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Forecasting the Monthly Real Wage Rate of the Public Sector in Sri Lanka

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Abstract

This study assesses the monthly real wage rate of the public sector of Sri Lanka by elaborating a suitable time series model to identify the future trends associated with the real wage rates of Sri Lanka. The sample data set consists of monthly real wage rate data from January 2018 to March 2024 from the Central Bank of Sri Lanka (CBSL). The real wage rate has been calculated selecting 2016 as the base year. Suitable parsimonious models were identified through the patterns of the sample partial autocorrelation function (PACF) and sample auto-correlation function (ACF) of the stationary series. Based on the indications such as Akaike information criterion (AIC), Schwarz Criterion (SC) and log likelihood an autoregressive integrated moving average (ARIMA) model of the type (0,1,2) was distinguished as the best fitted model. The residuals of the best fitted model were ascertained to be white noise. The model has been validated for the first three months of 2024. The Mean Absolute Percentage Error (MAPE) for the validation data is 9.59%. The forecasted wage rate values from April 2024 to September 2024 are 54.562, 54.096, 53.631, 53.165, 52.7 and 52.234 respectively. The study's findings can be utilized by policymakers, economists, and government workers to improve their financial planning.

Keywords: ARIMA models; Box Jenkins Methodology; Forecasting; Real wage rate; Time series analysis

Introduction

Sri Lanka, a country that lies on ancient trade routes, arrays the initial roots of its economic prospects for native Sri Lankans. The vast history woven around the country exhibits the endeavors of fellow Sri Lankans who rose for their rights. With the evolving world and culture, the barter system has flourished to artificial intelligence whilst the employees who were contended with minimum wages have initiated moves for equal pay unbothered by socio - economic factors. Sri Lanka currently faces multiple external crises, the combined result of long-standing macroeconomic imbalances, the impact of COVID-19 and critical policy missteps which made a bad situation much worse. (Gunatilaka, Chandrasiri, & International Labour Organization, 2022). Perhaps this would have fostered notable transformations in the economy of Sri Lanka, particularly regarding wage rate patterns in the recent past.

The wage rate is the measure of the rate of compensation for a worker (Landefeld et al., 2019). Analysing the trends in Sri Lanka's wage rate is crucial for comprehending the country's economic health, as it provides an insight into the welfare of the nation's labor force. Productivity levels, labor market conditions, exchange rates, technological advancements and political conditions are among the various factors that contribute to changes in the country's wage rate. Forecasting the wage

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rate is essential for policymakers, facilitating the formulation of effective labor policies and regulations concerning minimum wage standards that ensure fair compensation and contribute to the overall stability of the economy.

To accurately depict an individual's earnings in relation to their purchasing power, economists often refer to real wages. The real wage rate of a country is calculated through the following equation.

Real wage rate = Nominal wage rate – (Nominal wage rate × Inflation rate). __________ (1)

Real wages are adjusted for inflation, reflecting the amount of goods and services that can be bought with a given income. This contrasts with nominal wages, which are not adjusted for inflation. By accounting for inflation, real wages provide a more precise measure of an individual's economic well-being and the true value of their earnings over time. The real wage indices of the public and private sector of Sri Lanka are calculated by the Statistics Department of the Central Bank of Sri Lanka considering National Consumers' Price Index (NCPI) and Colombo Consumers' Price Index (CCPI) (Dissemination Standards Bulletin Board, 2018). Conventionally, in Sri Lanka real wage rate fluctuates rapidly due to unstable political and economic conditions.

The real wages have been utilized in the development of time series models to enhance the accuracy and reliability of economic forecasts in Sri Lanka (Liyanage,2019). However, no statistical models have yet been developed to forecast the real wage rate in Sri Lanka's public sector. Accordingly, this study aims to develop a forecasting model for the real wage rates within Sri Lanka's public sector and apply the verified model to short-term forecast real wage rates.

Materials and Methods

The method used in this study to develop the forecasting model for the observed data is the ARIMA model, which is widely recognized as a powerful statistical method for analyzing and predicting future values in time series data (Box, Jenkins, Reinsel & Ljung, 2015). The ARMA (p,q) model is represented by,

$$Y_t = \mu + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots + \phi_p Y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots - \theta_q \varepsilon_{t-q} \quad (2)$$

where: ϕ_i(i=1,2…,p) are the coefficients of the autoregressive (AR) process and θ_i (i =1,2…,q) are the coefficients of the moving average (MA) process. The series $\{\varepsilon_t\}$ is white noise and it is independently and identically distributed normally with zero mean and constant variance. The ARMA models are only appropriate if the time series is stationary. A stationary model is characterized by data that remains constant over time. Economic and market data often exhibit trends; hence differencing is applied to eliminate these trends and any seasonal patterns (Hayes, 2024). The ARIMA (p,d,q) is used to convert the non-stationary series to stationary series, where d is the order of differentiation (Box, Jenkins, Reinsel & Ljung, 2015).

Secondary Data

The monthly real wage rate indices were obtained from 2018 January to 2023 December from the CBSL wage rate indices database including 72 observations (Prices, Wages and Employment | Central Bank of Sri Lanka, 2024) including the data during the global pandemic and economic crisis of Sri Lanka in 2022 and its aftermath. The statistical analysis is carried out using Eviews 12.

Results and Discussion

Temporal variability of the original series

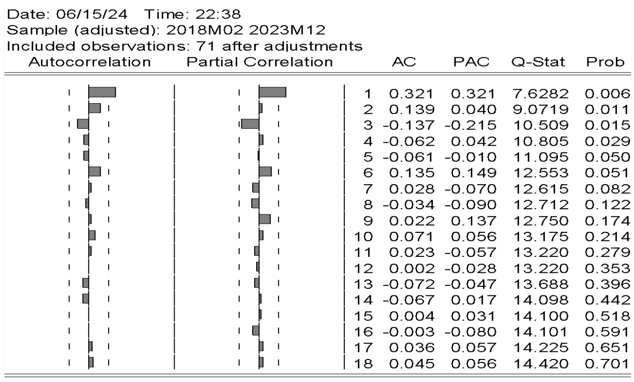
Figure 1. The Time Series Plot of the Original Series.

The temporal variability of the monthly real wage rate of the public sector in Sri Lanka from 2018 to 2023 is denoted in the time series plot in figure 1. It has varied from a minimum rate of 56.72 during the year 2023 along with a maximum rate of 96.75 in the year 2020. The mean real wage rate of the public sector in Sri Lanka is 82.56 with a standard deviation of 14.67. There is a gradual decline in the real wage rate from 2022 January to 2023 December.

The Augmented Dicky-Fuller (ADF) test discloses that the original series is non-stationary, as the p value is 0.931 ($p > 0.05$). Accordingly, to make the series stationary, the first difference of the original series is obtained, and ADF test is carried out and it reveals that the 1st differenced series of the original series is stationary as the test statistic is significant with a corresponding p value (0.000) less than 0.05.

ACF and PACF of the stationary series and identification of suitable models

The correlogram of the 1st differenced series of the original series was obtained to distinguish the possible models for the stationary series.



	AC	PAC	Q-Stat	Prob
1	0.321	0.321	7.6282	0.006
2	0.139	0.040	9.0719	0.011
3	-0.137	-0.215	10.509	0.015
4	-0.062	0.042	10.805	0.029
5	-0.061	-0.010	11.095	0.050
6	0.135	0.149	12.553	0.051
7	0.028	-0.070	12.615	0.082
8	-0.034	-0.090	12.712	0.122
9	0.022	0.137	12.750	0.174
10	0.071	0.056	13.175	0.214
11	0.023	-0.057	13.220	0.279
12	0.002	-0.028	13.220	0.353
13	-0.072	-0.047	13.688	0.396
14	-0.067	0.017	14.098	0.442
15	0.004	0.031	14.100	0.518
16	-0.003	-0.080	14.101	0.591
17	0.036	0.057	14.225	0.651
18	0.045	0.056	14.420	0.701

Figure 2. Correlogram of the First Order Difference Series.

ACF and PACF denoted in the correlogram (Figure 2) were statistically significant only at lag 1. Therefore, p and q values can be taken as 1. By comparing the theoretical PACF of AR (1) and theoretical ACF of MA (1) it can be postulated that ARIMA (0,1,1) and ARIMA (1,1,0), ARIMA (1,1,1) and ARIMA (0,1,2) as possible models. These models were considered as the most suitable parsimonious models for the stationary series obtained by getting the first difference of the original series.

Selecting the Best-Fitted Model

Table 1. A Comparison of Estimated Models

Model	ARIMA (0,1,1)	ARIMA(1,1,0)	ARIMA (1,1,1)	ARIMA (0,1,2)
MA (1)	Significant	Significant	Not significant	Significant
MA (2)	N/A	N/A	N/A	Significant
AR (1)	N/A	N/A	Not Significant	N/A
AIC	4.512255	4.488811	4.516271	4.487055
SC	4.607861	4.644417	4.643746	4.614530
Log Likelihood	-157.1851	-156.3528	-156.3276	-155.2904

Amidst the four possible models shown in the table, the ARIMA (0,1,2) was selected as the best fitted model by considering the significance of parameters and the lowest AIC, SC and maximum log likelihood. Thus, the best fitted model can be derived as,

$$(1-B)Y_t = \varepsilon_t(1+0.34B+0.24B^2). \qquad (3)$$

Model Diagnostics

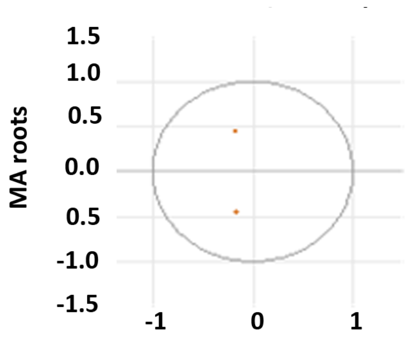
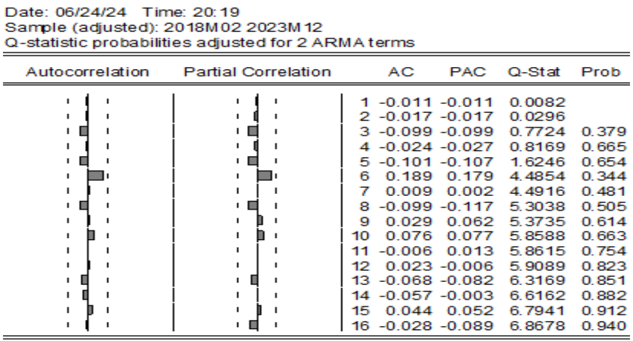


Figure 3. Inverse Roots of MA Polynomial.

The inverse MA roots of the best fitted model are inside the unit circle as illustrated in Figure 3; hence it implies that the roots lie outside the unit circle which makes the ARIMA process stationary and invertible. Thus, the fitted **ARIMA (0,1,2)** model can be used for further diagnostic tests.

Residual Diagnostics



Date: 06/24/24 Time: 20:19
Sample (adjusted): 2018M02 2023M12
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.011	-0.011	0.0082	
		2	-0.017	-0.017	0.0296	
		3	-0.099	-0.099	0.7724	0.379
		4	-0.024	-0.027	0.8169	0.665
		5	-0.101	-0.107	1.6246	0.654
		6	0.189	0.179	4.4854	0.344
		7	0.009	0.002	4.4916	0.481
		8	-0.099	-0.117	5.3038	0.505
		9	0.029	0.062	5.3735	0.614
		10	0.076	0.077	5.8588	0.663
		11	-0.006	0.013	5.8615	0.754
		12	0.023	-0.006	5.9089	0.823
		13	-0.068	-0.082	6.3169	0.851
		14	-0.057	-0.003	6.6162	0.882
		15	0.044	0.052	6.7941	0.912
		16	-0.028	-0.089	6.8678	0.940

Figure 4. Correlogram of Residuals

According to the diagram, the Q statistic of residuals probabilities is not significant (p value > 0.05), thus it can be concluded with 95% confidence that the residuals are random and are identically distributed and errors are white noise. The nonsystematic pattern of residuals versus fitted value suggests that of a constant variance for residuals. Moreover, the heteroskedasticity; the ARCH test confirms there is no auto regressive conditional heteroskedasticity (p value = 0.999 > 0.05), which implies that the variance or else the volatility of the residuals is constant over time and does not depend on past terms.

Comparison of observed and predicted values of training data set.

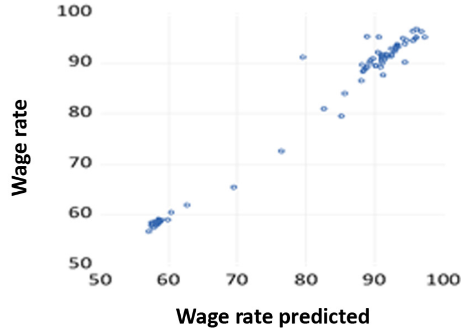


Figure 5. Actual and Predicted Wage Rates for the Training Set (January 2018 - December 2023)

A strong linear relationship between actual and predicted monthly real wage rates (r = 0.989) close to 1 can be confirmed using Figure 5. The MAPE of the training data set is 11.43%. According to econometrics, percentage errors less than 15% are optimum (Wilhelm, Jochen ,2015). Hence, it can be concluded that there is a fine and rich prediction power. On that account the model is better for forecasting.

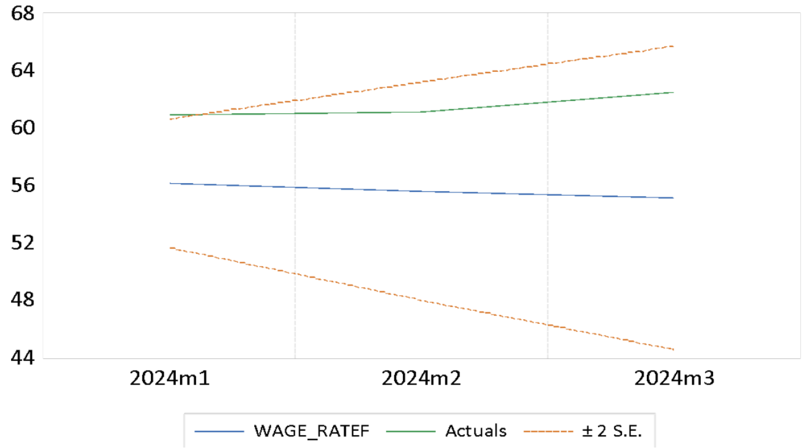
Validation of the Model for the Independent Data Set

Utilizing the forecasted values from the best fitted model for the first quarter of 2024 was compared with the actual values for the quarter.

Table 2. Forecasts of the Independent Data Set.

Period	Forecast	Lower limit (95%)	Upper limit (95%)	Actual	Percent age Error
1/1/2024	56.0727	51.7629	60.3824	60.9	7.92%
2/1/2024	55.5330	48.3256	62.7404	61.1	9.11%
3/1/2024	55.0670	45.1614	64.9726	62.4	11.75%

The percentage error values vary from 7.92% to 11.75%, and MAPE is 9.59%. These results indicate that the model can be validated for the independent data set. Furthermore, the Theil Inequality Coefficient being closer to 0 (0.051) exhibits the model's sound predictive performance.



Forecast: WAGE_RATEF	
Actual: WAGE_RATE	
Forecast sample: 2024M01 2024M03	
Included observations: 3	
Root Mean Squared Error	5.984985
Mean Absolute Error	5.892972
Mean Abs. Percent Error	9.570351
Theil Inequality Coef.	0.051134
Bias Proportion	0.969488
Variance Proportion	0.001887
Covariance Proportion	0.028624
Theil U2 Coefficient	6.985967
Symmetric MAPE	10.06602

Figure 6. Plot of Actual and Forecasted Wage Rates for Independent Data (January 2024 to March 2024)

As demonstrated in Figure 6, the forecasted value for the 3 months has been underestimated. Although the forecasts denote a decline, the actual values have been inclined slightly. The main cause for this slight raise in the actual real wage rate of March 2024 in the public sector is that the Cabinet of ministers of the Sri Lankan parliament had approved a proposal to increase the national minimum wage of the public sector employees by Rs. 5000 from March 2024 as per the recommendation of trade unions (Ranasinghe, n.d.).

Short Term Prediction

Table 3. Predicted Values of the Subsequent Months

Month	4/1/2024	5/1/2024	6/1/2024	7/1/2024	8/1/2024	9/1/2024
Predicted values	54.5617	54.0961	53.6306	53.1650	52.6995	52.2340

Using the best fit model, wage rate values were forecasted for the upcoming 6 months. Appropriate decisions can be made accordingly using the above results.

Conclusion

The study intends to provide a precise model and predict the real wage rate of the public sector of Sri Lanka. Depending on monthly data from January 2018 to March 2024, the best fitted model has been developed as ARIMA (0,1,2) based on its statistically significant parameters with the aid of Box Jenkins ARIMA approach. The residual series of the best fitted model is white noise. The model was tested for the independent data set, and it unveils that the percentage errors are significantly low, and forecasts are within 95% confident interval. The best fitted model is ; $(1- B)Y_t = (1+ 0.34B+ 0.24 B^2) \varepsilon_t$. The future monthly public sector real wage rates in Sri Lanka are contributed by the model. The forecasts have a great impact for the econometricians to devise vital decisions and notions which would eventually lead to the favorable economic growth in Sri Lanka. Despite this, it is salient to consider the forecasted values may not always be able to provide accurate figures due to sudden external variations in the economy. Advanced study on multivariate time series could be explicated using suitable independent variables.

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