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Modeling Covid-19 Cases and Deaths in Benelux Countries (Belgium, the Netherlands, and Luxembourg) With Different Regression Methods

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ABSTRACT: In this study, the number of Covid-19 cases and deaths in Benelux countries were examined with linear, quadratic, cubic, logarithmic, and exponential regression models. The number of Covid-19 cases and deaths, within a 50-day period between March 1, 2022, and April 19, 2022, in Belgium, the Netherlands, and Luxembourg were examined. Models with the highest coefficient of determination (R^2) and corrected coefficient of determination with significant parameter estimates were preferred in the selection of the most appropriate regression model. ($\bar{R}^2$) The cubic regression model for the number of cases and the quadratic, cubic, and linear regression models for the number of deaths were found to be appropriate respectively in Belgium, the Netherlands, and Luxembourg. The R^2 values of these models are 0.997, 0.9993 and 0.9982; $\bar{R}^2$ respectively and the values are 0.996, 0.9987 ve 0.9979 respectively. Regression models for the number of deaths were obtained as quadratic, cubic, and linear regression models in these countries, respectively. The R^2 values of these models were 0.996, 0.9982 and 0.9848 respectively; $\bar{R}^2$ and the values were 0.995, 0.9977 and 0.9845 respectively. As a result, it was observed that regression models were an appropriate method to reveal the number of cases and deaths.

KEYWORDS: Regression, covid, case, death.

INTRODUCTION

Belgium, the Netherlands and Luxembourg, which are called the Benelux countries, created a common customs area in 1943. The Second World War and the following years accelerated the efforts for unification, economic integration, preventing and stopping wars. Thus, the first step towards the European Union was taken (Rodoplu, 1996).

As in every country in the world, the covid-19 epidemic has created serious dangers in the Benelux countries and many cases and deaths have been recorded.

COVID-19 has disrupted many countries world, crushing their healthcare systems. Hence, it has turn into important to identify reliable predictors of disease severity and morbidity which would streamline healthcare resources into improving efficiency of management and thus improving the clinical liability and whole outcome (Sheshan et al., 2021).

COVID-19 is a newfangled coronavirus that has resulted in an outbreak of viral pneumonia around the world. Though the virus was first seen in Wuhan (China), it spread to the entire world in a short time due to being contagious. The virus can cause the death of people of all ages, especially those with chronic illnesses or older people (WHO, 2020).

In this study, it is aimed to analyze the number of covid-19 cases and deaths in Benelux countries (Belgium, Netherlands and Luxembourg) with different regression models.

MATERIAL AND METHOD

It was obtained daily updates of the cumulative number of reported confirmed cases and deaths for the 2019- nCoV pandemic of Belgium, the Netherlands and Luxembourg between March 1, 2020 and April 19, 2022, from Worldometer and WHO websites.

In this study, the data is modeled via some regression curve estimation models to estimate the number of COVID-19 cases and death. The analyses are conducted by IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp and R Studio Team (2015).

Some curve estimation models (Orhunbilge, 1996; Akdi, 2010, Cue, 2003; Kadılar, 2009, Rao and Toutenburg, 1995).

Linear regression model: $y = a + bx + \varepsilon$
Quadratic: $y = a + b_1 x + b_2 x^2 + \varepsilon$
Cubic regression model: $y = a + b_1 x + b_2 x^2 + b_3 x^3 + \varepsilon$
Exponential regression model: $y = a\, exp(bx)$
Logarithmic: $y = \mathrm{a} + bln(x) + \varepsilon$

RESULTS

The results of the regression analysis modeling the number of covid-19 cases and deaths in Belgium, Netherlands and Luxembourg are presented in Table 1-6, respectively.

Table 1. Different regression models for estimating the number of covid-19 cases in Belgium

Regression models	Model summary				Parameter coefficients			
	R^2	$\bar{R}^2$	F	p	a	b_1	b_2	b_3
Linear	0.994	0.993	7768.98	0.001	3535928.32	9422.35***		
Quadratic	0.994	0.993	3805.34	0.001	3535381.59	9485.43***	-1.237	
Cubic	0.997	0.996	4574.96	0.001	3556902.51	4659.013***	233.026***	-3.062***
Logarithmic	0.804	0.800	17.185	0.001	3363551.87	138958.96***		
Exponential	0.994	0.993	7568.11	0.001	3540926.24	0.002***		

*** (p<0.001). a: The constant term in the regression equation. b1, b2 and b3: Parameter coefficients

As seen in Table 1, the cubic regression model with significant parameter estimates and the highest R^2 value is the most appropriate model.

Table 2. Different regression models for estimating the covid-19 death toll in Belgium

Regression models	Model summary				Parameter coefficients			
	R^2	$\bar{R}^2$	F	p	a	b_1	b_2	b_3
Linear	0.994	0.993	8390.38	0.001	30141.10	21.521***		
Quadratic	0.997	0.995	5258.499	0.001	30167.131	18.517***	0.059***	
Cubic	0.996	0.995	3450.555	0.001	30171.777	17.475***	0.109	-0.001
Logarithmic	0.797	0.793	188.699	0.001		315.926***		
Exponential	0.995	0.994	8915.482	0.001	30144.568	0.001***		

*** (p<0.001). a: The constant term in the regression equation. b1, b2 and b3: Parameter coefficients

According to the results in Table 2, the quadratic regression model with significant parameter estimates and the highest R^2 value is the most appropriate model.

Table 3. Different regression models for estimating the number of covid-19 cases in the Netherlands

Regression models	Model summary				Parameter coefficients			
	R^2	$\bar{R}^2$	F	p	a	b_1	b_2	b_3
Linear	0.893	0.891	401.338	0.001	6775974.73	32922.15***		
Quadratic	0.999	0.998	16584.96	0.001	6387715.181	77721.327***	-878.415	
Cubic	0.999	0.998	23629.334	0.001	6358926.131	84177.75***	1191.794***	4.096***
Logarithmic	0.947	0.946	858.629	0.001	5965052.54	555785.89***		
Exponential	0.878	0.876	346.757	0.001	6787958.16	0.004***		

*** (p<0.001). a: The constant term in the regression equation. b1, b2 and b3: Parameter coefficients

According to the results in Table 3, the cubic regression model with significant parameter estimates and the highest R^2 value is the most appropriate model.

Table 4. Different regression models for estimating the number of covid-19 death toll in the Netherlands

Regression models	Model summary				Parameter coefficients			
	R^2	$\bar{R}^2$	F	p	a	b_1	b_2	b_3
Linear	0.993	0.992	6538.82	0.001	21642.29	13.466***		
Quadratic	0.993	0.992	944301.74	0.001	21634.16	14.403***	-0.018	
Cubic	0.998	0.997	632583.94	0.001	21674.515	5.353***	0.421***	-0.006***
Logarithmic	0.810	0.806	204.36	0.001	21393.56	199.389***		
Exponential	0.993	0.992	6458.09	0.001	21644.05	0.001***		

*** (p<0.001). a: The constant term in the regression equation. b1, b2 and b3: Parameter coefficients

According to the results in Table 4, the cubic regression model with significant parameter estimates and the highest R^2 value is the most appropriate model.

Table 5. Different regression models for estimating the number of covid-19 cases in Luxembourg

Regression models	Model summary				Parameter coefficients			
	R^2	$\bar{R}^2$	F	p	a	b_1	b_2	b_3
Linear	0.992	0.991	5318.20	0.001	180760.93	1053.041***		
Quadratic	0.991	0.990	2616.09	0.001	180526.09	1080.14***	-0.531	
Cubic	0.998	0.997	7765.09	0.001	184317.742	229.796**	40.742***	-0.54***
Logarithmic	0.798	0.793	189.25	0.001	161619.39	15488.54***		
Exponential	0.990	0.989	4864.44	0.001	181852.07	0.005***		

** (p<0.01), *** (p<0.001). a: The constant term in the regression equation. b1, b2 and b3: Parameter coefficients

According to the results in Table 5, the cubic regression model with significant parameter estimates and the highest R^2 value is the most appropriate model.

Table 6. Different regression models for estimating the covid-19 death toll in Luxembourg

Regression models	Model summary				Parameter coefficients			
	R^2	$\bar{R}^2$	F	p	a	b_1	b_2	b_3
Linear	0.985	0.984	3108.804	0.001	908.065	1.426***		
Quadratic	0.985	0.984	1522.64	0.001	987.944	1.44***	0.001	
Cubic	0.993	0.992	2105.602	0.001	993.469	0.201	0.06***	-0.001***
Logarithmic	0.791	0.786	181.45	0.001	962.21	20.957***		
Exponential	0.985	0.984	3096.825	0.001	988.492	0.001***		

** (p<0.01), *** (p<0.001). a: The constant term in the regression equation. b1, b2 and b3: Parameter coefficients

According to the results in Table 6, the linear regression model with significant parameter estimates and the highest R^2 value is the most appropriate model.

The cubic regression model for the number of cases and the quadratic, cubic, and linear regression models for the number of deaths were found to be appropriate respectively in Belgium, the Netherlands, and Luxembourg. The cubic regression models representing the number of cases in Belgium, the Netherlands, and Luxembourg are

$$y = 3556902.506 + 4569.013\,x + 233.026\,x^2 - 3.062\,x^3$$

$$y = 6358926.513 + 84177.745\,x - 1191.794\,x^2 + 4.096\,x^3$$

and

$$y = 184317.742 + 229.796\,x + 40.742\,x^2 - 0.54\,x^3$$

Respectively.

Regression models for the number of deaths were obtained as quadratic, cubic, and linear regression models in these countries, respectively. These models are y=30167.131+18.517 x+0.059 x^2, y=21674.515+5.353 x+0.421 x^2-0.006 x^3 and y=988.065+1.426 x respectively. The R^2 values of these models were 0.996, 0.9982 and 0.9848 respectively; $\bar{R}^2$ and the values were 0.995, 0.9977 and 0.9845 respectively.

Japan (Holt Model), Germany (ARIMA (1,4.0)) and France (ARIMA(0,1,3)) provide statistically significant but not clinically qualified results in a study Yonar et al (2020). UK (Holt Model), Canada (Holt Model), Italy (Holt Model) and Turkey (ARIMA(1,4,0)) and in the results are more reliable. Specified for the particular model used in the case Turkey (Yonar et al, 2020).

CONCLUSION

In future studies, more data and healthier evaluations can be made as a matter of course by using alternative methods. However, since this study provides information about the levels that the number of cases can reach provided that the course of the current situation cannot be intervened, it may pioneer countries to take the necessary measures.

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