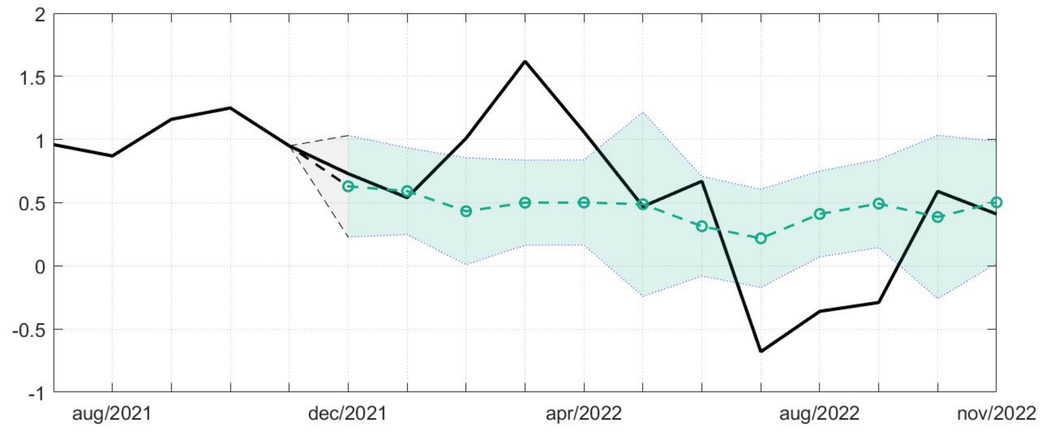

Figure 3. Forecast inflation (traced line) and confidence interval (shaded area) in comparison with IPCA (continuous line).

CONCLUSIONS

Neural networks and the proposed wavelet core inflation index are a powerful tools for the inflation forecast. With confidence intervals, we obtain a robust analysis of the results. We emphasize that inflation forecasts and respective confidence intervals are smoothed version of IPCA and its implies that we cannot identify future transitory variations of inflation. Even so, we can identify the inflation trend up to a certain time interval (12 months).

Between the limitations of the model, we cite the data scarcity due to the economic context of hyperinflation (between 1960 and early 1990) and the introduction of the Real Plan. Thus, it is fundamental the use of replication techniques (such as bootstrap); however, the perturbation addition can increase inconsistencies in the data. Other limitation is the computational usage: it is a time consuming task to train the neural networks.

This work contributes to previous inflation forecasting studies by incorporating brazilian macroeconomics index. For future works, we propose the study of different neural network architectures and incorporation of others macroeconomics index. Besides, unpredictable events like the COVID-19 bring additional complexity because of the new context of increase of inflation worldwide. We still have to investigate how this impacts on the economics context.

Bibliography

[1] D. Baqaee, *Using wavelets to measure core inflation: The case of New Zealand.* The North American Journal of Economics and Finance , 21(3), 241–255., 2010.

[2] M. F. Bryan, S. G. Cecchetti, *Measuring core inflation. Monetary policy,* The University of Chicago Press, 195-219, 1994.

[3] S. Haykin, *Neural Networks: A Comprehensive Foundation,* 2 edn, Prentice Hall, Ontario, Canada, 1999.

[4] C. Zaniol, C. Pazinatto, A. P. S. Schiller, J. C. P. de Moraes, *Previsão de inflação com o uso de Inteligência Artificial.* Revista Brasileira de Computação Aplicada, 13, 2, 96-104, 2021.