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ORIGINAL ARTICLE

Prediction of Damage Cost of Bronchitis Due to Haze in Malaysia

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Abstract

Awareness of haze pollution and management increased in Southeast Asia since 1990. However, the focus on environmental management is decreasing especially in Malaysia due to the abundant resources and increased development pressure. The total health damage cost because of haze in the country became significantly high due to the long duration of haze events year by year. This paper discusses the health damage caused by bronchitis due to the haze events in Malaysia. The analysis shows positive coefficient of independent variables which indicates the positive relationship between dependent variable and independent variables. Multiple linear regression analysis shows that 45.3% variation in damage cost of bronchitis could be explained by FAI, GDPPC, and CO_2.

Keywords: Health damage cost; environmental management; haze; Malaysia; prediction.

Introduction

Haze is the air mixture of pollutant particles, such as soot particles, carbon dioxide (CO_2), carbon monoxide (CO), nitrogen dioxide (NO_2) and other toxic gases. An atmosphere has moisture, dust, smoke, and vapor which diminish visibility. The haze pollution always affects several Southeast Asian countries, such as Indonesia, Singapore, Malaysia and Brunei. The haze usually occurs during the southwest monsoon season between June and September, and becomes severe during the period of dry weather (Azid et al., 2016; Davies, & Unam, 1999). Trans-boundary air pollution, which is the smoke from the forest fires, has not only caused the widespread of air pollution in the country itself but also in neighboring countries. Since 1982, this case developed into an almost annual occurrence in the region with the worst episode being in the period of 1997 to 1998 and in 2006 to 2007 (ASEAN Secretariat, 2008; Herawati, & Santoso, 2011). The increasing number of fires is a serious issue and is often related to land clearing for major commodity plantations. The aim of the authority is to eliminate trans-border haze from forest fires by stopping the forest burning, monitoring prevention efforts, exchanging information and helping each government involved in the problem.

Gross domestic product (GDP) per capita is used as an indicator of standard of living. When household income increases, people intend to escalate their spending on health. Most households with high income spend more on medical expenditure compared to households of middle and low incomes. There is a positive correlation between health expenditure and GDP per capita. Yet, the countries with higher levels of CO_2 emissions are also likely to experience higher level of other harmful chemicals and pollutants, further increasing the risk of health problems among its citizen. Thus, it is hypothesized that as CO_2 emissions per capita increases, average life expectancy will decrease (Schneider, et al., 2005). The country incurs productivity losses as a result of the haze related illnesses suffered by population at risk. These productivity losses occur in terms of forgone production opportunities during the workdays of hospital admission and sick leave obtained by a fraction of the population at risk (Othman, & Shahwahid, 1999). A number of studies have reported associations of health impacts with the use of biomass fuels and a few has directly measured exposure and increased acute respiratory illness in children (Ostermann, 2001). Bronchitis is a respiratory disease when the mucus membrane in the lung's bronchial passage becomes inflamed. During air pollution, the haze particles exacerbate episodes of acute bronchitis with chronic lung diseases. The productivity losses could occur when workers are in hospital and on sick leave during the working days. This research is conducted to determine which determinants correlate on the health damage cost of bronchitis in Malaysia.

Methodology

Data entry and analysis were done using XLSTAT 2014. Descriptive statistics were used and this includes frequency (%) for categorical data and mean (SD) for numerical data. Multiple linear regression was applied to predict the health damage cost of bronchitis (DCB) due to haze in Malaysia. The predictors in this study were forest area in Indonesia (FAI), gross domestic product per capita (GDPPC) and carbon dioxide emission (CO_2). The data of the dependent variable was collected from Department of Health and Human Service. The data of forest area in Indonesia (FAI), GDP and CO_2 emission were obtained from World Bank, The Global Economy.com, and Econstats. Ordinary Least Squares (OLS) method or simple linear regression was applied for univariable analysis. Variables chosen for multiple linear regression analysis were decided not only based on statistical significance in univariable analysis ($p < 0.25$) but also on principles of parsimony and biological plausibility. Level of significance (α) was set as <0.05 for this study. Final results were presented by using crude and adjusted regression coefficients with 95% Confidence interval (CI), t-statistic and corresponding P-values.

The use of multilinear regression as a tool for prediction, to predict the corresponding value of y or dependent variable are related to one another by the same regression described by sample data. The damage cost of bronchitis (DCB) as independent variable which computed in MLR. R-square was then used to measure the prediction performance of MLR and further analysis was carried out (Niu, 1998). The DCB can be determined using the formula below:

$$DCB = f(FAI, gdppc, CO_2) \quad (1)$$

$$\ln\ DCB = \ln \beta 0 + \ln \beta 1 FAI + \ln \beta 2 gdppc + \ln \beta 3 CO_3 + e0 \quad (2)$$

Where:

DCB	= Health damage cost of bronchitis due to haze in Malaysia
FAI	= Forest area in Indonesia
GDPPC	= Gross domestic product per capita
CO_2	= Carbon dioxide emission
e0	= Regression error

Results and Discussion

Table 1 shows the OLS method used in this study. The constant is 3.203 when all the independent variable values are zero to signify that contain no functions of the independent variable, other than constant functions. The regression coefficient shows positive sign which suggests the positive correlation between the independent variables and dependent variable whilst the negative coefficient shows the negative relationship. The regression coefficient (β) not only shows the correlation but predicts the variation of dependent variable by changing one unit of independent variable. As shown in the result below, one unit measurement of FAI and CO_2 emission will increase the DCB by 0.561and 0.519 respectively. The coefficient of GDPPC shows negative sign where the increase in GDPPC will decrease the DCB by 0.044. Numerically, FAI and CO_2 elasticity are about 0.561 and 0.519. Thus, as for GDPPC, if one unit measurement of GDPPC increases, the DCB value will decrease by 0.044 while controlling other variables. This result shows that all independent variables influence the DCB.

Table 1. Multi Linear Regression (OLS method)

Variable	Coefficient	Std. Error	t-Statistic	Prob
C	3.203299	5.873242	0.545406	0.5895
LRFAI	0.561468	1.189563	0.471995	0.6403
LGDPPC	-0.044412	0.200382	-0.221635	0.8261
LCO_2	0.518604	0.263927	1.964952	0.0587
R-squared	0.453013	Mean dependent var		5.919274
Adjusted R-squared	0.398314	S.D. dependent var		0.261381
S.E. of regression	0.202749	Akaike info criterion		-0.243562

Dependent Variable: LRDCB
Method: Least Squares
Date: 05/26/15
Time: 09:26
Sample 1980 2013

The results in Table 2 show the multiple R (0.6514) value is equal to the square root of the R square value. The multiple R is equal to the absolute value of the correlation between the dependent variable and the predictor variable. R square = 0.4243 measures the closeness of fit of the regression function to the observed value of y. It represents the percentage of the response variable variation that is explained by a linear model. The MLR – DCB model were then used to estimate DCB value for unknown samples. The standard error measures the size of a typical deviation of an observed value of [x, y]. There are 34 observations which take data related to the variables from 1980 until 2013. The sum of squares represents a measure of variation or deviation from the mean. It is calculated as a summation of the squares of the differences from the mean. The calculation of the total sum of squares considers both the sum of squares from the factors and from randomness or error. The SS (Sum of square) column gives the sums of squares. The total sum of squares is the sum of the squared deviation of the SS concentration from the overall mean. 235090.2504/554061.7131 = 0.424(42.4%).

Table 2. Regression of statistic method

Regression Statistics	
Multiple R	0.651385728
R Square	0.424303367
Adjusted R Square	0.366733704
Standard Error	103.1134428
Observations	34

Tables 3 and 4 show the analysis exhibits the signs of multicollinearity, such as the estimation of the coefficients vary from model to model. The multicollinearity information included dependent and independent variable. The concern is with the relationship among the independent variables, the functional form of the model for the dependent variable is irrelevant to the estimation of collinearity (Menard 2002, p. 76). In other words, the OLS regression will be run and ignore most of the results but still use the information that pertained to multicollinearity. In multiple regression, the variance inflation factor (VIF) is used as an indicator of multicollinearity. Computationally, it is defined as the reciprocal of tolerance: 1 / (1 - R^2). All other things equal, researchers desire lower levels of VIF, as higher levels of VIF are known to affect adversely the results associated with a multiple regression analysis. In fact, the utility of VIF, as distinct from tolerance, is that VIF specifically indicates the magnitude of the inflation in the standard errors associated with a particular beta weight that is due to multicollinearity.

The R square value is 42.4% which measure the percentage of the variability explained by the independent variables. The coefficients and standard error value of independent variables shows the most until the least significant parameter are GDP, FAI and CO_2 respectively (table 2). By using the 95% confidence interval, we can also decide the p-value of that variable for each intercept parameter about the lowest are 0.045846 of GDP, 14.22744 of FAI and the least significant is 19.3393 of CO_2. Using 95% CI interval, we can also decide the p value of that variable. For instance, if 95% CI interval includes zero (0), we can decide that that variable is not a significant predictor for outcome variable (table 4).

Table 3. Multicolinearity statistics

Statistic	**FAI**	**CO_2**	**GDPPC**
Tolerance	0.0674	0.0477	0.1051
VIF	14.8258	20.9859	9.5183

Table 4. ANOVA

	Coefficients	**Standard Error**	**t Stat**	**P-value**	**Lower 95%**
Intercept	-682.2875171	889.2576847	-0.767255126	0.448926489	-2498.393993
FAI	10.12780309	11.92556108	0.849251706	0.402467589	-14.22744183
GDP	-0.007549298	0.018752013	-0.402585992	0.690107253	-0.045846017
CO_2	77.20530173	47.27312821	1.633175224	0.112885369	-19.33930593

The box plots provide basic information about a distribution and is a powerful exploratory data analysis tool. It can also be used to visualize the median differences and to track the changes of the most important determinants which effected the health damages cost of bronchitis due to haze in Malaysia. For example, a distribution with a positive skew would have a longer whisker in the positive direction than in the negative direction. A larger mean than median would also indicate a positive skew. From figure of box plot below (Fig. 1) showed the longer whisker in the positive direction of FAI, CO_2 and GDPPC respectively.

Box plots are good at portraying extreme values and are especially good at showing differences between distributions. There is one more mark to include in box plots (although sometimes it is omitted). We indicate the mean score for a group by inserting a plus sign.

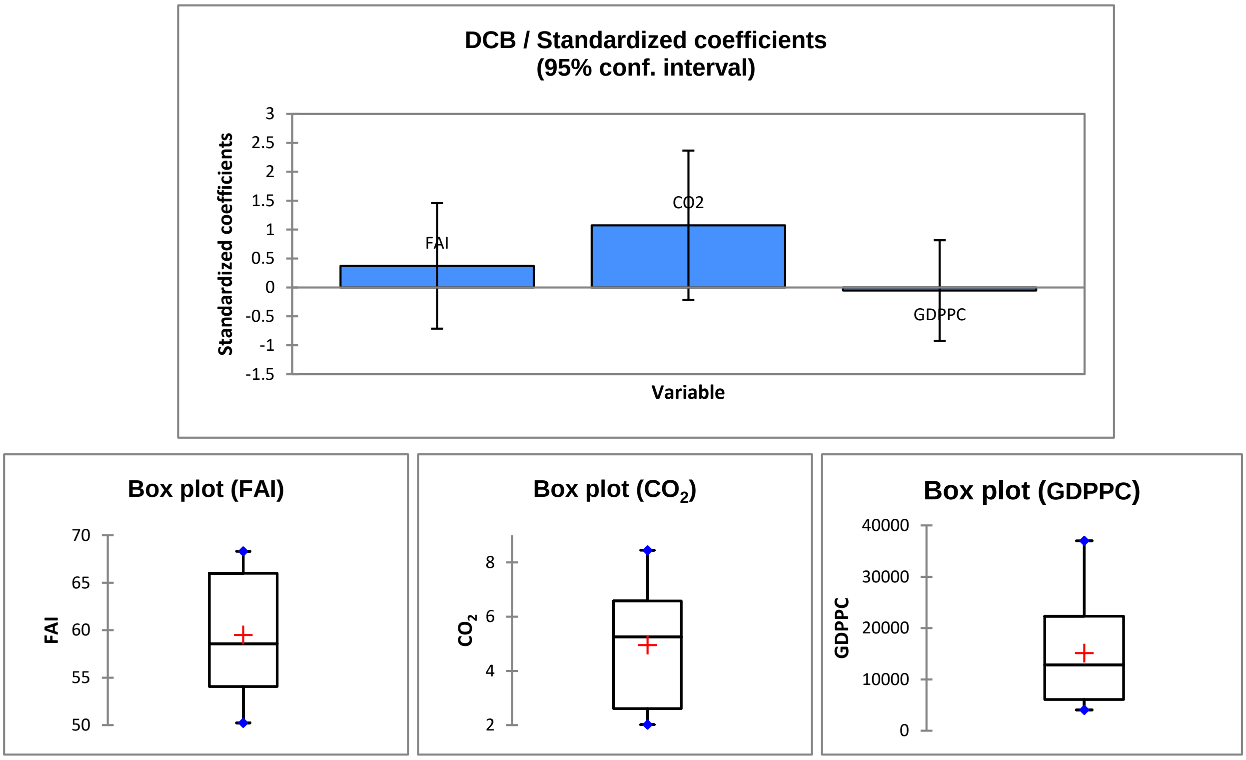

Figure 1. The independent variables extreme effect to dependent variable for FAI, CO_2 and GDPPC

The last part of the output consists of the residuals and predicted DCB values. The residuals play an important role in determining the appropriateness of the regression model. The validation results have been shown in (Fig. 2). In Fig. 3, predicted is compared with actual DCB. The results are in perfect agreement with observed values to 90%. This is accumulated from 34 observations. The results are also in good agreement with the expert survey for about 75%, indicating that human also makes mistake sometime. The method of this study proved the measurement used give the same result with the expert survey which means the researchers can save their time and cost by using the secondary data to make the better research about this issue.

Conclusion

As conclusion for this study showed positive relationship with two variables. The rest one variable has negative relationship with outcome variable which from the coefficient sign by using regression either in econometric method or multi linear regression (MLR) method. However, the coefficient of GDPPC is semi elasticity which holding variables constant shows in econometric method but the estimated semi elasticity is also highly statistically significant.

This result prove, the FAI and CO_2 most correlated with the dependent variable, DCB, this means these two variables most effected to increase the DCB in Malaysia and the main factors the DCB increased in Malaysia are FAI and CO_2. From Ministry of Health Hospital, Malaysia, the number of discharge of acute bronchitis (Influenza Pneumonia and other Acute Lower Respiratory Infections) increased from year to year followed by the increasing of the haze pollution conducted in Malaysia, it is already 23 years since the Environmental Quality

(Clean Air) Regulation 197 were introduced in the country. As a result, many strategies such as 3R (Reduce, Reuse, Recycle) campaign and air cleaning systems have been applied to improve air quality. Many studies can be conducted to evaluate the strengths, weaknesses, the impacts of the country's adopted, regulations, programs, and strategies.

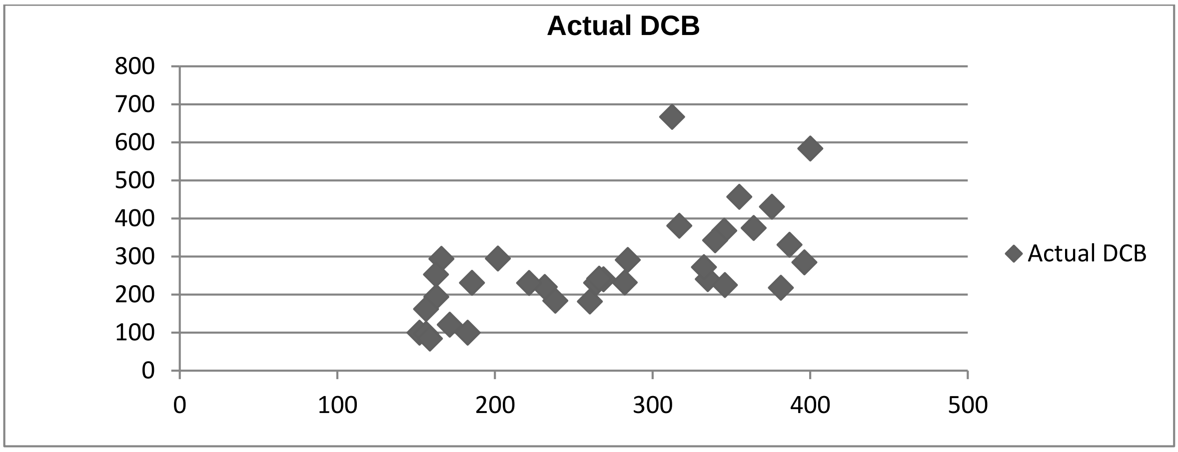

Figure 2. Validation of Actual DCB vs Predicted DCB

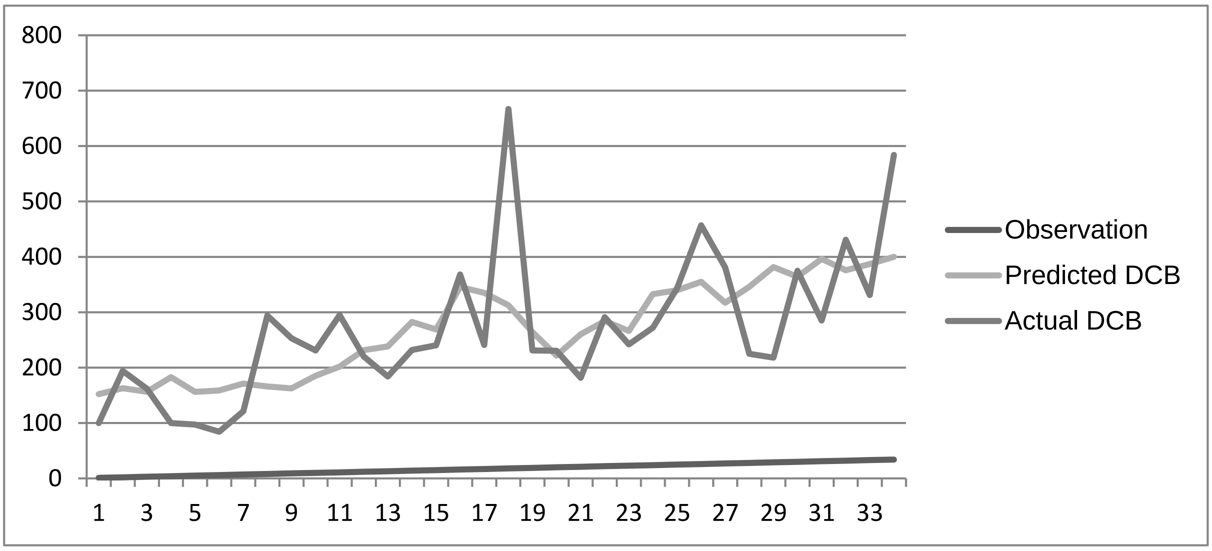

Figure 3. Actual DCB vs Predicted DCB

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