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The Effect of Urbanization and Economic Performance on Metropolitan Water Consumption: Theoretic Model and Evidence from Guangzhou of China

Shaohui Gao[1,2], Yiming He[3,4]

[1]College of Economics & Management, South China Agricultural University, Guangzhou, Guangdong 510642, China

[2]College of Business Administration, University of Texas at El Paso, El Paso, TX 79968-0543, USA

[3]Division of Resource Management, P.O. Box 6108,West Virginia University, Morgantown, WV 26506, USA

[4]School of National Agricultural Institution and Development, South China Agricultural University, Guangzhou, Guangdong 510642, China

Correspondence: Yiming He, Division of Resource Management, P.O. Box 6108,West Virginia University, Morgantown, WV 26506, USA & School of National Agricultural Institution and Development, South China Agricultural University, Guangzhou, Guangdong 510642, China.

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Abstract

This paper examines the effect of urbanization and economic performance on metropolitan water consumption in Guangzhou of China. We develop social and individual optimal models to reveal the impact of urbanization and economic performance on metropolitan water consumption. Based on aggregated annual data from 1949 to 2014, the empirical results from OLS and ARDL suggest that previous water consumption per capita, urbanization and GDP per capita each play vital roles impacting metropolitan water consumption per capita in Guangzhou.

Keywords water consumption, urbanization, metropolitan performance, ARDL, Guangzhou

JEL classification Q25, O11, C32

1.Introduction

There are many studies on nexus between water and urbanization(Haase, 2009; Gober,2010; Wu et al.,2012; Barron and Donn,2013; Srinivasan et al.,2013; Yan et al., 2015; Engel et al.,2015; Maheshwari and Bristow,2016), but not many which examine the nexus among water consumption, urbanization, and economic growth. So, the objective of the paper is to examine the relationship among these variables. In this paper, we focus on the impact of urbanization and economic performance on water consumption, in Guangzhou of China from 1949 to 2014, applying OLS and ARDL these two econometric approaches.

Meanwhile, in terms of the research on the nexus between water consumption and urbanization, relatively little published literature examine this relationship (Katz, 2015). Gleick (2003) discusses definitions of water use, explores the history of water use around the world and in characteristic regions, identifies problems with collecting and analyzing water data, and addresses the question of improving water-use efficiency and productivity in different regions and economic sectors. He even found no discernable relationship between per capita national water withdrawals and income.

Barbier (2004) builds a growth model that includes this congestible nonexcludable good as a productive input for private producers. Growth is negatively affected by the government’s appropriation of output to supply water but positively influenced by the contribution of increased water use to capital productivity, leading to an inverted-U relationship between economic growth and the rate of water utilisation. Cross-country estimations confirm this relationship and suggest that for most economies current rates of fresh water utilisation are not yet constraining growth. However, for a handful of countries, moderate or extreme water scarcity may adversely affect economic growth. Nevertheless, even for water-scarce countries, there appears to be little evidence that there are severe diminishing returns to allocating more output to provide water, thus resulting in falling income per capita. These results suggest caution over the claims of some hydrological-based studies of a widespread global ‘water crisis.

Cazcarro, et al., (2013) examine how technology, processes of input substitution, and changes in final demand, all of which underlie economic growth, influence water consumption. Their analysis is undertaken for Spain during a significant socio-economic period, from 1980, the beginning of the democratic era, to 2007, the onset of the current economic crisis. To this end, they construct water consumption series linked to a time series of input-output tables generated for the Spanish economy, and they develop a structural decomposition analysis to study mainly changes in water consumption embodied in final demand. They find that the growth in Spanish demand would have implied an increase in water consumption almost three times the growth actually observed. However, this demand effect is largely offset by technology and intensity effects, mainly due to changes in agricultural crops. Given the importance of the demand growth, the final demand effect is also analyzed in detail, broken down by categories as well as level and composition. Household demand and the increase of exports appear as key explicative factors.

Ngoran et al.,(2016) suggest that economic growth in Sub-Saharan African countries is driven mainly by water and labor. Capital and energy were found not to significantly drive economic growth.

Obviously, previous empirical studies above have come under scrutiny in distinct literatures, the literatures remain disjointed. On one hand, the literature on the nexus between water consumption and economic growth does not consider the effect of urbanization. On the other hand, the studies on water consumption and urbanization just refer to their relationship but not the direct influence from economic performance. Although some empirical researches have calculated the empirically the links between water consumption and GDP, and the nexus between water consumption and urbanization, they do not examine the logic linkage among urbanization, economic performance and water consumption with theoretic models and in the same regression function. So, this study begins by explicitly linking the two literatures while providing insights into the interaction relationship among urbanization, economic performance and water consumption and investigates the interaction relationship among those three variables.

The rest of the paper is organized as follows. Section two presents a social and individual optimization model of water consumption in the presence of equipment complimentary and concerning water equipment capacity in the metropolitan economic growth. Section three describes the data used to carry out the econometric analysis and then summarizes empirical results. Section four provides the conclusions.

2. Theoretic Model

Consider the optimization problem of an individual who cares about the water resource that consumed indirectly through water access equipment, such as water tube and tap, and who takes into account the complimentary effect of water equipment on the water consumption. On the other hand, water is most used by industries, so when the total production output increase, as one kind of input, water also increase with a stable marginal speed respect to total income. In terms of the equipment for water use, individuals just need the tap and hose that are public goods supplied by government.

(1) Social Optimal Model

The social optimal model that we apply is originally introduced by Carroll et.al, (2000). But comparing with Carroll et.al,(2000)’s model that focus on saving behavior with habit, our model that just concentrates on water consumption with equipment is

$$\max_{wc,E}\int_0^{\infty} U(wc,E)e^{-\theta t}\,dt = \max_{wc,E}\int_0^{\infty}\frac{(\frac{wc}{E^{\gamma}})^{1-\sigma}}{1-\sigma}e^{-\theta t}dt \tag{1}$$

$$s.t.\begin{cases}\dfrac{dE}{dt}=\rho(wc-E) & (2)\\[2ex] \dfrac{dk}{dt}=(A-\delta)k-wc & (3)\end{cases}$$

Where U(.) represents the individual’s utility function, E is the equipment to water use, wc is the water consumption, σ is the coefficient of relative risk aversion, and γ indexes the importance of equipment and we assume $\sigma > 1$ and $0 \le \gamma < 1$. Equation (2) represents the equipment complimentary degree to water consumption, with the parameter $\rho(\ge 0)$ determining the relative weights of equipment complimentary to water consumption at different times.

We assume the metropolitan economic growth function with the urbanization A and water equipment capacity K is $Y = AK$. So, according to Carroll et.al,(2000)’s model, we get the water capacity evolves like equation (3), where water vaporization and leak because of the water equipment expired depreciates at rate $\delta \ge 0$.

The Hamiltonian function (Chiang and Wainwright,2004) is

$$H = U(wc, E) + \varphi[(A-\delta)k - wc] + \mu\rho(wc - E)$$

Carroll et.al,(2000) present the full solution to this problem with equations of motion relating consumption.

$$\frac{d}{dt}\left(\frac{\frac{dwc}{dt}}{wc}\right) = \sigma\left(\frac{\frac{dwc}{dt}}{wc}\right)^2 + \frac{\frac{dwc}{dt}}{wc}[2\theta+\rho+\delta-A-2\gamma\rho(1-\sigma)] - \rho^2\gamma[\gamma(1-\sigma)+1]\left(\frac{wc}{E}\right)^2$$

$$+2\gamma\rho(1-\sigma)\frac{dwc}{dt}\frac{wc}{E} + \left(\frac{\rho\gamma}{\sigma}\right)\frac{wc}{E}[\rho\gamma(1-\sigma)(2\sigma-1)+\theta+\rho-\sigma(2\theta+\delta-A)] + \frac{1}{\sigma}\{(\rho+\theta)(\theta+\delta-A)+\rho\gamma(1-\sigma)[\rho(\gamma(1-\sigma)+1)-(2\theta+2\rho+\delta-A)]\}=0$$

Setting the dynamic equation above equal to zero determines the steady state of the model,

$$\frac{\frac{dwc}{dt}}{wc} = \frac{A-\delta-\theta}{\gamma(1-\sigma)+\sigma}$$

In the steady state, water consumption (wc) and metropolitan economic growth (g) both grow at the same rate.

$$g = \frac{\frac{dY}{dt}}{Y} = \frac{\frac{dwc}{dt}}{wc}$$

So, $g = \frac{A-\delta-\theta}{\gamma(1-\sigma)+\sigma}$ and then $\frac{dg}{dA} = \frac{1}{\gamma(1-\sigma)+\sigma}$.

Here, we assume metropolitan aggregate demand function is $Y = (E + wc) + \varepsilon$. Where ε represents other types of aggregate demand in metropolitan level such as investment, government expenditure and net export. With an AK production function with depreciation rate δ, water consumption must be enough to make the water capacity grow at rate g after depreciation:

$$E = Y - wc - \varepsilon = (g+\delta)\mathrm{K} = \frac{(g+\delta)\mathrm{Y}}{A}.$$

Differentiating this expression with respect to g yields

$$\frac{\mathrm{dE}}{dg} = \frac{AY-(g+\delta)\frac{dA}{dg}Y}{\beta A^2} = Y\left[\frac{A-(g+\delta)\frac{dA}{dg}}{\beta A^2}\right] = \mathrm{Y}\left[\frac{A-(g+\delta)[\gamma(1-\sigma)+\sigma]}{\beta A^2}\right].$$

As a result, if $A-(g+\delta)[\gamma(1-\sigma)+\sigma] > 0$ or $\sigma < 1 + \frac{\theta}{\delta(1-\gamma)}$, and then $\frac{\mathrm{dE}}{dg} > 0$.

Additionally, according to the definition of rate of economic growth $g(t) = \frac{\frac{\mathrm{dY}}{dt}(t)}{Y(t)}$, we get the derivative of g with respect to t,

$$\frac{\mathrm{dg}}{dY} = \frac{\frac{d}{dt}\left(\frac{\mathrm{dY}}{dt}\right)Y - \left(\frac{\mathrm{dY}}{dt}\right)^2}{Y^2}$$

So, If $\sigma < 1 + \frac{\theta}{\delta(1-\gamma)}$ and $\frac{d}{dt}\left(\frac{\mathrm{dY}}{dt}\right)Y > \left(\frac{\mathrm{dY}}{dt}\right)^2$, $\frac{\mathrm{dE}}{dY} = \frac{dE}{dg}\frac{\frac{d}{dt}\left(\frac{\mathrm{dY}}{dt}\right)Y - \left(\frac{\mathrm{dY}}{dt}\right)^2}{Y^2} > 0.$

On the other hand, from the steady state condition $\frac{\frac{dY}{dt}}{Y} = \frac{\frac{dwc}{dt}}{wc}$, we take integration in both sides

$$\int \frac{1}{Y}dY = \int \frac{1}{wc}dwc + \mathrm{B}$$

The solution of the equation above is $LnY = Lnwc + B$ or $\mathrm{Y}=e^{Lnwc+B}$. Then by the equation $F(Y, wc) = LnY - Lnwc - B = 0$ and the implicit function theorem, we obtain the a corollary

Corollary 1 $\frac{dwc}{dY}=-\frac{\frac{\partial F}{\partial Y}}{\frac{\partial F}{\partial wc}}=-\frac{\frac{1}{Y}}{-\frac{1}{wc}}=\frac{wc}{Y}=\frac{wc}{e^{Lnwc+B}}>0$

From equation (3), in terms of the short run, we have $\frac{dk}{dt}=0=(A-\delta)k-wc$. That's to say, $wc=(A-\delta)k$. So, we obtain the second corollary:

Corollary 2 $\frac{dwc}{dA}=k>0$.

(2) Individual's Optimal Model

The individual's optimal model that we continue to apply Carroll et.al, (2000) model, but comparing with Carroll et.al,(2000)'s model that focus on saving behavior with habit.

$$\max_{c,h} U(c,h)=\max_{c,h}\frac{(\frac{c}{h^{\gamma}})^{1-\sigma}}{1-\sigma}e^{-\theta t}dt \tag{4}$$

$$s.t.\begin{cases}\dfrac{dh}{dt}=\rho(c-h) & (5)\\ \dfrac{dk}{dt}=y-(oc+c)-(n+\delta)k & (6)\end{cases}$$

Where U(.) represents the individual's utility function, h is the stock of habits, c is the instantaneous flow of the sum of consumption of water and water equipment, oc represents other consumption except from c, σ is the coefficient of relative risk aversion, and γ indexes the importance of consumption habits and we assume $\sigma>1$ and $0\leq\gamma<1$. Following Carroll et.al(2000), if γ =0 then only the absolute level sum of consumption matters and consumption habits does not matter. If γ =1, then consumption relative to the habit stock is all that matters. Note that, in Carroll's paper, habits and consumption can move in opposite directions (consumption goes up habits go down, or vise versa). Here, we assume c is an increasing functional of water consumption (wc) and water equipment consumption(E): $c=c(wc,E)$, $\frac{\partial c}{\partial wc}>0$, and $\frac{\partial c}{\partial E}>0$.

Equation (5) represents the habit stock is a weighted average of past sum of consumption with the parameter $\rho(\geq 0)$ determining the relative weights of sum of consumption at different times. The larger is ρ, the more important is the sum of consumption in recent past.

Furthermore, we assume the long run economic growth function with the urbanization A and per capita water k(=K/L) is $y=AkL$. Here, y(=Y/L) is per capita output, K represents total water supply and L represents total labor.

When we denote labor grows as $\frac{dL/dt}{L}$=n (n>0) , we can obtain the dK/dt by differentiating K(t)=k(t)L(t): $\frac{dK}{dt}=L\frac{dk}{dt}+k\frac{dL}{dt}=L\frac{dk}{dt}+knL$. On the other hand, when I represents investment and S represents saving, and the rate of water equipment depreciation is $\delta\geq 0$, according to the water stock identity $\mathrm{K(t)=K(t-1)+I-\delta K}$ and macroeconomic equilibrium for two sectors(I=S), we get $\frac{dK}{dt}=\frac{\mathrm{K(t)-K(t-1)}}{t-(t-1)}=\mathrm{S-\delta K}$. So, $L\frac{dk}{dt}+knL=\frac{dK}{dt}=\mathrm{S-\delta K}$. And through saving function S=Y-C, and then $L\frac{dk}{dt}+knL=Y-C-\delta\mathrm{K}$, so $\frac{dk}{dt}=y-tc-(n+\delta)k=y-(oc+c)-(n+\delta)k$, where tc is per capita total different kinds of consumption.

The Lagrange function is

$$\mathcal{L}=U(c,h)+\varphi[y-(oc+c)-(n+\delta)k]+\mu\rho(c-h) \tag{7}$$

The resulting first-order conditions are

$$\frac{\partial \mathcal{L}}{\partial c} = (\frac{c}{h^{\gamma}})^{-\sigma} e^{-\theta t} - \varphi + \mu\rho = 0 \quad (8)$$

$$\frac{\partial \mathcal{L}}{\partial h} = -\gamma h^{\gamma(\sigma-1)-1} c^{1-\sigma} e^{-\theta t} - \mu\rho = 0 \quad (9)$$

$$\frac{\partial \mathcal{L}}{\partial \varphi} = y - (oc + c) - (n + \delta)k = 0 \quad (10)$$

$$\frac{\partial \mathcal{L}}{\partial \mu} = \rho(c - h) = 0 \quad (11)$$

So, the optimal solutions are

$$\varphi^* = e^{(n+\delta-\mathrm{AL})t}\varepsilon \ \ , \ \ \varepsilon\ is\ a\ constance \quad (12)$$

$$\mu^* = e^{\rho t}\epsilon\ , \ \ \epsilon\ is\ a\ constance \quad (13)$$

$$c^* = h^* = y^* - oc - (n+\delta)k \quad (14)$$

So, we get a corollary:

$$\frac{dwc^*}{dy^*} = \frac{dwc^*}{dc^*}\frac{dc^*}{dy^*} = \frac{1}{\frac{dc^*}{dwc^*}} \times 1 > 0$$

Corollary3 If c is an increasing functional of wc, $\frac{dwc^*}{dy^*} = \frac{dEC^*}{dY^*} > 0$.

The economic implication of corollary 3 is that in short run, only if c is an increasing functional of wc, on the equilibrium, output will improve water consumption.

In short, the economic explanation the relationship between the social optimal model and individual's optimal model is that the social optimal model aggregates the individuals' preference relation and replaces the individual's utility function with the social welfare function subject to dynamic conditions. Furthermore, individual's optimal model only considers the static conditions. As a result, social optimal model represents the long run status, while individual optimal model represents the short run status, which will be tested in the empirical section.

3. Empirical Tests

3.1 Data Sources and Hypothesis

The time series data about the water consumption, urbanization and economic performance of Guangzhou are from 1949 to 2014. The time series data about the GDP, water consumption, urbanization are obtained from the Guangzhou statistical yearbooks from 2000-2015 and the "Guangzhou 50 years"(GSD,2015).The direction of causality among urbanization, water consumption and metropolitan economic growth in the light of the literature overview is not consistent and depends on different datasets, the characteristics of different countries and the different econometric methodologies applied. Taking into account about the three corollaries in the section part, we may expect that the following hypothesis might hold true for Guangzhou:

Hypothesis 1 There exists positive effect from metropolitan economic performance on water consumption of Guangzhou.

Hypothesis 2 There is positive effect of urbanization on water consumption of Guangzhou.

3.2 Variable Descriptions and Summary Statistics

Table 1. Variable Definitions

Variable	Mnemonic	Definition	Unit
Metropolitan Economic Performance	Y	Annual GDP in Guangzhou/Total population	10000 Yuan RMB/person
Urbanization	U	(non-agricultural population / total population)*100	%
Water Consumption	W	Total annual Consumption of Water/ Total population	10000 cu.m/person

Table 1 lists all variables and their definitions used in the empirical analysis.

Table 2. Descriptive statistics

VARIABLE	Y	W	U
MEAN	2.633973	0.009978	55.82714
MEDIAN	0.131641	0.009169	55.56978
MAX	19.83207	0.020340	67.96087
MIN	0.008424	0.000444	47.01945
STD DEVIATION	4.885201	0.007028	5.169785
SKEWNESS	2.135621	0.047695	-0.022636
KURTOSIS	6.627690	1.486626	1.945452
OBSERVATION	66	66	66

Table 2 lists summary statistics for every variable included in the sample. As shown by the information contained in Table 2, the sample data exhibit good variability. As would be expected for data from growing metropolitan economies, the skewness coefficients for the variables in Table 2 are noticeably greater than zero. The variables are also found to be strongly leptokurtic.

3.3 Econometric Results

In this section, the unit root tests with ADF approach, Perron's modified ADF with exogenous breakpoint and Zivot and Andrews's approach by break data endogenously are given before the Johansen Cointergration Test and ARDL Bounds Test Approach to Cointegration. At the end, the regressions for long run and short run using OLS and ARDL show the final empirical results about the relationship among urbanization, economic performance and water consumption.

3.3.1 Unit Root Tests

(1) ADF Test

Standard Granger causality tests have to be conducted on stationary time series. Following this line, we first test the unit roots of Xt to confirm the stationary properties of each variable. This is achieved by using the Augmented Dickey-Fuller test.ADF test is applied to detect the possible presence of unit roots in Y,W, and U. The null hypothesis of unit root can be rejected in favor of the alternative hypothesis of no unit root when the absolute value of ADF-test statistic is greater than the absolute value of critical value.

Table 3. ADF unit root test results

Levels				First differences			
Variables	ADF-test statistics	Lag length	MacKinnon critical values (5%)	Variables	ADF-test statistics	Lag length	MacKinnon critical values
Y	1.605244	8	-3.490662	ΔY	1.647814*	9	-1.612999
U	-1.328671	0	-3.480463	ΔU	-6.708105***	0	-4.107947
W	-1.938298	0	-3.480463	ΔW	-6.232793***	0	-4.107947

Note: * shows significance at 10% level;** shows significance at 5% level;*** shows significance at 1% level.

The results in table 3 show that all variables are non-stationary in their levels since the absolute values of test statistics for each variable are smaller than 5% critical values. On the other hand, W,Y and U are stationary processes in their first differences because the absolute values of test statistics for each variable are greater than MacKinnon critical values. Specifically, the absolute values of test statistics for Y are greater than 10% critical values, and the absolute values of test statistics for U and W are greater than 1% critical values. The leg length for each variable is chosen by the Eviews 9.0.

(2) Perron's modified ADF test with exogenous breakpoint

Perron's computation of modified Dickey-Fuller tests allows for levels and trends that differ across a single break date.

Table 4. Perron's modified ADF unit root test results

Variables	T-statistic	Break Data	5%critical values	Variables	T-statistic	Break Data	5%critical values
Y	-3.877079	2005	-4.443649	ΔY	-5.033726**	2003	-4.443649
U	-2.847252	1983	-4.443649	ΔU	-8.170638**	2002	-4.443649
W	-2.020571	1968	-4.443649	ΔW	-7.071947**	2001	-4.443649

Note: **indicates significance at 5% level.

Table 4 reports that all variables are integrated of I(1) and thus stationary in first difference, comparing the absolute values of test statistics for each variable with the 5% critical values. The break date for each variable is chosen by the Eviews 9.0.

(3) Zivot and Andrews's test by break data endogenously

The results of Zivot–Andrews are detailed in Table 5 which shows that non-stationary process is found in all series at level with intercept and trend but variables are found to be stationary at first difference.

Table 5. Zivot-Andrews's structural break trended unit root test results

Variables	At Level			Variables	At First Difference		
	T-statistic	Break Data	5%critical values		T-statistic	Break Data	5%critical values
Y	-7.072308	1995	-4.93	ΔY	-4.860837**	1998	-4.42
U	-2.699559	1984	-4.93	ΔU	-8.147100**	2003	-4.93
W	-3.202217	1985	-4.93	ΔW	-7.072308**	1995	-4.93

Note: **indicates significance at 5% level.

Table 5 confirms that W,Y and U are integrated at I(1). The break date for each variable is chosen by the Eviews 9.0.

3.3.2 Cointegration Tests

According to the unit root test results, integration of the variables is of the same order. We continued to test whether these variables are cointegrated over the sample period.

(1) Johansen Cointergration Test

Table 6 shows the results of the Johansen test.

Table 6. Johansen cointegration test results

Hypothesized Number of Cointegrating equation	Trace Statistic	5%Critical Value	Eigenvalue
None**	43.34525	42.91525	0.267003
At most1	23.77660	25.87211	0.254798
At most2	5.248292	12.51798	0.079931

Note: **indicates significance at 5% level.

Because the trace statistic of none cointegrating equation and at less one cointegrating equation are greater than the 5% critical values, respectively, the test rejects the hypothesis of no cointegration, and indicates that there is at least one cointegrating equation at the 5% significance level, i.e. there may be a long-run relationship among Y, W and U for Guangzhou.

(2) ARDL Bounds Test Approach to Cointegratio n

Armed with information about stationarity, we apply the ARDL bounds testing approach to cointegration.

Table 7. Bounds Test Results

Bounds testing to cointegration				
Estimated model	Lag length	F-statistic	5% critical values	
			I(0)	I(1)
f(Y/U,W)	(4,0,0)	2.023761	3.1	3.87
f(W/Y,U)	(1,0, 4)	10.74961**	3.1	3.87
f(U/Y,W)	(2,3,0)	2.024336	3.1	3.87

Note: **indicates significance at 5% level.

The results of the bound test are given in Table 7. From these results, it is clear that there is only a long run relationship among the variables when W is the dependent variable, because the F-statistic is higher than the upper-bound critical value at the 5% level. This implies that the null hypothesis of no cointegration among the variables are rejected, when W is dependent variable. However, when Y and U are dependent variables, the null hypothesis of no cointegration is accepted.

3.3.3 Results in the Long Run and Short Run using ARDL model

After establishing cointegration among the series, we explore the long and short run relationship among Y and U on W in case of Guangzhou.

In terms of long run OLS model, the results reported in Table 8 show that Y and U both are positively related to W and it is statistically significant at one percent level. This implies that Y and U play vital role to drive up W in Guangzhou, which is consistent with hypothesis 1 and 2.

Table 8 also reveals that the estimated error correction term of coefficient for ARDL short run regression is negative and significant at one percent level ensuring that the adjustment process from the short-run deviation to equilibrium is fast. The ARDL in long run and ARDL in short run estimated coefficients of Y_{t-4} and ΔY_{t-4} are positive and significant at ten percent level. This implies that there is a statistically significant, short-run lag over four periods with a positive impact of change of Y on the change of W in Guangzhou. That is to say, Y does not push up the W instantaneously, rather their impact appears four years later. The economic explanation of the result above is that there is a time tag effect of metropolitan economic performance on water consumption. So, there is a four years long process for the Y influencing W.

Additionally, the OLS and ARDL estimated coefficients of W_{t-1} and ΔW_{t-1} are positive and significant at one percent level. This implies that there is a statistically significant short-run (lag one period) positive impact of change of W in last year on the change of W. The economic meaning about the OLS and ARDL estimated coefficients of W_{t-1} and ΔW_{t-1} is that the usage of water has been continuously increasing because of the effect of "path dependence" during the process of metropolitan economic development.

Table 8. Regressions for Long run and Short run using OLS and ARDL

Long Run Regression			Short Run Regression		
OLS (Dependent variable =W_t)			OLS (Dependent variable = ΔW_t)		
Independent Variables	Coefficient	T-Statistics	Independent Variables	Coefficient	T-Statistics
Y_t	0.000597	4.537936***	ΔY_t	-4.70E-05	-0.925514
U_t	0.000663	5.333297***	ΔU_t	-0.000183	-1.515664
Constant	-0.028593	-4.219925***	ΔECT_{t-1}	0.015791	1.082028
			Constant	0.000362***	4.996196
ARDL(Dependent variable =Wt)			ARDL(Dependent variable =ΔWt)		
W_{t-1}	1.032329	67.49180***	ΔW_{t-1}	1.256647***	4.117412
Ut	2.98E-07	0.018253	ΔUt	-3.02E-05	-0.610444
Y_t	0.000210	0.547253	ΔY_t	2.30E-05	0.061416
Y_{t-1}	-0.001366	-2.140936**	ΔY_{t-1}	-0.000991*	-1.771700
Y_{t-2}	-0.000140	-0.217858	ΔY_{t-2}	-8.28E-05	-0.191726
Y_{t-3}	-0.000406	-0.531765	ΔY_{t-3}	0.000129	0.228411
Y_{t-4}	0.002200	2.814121***	ΔY_{t-4}	0.001323*	1.675756
Constant	0.000171	0.200454	ECT_{t-1}	-1.264877***	-3.781713
			Constant	-7.38E-05	-0.567226

Note:* Shows significance at 10% level;** Shows significance at 5% level;*** Shows significance at 1% level.

4. Conclusion

To analyze the impact of urbanization and metropolitan economic performance on water consumption in Guangzhou City of China, econometric models are utilized with and without break date. The results of OLS and ARDL in long run show that metropolitan economic performance and urbanization both are positively related to water consumption and it is statistically significant at one percent level. This implies that metropolitan economic performance and urbanization play vital role to drive up water consumption in Guangzhou. So, the hypothesis 1 and 2 cannot be rejected. The empirical results also reveal that the OLS and ARDL estimated coefficients of Y_{t-4} and ΔY_{t-4} are positive and significant at ten percent level. This implies that metropolitan economic performance does not push up the water consumption instantaneously, rather their impact appears four years later. So, there is a four years long process for the metropolitan economic performance influencing water consumption.

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