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TRAJECTORY GENDER PARITY IN UK HIGHER EDUCATION BY USING ARIMA

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Abstract. *Based on the data set in UNESCO (United Nations Educational, Scientific and Cultural Organization), this study selected United Kingdom's GER (gross entrance ratio) as an example to tackle her higher education expanding with gender parity patterns. Since the United Kingdom's GER development provides a unique experience in global higher education settings, both her expanding and gender parity patterns may offer good examples for developing countries to realize their higher education systems what should be and what will be. The target series data covered 46 periods (from 1971 to 2016). In this study, we conducted trend analysis, D (Becker's discriminant coefficient) transformation and ARIMA (autoregressive integrated moving average) model to deal with the future trends. The proposed ARIMA model has been verified by ACF (autocorrelation function), PACF (partial autocorrelation function) and Ljung-Box test. The finding reveals the enrollment of female has over that of the male in the system in 1993. This trend displays that the D coefficient will steadily decline in future in terms that the higher education will become a female dominated system. While the system may turn over after 2025, the female dominated phenomenon will diminish the discrepancy as our predicted model. The finding may provide useful information for the related higher education systems.*
Keywords: ARIMA model, Gender parity, Gross entrance ratio, Higher education, Ljung-Box test

1. **Introduction.** Higher education has been evolving rapidly to respond to fast changing demands. In the 2015 Implementation Report, it identified 60% of European Higher Education Area (EHEA) countries that take account of demographic projections in their steering documents for higher education. Currently, most of the tertiary education students (58.8%) are enrolled in first-cycle programs (Bachelor's or equivalent level); 21.7% are enrolled in second-cycle programs (Master's or equivalent level); and 16.8% are enrolled in short cycle tertiary education. Only 3% of students are enrolled in third-cycle programs (doctoral or equivalent level) [1]. Students in the five countries with the highest number of tertiary education students (Russia, Turkey, Germany, France and the United Kingdom) amount to 56.3% of the total. Spain, Italy, Ukraine and Poland have more than 1,500,000 tertiary students each, while there are fewer than 1,000,000 students per country in 38 EHEA countries analyzed [1]. Among these countries, United Kingdom (UK) is a unique country for her traditional higher education development style. The UK has initiated the White Paper – The Future of High Education in 2003. The enrollment in higher education for 18-30 has shown increase from 30% to 50% [2]. Even though the UK still dedicated to raising youth's aspiration, prompting equality and implementing substantive development in education [3,4], she might shift from an increase to a decrease in tertiary enrolment [1]. Moreover, the work of the Department is shaped by the draft

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Program for Government (2016-2021), which sets the strategic direction of travel for the work of the Executive, expressed in terms of wellbeing-focused outcomes. The document identifies innovation, research and development, and skills and employability as the key drivers of achieving a strong, competitive, regionally balanced economy [5]. While there are some issues in the expanding system, for example, Blanden and Machin indicated despite the fact that many more children from higher income backgrounds participated in higher education before the recent expansion of the system, the expansion acted to widen participation gaps between rich and poor children during 1970s and 1990s [6]. In recent years, the UK-based Athena Swan and Gender Equality Charter Mark agendas have prompted universities to address gendered disparities. Findings show that although the gender gap is closing within higher education geography in the UK there are significant ongoing gender disparities [7]. What happens in the system? Compared to other high participation higher education systems, UK's higher education did not expand so rapidly. However, facing the unstable future in terms of Brexit (British exits EU), what might happen in the system? At this movement, this study tries to tackle the gross entrance ratio (GER) and gender parity of higher education in UK.

UNESCO's (United Nations Educational, Scientific and Cultural Organization) World Atlas of Gender Equality in Education, published in 2012 [8], is the clearest example of this international commitment to global gender equality across and including all levels of education. This atlas provides a vast amount of statistical information about where women and men are as students across the globe, relating the information to international criteria. Even the UNESCO Atlas argues that whilst there has been enormous growth in student numbers, including a 500 percent increase across the globe, over the last 40 years, women do not benefit as well as men from their involvement in higher education [9]. Over the last decades, enrollment in higher education has experienced explosive growth across Asia and other countries. This change offers a very good opportunity to examine patterns of gender parity in different systems. As previous studies, higher education expansion has been presented in two different forms: 'expand out', and 'expand up' [10]. Considering the data constrained, this study only focuses on the effect of 'expand out' in the higher education system. Previous studies have also demonstrated the gender parity issue in the high participation higher education system, and it seems that the expansion of higher education has had a significant impact on the long-term patterns of gender parity [11-13]. While most of countries did not fit the high participation patterns, this is why we engaged in this study. UK's higher education expansion belongs to smooth one. Since the United Kingdom's GER development provides a unique experience in global higher education settings, both her expanding and gender parity patterns may offer good examples for developing countries to realize their higher education systems what should be and what will be. Taking UK as an example, we applied more complicated statistical techniques for deepening inquiry in this issue. The result may reflect different meanings for other developing countries. Based on the GER data from 1971 to 2016 in UK, we estimate the gender parity index and build a fitted predicated model to project its future trend. The related research questions are listed as follows.

a). Did the higher education expansion impact gender parity in the system?

b). Which model can be used to predict the trend of gender parity in future?

c). What is the meaning of gender parity pattern in UK?

To answer the questions, this study begins with method section which includes data transformation, trend analysis, and ARIMA (autoregressive integrated moving average) model building process. Then, the result will display with the GER patterns, trend analysis, D trends, logics of ARIMA model selection, and the predict Becker's discriminant coefficient (D) for next decade. Finally, the conclusion and suggestion will be addressed.

2. **Method.** In this section, we will present the target data set and how the data have been transformed to fit ARIMA model, and then address how the trend analysis was conducted to review the data set. Finally, demonstrate the ARIMA model was processed and predict the future trend.

2.1. **Data transformation.** The GER data were collected from the World Bank coving 46 periods from 1971 to 2016 [14]. The series data have two-year publication lag. This study evaluated 46 years of GER data in UK higher education system. In order to interpret the gender parity properly, we applied Becker's D as the index of gender parity. The D is defined as follows [15]:

$$\mathrm{D} = (\mathrm{EM}/\mathrm{EF}) - 1$$

EM: The enrollment of males in higher education; EF: The enrollment of females in higher education.

According to the transformation, the positive calculated D implies the female's education opportunities less than male's. Whereas, the negative D means that the education opportunities are more favored for female [12,13].

2.2. **Trend analysis.** This study conducted trend analysis to view the development of series data. Using trend analysis, we can fit a general trend model to time series data and to provide forecasts roughly. We can choose between the linear and quadratic trend models in this case study. Basically, the trend analysis works as the following process, see Figure 1. This function in ARIMA model was used to analyze the tendency with GER and D. GER and D will be assigned as the dependent variables specifically to plot time line.

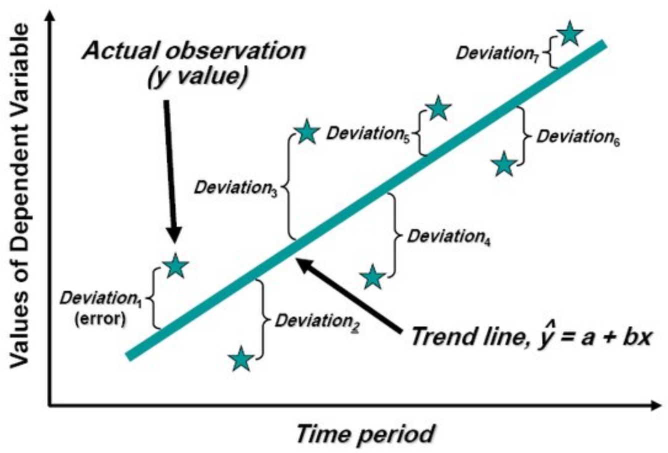


Figure 1. The concept of trend analysis

2.3. **ARIMA model building.** In this study, ARIMA models were used to build fittest model predicting the future trend of D. We follow the series data checking process to select differencing and test white noise to build fittest parameters for the proposed ARIMA model. In the beginning, this study checked the series data whether it is stationary or non-stationary series [16-18]. Typically, a non-seasonal ARIMA model is classified as an "ARIMA(p, d, q)" model, where p is the number of autoregressive terms, d is the number of non-seasonal differences needs for stationarity, and q is the number of lagged forecast error in the prediction equation.

When the difference fits the model building. The fittest model selection will depend on its parameters, BIC (Bayesian information criterion) and Q test. In this study, Box-Pierce Chi-square statistics (Ljung-Box test) were used to determine whether the model met the assumptions that the residuals were independent [16,17]. For Q test, the calculations were listed as follows [19,20]:

$$Q^*(K) = (n-d)\cdot(n-d+2)\cdot\sum_{l=1}^{K}(n-d-l)\cdot r_l^2(\hat{a})$$

where n is the sample size, d is the degree of non-seasonal differencing used to transform the original series to a stationary one, $r_l^2(\hat{a})$ is the sample autocorrelation at lag l for the residuals of the estimated model, and K is the number of lags covering multiples of seasonal cycles, e.g., 12, 24, 36, ... for yearly data.

The null hypothesis of the Ljung-Box test, H_0, is that our model does not show lack of fit (or in simple terms the model is just fine). The alternate hypothesis, H_a, is just that the model does show a lack of fit. It means that $Q > \chi^2_{1-\alpha,h}$.

A significant p-value in the test rejects the null hypothesis that the time series is not autocorrelated, see Figure 2.

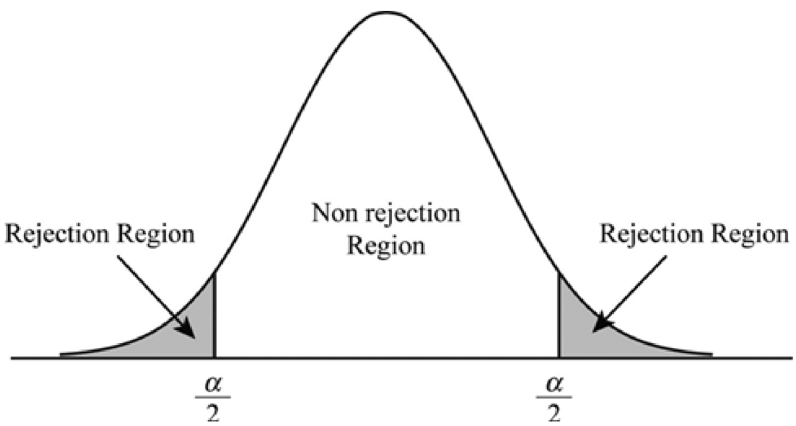


FIGURE 2. Q test for justifying H_0

Even though the method of this study is devoted to existing knowledge, the processes of integrating the series data, transforming the series data and testing predicted model will provide a quick and useful example for tackling similar issues.

3. Result.

3.1. The GER patterns of males and females. According to the GER data in UK, we found the higher education system has moved to mass stage in 1972 and universal stage in 1996 as Trow's classification [21]. Typically, higher education with GER less 15% belongs to elite system; GER moving into 15%-50% belongs to mass stage; the GER is over 50%, and it belongs to universal stage. The UK's GER is 15.44% in 1972 and 50.5% in 1996. It took 24 years to across the mass stage to universal stage. According to the trend analysis, the GER in UK will increase steadily in future, see Figure 3. The fitted trend equation is $Y_t = 8.90 + 1.2954 \times t$.

We found when the system entering into post-mass and universal stage, the females have become the critical mass in the higher education. In 1993, the enrollment of female has found over that of the male in the higher education system, see Figure 4. The gender gap in universal stage has shown increasing with different meanings when compared with that of mass stage.

3.2. Trend analysis for D in UK. In this study, we conducted trend analysis to detect the trend of D indices. Both linear and quadratic trend models have been displayed in Figure 5. The trend analysis plot shows a downward trend in linear model, while the

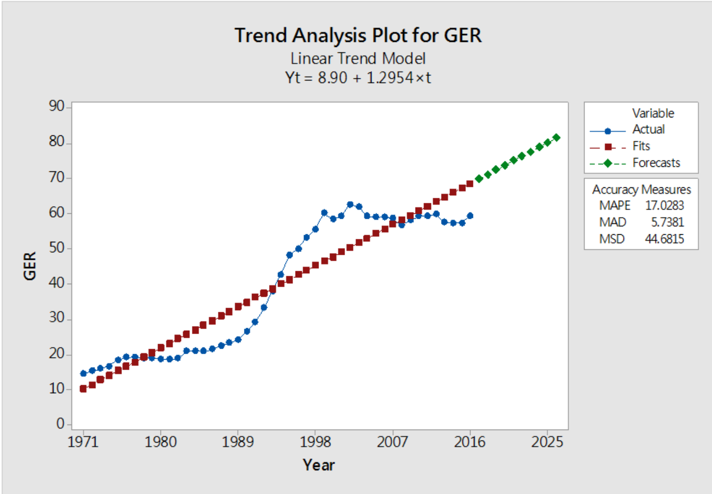


FIGURE 3. The trend analysis for UK's GER

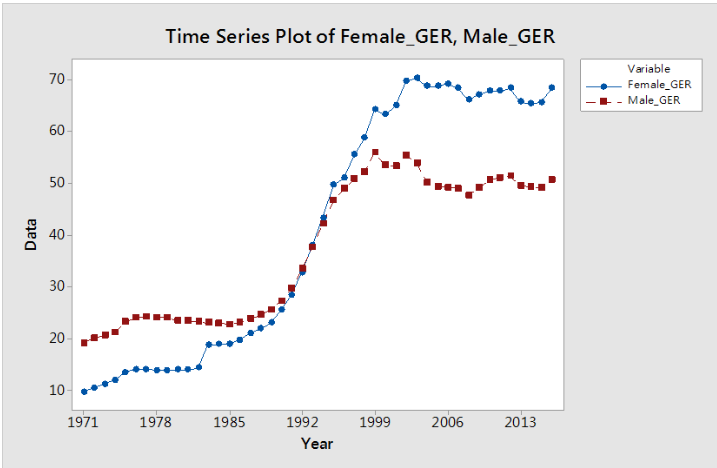


FIGURE 4. The GER of female and male in UK

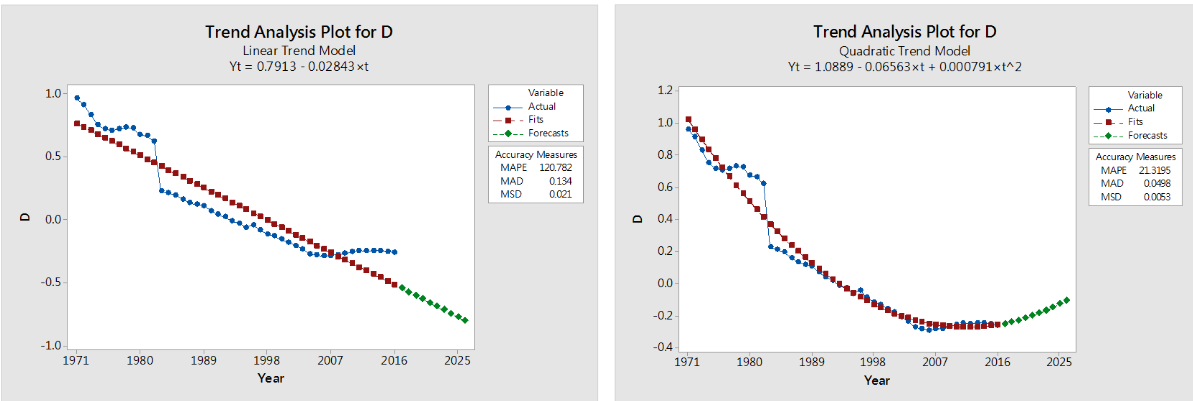


FIGURE 5. Trend analysis for D with linear and quadratic models

other one shows an upward trend in quadratic model. There is a curvature and the model appears to fit the data not so well with trend analysis.

3.3. **D transformation for building ARIMA model.** Based on the differences, we selected ARIMA$(1, 2, 2)$, ARIMA$(1, 2, 1)$, ARIMA$(1, 2, 0)$ and ARIMA$(0, 2, 1)$ to compare. Considering their AR, MA, white noise, AIC and BIC, we selected the ARIMA$(0, 2, 1)$

TABLE 1. ARIMA model selection for predicting D

D	AR(1)	MA(1)	MA(2)	White noise test	AIC	BIC	Selection
ARIMA(1, 2, 2)	×	×	×	✓	−114.70	−107.57	
ARIMA(1, 2, 1)	×	×	–	✓	−97.74	−90.61	
ARIMA(1, 2, 0)	✓	–	–	✓	−101.75	−98.18	
ARIMA(0, 2, 1)	–	✓	–	✓	−115.47	−111.90	⊚

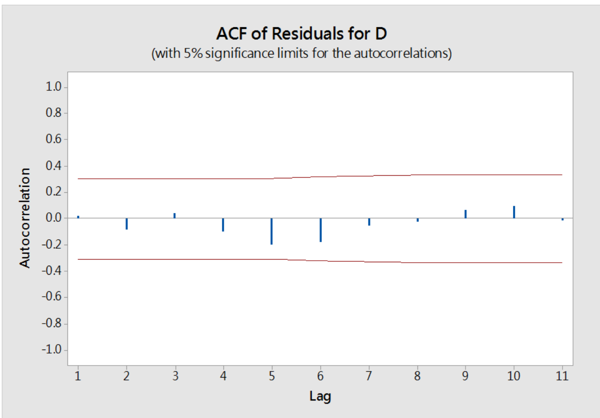
Note. ✓ represents accepted; × represents rejected; Based on AIC & BIC, ARIMA(0, 2, 1) model was selected.

TABLE 2. Final estimates of parameters and Ljung-Box Chi-square statistic

Type	Coef	SE Coef	t-value	p-value
MA(1)	1.025	0.112	9.19	0.000
Constant	0.000870	0.000848	1.03	0.311

Lag	12	24	36	48
Chi-square	5.54	7.19	8.67	*
DF	10	22	34	*
p-value	0.853	0.999	1.000	*

Note. Differencing: 2 regular differences; Number of observations: Original series 46, after differencing 44.



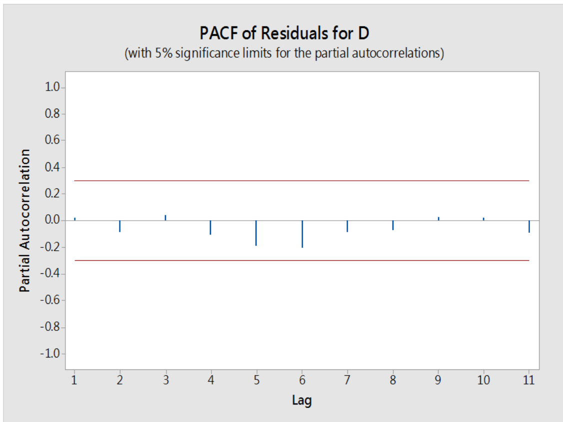


FIGURE 6. ACF and PACF for predicting D

as the fittest model used to predict the series, see Table 1. The related information of ARIMA(0, 2, 1) fittest model has displayed in Table 2. The coefficient of MA(1) is 1.025 ($p = .000$), while constant is not significant ($p = .311$). Ljung-Box Chi-square statistic test shows there is no white noise when we check 12, 24, and 36 lag respectively. Figure 6 demonstrates both ACF and PACF fit the model building criteria.

3.4. **Comparing the D and predicted D.** In the model building process, we considered the model fit issues with other information. Table 3 demonstrates the D (actual one) and D_predicted (forecasting D). Based on ARIMA(0, 2, 1), the sum and sum of square between D and D_predicted are −0.0143 and 0.160989 respectively. The result reveals both are slim as we expected, see Table 3.

3.5. **Forecasting D in next ten years.** Based on the fittest model ARIMA(0, 2, 1), we predicted D in the next ten years for UK higher education system. Table 4 reveals the D is −0.267052 in 2017 and will little decrease to −0.286646 in 2026. The predict gender parity values reveal the system will favor females in next decade. The D series plot displays in Figure 7. The result indicates that the trend will increase and then decrease steadily in future. Even though the system still favored females, according to that the D will turn over in 2025, the gender parity in this system might diminish in future.

Table 3. Comparing D and predicted D (D_predicted) in the ARIMA$(0, 2, 1)$

Year	D	D_predicted	D-D_predicted	Year	D	D_predicted	D-D_predicted
1971	0.963	ARIMA$(0, 2, 1)$	–	1994	−0.0283	−0.0411	0.0128
1972	0.9132	(Difference = 2)	–	1995	−0.0603	−0.0557	−0.0046
1973	0.8335	0.8647	−0.0312	1996	−0.0397	−0.0866	0.0469
1974	0.7526	0.7707	−0.0181	1997	−0.0846	−0.0628	−0.0218
1975	0.7173	0.6851	0.0322	1998	−0.1125	−0.1073	−0.0052
1976	0.7077	0.6592	0.0485	1999	−0.1294	−0.1341	0.0047
1977	0.7176	0.6605	0.0571	2000	−0.1554	−0.1495	−0.0059
1978	0.7326	0.6812	0.0514	2001	−0.1783	−0.1744	−0.0039
1979	0.7257	0.7049	0.0208	2002	−0.2066	−0.1961	−0.0105
1980	0.6734	0.7019	−0.0285	2003	−0.2327	−0.2234	−0.0093
1981	0.6657	0.6477	0.018	2004	−0.2719	−0.2485	−0.0234
1982	0.621	0.6431	−0.0221	2005	−0.2806	−0.2872	0.0066
1983	0.226	0.5978	−0.3718	2006	−0.2886	−0.2944	0.0058
1984	0.2127	0.1731	0.0396	2007	−0.2825	−0.3009	0.0184
1985	0.1964	0.1642	0.0322	2008	−0.2784	−0.2929	0.0145
1986	0.1635	0.1514	0.0121	2009	−0.2676	−0.2871	0.0195
1987	0.1335	0.1206	0.0129	2010	−0.2529	−0.2745	0.0216
1988	0.1208	0.0927	0.0281	2011	−0.2458	−0.258	0.0122
1989	0.1097	0.083	0.0267	2012	−0.2474	−0.2493	0.0019
1990	0.0713	0.0747	−0.0034	2013	−0.2452	−0.2496	0.0044
1991	0.0431	0.0374	0.0057	2014	−0.2443	−0.2459	0.0016
1992	0.0212	0.0108	0.0104	2015	−0.2521	−0.2437	−0.0084
1993	−0.0118	−0.0092	−0.0026	2016	−0.2605	−0.2503	−0.0102

Table 4. Forecasts of D from period 47 to 56 (2017-2026)

Period	Year	Forecast	95% Limits	
			Lower	Upper
47	2017	−0.267052	−0.381969	−0.152136
48	2018	−0.272711	−0.433171	−0.112250
49	2019	−0.277499	−0.471516	−0.083481
50	2020	−0.281416	−0.502569	−0.060264
51	2021	−0.284464	−0.528516	−0.040412
52	2022	−0.286641	−0.550495	−0.022786
53	2023	−0.287948	−0.569192	−0.006703
54	2024	−0.288384	−0.585061	0.008293
55	2025	−0.287950	−0.598420	0.022520
56	2026	−0.286646	−0.609506	0.036215

4. **Conclusions.** The findings reveal when the higher education system is going to mass stage, the gender discrepancy is diminishing in UK. The higher education expanding has caused significant changes that female has become the critical mass in the system. The D transformation displays the phenomenon that the gender parity in the system is accompanying with her expansion. The result indicates that the female dominated phenomenon will not be changed fundamentally in future. This trend displays that the D coefficient will steadily decline in future in terms that the higher education will become a female dominated system. While the system may turn over after 2025, the female dominated phenomenon will diminish the discrepancy as our predicted model. The ARIMA$(0, 2, 1)$

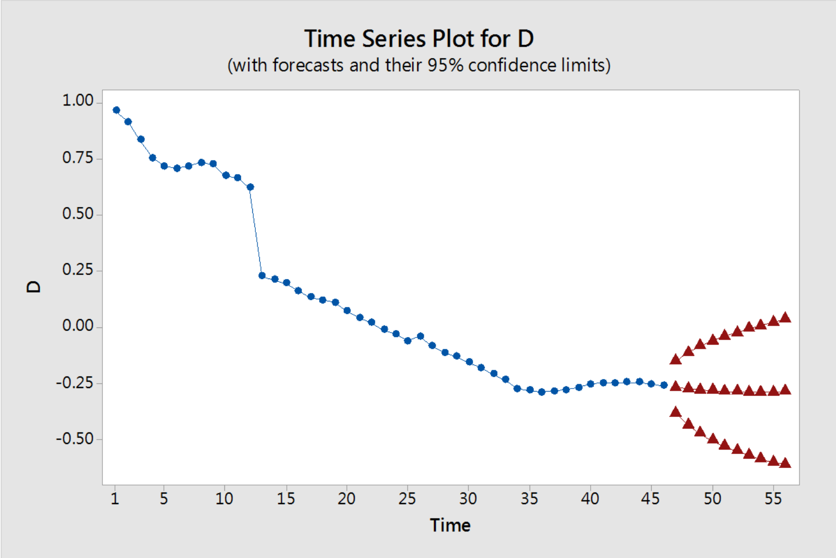


Figure 7. The D series plot from 1 (1971) to 56 (2026) periods

model has found with supportive evidences for this argument. Meanwhile, the ARIMA model is a useful predicted tool for similar series data transforming. Since the development of UK is a model in European area, this finding will provide useful message to other countries in this area or other areas. For future studies, we suggest including related factors, like gross domestic product (GDP) or GDP per capital which will enhance the robustness of argument.

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