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Core Inflation in Iran: A Maximum Overlap Discrete Wavelet Transformation (MOWT) and Multi Resolution Analysis (MRA)

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Abstract:
Identification of permanent part of inflation and prediction about future inflation structure is a crucial ingredient of an inflation targeting strategies or other related monetary policies. Monetary policy makers perform this task by estimating the measure known as "core inflation". This measure is a good indicator for tracking trend of inflation and forecasting future inflation. Measures of core inflation was developed by using wavelet methods in our research. The maximum overlap discrete wavelet transformation (MOWT) and Multi Resolution Analysis (MRA) methods are performed for extracting core inflation in period 1381(1)-1400(6) in Iran by monthly data. Using this methods is relatively new in the literature and are ideally appropriated for this task. The best wavelet in each wavelet families choose in accordance with Shannon entropy and logarithm of energy. On the other hand the properties of wavelet-based core inflation measure was evaluated by some tests. The results reveal that our new measure is more superior to the traditional approaches that used in previous studies in Iran.

1. Introduction

Inflation is a term that refers to a permanent increase in price levels and is one of the most serious difficulties that economic systems face. Unpredictable and uncontrolled changes in inflation (high rates of inflation) have a severe influence on economic systems, and central banks (monetary policymakers) normally set maintaining low inflation and price stability as their goal. Given the deleterious impact of uncontrolled (high)

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inflation rates on countries' economic systems, central banks (monetary policy-maker organizations) often opt to maintain inflation low and price stability constant over the long run periods. Thus, inflation targeting is a medium- or long-term objective, necessitating the development of criteria that is influenced by short-term variations in the prices of certain components of the consumer price index, such as energy costs, the prices of certain food products, etc. Because not all changes in the general level of prices are equal in importance to monetary policymakers, and if the increase in inflation is temporary, there is no reason to interfere and implement a corrective policies. As a result, monetary policymaker needs a metric that accurately captures long-run changes in price levels and inflation.

The consumer price index is composed of many components and is typically constructed using the Laspeyres index's average weight. There are many significant disadvantages to adopting this indicator as a criterion for inflation targeting. And there is much dispute over this indicator's incapacity to discriminate between supply and demand shocks. Because the inflation rate estimated using this indicator takes into account variables impacting both forms of inflation, including demand pull and cost push inflation.

The core inflation index is seen as a component of the inflation rate that is directly tied to demand variables and so indicates the inflation rate's sustainable and long-term component (Giannone & Matheson, 2007). There are several ways for calculating and estimating core inflation, which may be categorized into statistical and model-based approaches. Naturally, the most comprehensive technique is to compute core inflation by excluding food and energy groups from the consumer price index. However, the approach is still questionable. In general, all methods of estimating inflation are based on the extraction of a stable component of inflation, and when this problem is taken into account, the usage of signal processing techniques is also quite practicable. Because these techniques enable the separate low-frequency components (signals) from high-frequency components (noises). Which is less frequently employed in Iranian researches. As a result, this work will focus on deriving core inflation via wavelet analysis. As such, the next section examines and highlights the theoretical basis of core inflation. In the third part of this article the wavelet literature review will discuss the multi resolution and maximum overlap approaches. The core inflation is then extracted and analyzed using maximum overlap discrete wavelet transformation and multi resolution analysis and the available tests. The final part summarizes and presents the findings.

2. The theoretical underpinnings of core inflation

In the economic literature, there are six fundamental theories and viewpoints on core inflation. In the first method, core inflation is defined as an output-neutral inflation. In the second viewpoint, on the other hand, core inflation is viewed as the expected inflation from different price index series. The third method regards core inflation as a persistent component of measured inflation. The fourth technique assumes that each commodity's price movements are composed of two components (a general trend and a relative price shock), with base inflation attempting to estimate the general trend. In the fifth perspective, a list of commodities that are more susceptible to supply shocks is determined, and the price index is constructed by subtracting these goods from the initial basket in order to account for demand pull inflation. Core inflation was thought to be money-induced inflation in the sixth method. And it is predicted that this index would remain consistent in the near and medium run (Shrestha, 2006).

In the first method, and according to the concept of Quah and Vahey, core inflation is defined as "a component of measured inflation that has no influence on (real) output in the medium to long run" (Quah & Vahey, 1995). Accordingly, core inflation is the component of inflation caused by shocks that have no influence on real output in the medium to long run. In this situation, if we analyze the short-term aggregate supply curve as follows:

$$\Pi_t = \Pi_t^{LR} + g(X_{t-1}) + v_t \quad (1)$$

Where π_t is the total inflation rate during period t, π_t^{LR} the long-term inflation rate or inflation trend (which may fluctuate over time), X_{t-1} is a criterion to measure the periodic demand pull pressure, and v_t an indicator of transitory inflation deviations. Thus, Quah & Vahey represent core inflation and non-core inflation using the relations (2) and (3):

$$\Pi_t^c = [\Pi_t - v_t] = \Pi_t^{LR} + g(X_{t-1}) \quad (2)$$

$$\Pi_t^{nc} = v_t \tag{3}$$

Core inflation will be essentially equal to demand-driven component of inflation in this instance.

Eckstein divides inflation into three components: core inflation, a component related to aggregate demand, and a “shock” component. According to his definition, core inflation is a component of inflation that happens during long-term economic development, in the absence of shocks, and at a neutral state of demand. In other words, core inflation is the inflation rate that the economy encounters in the long-run equilibrium (Eckstein, 1981). Core inflation and non-core inflation are defined in terms of the equations (4) and (5) according to Eckstein:

$$\Pi_t^{c} = [\Pi_t - g(X_{t-1}) - v_t] = \Pi_t^{LR} \tag{4}$$

$$\Pi_t^{nc} = g(X_{t-1}) + v_t \tag{5}$$

To demonstrate how the second technique extracts core inflation, actual inflation is represented by equation (6):

$$\Pi_t = \Pi_t^{e} + g(X_t) + v_t \tag{6}$$

Where π_t is the aggreagate inflation rate in period t, π_t^e is the expected inflation, X_{t-1} is an index to measure demand pull pressure, and v_t is the indicator of supply shock. As a result, core and non-core inflation will be as following equations (7) and (8):

$$\Pi_t^{c} = [\Pi_t - g(X_t) - v_t] = \Pi_t^{e} \tag{7}$$

$$\Pi_t^{nc} = g(X_t) + v_t \tag{8}$$

Price changes in the third and fourth approaches are viewed as a equation (9):

$$\Pi_t = \pi_t + X_t \tag{9}$$

In this equation, $\Pi_t = \ln(P_t) - \ln(P_{t-1})$ is each commodity's distinct price change consisting of a stable component of aggregate inflation (π_t) and

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and a component of transitory price changes (X_t). As a result, it is important to extract π_t for all prices in these approaches.
The fifth method views inflation as a relationship between inflation driven by demand forces (Π_d) and inflation caused by supply shocks (Π_s), as well as a link between the two (10). Core inflation will be obtained after supply-affected inflation is removed.

$$\Pi_t = \Pi_d + \Pi_s \qquad (10)$$

In the sixth method, core inflation is assumed equal to the growth rate of money ($\Pi_c = money\ growth$).
According to the aforementioned circumstances, core inflation is not a directly observable variable and must be estimated and calculated using existing data (Landau, 2000).
There are various ways for estimating core inflation, among which the following are the most important:
A) Core inflation as the expected inflation
In this approach, the expected inflation - as determined by several models - can be considered the core inflation. In this approach, it is important to initially estimate prediction models (Jefferis, 1990).
B) Univariate methods, such as weighted average, Hodrick-Prescott filter, and Kalman filter.
This method is based on data smoothing and filtering techniques, and it obtains the core inflation by eliminating undesired components from the inflation trend (Roger, 1998).
C) Multivariate methods like Structural Vector Auto Regression (SVAR).
Kovah and Vahi estimated the baseline of the inflation in the form of Structural Vector Auto Regression and with the help of this model the inflation rate was divided into two independent concepts: basic inflation and noise inflation.
D) Random standards of minimum like weighted median and trimmed mean.
Some random standards like the revised minimum and the weighted median considers the titled sectional distribution of price changes as practical standards of the basic inflation. Usually, the sectional distribution

of price changes has a positive skewness and high kurtosis. In this way, the simple minimum or a scale to estimate the baseline of the inflation is inferior compared to the standards like median and trimmed mean. (Bryan & Cecchetti, 1993)

The revised average of the weighted mean is a subset of the consumer price index which results by adjusting the extreme movement in the inflation.

In the alternative method of the median CPI inflation rate, there exists no essential need to select specific concepts to put out from the index. This method is robust against the huge shocks to the inflation rate as well. However, the firms due to the menu cost change prices when they are shocked by high costs. It is also concluded that the median is a better scale for the inflation rate standard compared to the average. In estimating the inflation rate basis with the help of the median method, the concepts which have been influenced by great costing changes are quitted from the consumers' index rate. So the estimated inflation with this method may ignore some important information about the price changes in the inflation rate (Smith, 2004). However, the median is not well known among the people and, the central banks have no intention for these kinds of standards (Clark, 2001).

At first, the groups and the articles are categorized ascendingly or descendingly or the price changes rate in the revised average method, and then, specific percentages of the articles are quitted at the first and the ned of the list. The advantages and disadvantages of the standard are similar to the mentioned method in the basic inflation of the median way (Meyer & Venkatu, 2014).

E) based on standards of deletion that exist in some of the articles in this method, the weighting system of the consumer price index is reviewed and some of the included concepts are considered as zero weight and some others are reestimated. If the consumer rate index is considered as below (11):

$$CPI_t = \sum_{i=1}^{n} \frac{w_{i0} P_{it}}{P_{i0}} \times 100 \quad (11)$$

The basic inflation can be estimated based on the exit of some concepts, which are mentioned below (12):

$$CPI_{it} = \frac{\sum_{i=1}^{m} w_{i0} \frac{P_{it}}{P_{i0}} \times 100}{\sum_{i=1}^{m} w_{i0}} \quad where \;\; m \le n \tag{12}$$

Usually, central banks exclude food and energy from the consumer price index to estimate the baseline of inflation. In some points the indirect taxes administrated prices, and interest charges are excluded from the indexes too (Shrestha, 2006).

The basis of scrutinizing the basic inflation in the mentioned methods to delude groups and the articles concerns the fact that these groups go through so many considerable changes during the time and these changes cause noise and signal inflation.

As a result, excluding these types of articles deteriorates any error and noise and the resulting estimation will portray the related inflation to the implementation of economic policies in a better way. For estimating the baseline of inflation in most countries, usually, some groups such as food and energy are excluded from CPI for the estimation of the inflation, and then a new estimation is done. This method in Iran is done by excluding the issues related to the house, education (Tashkini and Afzali, 2012), furniture, entertainment, food, drug, and education (Naghdi and Matlabi, 2016).

This method is easily comprehensible and observable in any situation, but the choice of the concepts and the groups which should be excluded regarded to the researcher's resolution and the topic can significantly divert the results.

It is previously mentioned that the inflation rate (π_t) divided by the time (t) is generally analyzable into two permanent (π_t^*) and temporary (ε_t) concepts. The permanent concept or the inflation rate is considered the baseline of the inflation, so in this case, the model-based methods are regarded as a great solution for the trend estimation. Although it is a proper and tangible method, some primary theories need to be considered for the practicability of the method which provides the fact that it may not be in harmony with reality and also cause incorrect results.

$$\pi_t = \pi_t^* + \varepsilon_t \tag{13}$$

In this case, the main issue is to determine the permanent concept in the baseline of inflation or in other words to identify the transient concept from the everlasting one. Currently, it is possible to utilize a method which it's not been mentioned yet to analyze the inflation rate to permanent and temporary concepts and to solve most problems related to the model of the method (Stock & Watson, 2016). The methods require utilizing signal processing a series of times in the models. The Fourier transformation and Wavelet analysis are the most well-known methods. The mentioned methods are capable of analyzing and presenting permanent and temporary processes a series of times (Rich & Steindel, 2005).
The Fourier transformation is used to transfer a signal from a time domain to a signal in the frequency domain. This transformation is done by showing a signal from a specific sine and cosine in different wavelengths and amplitudes. This situation clarifies a signal's movement in a specific frequency. In Fourier transformation, it is assumed that the lengths of the frequencies are stable. This assumption causes an incorrect portrayal of some series of times that have gone through non-periodic changes and structural breaks (Cerny, 2004).
The wavelet transformation is similar in the case of displaying the time series in the frequency domain. However, the equal assumption is not involved in the transformation, and considering the issue, the analyses of time series in non-periodic changes and different organizations are regarded as suitable. Also, most of the frequency features of the economical time series depend on the time and it's essential to analyze and study the time features and frequency data simultaneously. In the conclusion, there is no need for the variables to be everlasting in the transformation process. And most of the statistical hypothesis in the mentioned model-based method is ignored (Gallegati & Semmler, 2014, pp. 15-16).
Using the wavelet transformation can cause different series of basic inflation in different shapes. Therefore, considering the meer goal, it makes it possible to have the best inflation series used. We can elaborate on the wavelets that some of them are capable of influencing a series of basic inflation. However, some other wavelets can make the baseline of the inflation series ascending way. In this case, the estimation of the core inflation (by analyzing the inflation rate to permanent and temporary concepts) is accomplished by considering the variation of wavelets so it can answer any question relatable question if it is encountered in research.

For instance, it is proper to have a wavelet with smooth output, if the researcher is after the inflation expectation prediction or the inflation rate knowledge. On the contrary, if the researcher is after inflation turning points, the wavelet will have a more efficient output. In the end, if the researcher's goal is to determine the periods of inflation phase change or to examine the differences between inflation transformations, the ascending trend for the wavelet would be a better idea. Because the output of this type of wavelet indicates the stability period of the core inflation in a better way and also displays the time and size of the regime change.
It needs to be mentioned that the inflation rate estimation has been done in Iran with statistical methods, elimination methods, and model-based methods in studies (Tashkini & Afzali, 2011), (Abbasinejad, Komijani, Tayebnia, & Tashkini, 2010), (Naqdi & Motalebi, 2015) and (Rezaei Moghadam, Mostofi, & Cheshmi, 1395). The mentioned studies by utilizing traditional approaches have been implemented in studying the inflation rate and naturally consist of some errors in this approach. For the first time, in the research, the wavelet method and multi-level resolution analysis are used to estimate the core inflation series. In the upcoming section, there will be a general explanation of the wavelets, analyzing methods of multilevel resolution and maximum overlap.

3. Wavelet, multi-Resolution Analysis (MRA), and maximum overlapping

The subordinate will be considered as a wavelet if it has the features mentioned the below:

The result of the term would be equal to zero ($\int_{-\infty}^{+\infty} \psi(s)\, ds = 0$).

The fourth multitude of the term would be equal to one ($\int_{-\infty}^{+\infty} \psi^2(s)\, ds = 1$).
The second feature is known as unit energy and is representative of the fact that ψ(s) is not always equal to zero. The first attribute also is the indicator of the fact that the combination of the positive and negative numbers neutralizes each other. The mentioned features cause the ψ(s) subordinate to be in Oscillation in the closeness of the zero results. However, this oscillation is done in a certain range; contrary to the sine and cosine subordinates, and considering the issue ψ(s) subordinate is

regarded as a small wave or a wavelet (Gencay, Selcuk, & Whitcher, 2002, pp. 1-14).

14) Haar is the most primitive wavelet which can be solved according to the (14) attribute.

$$\psi^{H}(t)=\begin{cases} -\frac{1}{\sqrt{2}} & , -1<t\leq 0 \\ \frac{1}{\sqrt{2}} & , 0<t\leq 1 \\ 0 & , other \end{cases} \qquad (14)$$

The well-known wavelets of Morlet, Haar, Morlet, and Mexican hat are shown in the picture (1). The wavelet subordinates are the representative of how the rhythmic averages of a signal go through changes in the periods (Graps, 1995). If the $x(.)$ considered as a real attribute in a subordinate (signal), the average result $[a, b]$ is shown the below (15):

$$\alpha(a,b)\equiv\frac{1}{b-a}\int_{a}^{b}x(u)\,du\ ,\ a<b \qquad (15)$$

If the $\lambda=b-a$ is considered as $t=\frac{a+b}{2}$ the result would be like in the below (16):

$$A(\lambda,t)\equiv\alpha(t-\frac{\lambda}{2},t+\frac{\lambda}{2})=\frac{1}{\lambda}\int_{t-\frac{\lambda}{2}}^{t+\frac{\lambda}{2}}x(u)\,du \qquad (16)$$

In the wavelets language, λ is known as the scale (size) of the subordinate. Therefore, $A(\lambda,t)$ the average signal $x(.)$ in the scale λ is concentrated on time t. A change from $A(\lambda,t)$ subordinate from one period to another is portrayed in the picture (17):

$$D(\lambda,t)\equiv A(\lambda,t+\frac{\lambda}{2})-A(\lambda,t-\frac{\lambda}{2})=\frac{1}{\lambda}\int_{t}^{t+\lambda}x(u)\,du-\frac{1}{\lambda}\int_{t-\lambda}^{t}x(u)\,du \qquad (17)$$

For instance, if the consists of monthly inflation data, the chart $D(3,t)$ is representative of how the inflation average (in a month) changes from month to month. With the increase λ in a year, the chart $D(\lambda,t)$ is representative of how the average inflation is changeable during a year.

The subordinate in the picture (17) could be portrayed as an integral and shown in the below (18):

$$D(\lambda,t)=\int_{-\infty}^{+\infty} x(u)\,\psi_{\lambda,t}(u)\,du \qquad (18)$$

In this case, the $\psi_{\lambda,t}$ would-be shown like this:

$$\psi_{\lambda,t}(u)\equiv\begin{cases}-\dfrac{1}{\lambda} & ,\ t-\lambda<u\le t\\ \dfrac{1}{\lambda} & ,\ t<u\le t+\lambda\\ 0 & ,\ Otherwise\end{cases} \qquad (19)$$

Continuous Wavelet Transform (CWT) with the help of picture (18) is presented as $W(\lambda,t)=\int_{-\infty}^{+\infty} x(u)\psi_{\lambda,t}(u)\,du$. Every coefficient CWT results from dilation and transformation from a mother wavelet ($\psi_{\lambda,t}(u)$). The signal analyses with the help CWT provide lots of information from the nature of the data. However, regarding the fact that correct analysis of the information is hard, usually in the estimation of the core inflation, one can use a simplified version or discrete wavelet transform in this study or the related studies. The DWT has fewer computational problems which is an advantage compared to CWT and so, the algorithms related to this type of wavelet transformation are much easier and optimized. Signals in the method DWT with the help of the Mallat algorithm is analyzed to two up and down frequency. The concept with a lower frequency is known as Approximation, which presents the feature and main characteristic of the signal. On the contrary, the concept with a higher frequency which is known as details is the presenter of the accurate signals. So DWT in this case, is a sample of CWT which is resulted from the even scales 2^j if $j=1,2,\dots,J$. Considering the restrictions has caused the method to face failure in analyzing the time series. Because this assumption is not always common and considering this restriction in higher scales, many periods have been gone and as a result, the power of surmise has been reduced by using the method (Lahura & Vega, 2011). To solve the restriction, it has been suggested that the considered analyses are to be accomplished with a discrete wavelet approach with maximum overlap discrete wavelet transform (MODWT). In the approach, there is no need for the size of the scale (time series or signal under the estimation) to be limited to numbers that are squared (Percival & Walden, 2000).

Multi-level resolution analysis of a mathematical approach is usable in the theory of wavelets, in which a sequential series of approximations is revived with the help of it, a way that the new approximation would be better than the previous ones. It $\{..., S_{J-2}, S_{J-1}, S_J, ...\}$ is the portrayer of a multi-level analysis S_J and is a better approximation compared S_{J-1}. Also, the difference between sequential approximations is known as details $D_J = S_J - S_{J-1}$. It S_1 is the best representative of the signal $f(t)$ $f(t) = S_1 + D_1$ and will be an existent subordinate. If there exists the multi-surface resolution analysis of a signal, there is also the possibility of showing a different approximation of it which has a fewer resolution and is considered a concept with lower frequency.

This is a general way: $S_1 = S_2 + D_2$ ، $S_2 = S_3 + D_3$ ، ... ، $S_{j-2} = S_{j-1} + D_{j-1}$ ، $S_{j-1} = S_j + D_j$ and in this case by analyzing the multi-levels one can show the signal $f(t)$ in the picture (20) and a form of a concept with a lower frequency S_j and upper frequency D_j (lahura & Vega, 2011).

$$f(t) = S_j + D_j + D_{j-1} + ... + D_1 \tag{20}$$

Daubechies in 1992 showed that if a signal in space is analyzable for multi-resolution cases in $L^2(\Re)$ space, there will be a base orthogonal wavelet that is related to the space, and the signal can be analyzed to orthogonal concepts S_j , D_j (Conlon, Cotter & Gencay, 2018).

$$\begin{aligned} D_j &= \sum_t d_{j,t} \Psi_{j,t}(u) \quad , \quad j = 1,2,3,...,J \\ S_j &= \sum_t s_{j,t} \Phi_{J,t}(u) \end{aligned} \tag{21}$$

In the picture (21) the concept of a high frequency D_j is related to scale $j = 1, 2, 3, ..., J$. As usual, these concepts are made of the transformation of a discrete wavelet from a wavelet group $\psi_{j,t}(u)$ which transformation and dilation from the mother wavelet ψ with considering the dilation factor $\lambda = 2^j$ and the reason for the transformation $t = k\,2^j$. On the other hand, the concept S_j belongs to the higher frequency scale J and it results from the wavelet group (father wavelet) $\phi_{j,t}(u)$. Usually, the father wavelet belongs to the lower frequency and derives the stable and rated concepts and on the contrary, the mother wavelet is used to get the concepts related to the lower scales and higher frequency. Considering the mentioned information a subordinate could be presented below (22): (2010 Sanderson)

$$f(t) = \sum_t s_{j,t}\phi_{J,t}(u) + \sum_t d_{j,t}\psi_{j,t}(u) + \sum_t d_{j-1,t}\psi_{j-1,t}(u) + \ldots + \sum_t d_{1,t}\psi_{1,t}(u) \qquad (22)$$

4. Deriving the core inflation with the help of multi-leveled resolution of discrete wavelet and maximum overlap:

As was mentioned, by optimizing the language of the wavelets in analyzing them and removing the details with high frequency, the sequential approximation of a signal can be derived. It is essential to mention that with increasing the levels quantity, there is the possibility that a part of the main signal is removed. Therefore, the program should be in a way that avoids removing the main part. Minimum (low) entropy is the certain way of not permitting the removal process in this research. In this method, the best level of analyzing a signal is a level with a low chance of entropy amount (He, Tan & Wang, 2015).

Also, the Log energy methods and Shannon are the scales of entropy used in the levels.

Considering the mentioned information, initially, the core inflation is calculated and presented with the lowest entropy scale using the wavelets of Daubechies, Symlet, and Coiflet. Then, the best scale is chosen from the mentioned scales.

In this research, the inflation rate is estimated and optimized by statistical data of the consumer's price index between April 2001 and September 2022 in monthly inflation rate and point-to-point inflation rate (compared to the same month of the previous year). After choosing the best standard of inflation rate by using the monthly inflation rate and point-to-point

inflation rate and these standards are compared separately with the presented core inflation in other studies.
This resulted in approximation by using the Daubechies, Symlet, and Coiflet in the charts of (1) till (3) is presented. The least entropy amongst the Coiflet wavelet group related to the Coiflet wavelet No. 5 in the level 1, Daubechies wavelet group related to Daubechies wavelet No. 10 in the level 1, Symlet wavelet group related to Symlet wavelet No. 8 in the level 1.

Table (1): Estimation of Average and variance of different core inflation by using different wavelets (percentage)

	Point to point inflation		Monthly inflation	
Explanation	variance	average	variance	average
Inflation rate	683451	168039	2941	12634
Inflation rate with Daubechies wavelet	68147	168039	1563	12634
Inflation rate with Coiflet wavelet	68149	168039	1566	12634
Inflation rate with Symlet wavelet	68142	168039	1557	12634

Source: the accurate calculation with Matlab software

The evaluation of the considered standards as the core inflation makes it possible to evaluate the efficiency and functions of the estimated indexes as the core inflation with having some exams.
If the core inflation is estimated as a stable component and inflation trend, at first, one could expect the average core inflation to be equal to the average inflation rate in the reviewed period (Clark, 2001). On the other hand, one could expect that the core inflation has fewer variances compared to the main inflation series (Dowd, Cotter, & Loh, 2006).
It is also expected that the core inflation rate has fewer turning points compared to the main time series (Wynne, 1999). On the other hand, the estimated core inflation should be in harmony with the main inflation series, or other words, the differences between the series should be everlasting Marques (Marques, Neves, & Sarmento, 2003).
On the contrary, if the core inflation is considered as a standard to predict upcoming inflations, some evaluations would be great with the purpose of examining the intervals between the current core inflation and upcoming inflation. For instance, the variance of the difference between the current core inflation and upcoming inflation could be a standard for evaluating the next inflations (Khettry & Mester, 2006). It is also expectable that the

numbers in both current inflation and upcoming inflation to be in harmony and the error of prediction to be everlasting. Finally, it is possible that by using predictive evaluation standards like $RMSE$, etc. to choose the best evaluation standard (Mishra, Vairam, & Debasis , 2018, pp. 11-15).

The evaluations presented by Cogley in 2002 could be the core inflation evaluation method. In this case, in every period H, the conditions $\alpha = 0$ $\beta = 1$ will be evaluated which is shown below (23):

$$\pi_{t+H} - \pi_t = \alpha + \beta\,(\pi_t - \pi_t^c) + u_{t+H} \qquad (23)$$

In this picture, the π_{t+H} is representative of the inflation rate in the term of H in the upcoming inflations, π_t is the inflation price in the term of time t, π_t is the core inflation rate in the term of time t + H, u_{t+H} is a part of disturbance in $t + H$.

Having a suitable standard to predict the alternation of the upcoming inflation most correctly is the reason for having these conditions. For example, it β is smaller (bigger) than one, which is representative of the fact that it is showing the considered core inflation rate in a better (worse) way than usual. It is also expected that they R^2 have a high regression chance (Cogley, 2002).

The average and core inflation variance is estimated by the Daubechies wavelet, Coiflet wavelet, and Symlet wavelet and it is shown in the Table (2). As you can see the average in both series, the monthly inflation and point0 to-point inflation have the same result and so none of the standards have a better result compared to each other. On the other hand, the estimated core inflation has less variance in using the Symlet wavelet. The estimated core inflation in Coiflet and Daubechies wavelet has a worse impact in comparison to the Symlet wavelet.

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Table (2): evaluation of the convergence between the different core inflation and inflation rates

	Point To Point		Monthly	
Explanation	Static	Possibility	Static	Possibility
convergence between the inflation rate and core inflation in Coiflet wavelet	٢,٥٥٠	٠,٩٢٥	٠,٩٢٦	٠,٩٦٠
convergence between the inflation rate and core inflation in Daubechies wavelet	٠,٩٠٣٩	٠,٤٨٠٨	٠,٩٢٦	٠,٩٦٠
convergence between the inflation rate and core inflation in Symlet wavelet	٠,٩٠٢٨	٠,٤٨١٢	٠,٩٢٤	٠,٩٦٠٧

Source: the accurate calculation with Matlab software

The results from the Johansson test in the convergence between each presented standard as the core inflation and the consumer inflation rate are shown in Table (3). It needs to be mentioned that the numbers in the chart are possibly representative of a convergence interaction considering the assumption of the width in the interaction and deterministic linear trend in an assurance level of 95%. The numbers resulted show that the reason for the zero assumption to face failure is because of a convergence relationship between the consumer inflation rate and presented standards of core inflation.

Table (3): The Coefficient of long run relationship between different standards core inflation and consumer inflation rate:

	Point to point		monthly	
Explanation	R^2	Coefficient of long term relation	R^2	Coefficient of long term relation
Core inflation with Coiflet wavelet	٩٩,٧٨	١,٠٠٠١	٥٩,٩٧	١,٠٣٠٧
Core inflation with Daubechies wavelet	٩٩,٧٩	١,٠٠٠١	٦٠,١٧	١,٠٣٢٠
Core inflation with Symlet wavelet	٩٩,٧٩	١,٠٠٠١	٦٠,٧٨	١,٠٣٥٨

Source: the accurate calculation with Matlab software.

The coefficient between the long-term relationships in consumer inflation rate and different standards of core inflation are shown in the Table (3). As

you can see the coefficient of long-term relation using point-to-point data in all the three standards evaluated they are almost equal to one (1.0001). Considering the numbers of the coefficient, the core inflation estimation resulted from the Symlet wavelet and Daubechies wavelet are ranked in the first and the second-ranking, and also, and the next rank belongs to the Coiflet wavelet. In the case of using the monthly data which has the closest relation to the coefficient resulting from the Coiflet wavelet in an core inflation and also the core inflation resulting from the Daubechies wavelet in the second and core inflation resulting from the Symlet wavelet is ranked in the next ranking.
Considering the determination coefficient the core inflation resulting from the Symlet wavelet is the first, the core inflation resulting from the Daubechies wavelet is the second and the result of the Coiflet wavelet has the last rank. The comparison between this standard with the previous standards estimated by the other domestic researchers shows that the current standard has the closest average to the main inflation rate, less variance, and a long-term coefficient of close to one.

5. Conclusion

In this article, the core inflation is derived from the method of discrete wavelet transformation by monthly alternations of the consumer's index and point-to-point alternation index. The wavelet transform method is very suitable for using unfix time series and in this case there will be no worries in calculating the core inflation about the unfix variations. Because the discrete wavelet transformation has faced failure when used as a method like the change in the results and the change from the starting point and the condition of being equal in the case of making the numbers squared. In this research, the discrete wavelet transformation is done with maximum overlap discrete wavelet transform to solve the occurred problems. In addition, the utilization of the multi-level resolution analysis approach has not only solved the mentioned errors but, creates less sensitivity in choosing the mother wavelet. The information resulting from the studies shows that the resulted core inflation standard using the Symlet wavelet No.8 in the same level of analyses, Daubechies wavelet No.10 in the same level of analyses, and Coiflet wavelet No.5 in the same level of analyses has the least amount of entropy and logarithm of reported energy of Shanon and logarithm of energy in the mentioned groups. According to this, the estimated core inflations from these wavelets were chosen and evaluated as the sample for the core inflation.

These standards have the same averages as the main series of the inflation rate and have a smaller variance in comparison to the others. The convergence relation between the inflation rate and core inflation by using the Johanson evaluation has not been rejected in any of the mentioned standards. On the other hand, the relationship between the long-term inflation rate and each core inflation standard is close to one (especially in the core inflation rate which is derived from point to point trend).

In the end, considering the evaluations the core inflation is estimated by using the Symlet wavelet transformation No.8 with the same level of analyses chosen as the best standard of core inflation. The comparison between the standard with the other estimated standards by the other domestic researchers gains good descriptions.

References

1. Abbasinejad; H., Komeyjani; A., Taiebnia; A., Tashkini, A. (2010). Measuring core inflation in Iran (Statistical Approach). Economic Research, 10(38) , 39-65. (In Persion)

2. Bryan , M., & Cecchetti, S. (1993). Measuring Core Inflation. National Bureau of Economic Research. doi:10.3386/w4303

3. Cerny, A. (2004). Introduction to Fast Fourier Transform in Finance. London: Imperial College London. Retrieved from http://www3.imperial.ac.uk/pls/portallive/docs/1/40346.PDF

4. Clark, T. (2001). Comparing measures of core inflation. Economic Review, 2001, issue Q II, No v. 86, no. 2, 5-31, 86(2), 5-31. Retrieved from http://www.kansascityfed.org/PUBLICAT/ECONREV/PDF/2q01clar.pdf

5. Cogley, T. (2002). A Simple Adaptive Measure of Core Inflation. 34(1), 94-113. Retrieved from https://www.jstor.org/stable/3270677

6. Conlon, T., Cotter, J., & Gencay, R. (2018). Long-run wavelet-based correlation for financial time series. European Journal of Operational Research, 271(2), 676-696.

7. Dowd, K., Cotter, o., & Loh, L. (2006). U.S. Core Inflation: A Wavelet Analysis. Macroeconomic Dynamics, 15(4), 513-536. doi:10.2139/ssrn.993936

8. Eckstein, O. (1981). Core inflation. Prentice Hall Books.

9. Gallegati, M., & Semmler, W. (2014). Wavelet Applications in Economics and Finance. Springer.

10. Gencay, R., Selcuk, F., & Whitcher, B. (2002). An Introduction to Wavelets and Other Filtering Methods in Finance and Economics. Elsevier. Retrieved from https://doi.org/10.1016/B978-0-12-279670-8.X5000-9

11. Giannone, D., & Matheson, T. (2007). A New Core Inflation Indicator for New Zealand. International Journal of Central Banking, 3(4), 148-180.

12. Graps, A. (1995). An Introduction to Wavelets. IEEE Computational Science & Engineering, 2(2), 50-61. doi:10.1109/99.388960

13. He, H., Tan, Y., & Wang, Y. (2015). Optimal Base Wavelet Selection for ECG Noise Reduction Using a Comprehensive Entropy Criterion. Entropy, 17(9), 6093-6109. doi:10.3390/e17096093

14. Jefferis, R. (1990, Feb). Expectations and the Core Rate of Inflation. Economic Review, 26(4), 13-21.

15. Khettry, N., & Mester , L. (2006). Core Inflation as a Predictor of Total Inflation. Federal Reserve Bank of Philadelphia. Retrieved from https://www.philadelphiafed.org/-/media/research-and-data/publications/research-rap/2006/resrap-sr2006.pdf
16. Lahura, E., & Vega, M. (2011). Evaluation of Wavelet-based Core Inflation Measures: Evidence from Peru. Working Papers. Retrieved from https://www.researchgate.net/publication/254441456_Evaluation_of_Wavelet-based_Core_Inflation_Measures_Evidence_from_Peru
17. Landau, B. (2000). Cor inflation rate: a comparison of methods based on west German data. Frankfurt: Economic Research Centre of the Deutsche Bundesbank.
18. Marques, C., Neves, P., & Sarmento, L. (2003). Evaluating core inflation indicators. Economic Modelling, 20(4), 765-775. Retrieved from https://doi.org/10.1016/S0264-9993(02)00008-1
19. Meyer, B., & Venkatu, G. (2014). Trimmed-Mean Inflation Statistics: Just Hit the One in the Middle. FEDERAL RESERVE BANK of ATLANTA. Retrieved from https://www.frbatlanta.org/-/media/documents/research/publications/wp/2014/wp1403.pdf
20. Mishra, A., Vairam, A., & Debasis , P. (2018). Current Issues in the Economy and Finance of India. Springer.
21. Percival, D., & Walden, A. (2000). Wavelet Methods for Time Series Analysis. Cambridge University Press.
22. Quah, D., & Vahey, S. (1995). Measuring Core Inflation. Economic Journal, 105(432), 1130-1144.
23. Rezaee-Moghaddam; N., Mostafavi; M., Cheshmi, A. (2016). Separating Core Inflation from Temporary Components in Iran Using Kalman Filter. Economic Research, 16(60) , 51-73. (In Persion)
24. Rich, R., & Steindel, C. (2005). A Review of Core Inflation and an Evaluation of Its Measures. Federal Reserve Bank of New York.
25. Roger, S. (1998). Core Inflation: Concepts, Uses and Measurement. Reserve Bank of New Zealand.
26. Sanderson, J. (2010). Wavelet Methods for Time-series with Bivariate Observations and Irregular Sampling Grids. PhD dissertation. University of Bristol: School of Mathematics.
27. Shrestha, P. (2006). Some Measures of Core Inflation and Their Evaluations in Nepal. NRB Economic Review, 18, 37-69.
28. Smith, J. (2004). Weighted Median Inflation: Is This Core Inflation? Journal of Money, Credit and Banking, 36(2), 253-263.

29. Stock, J., & Watson, M. (2016). Core Inflation and Trend Inflation. Review of Economics and Statistics, 98(4), 770-784.
30. Tashkini A, Afzali H. (2011). The Optimal Method of Measuring Core Inflation: The Case of Iran. Quarterly Journal of Economic Research and Policies, 19 (59) :101-102. (In Persion)
31. Wynne, M. (1999). Core inflation: a review of some conceptual issues. Federal Reserve Bank of Dallas. Retrieved from https://ideas.repec.org/p/fip/feddwp/99-03.html
32. Yazdan Naghdi, Y., Motallebi, M. (2015). Estimation and Comparison of Core Inflation in Iranian Economy, Utilization of Trimmed Mean and Omission Methods, *Quarterly Journal of Ravand*, 22(69), 15-42. (In Persion)

پژوهشگاه علوم انسانی و مطالعات فرهنگی
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تورم پایه در ایران: رهیافت تبدیل موجک گسسته با حداکثر همپوشانی(MODWT) و تحلیل وضوح چندسطحی موجک‌ها (MRA)

چکیده

شناسایی جزء ماندگار تورم و پیش‌بینی ساختار تورم آتی به‌عنوان بخش مهمی در استراتژهای هدف‌گذاری تورمی و یا سایر سیاست‌های پولی مرتبط می‌باشند. سیاست‌گذاران پولی این موضوع را از طریق استخراج معیاری به نام "تورم پایه" انجام می‌دهند. این شاخص، معیار مناسبی برای اندازه‌گیری روند تورم و پیش‌بینی تورم آتی است. در این تحقیق تورم پایه در اقتصاد ایران براساس تغییرات ماهانه شاخص قیمت‌مصرف‌کننده و تغییرات نقطه به نقطه این شاخص در دوره زمانی ۱۳۸۱:۱– ۱۳۹۷:۱ با استفاده از رهیافت تبدیل موجک گسسته با حداکثر همپوشانی($MODWT$)
و روش تحلیل وضوح چندسطحی موجک‌ها (MRA) استخراج و مورد ارزیابی قرار گرفته است. بهره‌گیری از این رویکردها در ادبیات تورم پایه نسبتاً جدید بوده و جهت استخراج تورم پایه بسیار مناسب است. بهترین موجک در هر خانواده از موجک‌ها براساس آنتروپی شانون و لگاریتم انرژی انتخاب شده است. از طرف دیگر خصوصیات معیار محاسبه تورم پایه مبتنی بر رهیافت موجک توسط برخی آزمون‌ها مورد بررسی قرار گرفته است. نتایج نشان می‌دهد که معیار جدید بکارگرفته شده در این تحقیق در مقایسه با رویکردهای سنتی استفاده شده در مطالعات قبلی در ایران دارای خصوصیات بهتری است.

کلمات کلیدی: شاخص قیمت مصرف کننده، تورم پایه، آنالیز موجک، تحلیل وضوح چندسطحی موجک‌ها، تبدیل موجک گسسته با حداکثر همپوشانی.

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