Research on the Effect of Policy on Real Daily Wages in the UK from 1260 to 1994 Based on Multiple Models

Xingmu Chen[1, *]

[1]School of Social Sciences, The University of Manchester, Manchester, M13 9PL, England

*Corresponding author: Xingmu.chen@student.manchester.ac.uk

Abstract. Between 1900 and 1994, daily wages in the UK changed dramatically, therefore, in order to explore how the UK policies had significant impacts on daily wages, the main objective of this research is to identify the changes in UK daily wages before and after the implementation of the policies, and to forecast the future, compare simulative models and select the most appropriate forecasting model. The methodology of this study was to collect data on daily wages in the UK from 1900 to 1994, then forecasting the data through simple exponential smoothing, ARIMA model, ETS function. After predicting the daily wages in the given time period, make comparisons between the real-time statistics and the results produced by the simulative methods. The outcome of this research is the daily wages in the UK has been affected certainly by the policies, through comparing the values conducted by each model. All three models predicted the daily wages should be decreasing slightly in 1994, only fewer than 40 GBP, however, the real statistics has shown the significant increase in 1994. Therefore, the effects brought by the policies are detrimental and significant.

Keywords: wage policy; time series; ARIMA; ETS.

1. Introduction

The impacts brought by the wage-setting system has become the most concerning problem, as many countries have experienced the wars, e.g., UK, US, France and so on. During the wars, the profits of all businesses have dropped dramatically. By assessing whether the impacts of previous wage policies on wages can be applied to the current wage setting system to ensure more equitable income redistribution and reduce inequality. Also, by comparing the results of predicted outputs to determine whether the future wage settings are consistent with markets and companies' expectations and whether they are reasonable. Lockwood and Manning (1993) concluded that an increase in income taxes and payroll taxes will reduce pre-tax wages before taxes are paid [1].

Therefore, the tax system can affect the firms' cooperation tax; as a result, the profits will decrease. When a firm's profit decreases, the daily wage will drop simultaneously. This shows that the government policies have profound effects on daily wages in the UK. Through processing the forecasting models based on data from 1900 to 1994, combined with all the policies implemented by the UK government during this period, to examine whether the introduction of any policy has caused fluctuations in daily wages. However, in terms of policy implementation, government intervention may distort the market price mechanism and government failure is likely to occur due to the existence of information gap. These issues will be useful to explore and study the UK daily wages and the effectiveness of policies. This research places the issue of policy implementation and the prediction of possible future impacts under objective data analysis, based on the data given from 1900 to 1994. Firstly, the simple exponential smoothing will be used to make forecasts for this period and comparisons are made to determine whether the outcomes are valid and reliable. When all three simulative models have conducted the results, they will be compared in terms of the fitness and the real situation.

2. Data Selection and Analysis

2.1 Select Data

By comparing different time series, the real daily wage in the UK better reflects the changes in real-time policies. Therefore, this data set was selected as the basis of the study. This gives the statistics of "Real daily wages in the UK, 1260-1994".

2.2 Visualise Data

Firstly, plot the graph through R Studio. Then observe the plot of the daily wage drawn by "R Studio" and analyse the characteristics of the plot. It takes time and effort to look at the numbers to find out the characterises of the data, by visualising the data, the analysis becomes more efficient.

2.3 Collecting data

Collecting all the daily wages in the UK found that the data starting from 1260 was relatively flat and did not worth to investigate, since the time gap was large. From 1900 forwards, the data started to fluctuate significantly, therefore, this research selected all the data of daily wages in the UK from 1900 to 1994.

2.4 Analyse Data

As can be derived from the graph, the statistics fluctuate dramatically from about 1900 onwards, rising rapidly. There was an obvious drop around 1950. After this, the data has climbed to the highest rate £50. These two important points will be used as the focus of comparison to judge the accuracy of the predictions. And the statistics will be correlated with the policies adopted by the government. After World War II, the British economy began to recover gradually, albeit slowly, but it was a long period of growth, and in 1954, in order to eliminate the effects of inflation, the British government raised the personal income tax deduction limit, which in effect raised people's real wages, so this led to increase in daily wages. Flexner (1947) stated wages and prices in the UK were relatively stable during the World War II and post war periods, compared to the fluctuated wages and prices in France and other countries of Europe [2]. Since the data were relatively flat during this period, it was not the focus of this study.

3. Models

3.1 Choosing models

Determine the specificity of the data and whether the selected data can be used by different models. For example, seasonality, regularity, flatness, etc. According to various characteristics of each model to decide whether it can conduct the expected results potentially.

3.1.1 Simple exponential smoothing

Exponential smoothing is a practical and convenient forecasting method where the forecast is composed of exponentially weighted average values of past observations [3]. This method is applicable to forecast data with no clear trend or seasonal pattern. Thus, it can be used to predict the data for daily wages in the UK. Input the collated data to R Studio, and then run the code of SES model to produce the forecasting plot and the value.

3.1.2 ETS model

Unlike the simple exponential smoothing model, ETS model can be used to forecast data with trends or seasonality. As a method, the exponential smoothing method has the disadvantage of lacking an objective model identification procedure. There is also no procedure for judgmental checking of the selected models [4].

3.1.3 ARIMA model

Autoregressive integrated moving average (ARIMA) is one of the widely used linear models in forecasting time series over the past three decades [5]. This model might be appropriate for predicting future daily wages, which are apt to be influenced by socioeconomic event.

3.2 Evaluate models

3.2.1 Simple exponential smoothing model

Simple exponential smoothing model specialises in simple data forecasting, such as predicting data without clear trends and seasonal patterns. For the daily wages, it tends to be a figure without a clear trend because the real wage is vulnerable to inflation. However, in this study, the effects of inflation will be adjusted, as the data is about the real daily wages. The simple exponential smoothing model is relatively simple but powerful approaches to forecasting. It is often used in business to forecast the need for inventory. It can even predict accurately in some more complex situations [6].

3.2.2 ETS model

Based on simplicity and affordability, exponential smoothing provides accurate short-term forecasts. This model is cost-effective relative to other more complicated and expensive models. [7]. Therefore, for the ETS model, it is considered efficient and convenient and can be used in a wide range of scenarios.

3.2.3 ARIMA model

Ahmed and Cook (1979) have used the ARIMA model to forecast the freeway traffic, the ARIMA model is more advantageous in predicting similar highway time series data. It is more precise than other models [8]. For these statistics, ARIMA model can conduct perfectly well. But for data with variable time and location, ARIMA model does not always perform well.

4. Expected results

4.1 SES model

Since the real daily wages with no clear trend or seasonality, it can forecast future data quickly, based on its previous performance in other studies. However, for the data 1920 to 1970, it is gradually increasing and therefore regular. This could potentially lead to undesirable results.

4.2 ETS model

ETS is capable to work with complex data, for example, it can process data with a combination of various trends. Therefore, it is estimated to produce suitable and accurate results. A major advantage of ETS model is that it can conduct prediction intervals, which cannot be done by methods.

4.3 ARIMA model

The high productivity of ARIMA model in forecasting short-term data proves that although it is less complex than other models, it can still generate excellent outcomes [9]. Therefore, for short-term daily wage forecasting, the ARIMA model can predict daily wage changes precisely and simply. Although the ARIMA model is accurate in predicting daily wages in the short run, it is important to consider whether ARIMA is still as valid in the long run as it is in the short run. This is worth to be considered in the study. Once the simulations are completed, the obtained results need to be compared with the real-time statistics. The selection of results conducted by ARIMA needs to be based on the performance of the ARIMA model for various time durations.

4.4 Error analysis

After using SES model, the accuracy of outcomes should be tested. By using R Studio to test the precision of the model y overlaying two graphs and observing the differences between these graphs.

And calculate the error of both SES model and ARIMA model, such as MASE (mean absolute scaled error), ME (mean error), RMSE (root mean square error), etc.

4.5 Plot data

The figure 1 is drawn from 1900 to 1994 by R Studio. After visualising the data, the analysis of data and graph can be more intuitive and clearer. After drawing the image, there is a significant drop between 1910 and 1920, which is an abrupt change, and therefore, can be a point of comparison when comparing the accuracy of the forecast data subsequently. Moreover, there is a gradual upward trend from 1920 until 1939, which is smooth compared to the other trends in this graph relatively. Dynamics are found to be crucial in the UK, which means that regional labour market situations affect wages over a long period of time [10]. In other words, mobility plays a vital role in the UK real daily wages. When Second World `War ended, jobs became more available, and the population grew simultaneously. More highly skilled workers were flowing into the market, which brought a continuous rise in wages and had a positive impact on the UK economy.

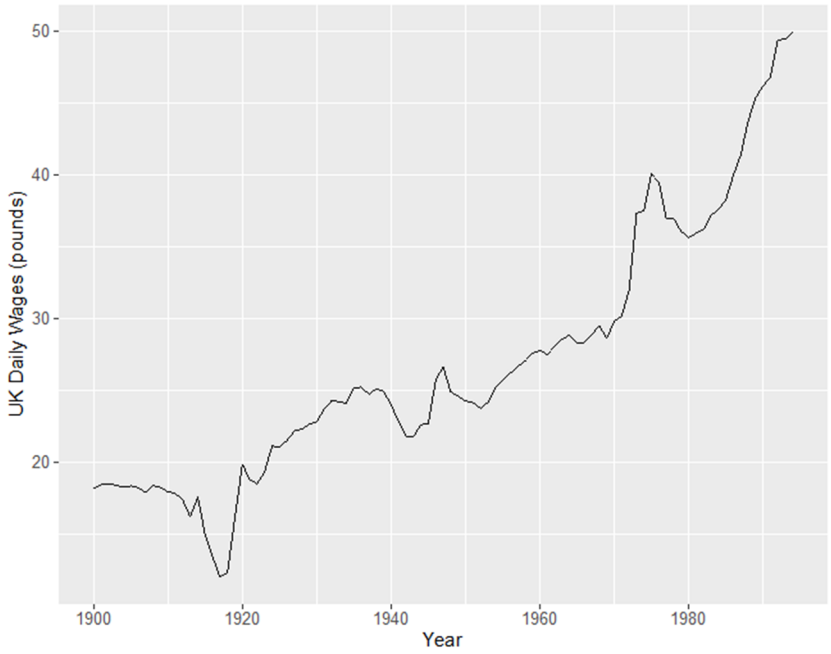

Fig. 1 Graph of UK real daily wages in pounds

Furthermore, the rapid increase in real daily wages has led to inequality in daily earnings in the UK, a phenomenon that has been evident since the late 1970s[11].

4.6 SES model

Through simple exponential smoothing forecast method, the data has shown a similar trend compared to the real-time data. In order to determine whether the predictions are accurate, the study will use the errors generated by the SES model as the evidence.(Figure 2)

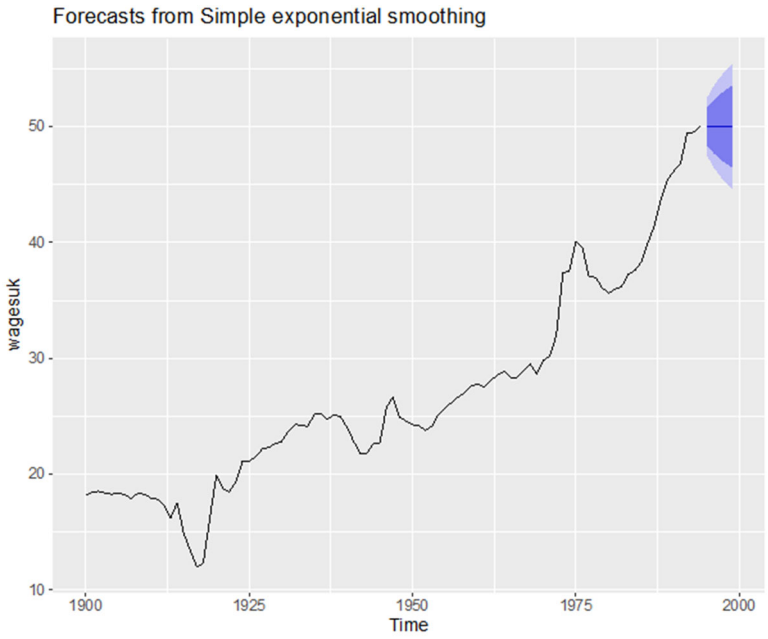

Fig. 2 SES forecast graph

By looking at ME (mean error), the value is 0.33, which is close to zero. This indicates the forecast conducted by SES model may be accurate and valid. (Table 1)

Table 1 Error analysis of SES model

	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
Training set	0.33	1.24	0.83	0.92	3.28	0.99	0.28

4.7 ETS model

The daily wages predicted by the ETS model contain slight differences compared to the original data. It is not enough to judge the accuracy of the model by the graph only, but an error analysis is also required before the conclusion can be derived. (Figure 3)

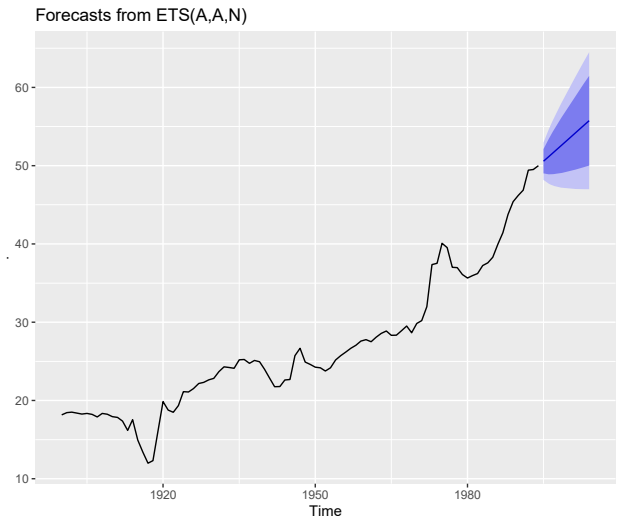

Fig. 3 ETS forecast graph

Compared the ME value conducted by ETS model with that of SES model, it can be concluded the ETS model has a lower error value, which demonstrates a better prediction than simple exponential smoothing method. (Table 2)

Table 2 Error analysis of ETS model

	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
Training set	0.1296	1.1940	0.7819	0.2261	3.2324	0.9474	0.2479

4.8 ARIMA model

After plotting the time plot, ACF and PACF plot, then the check for white noise must be done, which is crucial for the results. (Figure 4)

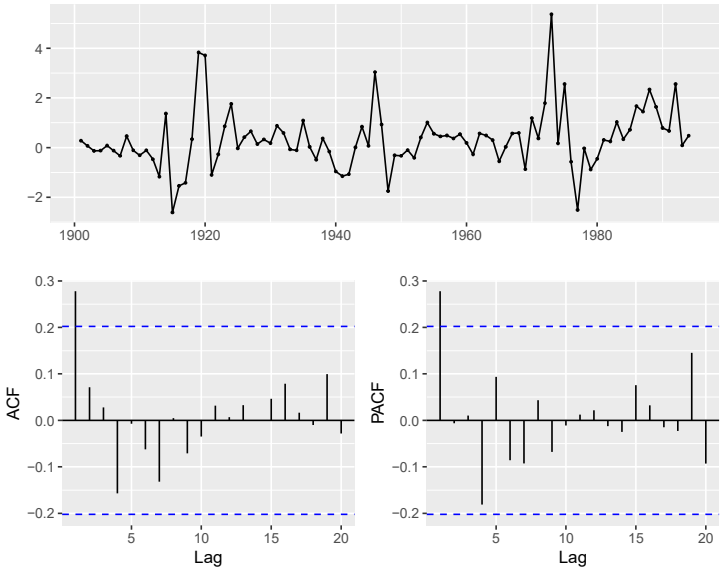

Fig. 4 Time plot and ACF and PACF plot

Table 3 Ljung-Box test

P-value	0.6162

As the p-value is large, this suggests the residuals are white noise. After checking the white noise, the later prediction steps can be started. (Table 3 & Figure 5)

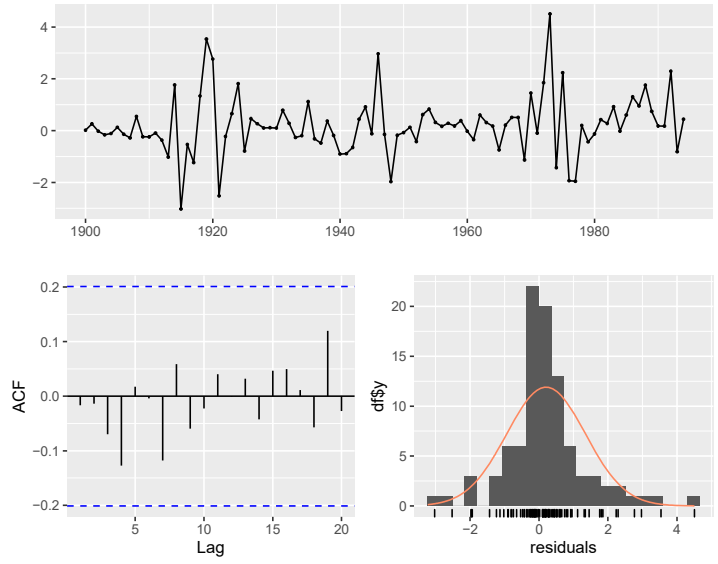

Fig. 5 Residual plots

After concluding the previous model selection, ARIMA model generates the following prediction results in Figure 6. The general trend shown in the figure is consistent with the focus of previous observations.

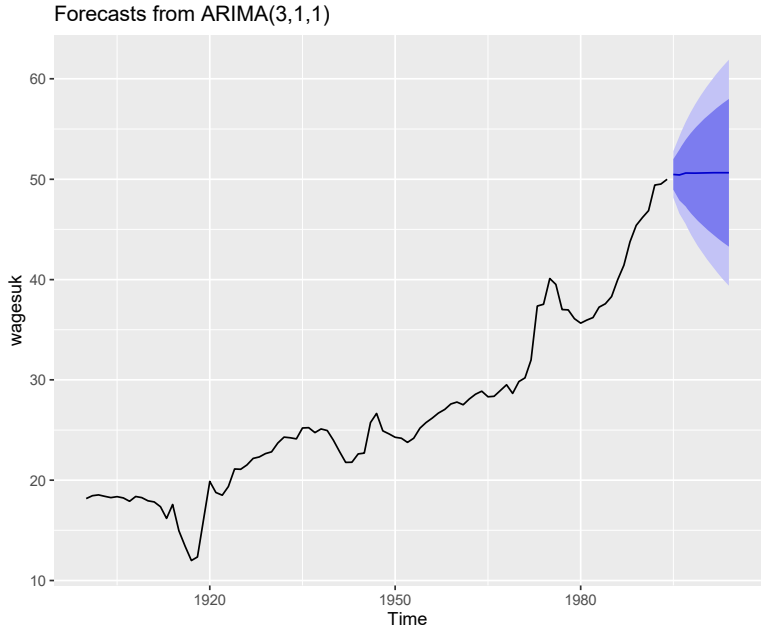

Fig. 6 Forecasts from ARIMA

5. Comparison Analysis

After comparing three models, the errors generated by models should be considered, ETS model has smaller value of error, which indicates that ETS is more adept at predicting daily wages. It is one-sided just to compare the errors generated previously, and the calculation of the overall model errors is also needed.

Table 4 CV Error

Model	SES	ETS	ARIMA
CV Error	1.584629	1.553024	1.706475

Cross-validation is a data resampling method used in many experiments to estimate the true prediction error of the model and to adjust the model parameters [12]. As shown in the Table 4, ETS has the lowest CV error. Therefore, the forecast generated by ETS model is the most accurate model among the three models. From comparison of three models, all models predict the results well. Although they have different details in the data, the trends are all close to the real-time data, which indicates that all three models are in the correct forecasting direction. All models predict nearly the same trend as the original data, but when comparing the size of errors, ETS model exhibits more accurate predictions and the smallest error value. The ARIMA model, which is predicted to be better at forecasting the real daily wages, has the largest error value, probably because from 1900 to 1994, the time length is too long for it to predict accurately. (Table 4)

6. Conclusion

By using three forecasting models to forecast the real daily wages in the UK during 1900-1994, the most accurate and appropriate forecasting model is identified. It facilitates the government's implementation of future wage policies, so that they can predict in advance whether the level of wage changes after the policy implementation is within expectation and thus adjusts the policy. The most appropriate and reliable forecasting model was derived by comparing the accuracy of the three forecasting models and the error analysis. This study found that the ETS model was the most accurate and reliable forecasting model, not only because it predicted trends that matched closely, but also because it generated the smallest error values. However, there are limitations to this study. Because only three models were applied in this study, but in fact there exist many forecasting models that can

be used to predict time series like real daily wages. For some government managers, they need to concentrate on the changes in wages instantly, in order to modify their policies. With the results of this study, the ETS model can be considered to predict the real daily wage changes when predicting daily wages. In future research, more time series prediction models can be used to find the one with the smallest error and thus achieve the ideal wage distribution.

References

[1] Lockwood B, Manning A. Wage-setting and the tax system: theory and evidence for the UK. Journal of Public Economics, 1993, 52(1):1-29.

[2] Flexner, Jean A. "Great Britain: Wage Trends and Policies, 1938-47." Monthly Labor Review,1947, 65(3): 285–92.

[3] Ostertagová E, Ostertag O. The simple exponential smoothing model.The 4th International Conference on modelling of mechanical and mechatronic systems, Technical University of Košice, Slovak Republic, Proceedings of Conference. 2011: 380-384.

[4] Gardner Jr E S. Exponential smoothing: The state of the art. Journal of forecasting, 1985, 4(1): 1-28.

[5] Peter G, Zhang. Time series forecasting using a hybrid ARIMA and neural network model. Neurocomputing, 2003.

[6] Billah B, King M L, Snyder R D, et al. Exponential smoothing model selection for forecasting. International journal of forecasting, 2006, 22(2): 239-247.

[7] Gardner Jr E S, Dannenbring D G. Forecasting with exponential smoothing: Some guidelines for model selection. Decision sciences, 1980, 11(2): 370-383.

[8] Ahmed M S, Cook A R. Analysis of freeway traffic time-series data by using Box-Jenkines. 1979.

[9] Ariyo A A, Adewumi A O, Ayo C K. Stock price prediction using the ARIMA model//2014 UKSim-AMSS 16th international conference on computer modelling and simulation. IEEE, 2014: 106-112.

[10] Brian, Bell, et al. Wage equations, wage curves and all that. Labour Economics, 2002.

[11] Machin S. Changes in UK wage inequality over the last forty years. The Labour Market in Winter-The State of Working Britain, 2011.

[12] Browne M W. Cross-validation methods. Journal of mathematical psychology, 2000, 44(1): 108-132.