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Applying of economic index data for municipal solid waste quantity prediction in Thailand

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Abstract

The population increased from past to present until the expansion of the community brought economic and prosperity in the society, but it also increases the municipal solid waste quantity. This research has studied the correlation between municipal solid waste quantity with economic growth factors in Thailand since 1993- 2019 to create an equation to predict the changes of municipal solid waste quantity that may occur in the future. This information analysis was organized into 4 datasets, 27 years (108 quarters: 1993-2019), 9 years (36 quarters: 1993-2001), 9 years (36 quarters: 2002-2010), and 9 years (36 quarters: 2011-2019) found that the population increase of all of 27 years from 58.44 million people in 1993 to 66.56 million people in 2019 same as municipal solid waste quantity constantly increase from 10.91 million tons in 1993 to 28.71 million tons in 2019, Causing the difference of change of each year (36 quarters) between municipal solid waste quantity with economic growth factors in Thailand. The correlation between municipal solid waste quantity with economic growth factors found that most of all 4 datasets have a correlation with almost all economic growth factors ($R>0.6$) except retail sales index (36 quarters: 2002-2010) and consumer price index, core consumer price index (36 quarters: 2011-2019) have a correlation less than 0.6 ($R<0.6$). The creation of equation municipal solid waste quantity predict from 4 datasets show that 2 datasets were suitable for application considering by R^2 value more than 0.6 were equation predict of 27 years (108 quarters: 1993-2019) for prediction in long-times between 10-27 years and equation predict of 9 years (36 quarters: 2011-2019) for prediction in short-times between 1-9 years.

Keywords: Economic index, Municipal solid waste quantity, Solid waste prediction

1. Introduction

Technological science in the present has progressed rapidly along with population growth tend to be higher, influences to the expansion of the community and development of the various countries to both technology industry and tourism, The changes and development will bring economically and prosperity in the society. The population growth rate effect to demand-consumption has increased, when demand-consumption increases the available resources were adopted wastage until leftover from consumption becomes to waste. Some part of waste was self-degradable but most of waste non-self-degradable and difficult to break such as packaging electronic-waste if the management methods were used improperly impact will have direct on the environment and human health.

Currently, Municipal solid waste quantity from humans in all countries has more than 2.01 billion tons per year and the quantity is increasing every year. The municipal solid waste quantity prediction may contain up to 3.4 billion tons in 2050 [1]. The problem of municipal solid waste has many factors composition same as Bangkok (Thailand) in 2001-2002 the population has increased about 56,000 people impact to increase of municipal solid waste 300 kg per day [2,3] which contains more than the municipal solid waste in Kuala Lumpur (Malaysia) 2 times while the population increased 36,00 people [4,5]. The increase in population was an important variable to municipal solid waste. In addition to the increase in the domestic population, there were also economic growth factors involved in the occurrence of municipal solid waste [6], and the economic growth

factors increase the impact on municipal solid waste quantity increase. From a study correlation to economic growth factors in 2005-2006 of EU-27 countries directly affect the quantity of municipal solid waste and effect to environmental degradation is increasing [7] same as the study correlation of The United States in 1990-2017 found that economic growth was an important variable occurrence of municipal solid waste to 31.70% [8]. Researchers in many countries have begun to study the important economic variables and it has the effect of municipal solid waste occurrence to prediction the quantity of municipal solid waste that may occur and economic growth in the future such as employment, consumer price index, gross domestic product (GDP), education and population [9]. The selection of important economic variables in prediction will have an impact on changes in the quantity of each type of municipal solid waste same as the study to prediction used by variables include population, income level, GDP, and dwelling unit size found a correlation of changes in the general waste type of municipal solid quantity more than other variables [10,11] and prediction used by variables include employment and taxable transactions found a correlation of changes in the commercial waste type of municipal solid quantity more than other variables [12,13].

The prediction about changes in the quantity of municipal solid waste by Thailand's mathematical equations has been extensively studied as with most prediction municipal solid waste quantity 1.5 kg per person per day of Thailand in 2025 [14]. But it was predicted that the population correlation with municipal solid waste quantity in the studied only one, as well as the study of Chang, et al [15], found the growth of economic factors was also important to municipal solid waste occur. Most studies in Thailand and abroad focus on the continuous analysis data of the prediction factors and the trend in the short and long term for defining policies [16,17,18]. Therefore, to study the trend of economic growth and prepare to manage with the municipal solid waste quantity that may occur in the future to cover. This research was to study and create an equation for predictions the municipal solid waste quantity in Thailand by used to data from 1993-2019 include population from the Department of Provincial Administration, the quantity of municipal solid waste from the Pollution control department, and economic growth factors from Bank of Thailand.

2. Materials and methods

2.1 Scope of data

Thailand's mathematical equations performed the selection of data analysis to the prediction about changes in the quantity of municipal solid waste from 1993-2019. The information analysis was organized into 4 datasets, 27 years (108 quarters: 1993- 2019), 9 years (36 quarters: 1993-2001), 9 years (36 quarters: 2002-2010) and 9 years (36 quarters: 2011-2019) in which the data was divided into 2 datasets for analysis include the first dataset was population from Department of Provincial Administration [3] and the second datasets were the quantity of municipal solid waste from Pollution control department [2,19] and economic growth factors from Bank of Thailand [20]. The definitions were shown in Table 1.

Table 1 Definitions of Thailand's economic growth factors.

Factors	Definitions
Population	The population of Thailand according to the civil registration from 1993-2019
Retail sales index	Used to measure the average price of processed products from sales data. It covers activities in the retail category, sales of cars and fuel from the taxation of the Revenue Department, Ministry of Finance.
Core consumer price index	Index-based inflation targeting information from the cost of living of the people in the daily consumption excluding energy and fresh food.
Consumer price index	The index to reflect the cost of living of the people, by the costs. The consumption of people that occurs in daily life covers all types of goods and services used by households.
Leading economic index	The index showed to overall economic condition of the country was calculating used important economic variables. This research was predicted data of short-term economic (3-4 months in the future) such as registered capital for newly established juristic person, exports at constant prices or the number of foreign tourists.

2.2 Scope of data analysis

The analyzes of the selected data were the municipal solid waste quantity of Thailand data and economic growth factors data since 1993-2019, Used statistical analysis software to obtain an equation to predict the changes in the quantity of municipal solid waste that was suitable for the application. The process of analysis was shown in Figure 1.

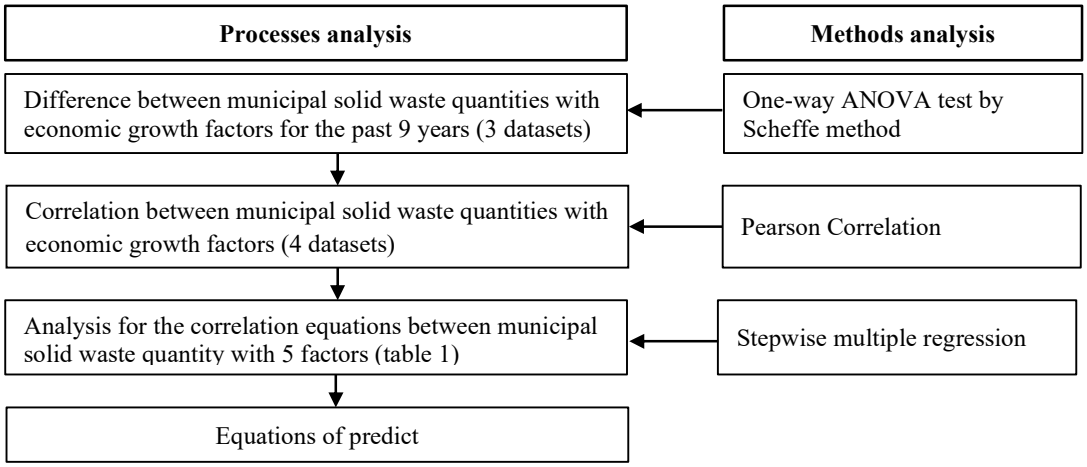

Figure 1 Processes of analysis.

3. Results and discussion

3.1 Background of municipal solid waste quantity in Thailand

This research was studied the total quantity of municipal solid waste in Thailand from the past to the present (1993-2019). A study correlated municipal solid waste quantity with economic growth factors include population, retail sales index, core consumer price index, consumer price index, and leading economic indexes. The study was divided into 4 periods as follows 27 years (108 quarters: 1993-2019) 9 years (36 quarters: 1993-2001) 9 years (36 quarters: 2002-2010) and 9 years (36 quarters: 2011-2019) to create an equation to predict the municipal solid waste quantity that will occur in the future impact from economic growth.

The population was one factor that impacts the economic growth due to high consumer demand. As a result, the production capacity in various industrial sectors has increased this coupled with the increase in population (Figure 2). The result of the study showed that the population increase of all of 27 years from 58.44 million people in 1993 to 66.56 million people in 2019 same as municipal solid waste quantity constantly increase from 10.91 million tons in 1993 to 28.71 million tons in 2019. But overlaps in 2010-2011, the quantity of municipal solid waste increased abnormally due to the floods and effect to economic growth decrease in 2011 [21]. Besides, the retail index was higher than ever thus impact to higher quantity of municipal solid waste than in 2009 [22]. The increase in population was an indicator of economic growth [6].

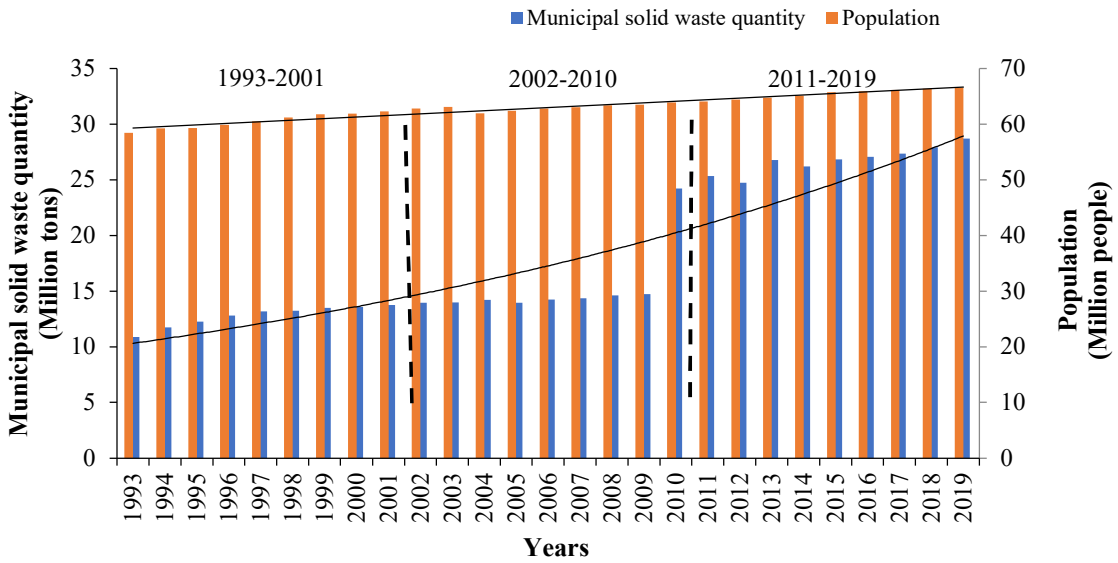

Figure 2 Municipal solid waste quantity and the population.

The analysis of the impact of population change on the municipal solid waste quantity found that the population variable affects the changes in the quantity of municipal solid waste can be described by R^2 values from Stepwise multiple regression method tests, which showed that 27 years (108 quarters: 1993-2019) population changes affect the quantity of municipal solid waste 76.40% besides that it was due to other factors 23.60% (R^2 =0.764), 9 years (36 quarters: 1993-2001) population changes affect the quantity of municipal solid waste 86.60% besides that it was due to other factors 13.40% (R^2 =0.866), 9 years (36 quarters: 2002-2010) population changes affect the quantity of municipal solid waste 28.90% besides that it was due to other factors 71.10% (R^2 =0.289) and 9 years (36 quarters: 2011-2019) population changes affect the quantity of municipal solid waste 80.80% besides that it was due to other factors 19.20% (R^2 =0.808). Therefore, changes in the quantity of municipal solid waste every year were largely dependent on the population but in the years 2002-2010, the change in the quantity of municipal solid waste depends on other variables (There was a flood with a high retail sales index) more than population variable.

The continued increase in the quantity of municipal solid waste corresponds to economic growth from 2011 onwards from figure 3.Wich retail sales index, core consumer price index, and consumer price index to increase can be used as a good indicator of economic growth and shows the population higher consumption. The leading economic indexes increased to predict data of short-term economic (3-4 months in the future) it was the result of the population, retail sales index, consumer price index, and core consumer price index as well.

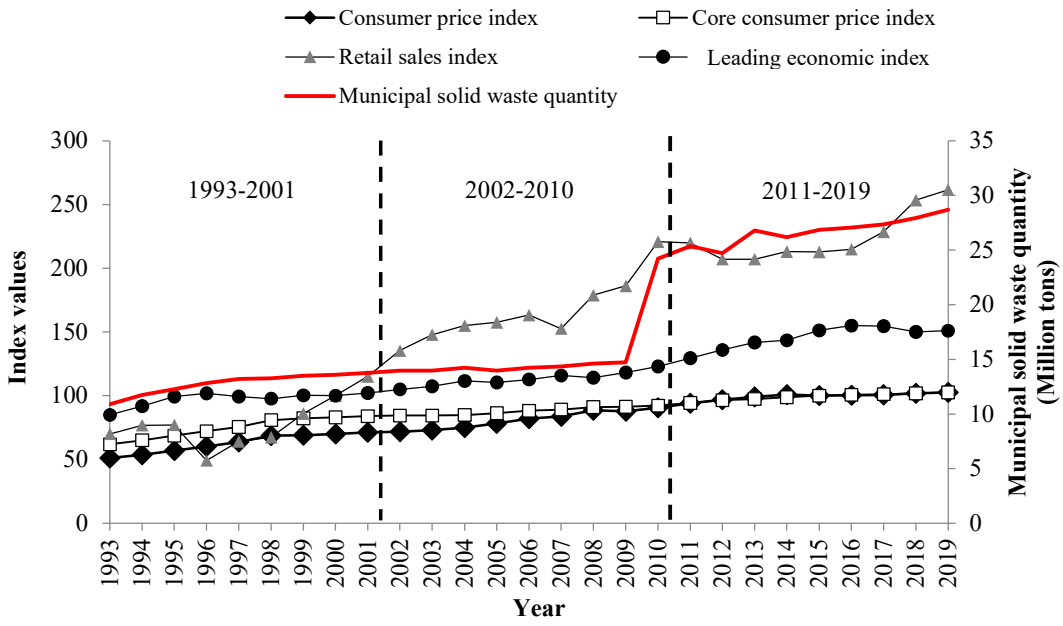

Figure 3 Economic growth index factors and municipal solid waste quantity.

3.2 Correlation of municipal solid waste quantity with economic growth in Thailand

Studied the difference in the municipal solid waste quantity in Thailand for each period which 3 different sets of data include 9 years (36 quarters: 1993-2001), 9 years (36 quarters: 2002-2010), and 9 years (36 quarters: 2011-2019) with economic growth factors (population, retail sales index, core consumer price index, consumer price index, and leading economic index) used by One-way ANOVA test at 0.05 significance level for analysis of differences and results of statistical tests found that 3 datasets from 1993-2019 most of the municipal solid waste quantity and the economic growth factors have changed significantly different at 0.05 (Sig. 0.000). However, when analyzing the double-difference datasets between the 3 datasets include 9 years (36 quarters: 1993-2001), 9 years (36 quarters: 2002-2010), and 9 years (36 quarters: 2011-2019) used by Scheffe method found that all of 6 factors were the differences significant at 0.05 (Sig. 0.000) except municipal solid waste quantity change for 1993-2001 and 2002-2010 no statistic difference (Sig. 0.053) as shown in table 2. Since 2010 there were huge floods in Thailand causing a lot of municipal solid waste quantity in conjunction with after years 2010-2019 the population constantly increase to cause of higher consumption than last year.

Table 2 Results of differences analysis between economic growth factors with transition period.

Factors of economic growth	Transition period (Years)		Results of one-way ANOVA test (Sig.)
Municipal solid waste quantity	1993-2001	2002-2010	0.053
		2011-2019	0.000
	2002-2010	1993-2001	0.053
		2011-2019	0.000
	2011-2019	1993-2001	0.000
		2002-2010	0.000
Population	1993-2001	2002-2010	0.000
		2011-2019	0.000
	2002-2010	1993-2001	0.000
		2011-2019	0.000
	2011-2019	1993-2001	0.000
		2002-2010	0.000
Consumer price index	1993-2001	2002-2010	0.000
		2011-2019	0.000
	2002-2010	1993-2001	0.000
		2011-2019	0.000
	2011-2019	1993-2001	0.000
		2002-2010	0.000
Core consumer price index	1993-2001	2002-2010	0.000
		2011-2019	0.000
	2002-2010	1993-2001	0.000
		2011-2019	0.001
	2011-2019	1993-2001	0.000
		2002-2010	0.001
Retail sales index	1993-2001	2002-2010	0.000
		2011-2019	0.000
	2002-2010	1993-2001	0.000
		2011-2019	0.000
	2011-2019	1993-2001	0.000
		2002-2010	0.000
Leading economic index	1993-2001	2002-2010	0.000
		2011-2019	0.000
	2002-2010	1993-2001	0.000
		2011-2019	0.000
	2011-2019	1993-2001	0.000
		2002-2010	0.000

For the study of the correlation between the quantity of municipal solid waste with economic growth factors include population, retail sales index, core consumer price index, consumer price index, and leading economic index divided into 4 periods as follows 27 years (108 quarters: 1993-2019) 9 years (36 quarters: 1993-2001) 9 years (36 quarters: 2002-2010) and 9 years (36 quarters: 2011-2019) and analyzed using Pearson correlation statistics. The results found that the quantity of municipal solid waste of 27 years (108 quarters: 1993-2019) has correlated value with all economic growth factors such as population, retail sales index, core consumer price index, consumer price index, and leading economic index more than 0.6 ($R>0.6$). For quantity of municipal solid waste of 9 years (36 quarters: 1993-2001) has correlated value more than 0.6 ($R>0.6$) with 4 factors of economic growth such as population, core consumer price index, consumer price index, and leading economic index but found retail sales index has correlated value of less than 0.6 ($R<0.6$). The same as the quantity of municipal solid waste of 9 years (36 quarters: 2002-2010) has correlated value more than 0.6 ($R>0.6$) with 3 factors of economic growth such as population, retail sales index and leading economic index but found core consumer price index and consumer price index has correlated value of less than 0.6 ($R<0.6$). The quantity of municipal solid waste of 9 years (36 quarters: 2011-2019) has correlated value with all economic growth factors more than 0.6 ($R>0.6$) same as 27 years. As shown in table 3.

Table 3 Correlation of each transition period with economic growth factors.

Transition period (Years)	Factors of economic growth	Correlation (R)	Sig.
27 years (108 quarters)	Population	0.879**	0.000
(1993-2019)	Consumer price index	0.899**	0.000
	Core consumer price index	0.852**	0.000
	Retail sales index	0.873**	0.000
	Leading economic index	0.942**	0.000
9 years (36 quarters)	Population	0.940**	0.000
(1993-2001)	Consumer price index	0.961**	0.000
	Core consumer price index	0.963**	0.000
	Retail sales index	0.420	0.260
	Leading economic index	0.887**	0.001
9 years (36 quarters)	Population	0.615	0.780
(2002-2010)	Consumer price index	0.566	0.112
	Core consumer price index	0.573	0.107
	Retail sales index	0.840**	0.005
	Leading economic index	0.722*	0.028
9 years (36 quarters)	Population	0.912**	0.001
(2011-2019)	Consumer price index	0.847**	0.004
	Core consumer price index	0.894**	0.001
	Retail sales index	0.777*	0.014
	Leading economic index	0.868*	0.011

*Correlation at the 0.01 level of significance.
** Correlation at the 0.05 level of significance.

3.3 Creation and application of equation predict for municipal solid waste quantity in Thailand

Creating an equation predict for the municipal solid waste quantity of future from 5 economic growth factors such as population, retail sales index, core consumer price index, consumer price index, and leading economic indexes divided into 4 periods as follows 27 years (108 quarters: 1993-2019) 9 years (36 quarters: 1993-2001) 9 years (36 quarters: 2002-2010) and 9 years (36 quarters: 2011-2019) for analyzed using Stepwise multiple regression statistics. Results shown in table 4 found that equation predicts of 27 years (108 quarters: 1993-2019) leading economic index only correlates while equation predicts of 9 years (36 quarters: 1993-2001) found 2 factors correlate include core consumer price index and leading economic index. For equation predict of 9 years (36 quarters: 2002-2010) found retail sales index only has correlation same as equation predict of 9 years (36 quarters: 2011-2019) only one-factor correlation same with the 27 years equation predict.

Table 4 Results of regression coefficient analysis between municipal solid waste quantity with economic growth factors.

Transition period (Years)	Index	Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
27 years	(Constant)	-15.363	2.474		-6.210	0.000
(108 quarters)	Leading economic index	0.283	0.021	0.942	13.480	0.000
(1993-2019)						
9 years	(Constant)	0.710	0.852		0.834	0.436
(36 quarters)	Core consumer price index	0.079	0.008	0.683	9.316	0.000
(1993-2001)	Leading economic index	0.063	0.013	0.370	5.054	0.002
9 years	(Constant)	-2.892	4.499		-0.643	0.541
(36 quarters)	Retail sales index	0.110	0.027	0.840	4.100	0.005
(2002-2010)						
9 years	(Constant)	13.822	3.213		4.302	0.008
(36 quarters)	Leading economic index	0.087	0.022	0.868	3.902	0.011
(2011-2019)						

Dependent variable: municipal solid waste quantity (Million tons per year). B= unstandardized beta, t= t-statistic.

The equation for prediction from regression coefficient analysis between municipal solid waste quantity with economic growth factors can be created in 4 formats by divided the dataset analysis shown in table 5. Results found that equation 1 and equation 2 have R^2 value more than 0.8 while equation 3 and equation 4 have R^2 value

less than 0.8 for the selection of equation predict of municipal solid waste quantity would be to use will consider the value of R^2 more than 0.6 because it is a value that is through the adjustment of various variables in creating the equation with the least error.

Table 5 Equation predicted the quantity of municipal solid waste.

Equation	Transition period (Years)	Equation predicted	R	R^2	Adjusted R^2	Std. error of the estimate
1	27 years (108 quarters) (1993-2019)	Municipal solid waste quantity (Million tons / year) = 0.283(Leading economic index) - 15.363	0.942	0.888	0.883	2.08389
2	9 years (36 quarters) (1993-2001)	Municipal solid waste quantity (Million tons / year) = 0.079(Core consumer price index) + 0.063(Leading economic index) + 0.710	0.993	0.986	0.982	0.12976
3	9 years (36 quarters) (2002-2010)	Municipal solid waste quantity (Million tons / year) = 0.110(Retail sales index) - 2.892	0.840	0.706	0.664	1.93154
4	9 years (36 quarters) (2011-2019)	Municipal solid waste quantity (Million tons / year) = 0.087(Leading economic index) + 13.822	0.868	0.753	0.703	0.52748

This research has to equation prediction testing in 2020 year for the selection of suitable equation for predicting the municipal solid waste quantity that may occur and prediction for economic growth. From the equation prediction testing where 2 equations to predicted value of municipal solid waste quantity was close to the current quantity (25.37 million tons in 2020 year) [2], found that the equation 1 and the equation 2 have municipal solid waste quantity equal to 27.88 and 27.12 million tons in 2020 year which increase to 9.90% and 6.88% from current quantity respectively and when statistical test to correlation between municipal solid waste current quantity with municipal solid waste quantity from equation predicted with by using Pearson showed correlated value more than 0.950 (R>0.950). Therefore, the equation 1 suitable for prediction in long-times between 10-27 years and equation 4 suitable for prediction in short-times between 1-9 years. However, equation 2 and equation 3 not suitable for prediction because was a specific index that occurs in that year.

Changes in the quantity of municipal solid waste, as well as economic growth prediction, can be explained by the variables taken into consideration found that equation 1 the leading to economic index changes that affect the quantity of municipal solid waste 88.30% indicates higher industrial investment growth another 11.70% was due to other factors not considered (R^2 =0.883) and equation 2 the core consumer price index and leading economic index changes affect the quantity of municipal solid waste 98.20% which core consumer price index changes affect the quantity of municipal solid waste to increase from the change in prices of goods and services decreased [23,22,24] another 1.80% was due to other factors not considered (R^2 =0.982). For equation 3 the retail sales index changes affect the quantity of municipal solid waste 66.40% this was due to the time when Thailand gained foreign influence in the establishment of the retail business in 1990 and the low inflation has led the industry to invest and grow big jump in the retail business [24] another 33.60% was due to other factors not considered (R^2 =0.664). And equation 4 the leading economic index changes affect the quantity of municipal solid waste 70.30% another 29.70% was due to other factors not considered (R^2 =0.703).

4. Conclusion

This research was to study and create an equation for predicting the municipal solid waste quantity in Thailand by used to data from 1993-2019 flowed as the population from the Department of Provincial Administration, the quantity of municipal solid waste from the Pollution control department, and economic growth factors from Bank of Thailand. The study was divided into 4 periods as follows 27 years (108 quarters: 1993-2019), 9 years (36 quarters: 1993-2001), 9 years (36 quarters: 2002-2010), and 9 years (36 quarters: 2011-2019). The result showed that population increase of all of 27 years from 58.44 million people in 1993 to 66.56 million people in 2019 same as municipal solid waste quantity constantly increase from 10.91 million tons in 1993 to 28.71 million tons in 2019. The continued increase in the quantity of municipal solid waste corresponds to economic growth which retail sales index, core consumer price index, and consumer price index to increase can be used as a good indicator of economic growth and shows the population higher consumption.

Most of The quantity of municipal solid waste and the economic growth factors in Thailand from 1993-2019 have changed significantly different at 0.05 (Sig. 0.000) except municipal solid waste quantity change for 1993-2001 and 2002-2010 no statistic difference (Sig. 0.053) because in 2010 there was a huge flood in Thailand

conjunction with after years 2010-2019 the population constantly increase to cause of higher consumption than last year. For the correlation between the quantity of municipal solid waste with economic growth factors (R>0.6), found that the quantity of municipal solid waste of 27 years (108 quarters: 1993-2019) and 9 years (36 quarters: 2011-2019) has correlated value with all economic growth factors which quantity of municipal solid waste of 9 years (36 quarters: 1993-2001) has correlated value more than 0.6 with 4 factors of economic growth same as 9 years (36 quarters: 2002-2010) has correlated value more than 0.6 with 3 factors of economic growth. The equation for predict from regression coefficient analysis between municipal solid waste quantity with economic growth factors can be created 4 formats found that equation predicts of 27 years (108 quarters: 1993-2019) and equation predict of 9 years (36 quarters: 2011-2019) have R^2 value more than 0.6 to a suitable equation for predict the municipal solid waste quantity that may occur and prediction for economic growth.

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