14th National Convention on Statistics (NCS) EDSA Shangri-La Hotel, Mandaluyong City October 1-2, 2013

IMPACT OF GROSS DOMESTIC PRODUCT TO WATER CONSUMPTION OF MANILA WATER (2010 TO 2017)

by

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ABSTRACT

Domestic water usage is categorized to have an inelastic demand, this conveys that regardless of the price the demand for the goods stay constant. To sustain the constancy of the demand it is crucial to have a model that could represent the future demand to enable sustainable water resource management. In this study, water consumption in east zone of Metro Manila and the socio-economic development represented by Gross Domestic Product (GDP) were analyzed. The water consumption in million liters per day (MLD) was patterned to quarterly data points to mimic GDP data and was segmented to three levels; residential commercial and global (all east zone of Metro Manila consumers). Each segment was processed and analyzed using linear regression and error correction model (ECM). The results based on the linear regression model showed that for every 1 unit increase in log of GDP, log of water consumption of global, residential and commercial increases by 0.406, 0.477 and 0.182 respectively, while for ECM 2^{nd} and 4^{th} lagged values of GDP constitute to the increase and decrease of water consumption.

INTRODUCTION

People in third world countries with scarce piped connections only use about 4 to 38 liters of water per person per day while those who live in cities in developed countries consume about 83 to 227 liters per capita per day. It is estimated that in WHO regions, specifically SouthEast Asia region, consume about 30 to 70 liters per capita per day (Argawal, 1981). Water being the most important natural resource that we have for sustainable development and quality of life, its usage is based on a highly complex process that is influenced by many factors such as water supply restrictions, tariff structure & pricing, household characteristics, and attitudes on water conservation. These factors drive, directly & indirectly, water consumption and water usage (Fan, Liu, Wang, Geissen, & Ritsema, 2013). It is one of the building blocks of regional economic development in urban areas – which constitutes one of the vital infrastructural inputs in regional socio-economic development (Munasinghe, 1992).

Several studies have shown that growing populations and Gross Domestic Product (GDP) results to a significant increase in municipal water use – both in percentage and volumetric terms. In the study by Vörösmarty, et.al. (2000), much greater demands of water in the future is pictured if socio-economic factors, such as GDP growth, only is accounted. However, household water demand per capita is greatly influenced by other measures (Gleick, 2003). Higher water usage is expected when GDPs are higher – but other measures that influence water demand may induce the opposite effect such as water price and technological improvements (Hejazi, Edmonds, Chaturvedi, Davies, & Eom, 2013).

STATEMENT OF THE PROBLEM

Modelling Manila Water's Water Consumption as a function of Gross Domestic Product (GDP) at constant prices.

SCOPE AND LIMITATIONS

The research focuses on the water consumption (in million liters per day (MLD)) of the Manila Water's East Zone Business Concession Area as modelled using the socio-economic development measured by the Gross Domestic Product (GDP) at Constant Prices.

The researcher used time series quarterly data from 2010 to 2017 of each variable.

OBJECTIVES OF THE STUDY

The study aims to identify and investigate the relationship between water consumption and the socio-economic development. Furthermore, the researcher wants to identify the effect of GDP and its lagged values to water consumption in different segments – residential, commercial, and global.

DEFINITION of TERMS

Water Consumption – consumed water by the Manila Water's East Zone concession measured in million liters per day (MLD).

Gross Domestic Product has two measures – constant & current.

- **GDP at constant prices**, or the real GDP, indicated economic growth to measure the performance of the economy over time or in comparison with other countries/in comparison with previous periods. For this study, we have used the GDP at constant prices to reflect the economic growth and performance over time.

METHODOLOGY

Data and Variables

The response variable is the Water Consumption which is computed as the sum of billed volume each quarter. The data were gathered from Manila Water's Business Intelligence (BI) for the Water Consumption and Philippine Statistics Authority (PSA) for the Gross Domestics Product at Constant Prices.

Statistical Tests and Techniques

The researcher employed various preliminary tests to strengthen the accuracy and validity of the model.

The researcher did an Augmented Dickey-Fuller Test to test if the variables are of Unit Root. The Augmented Dickey Fuller Test served as basis to know which among the variables has a unit root or not. With the null hypothesis that the variable has unit root and if the p-value is greater than 0.10 level of significance, then there is no sufficient evidence to conclude that the variable has unit root. If the series will be stationary using differencing, the variable is said to have a stochastic trend, else, it has a deterministic trend.

Johansen Cointegration Test was used to examine linear combinations of variables of unit roots. It will be the basis to know whether the variables are cointegrated or not and to know the effects of the long-run relationship. Since the p-values are all less than 0.1 level of significance, it can be concluded that all the variables are cointegrated with each other. The result has shown that the long-run relationship will be the Ordinary Least Squares estimate. Thus, getting the OLS estimate will yield the long-run model

Causality between the dependent and independent variables is checked using Granger Causality test. It also verifies if a variable can properly forecast the other variable. Given that the p-value is less than 0.1, we have sufficient evidence to conclude that a variable Granger Cause another variable. Error correction model is used for the short run model. The researcher regress lag values of the variables with the OLS model then insignificant variables were deleted to have the final short run model.

DATA ANALYSIS AND RESULTS

Given that the only available data for GDP is on a quarterly basis, we have patterned the water consumption thus summing up the three-month value to represent the quarter. Both variables were transformed to logarithmic function to normalize their values and be of the same unit. Log-levels were used in the analysis to capture the changes in the variables through time. The correlation matrix indicates positive correlation between the changes in each pair of variables. That is, a positive change in one variable corresponds to a positive change in another variable, and vice versa. This may be an implication that the variables move similarly through time.

We have performed various preliminary tests – such as the Augmented Dickey-Fuller for testing if the variables are of unit root and Johansen Cointegration Test for testing the cointegration between variables – to identify the correct and appropriate model to be used.

Table 1 shows the descriptive statistics of the transformed consumption and gross domestic product.

Table 1. Descriptive Analysis

	LOGGDP	LOGMWC	LOGDOM	LOGCOM
Mean	14.36776	7.101463	6.827008	5.675220
Median	14.35579	7.086326	6.810858	5.667799
Maximum	14.66718	7.224268	6.972981	5.733844
Minimum	14.10297	6.991297	6.696867	5.620165
Std. Dev.	0.153332	0.067310	0.078510	0.033113
Skewness	0.109984	0.227236	0.249351	0.029550
Kurtosis	2.018211	1.815238	1.845144	1.774890
Jarque-Bera	1.349727	2.146941	2.109863	2.005851
Probability	0.509226	0.341820	0.348216	0.366805
Correlation Matrix				
	LOGGDP	LOGMWC	LOGDOM	LOGCOM
LOGGDP	1	0.929037	0.932288	0.842548
LOGMWC	0.929037	1		
LOGDOM	0.932288		1	
LOGCOM	0.842548			1

Based on the Johansen Cointegration Test [Appendix 1], at 0.05 level of significance, we reject the null hypothesis that there is no cointegration between the variables, therefore we conclude that the variables are cointegrated. Thus, it implies that the linear regression model [Appendix 2] is a valid long run model for this study with equation.

Table 2. MWC Water Consumption and GDP Ordinary Least Squares Model

	Coefficient	Std. Error	p-value
C	1.241892	0.426073	0.0067
LOG(GDP)	0.407828	0.029653	0.0000

Disregarding differences in economic use, ceteris paribus, an increase in the logGDP will increase the log of global water consumption by 0.4078. That is, for every 1 unit increase in logGDP, log of water consumption increases by 0.4078 for the whole Manila Water Concession Area.

Table 3. Residential Water Consumption and GDP Ordinary Least Squares Model

	Coefficient	Std. Error	p-value
C	-0.031471	0.485860	0. 9488
LOG(GDP)	0.477352	0.033814	0.0000

Ceteris paribus, an increase in the logGDP will increase the water consumption by 0.4774. That is, for every 1 unit increase in logGDP, log of water consumption increases by 0.4773 amongst residential consumers.

Table 4. Commercial Water Consumption and GDP Ordinary Least Squares Model

	Coefficient	Std. Error	p-value
C	3.060985	0.305138	0.0000
LOG(GDP)	0.181951	0.021237	0.0000

For every 1 unit increase in logGDP, log of water consumption by increases by 0.1820.

Cointegration between variables does not specify the direction of a causal direction, thus the researcher used Granger Causality test. Based from the results of Granger Causality of the variables [Appendix 5], at 0.10 level of significance, the null hypothesis that an exploratory variable does not Granger Cause Water Consumption is rejected since the p-value of the test is less than 0.10. Therefore, the lag values of GDP have predictive probability in determining the present values of the independent variable water consumption.

Since water consumption does not Granger Cause GDP in all rate codes, therefore the OLS model will be the cointegrating equation. Regressing the lag values with the OLS model will give the error correction model which will be the short run model for this study. Table 3 shows the final short run model

Table 5. MWC Water Consumption and GDP Error Correction Model

	Coefficient	Std. Error	p-value
C	0.138587	0.264841	0.6060
LOGGDP	0.616669	0.191271	0.0039
EPSILON_MWC(-1)	0.062236	0.088541	0.4895
LOGGDP(-2)	0.259514	0.119134	0.0404
LOGMWC(-4)	0.756903	0.096368	0.0000
LOGGDP(-4)	-0.767056	0.185477	0.0004

Looking at the log of global water consumption of the concession area, with everything remaining the same, in the short run, as GDP increases by 1 unit, log of water consumption increases by 0.6167. Previous results of GDP (0.2595) of the previous two quarters, water consumption (0.7569) and GDP (0.7671) of the past year can explain the present value of log of water consumption.

Table 6. Residential Water Consumption and GDP Error Correction Model

	Coefficient	Std. Error	p-value
C	-0.258206	0.228592	0.2708
LOGGDP	0.691265	0.184051	0.0011
EPSILON_DOM(-1)	0.028304	0.073315	0.7032
LOGGDP(-2)	0.239099	0.119102	0.0571
LOGDOM(-4)	0.834030	0.085542	0.0000
LOGGDP(-4)	-0.834825	0.179396	0.0001

For the residential accounts of short run model, ceteris paribus, one unit increase in logGDP will lead to an increase of 0.6913 for log of water consumption; and 0.2391 and 0.8340 for unit increase of logGDP(-2) and logDOM(-4).

Table 7. Commercial Water Consumption and GDP Error Correction Model

	Coefficient	Std. Error	p-value
C	3.139862	0.333681	0.0000
LOGGDP	0.176462	0.023211	0.0000
EPSILON_COM(-1)	0.196318	0.192006	0.3153

For the commercial accounts, ceteris paribus, in the short run, as logGDP increases, water consumption increases by 0.1765. That is, one percent increase in GDP will lead to an increase of 0.1765 water consumption.

CONCLUSION

Based from the results, linear regression was used as the long run model. With the effect that for every 1 unit increase of logGDP, log of water consumption increases by 0.408 on a global scale. Log of residential and commercial water consumption increases as well by 0.477 and 0.182 respectively, when logGDP increases by 1 unit. For the global & residential water consumption, previous quarterly values affect the present water consumption, based from the short run model ECM.

APPENDICES

Appendix 1. Johansen Cointegration Test Results

Appendix 1.1. – GDP and MWC Water Consumption

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	p-value
None *	0.816666	51.92873	15.49471	0.0000
At most 1	0.033926	1.035439	3.841466	0.3089

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	p-value
None *	0.816666	50.89329	14.26460	0.0000
At most 1	0.033926	1.035439	3.841466	0.3089

Appendix 1.2. – GDP and Residential Consumption

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	p-value
None *	0.848217	57.86435	15.49471	0.0000
At most 1	0.042576	1.305255	3.841466	0.2533

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	p-value
None *	0.848217	56.55909	14.26460	0.0000
At most 1	0.042576	1.305255	3.841466	0.2533

Appendix 1.3. – GDP and Commercial Consumption

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	p-value
None *	0.454041	18.49309	15.49471	0.0071
At most 1	0.011163	0.336762	3.841466	0.5617

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	p-value
None *	0.454041	18.15633	14.26460	0.0015
At most 1	0.011163	0.336762	3.841466	0.5617

Appendix 2. Final Ordinary Least Squares Model

Appendix 2.1. – GDP and MWC Water Consumption

Variable	Coefficient	Std. Error	p-value
C	1.241892	0.426073	0.0067
LOGGDP	0.407828	0.029653	0.0000
[redacted]			
R-squared:	0.863109		
Adjusted R-squared:	0.858546		
F-statistic:	189.1525		
p-value	0.000000		

Appendix 2.2. – GDP and Residential Consumption

Variable	Coefficient	Std. Error	p-value
C	-0.031471	0.485860	0. 9488
LOGGDP	0.477352	0.033814	0.0000
[redacted]			
R-squared:	0.869160		
Adjusted R-squared:	0.864799		
F-statistic:	199.2879		
p-value	0.000000		

Appendix 2.3. – GDP and Commercial Consumption

Variable	Coefficient	Std. Error	p-value
C	3.060985	0.305138	0.0000
LOGGDP	0.181951	0.021237	0.0000
[redacted]			
R-squared:	0.709888		
Adjusted R-squared:	0.700217		
F-statistic:	73.40829		
p-value	0.000000		

Appendix 3. Granger Causality

Appendix 3.1. – GDP and MWC Water Consumption

Null Hypothesis	F-Statistic	p-value
LOGGDP does not Granger Cause LOGCONS	70.2981	5.E-11
LOGCONS does not Granger Cause LOGGDP	13.2663	0.0001

Appendix 3.2. – GDP and Residential Consumption

Null Hypothesis	F-Statistic	p-value
LOGGDP does not Granger Cause LOGCONS	90.7233	3.E-12
LOGCONS does not Granger Cause LOGGDP	15.7977	4.E-05

Appendix 3.3. – GDP and Commercial Consumption

Null Hypothesis	F-Statistic	p-value
LOGGDP does not Granger Cause LOGCONS	10.8950	0.0004
LOGCONS does not Granger Cause LOGGDP	4.82980	0.0168

Appendix 4. Error Correction Model

Appendix 4.1. – GDP and MWC Water Consumption

Variable	Coefficient	Std. Error	p-value
C	0.138587	0.264841	0.6060
LOGGDP	0.616669	0.191271	0.0039
EPSILON_MWC(-1)	0.062236	0.088541	0.4895
LOGGDP(-2)	0.259514	0.119134	0.0404
LOGMWC(-4)	0.756903	0.096368	0.0000
LOGGDP(-4)	-0.767056	0.185477	0.0004
[redacted]			
R-squared:	0.982974		
Adjusted R-squared:	0.979104		
F-statistic:	254.0220		
p-value	0.000000		

Appendix 4.2. – GDP and Residential Consumption

Variable	Coefficient	Std. Error	p-value
C	-0.258206	0.228592	0.2708
LOGGDP	0.691265	0.184051	0.0011
EPSILON_DOM(-1)	0.028304	0.073315	0.7032
LOGGDP(-2)	0.239099	0.119102	0.0571
LOGDOM(-4)	0.834030	0.085542	0.0000
LOGGDP(-4)	-0.834825	0.179396	0.0001
[redacted]			
R-squared:	0.988094		
Adjusted R-squared:	0.985388		
F-statistic:	365.1650		
p-value	0.000000		

Appendix 4.3. – GDP and Commercial Consumption

Variable	Coefficient	Std. Error	p-value
C	3.139862	0.333681	0.0000
LOGGDP	0.176462	0.023211	0.0000
EPSILON_COM(-1)	0.196318	0.192006	0.3153
[redacted]			
R-squared:	0.697546		
Adjusted R-squared:	*0.675942*		
F-statistic:	*32.28806*		
p-value	*0.000000*		

Appendix 5. Quarterly Data from 2010-2017

Quarter	GDP	MWC	DOMSEM	COMIND
2010Q1	1,333,040	1,087.13	809.86	277.36
2010Q2	1,453,390	1,139.48	856.68	283.77
2010Q3	1,380,231	1,155.18	861.44	292.01
2010Q4	1,534,877	1,119.76	841.71	277.91
2011Q1	1,394,150	1,098.71	823.87	275.93
2011Q2	1,500,321	1,142.95	864.44	278.35
2011Q3	1,422,446	1,133.87	853.95	280.02
2011Q4	1,593,285	1,130.15	847.75	283.89
2012Q1	1,480,580	1,129.25	846.31	282.66
2012Q2	1,592,299	1,176.72	890.00	288.73
2012Q3	1,522,288	1,149.31	869.91	286.91
2012Q4	1,710,061	1,164.20	879.43	285.14
2013Q1	1,593,347	1,152.32	870.16	282.05
2013Q2	1,717,614	1,224.84	937.54	287.12
2013Q3	1,624,837	1,189.94	903.15	287.80
2013Q4	1,814,833	1,180.11	891.25	289.31
2014Q1	1,681,987	1,181.74	892.79	289.49
2014Q2	1,833,846	1,269.61	967.47	302.93
2014Q3	1,715,368	1,240.02	940.42	300.15
2014Q4	1,934,277	1,225.52	926.61	299.61
2015Q1	1,767,389	1,201.10	912.17	288.57
2015Q2	1,944,664	1,301.21	995.51	305.90
2015Q3	1,824,442	1,283.54	982.22	301.50
2015Q4	2,063,680	1,264.90	968.42	297.59
2016Q1	1,889,409	1,264.97	967.72	295.56
2016Q2	2,083,189	1,348.14	1,038.79	309.16
2016Q3	1,954,481	1,319.27	1,017.79	301.45
2016Q4	2,199,324	1,301.13	1,002.55	298.93
2017Q1	2,010,290	1,289.01	995.51	293.41
2017Q2	2,222,797	1,372.33	1,067.40	305.00
2017Q3	2,091,655	1,352.20	1,048.96	303.48
2017Q4	2,343,545	1,336.82	1,034.66	302.96

References

Argawal, A. (1981). *Water Sanitation and Health for All.*

Fan, L., Liu, G., Wang, F., Geissen, V., & Ritsema, C. (2013). Factors Affecting Domestic Water Consumption in Rural Households upon Access to Improved Water Supply: Insights from the Wei River Basin, China. *PLos One*.

Gleick, P. (2003). Water Use. *Annual Review of Environment and Resources*, Vol. 28:275-314.

Hejazi, M., Edmonds, J., Chaturvedi, V., Davies, E., & Eom, J. (2013). Scenarios of global municipal water-use demand projections over the 21st century. *Hydrological Sciences Journal*, 58:3, 519-538, DOI: 10.1080/02626667.2013.772301.

Munasinghe, M. (1992). Water supply and developing applications.

Vörösmarty, C. J., Green, P., Salisbury, J., & Lammers, R. (2000). Global Water Resources: Vulnerability from Climate Change and Population Growth. *Science* , Vol. 289, Issue 5477, pp. 284-288.