HOW DOES THE DEGREE OF EXPORT DEPENDENCE AFFECT CHINA'S CLEAN DRINKING WATER?

check for updates

Abdelrahim A. M. Yahia[1+]
Ismaeel A. M. Ahmed[2]
Nada R. A. ALhassan[3]

[1]School of Economics, Huazhong University of Science and Technology, Wuhan, China, and Department of Economics, University of Kassala, Kassala, Sudan.
[1]Email: abdelrahim2uofk@gmail.com Tel: +249911202826
[2,3]Department of Economics, University of Kassala, Kassala, Sudan.
[2]Email: ismaeel8416@gmail.com Tel: +249915392983
[3]Email: nadaalabed2005@gmail.com Tel: +249124315995

(+ Corresponding author)

ABSTRACT

Access to clean drinking water has become an increasingly urgent concern for China's government in the current decade. However, with the continuous economic growth, high export orientation, and investment in infrastructure, the interconnected challenges related to clean drinking water are stressed. This study aims to explore the effects of exports, in addition to such greatest factors affecting clean drinking water in China during 2000–2017. To provide comprehensive results we employ a co-integration approach, and conduct the empirical analysis by applying a semi-parametric regression model. Empirical results show that while the degree of export dependence exerted on clean drinking water negative effects, but has no predictive linear Granger cause. The results from the nonlinear model indicate that the effect of exports on clean drinking water shows an inverted "U-shaped" nonlinear impact in the national and urban levels. This indicates that only in the earlier stages, the degree of export dependence driving clean drinking water, and did not play a promoting role in the later stages. On the contrary, it exerts a positive "U-shaped" pattern at the rural level. The evidence for the impact of income inequality on expanding or contracting access to clean drinking water at overall levels is mixed.

Contribution/ Originality: This study contributes to the existing literature on estimating the effect of the degree of export dependence on clean drinking water in China by employing the most robust econometric technique. The uniqueness of the study is examining nonlinear effects of the degree of export dependence in clean drinking water.

1. INTRODUCTION

In the last decades, China's economy has grown rapidly with high export orientation, strong investment in infrastructure, and heavy energy-intensive industrialization. Particularly, China's exports, population, and per capita resource consumption have increased (Dilekli & Cazcarro, 2019; Yahia & Li, 2021). However, with the continuous economic growth phase and population the interconnected challenges related to the water crisis, air pollution, energy, and environmental sustainability are stressed, particularly, clean drinking water. In this regard, Rudra (2011) emphasized that about 20% of the world population does not have to receive sufficient drinking water. Water is at the dynamo of economic development: it is essential to grow food, generate power, maintain health, and manage the environment. Clean water is the main target for the achievement of the 2030 development agenda.

179

Thus, without ensuring access to clean water, the nation will not be able to meet the SDGs, and still, now clean water remains elusive for numerous countries. In 2015, above 663 million people lived without access to drinking water from improved water sources (WHO/UNICEF., 2015), and 1.3 million deaths worldwide were attributable to unsafe water sources (Landrigan et al., 2018). Many countries struggled to meet other objectives of water security, including ensuring reliable supplies for productive activities and safety from the impacts of extreme events such as pollution, floods, and droughts.

China faces ever-increasing challenges in improving access to clean drinking water, has total water consumption continued to increase recently, accounting for about 170 billion cubic meters, and reached 610.32 billion cubic meters in 2015 (China Statistical Yearbook, 2015). However, the shortage of water resources in China provinces has been rising noticeably, in 2015, 24 provinces out of 31 provinces suffer from shortages in water resources, and 11 provinces are seriously short of water resources, and only 7 provinces are not face short in water resources. Moreover, the situation is the same at the city level, about 95% of Chinese cities with more than one million inhabitants suffering from long-term deficiency (China Water Resources Bulletin, 2015).

Among the all water resources in China, the effective water resources represented only by 39%, the per capita of water resources is also relatively low, was only 28% of the world average in 2016. In this regard, the enforcement of environmental regulations and standards are showed effectiveness which is evidenced by the statistics of pollution indicators. In response to this situation, and to achieve access to basic water and sanitation services by 2030 (SDGs goals), China's government has committed to improving water quality, water resources, and availability by introducing numerous new policies. For instance, the government initiated the "13th Five-Year Plan for Water-Saving Society Construction". The main objective of this proposal that China will implement the most stringent water resources management system, promote water resources and build a water-saving society. Nevertheless, in existing policy frameworks, export-clean water nexus policies are largely trapped in China's territory.

It is noteworthy that when the countries expand their levels of economic activity, international trade, as well as specialize in sectors in which they enjoy a comparative advantage; their economic sectors are probable to display changing economic activity water-quality patterns. As a result, trade has essential roles for example in agricultural goods will help countries have a lack of water for local production to attain food security. Also, a secure water supply is necessary for most industries to trade in their products. However, besides the positive link between trade and water, trade also has negative effects, when it encourages economic activities that harm the water environment. Furthermore, if the national regulation is not solid enough to protect the economic resource. Consequently, China's trade expansion posits the main question of whether the gain from international trade is good or bad for clean drinking water.

One might argue that the investigation of the water consumed in the agricultural and industrial export sectors is rooted in the crisis of potable water. Thus, agricultural exporters play a major role in the crisis of clean water through growing pesticide use, which leads to huge contamination of water supplies (Paarlberg, 1992). In developing countries the volume of exports from these sectors increasing rapidly, and no surprise that these two sectors are represented as the major consumer of water with annual water withdrawal on average accounts for 69% and 19% of global water withdrawals for the agriculture sector and industrial sector respectively (Infographics (AQUASTAT), 2014). Therefore, numerous scholars and policymakers have concern about the foreign trade consequences on drinking water, because access to safe drinking water is still an issue in many countries, and providing clean water to all is one of the greatest challenges of the 21st century especially in developing countries because has expected about 50% of the population to live in cities by 2050.

Based on the above understanding, it is particularly critical to explore the effect of China's international trade on clean drinking water, and from this perspective provides a supplement to explore the resource of clean water and environmental effects of China's exports.

We are not aware of any evidence that addresses empirically the impact of trade on clean water/water scarcity, it is an important area for policymakers active in economic development. Thus, this gap is worrisome, so this study aims to provide a preliminary framework for investigation in this area.

This present study has several distinguishing features to China's environmental quality. First, it investigates how previous research in international trade can be useful to contribute in the debate on the country of drinking water. Clean water is a fundamental natural resource for major economic activities, depending on trade theory, the study focused on the relationship between international trade (the degree of export dependence) and clean drinking water in China during the period 2000-2017. Second, the study also considered the imports side, by determining how clean water respond to change in imported goods. Third, major control variables, the study aims to examine the main factors that influence clean drinking water such as national income (GDP per capita), income inequality, and population density based on the full modified ordinary least squares (FMOLS) method to investigate the co-integration and vector error correction model (VECM) for heterogeneous co-integrated series. Furthermore, to the best of our knowledge, the study also contributes to this field by examining for the first time nonlinear effects of the degree of export dependence in clean drinking water. The reason for examining this technique can be justified also from a theoretical standpoint. Thus, different from the existing empirical researches, which assumes strong assumptions concerning the functional form and the distribution of the residual error term, to avoid the potential of the misspecification form, the study utilizes a flexible semi-parametric double residual estimator which expanded by (Robinson, 1988).

The remainder of the study is organized as follows: In the next section, we depict the definitions and measures of access to drinking water. In section 3 we present the relevant review literature. In section 4 we discussed the theoretical model, econometric specification, and data collection. Section 5 presents our empirical results. Section 6 discussion and Section 7 concludes.

2. CONTEXT OF CLEAN DRINKING WATER

China's environmental problems are extensive, but currently, the issue of water pollution is one of the most pressing issues. Therefore, in recent years, clean drinking water has been highlighted because it is an essential for economic development, fight against poverty as well as recognized as a human right

Thus, according to the target 6 of the SDGs, improving water quality and scarcity issues by growing water-use efficiency and reduce the number of persons prone to water shortages (UNDESA, 2015). Therefore, World Health Organization/United Nations Children's Fund (WHO/UNICEF) Joint Monitoring Programme (JMP), defined the access to drinking-water states that it the *"Percentage of population using an improved water source"*. However, some scholars argued that access to drinking water is *"a steady water resource that conveniently allocates adequate quantity and quality"* by Emenike et al. (2017).

Thus, the variable of clean water is measured as the change in the average ratio of the population using improved access to drinking water sources, this indicator is appropriate because it is playing a role to capture both kinds of water either quality or quantity of water. Regard with quality, because it includes improved sources, such as all piped water on-premises, public taps/standpipe, surface water, and rainwater collection. And quantity because it also considers the level of water by determining the daily amount of water for a person at least 20 liters within one kilometer of the dwelling. Actually, in 1993, WHO has defined the basic access to clean drinking water as having 50 liters per person per day (Smith & Hanson, 2003). Nevertheless, for everyone to be able to get enough clean water, in 2003 WHO redefines the basic access to denote having to average quantities not below 20 liters per capita per day (Hoekstra, 2003).

This indicator was mainly measured and established jointly by (WHO/UNICEF) in 1990 through JMP for drinking-water and sanitation monitoring. However, unimproved water sources include unprotected dug wells,

unprotected springs, tanker trucks, bottled water, and surface water. Thus, the main access metric used in our study is equivalent to the "improved drinking water access" metric tracked by the JMP.

3. LITERATURE REVIEW

Since the availability of clean drinking water has more benefits for the economic activity, quality of the environment, and human health, there is significant interest in international trade and consequences of providing clean drinking water, mainly to ensure economic development. The issue of availability of water related to growth and population size, it has been the subject of a numeral of scholars going back more than a decade (Vörösmarty, Green, Salisbury, & Lammers, 2000). Although, historically water scarcity has been more serious in developing countries as it is directly correlated with increasing world population, agricultural activities, industrial, and technology (Flendrig, Shah, Subrahmaniam, & Ramakrishnan, 2009). On the other hand, also water scarcity is a growing problem in rural areas, emerging trends indicate worsening quantity and quality in urban areas as a result of changes in clean water resources such as problems caused due to climatic shifts, poor sanitation, increasing population growth, as well as the lack of water treatment facilities. Thus, access to adequate improved clean drinking water supplies is mainly worrying considering the consequences for food production, public health, livelihoods, and wellbeing (Dos Santos et al., 2017). As a result, governments are constantly struggling to settle available water supply with growing demand.

In this study, to overview the related empirical evidence on the clean water-international trade variables relationship it can be divided into three groups: first, the studies focusing on the exports-clean drinking water indicators relationship and second, the empirical evidence which focused on the virtual water trade side, and third, the studies considering this linkage with the main factors that influences clean drinking water.

In the first group, the studies concentrated on the relationship between exports and clean drinking water indicators in a certain country or a group of countries. Despite the importance of international trade, we are not aware of many published empirical studies examining clean drinking water-international trade/exports nexus. An earlier study by Rudra (2011) has study focuses on the interaction of trade "both international and domestic" as the main driving forces behind promotes/constraints to access drinking water in 77 developing countries, in addition to case studies for two developing countries Vietnam and India. And therefore estimates the relationship using OLS model. The empirical evidence provides strong findings for the negative effects of exports on clean drinking water, especially in nations with a skewed distribution of income, after controlling her model by other factors, such as lower-income inequality can blunt this effect. Unlike our study, this model does not separate the analysis technique between urban and rural access.

Although researchers have examined how international trade indicators affect clean water, they have given much less thought to domestic water resources. For instance, the impacts in clean water which is concentrated in commodities that takes clean water in the exporting countries which can no longer be used for other (domestic) purposes. Besides, the role of international trade in clean water-intensive goods generates water savings in many countries that import those commodities (Allan, 2003).

In numerous countries, international trade in agricultural sectors effectively decreases domestic water demand (Hoekstra & Chapagain, 2011). Most of these countries export goods that are less water-intensive, and they import relatively water-intensive. Besides, an empirical analysis study by Hoekstra and Chapagain (2011) found that 16% of the water used in the world during the period 1997 to 2010, was not used for making products for local consumption but for producing products for export, and countries with the highest net annual water use for making export products were the USA, Australia, Argentina, Canada, Brazil, and Thailand respectively. Most of these countries used water to produce cereal crops and oil-bearing crops.

The second group of research is related to the virtual water trade. The empirical evidence mainly focuses on virtual water trade in most case studies which indicate water used in production and services (Allan, 2003). Virtual

water indicates that the total amount of water that is used to produce a product, according to this concept, international goods trade has been analyzed in terms of virtual water flows (Hoekstra, 2003). Thus, this definition examines the gain from trade between the high-intensity country and low-intensity water use, for instance, in most cases, most food exporters rely on high productive rain-fed agriculture. However, the major food importers depend on irrigation or low output rain-fed system. Therefore, trade in virtual water can decrease consumptive water use in agriculture, likewise, industry provided that exporters attain higher water productivity than imports (De Fraiture, Cai, Amarasinghe, Rosegrant, & Molden, 2004). Several studies mainly focus on the potential of virtual water trade to mitigate water stress by exporting or importing some goods have water-intensive for instances; (Dalin, Konar, Hanasaki, Rinaldo, & Rodriguez-Iturbe, 2012; Xu, Yao, Zhang, Dowaki, & Long, 2020) On the other hand, some strand of evidence concentrates on water transfers for purposes of the agricultural purposes such as irrigation (Dalin, Hanasaki, Qiu, Mauzerall, & Rodriguez-Iturbe, 2014).

The third group of study is related to the linkages between exports and main factors that influence clean drinking water, such as imports volume, national income (GDP per capita), and income inequality. Empirical evidence showed inconclusive relationships between number influencing variables and access to clean water. For instance, in several studies using different methods, countries with higher clean drinking water were found to be associated with a higher level of import volume, high levels of national income (economic development), and lower levels of income inequality (Rudra, 2011; Whitford, Smith, & Mandawat, 2010).

Many scholars declared an observed positive relationship between the imports volume of countries and clean drinking water, and highly imports countries tend to report higher access to clean drinking water because they depend on economies of scale which reduce the costs of access to clean water services. Absolute water scarcity is expected to hampers production and necessitates imports of water-intensive goods like cereals in the most water-scarce regions of the world (Yang, Reichert, Abbaspour, & Zehnder, 2003). The demand for cereal imports increases exponentially with decreasing water resources.

Several studies have declared that GDP per capita, a measure of a country's economic development and living standards (OECD, 2018), and is a strong indicator of access to clean water (Hopewell & Graham, 2014). The outcomes from previous studies revealed that higher-income countries tend to achieve greater access to clean water than lower-income countries, due to depending on more advanced technologies and robust regulatory environments Rudra (2011). Smith and Hanson (2003) a study in Cape Town, South Africa found out that household income is one of the main factors of access to water. The study revealed that households with lower incomes have inadequate opportunities to improve their water conditions. Likewise, UNICEF assessments that households in the highest wealth quintile are more likely to enhance improved clean water access, compared with households in the lowest wealth quintile in the same country. Bosch, Hommann, Rubio, Sadoff, and Travers (2001) assessed the income effects on access to safe water. They indicated that the income levels of households determine access to water facilities. Furthermore, the low-income individuals are hardly able to pay high fees to piped water, therefore, limit their connectivity. But the higher income groups can able to access clean water.

Furthermore, in the countries which have higher levels of income inequality, the poorer households will use unimproved water sources, characterized by collective action difficulties emanating from different group interests and weak governance institutions, therefore, these will be reflected in poor access to water service delivery (Rudra, 2011) and then access clean water failure. In the case of access to clean drinking water, the inequality reflects the broader socioeconomic inequality in the nation. However, most research that concentrated on the country level focused on the role of income inequality in clean access water and found that countries with high-income inequality received unimproved water sources (Lim & Prakash, 2020).

Previous studies that explored the relationship between water and international trade have largely based on water pollution as an environmental issue. Thus, a possible extension to the literature is to use other indicators on the environmental quality side, such as clean drinking water, which is the research objective of this study.

4. MATERIALS AND METHODS

In the last decades, China has undergone remarkable growth in population and economic growth rate which averaged 10% per year for more than 20 years. However, the country sustained growth and health are increasingly threatened by deterioration of the environment and constraints, mainly around water. Therefore, water is considered critical for economic growth, the health of the country, and well-being. Conversely, all economic activities have an essential role in water quality and availability. If water resources are scarce or contaminated, and economic activity is inadequately regulated, then serious social problems can arise. Thus, in China most of these indicators have come together which will lead to more severe and complex water challenges. Therefore, to investigate the role of international trade in clean drinking water this measure is widely used in studies investigating access to drinking water globally.

On the other hand, access to clean drinking water leads to increase consumption at less cost and improves the situation of health. This consequently will be reflected in improved living standards via a decrease in disease burden and reduction in poverty. Therefore, this study considers how international trade influences access to clean drinking water as the main objective of the research. The analysis of indicators that influence clean drinking water requires the use of a nonlinear regression model. The method is discussed in this section. Based on the previous evidence, we summarize the main indicators that affect clean drinking water in this section.

4.1. Selection of Variables

To investigate the objective of this study, three types of dependent variables (clean drinking water) were considered: National, urban, and rural levels, to identify the influence variables on access to clean water. The study focused on the "Percentage of population using an improved water source" as a measure of access to clean water as we mentioned in the previous section, the period of this study covers 2000 to 2017, following (Cesar, 2019; Rudra, 2011).

One of the most important factors (our key independent variable) is the degree of export dependence. The growth of the international trade sector constitutes a significant structural change in most sectors that influences clean drinking water. Thus, exports (measured by exports as % of GDP) are determined as an indicator of international trade.

We determined other control variables based upon how they affect clean drinking water, in this regard, the economic independent variables such as imports and national income used in this study, were largely informed by previous research (Hopewell & Graham, 2014; Yang et al., 2003). The income inequality parameter included in this study were selected as a factor of potential inequality access to clean drinking water to explain its influence and associations with the dependent variable. Due to the unavailability of provincial data for the factor of clean drinking water, and most of the existing evidence concentrated on the national-level analysis, therefore, our analysis focused on China's national, urban, and rural levels.

4.2. Data Sources

Clean drinking water data were calculated using water supply data obtained from the JMP report (World Bank, 2019) Joint Monitoring Programme (JMP) estimates which provide for a wide array of countries. The JMP uses drinking water data collected from household surveys and national censuses and regulators Table 1.

The data on the main independent variables used here such as exports, imports, national income, and population density come from the World Bank's Development Indicators (World Bank, 2019) while, the data sources for the income inequality variable (Gini index) were the United Nations University – World Institute for Development Economics Research (UNU-WIDER, 2020) and the World Bank (2019).

Table-1. The definitions of all the variables.

Variable name	Variable code	Variable description	Data sources
Clean drinking water	CDW	The percentage of the population that has access to clean drinking water	WHO/UNICEF.. (2019)
Urban clean drinking water	CDW_{urban}	The percentage of the urban population that has access to clean drinking water	WHO/UNICEF.. (2019)
Rural clean drinking water	CDW_{rural}	The percentage of the rural population that has access to clean drinking water	WHO/UNICEF.. (2019)
Exports	EXP	Refers to the total exports of goods and services measured as % of GDP	World Bank (2019)
Imports	IMP	Refers to the total imports of goods and services measured as % of GDP	World Bank (2019)
GDP per capita	GDPP	A measure of a country's economic development and thus an indication of national income (accounting for purchasing power parity)	World Bank (2019)
Gini-Index	GINI	Refers to income inequality for the country	UNU-WIDER (2020) and World Bank (2019)
Population density	POPD	The ratio of population to areas	World Bank (2019)

4.3. Model Specifications

This paper employs a co-integration and vector error correction model (VECM) methods by Granger (1988), to investigate the effects of exports on clean drinking water in China, and to provide evidence of the long-run relationship among the variables, as well as applies the semi-parametric regression model proposed by Baltagi and Li (2002) to avoid the possible specification errors.

To examine the long-run relationship among the variables, several econometric methods can be implemented, in this study we employ the technique of fully modified ordinary least squares (FMOLS) approach with the ideas in Phillips and Hansen (1990). The features of this model include not only the concerned co-integrating relationship but also it is enabled to the achievement of asymptotic efficiency by considering the account of the serial correlation effect, as well as the test for endogeneity.

The basic empirical model, within a time series framework, can be specified in Equation 1 as follows:

$$CDW = f(EXP, IMP, GDPP, GINI, POPD) \tag{1}$$

Where CDW denotes the percentage of the population that has access to clean drinking water, EXP denotes the degree of export dependence, IMP means the degree of import dependence, and GDPP represents the levels of national income, GINI is income inequality, and POPD means the population density. Furthermore, to avoid possible heteroscedasticity of the estimation results, the study logged all the variables. Thus, the specific form of equation.1 might be transformed into natural log-linear functional due to high skew as follows:

$$LnCDW_{it} = \beta_0 + \beta_1 LnEXP_t + \beta_2 LnIMP_t + \beta_3 LnGDPP_t + \beta_4 LnGINI_t + \beta_5 LnPOPD_t + \varepsilon_t \tag{2}$$

Where CDW_i (i=1, 2, 3) is the value taken by the dependent variable for the national, urban, and rural levels), "ε" is a residual error term, it assumed to be a normal distribution with zero mean and constant variance, the intercept and the relevant parameters to be estimated are expressed as β_0 and β_i (i=1, 2, 3, 4, 5) respectively, and "t" refers to time.

In the empirical evidence, to the extent of the authors' knowledge, this research is the first to establish a co-integration method combined with a semi-parametric analysis model between clean drinking water and its determinants.

Although the FMOLS long-run co-integration method is not required the same order integration relationship variables in stability regression, the stability test of the time series of variables must be applied first before the start

of the analysis. Therefore, to check the stationary of the variables three conventional tests were applied for the unit-roots tests; Augmented Dickey and Fuller test (ADF) (Dickey & Fuller, 1979), Phillips and Perron test (PP) Phillips and Perron (1988), and Zivot and Andrews unit root test (Zivot & Andrews, 2002). These tests require to rejection of the null hypothesis which states that the variables have a unit root it is not stationary.

Some scholars argued that the first two tests produce biased estimates due to the structural break issues in the data (Perron, 1989). Therefore, we employed Zivot–Andrews unit root test to overcome this issue, this method identifies the specific break year for each variable.

Therefore, to examine the existence of the long-run link between exports and clean drinking water, we employ the FMOLS approach to investigate the long-run relationship among the variables, due to some of its advantages. From a statistical point of view, FMOLS specification is equivalent to the standard error correction model. By applying the FMOLS approach the long-run dynamics can be estimated through a simple linear transformation and will check the robust estimation by adopting canonical co-integration regression (CCR) (Stock & Watson, 1993).

FMOLS technique is principally grounded on parametric and non-parametric methods to regression analysis which provides good fit estimation for endogeneity and serial correlation issues in time series data. Furthermore, Pedroni (2001) who proposed the FMOLS method, he examined that the FMOLS estimator is suited for estimations involving small sample sizes, which will more justify the appropriateness of the use of this technique in this study. Thus, we will follow (Murshed & Dao, 2020) as the recent discussions, the expression for the dimension mean time series FMOLS estimator is given by Equation 3:

$$\hat{\beta}_{FMOLS} = N^{-1} \sum_{i=1}^{N} \hat{\beta}*_{FMOLS}$$

$$(3)$$

Where $\hat{\beta}*_{FMOLS,i}$ is the conventional FMOLS estimator, we will apply it to the time series model. Similarly, the associated t-statistic for this estimator can be shown in Equation 4:

$$t_{\hat{\beta}FMOLS} = N^{-\frac{1}{2}} \sum_{i=1}^{N} t_{\hat{\beta}FMOLS}$$

$$(4)$$

4.3.1. The Vector Error Correction Model (VECM)

In this study, we will apply the Granger causality test (Granger, 1988) depend on the Vector auto-regression (VAR). This technique is very conditional, to identify short-run causal effects running for instances from the influence variables to the clean drinking water, and to avoid inefficient results this test can be applied only in stationary variables (Amountzias, Dagdeviren, & Patokos, 2017; Yahia, Li, Ebaidalla, & He, 2021). On the other hand, if the underlying variables are not co-integrated the stability condition is required to apply the VAR technique. While, if the variables are co-integrated, then VECM models would be applied (Marques, Fuinhas, & Menegaki, 2014; Pradhan & Bagchi, 2013) to capture the short-run deviations of variables estimation from their long-run equilibrium path.

Some arguments declare that the test for co-integration of the variables can be considered as a pre-test to avoid time series short-come such as "spurious regression" situations' as well as to know the common trend of the variables (Granger, 1988).

Thus, the co-integration test of the specific model aims to examine the existence of a long-run equilibrium relationship between the variables. A lack of co-integration indicates that the variables have no long-run equilibrium relationship (Dickey, Jansen, & Thornton, 1994). Thus, to test the existence of significant relationships between the variables of the VAR model, we depend on the Johansen method with k lags as follows:

$$y_t = A_1 y_{t-1} + \ldots + A_j x_{t-j} + u_t \tag{5}$$

Where y_t denotes endogenous variables in a $(k \times 1)$ vector, whereas A denotes coefficient matrices of exogenous variables (x) in $(K \times K)$, and u_t is the residuals, it assumed to be a normal distribution with zero-mean white noise and constant variance.

Furthermore, depending on the VAR process model of Equation 5, the basic VECM model can be written as the general form in Equation 6:

$$y_t = \Gamma_1 y_{t-1} + \Pi y_{t-k} + CD_t + \mu_t \tag{6}$$

Where y_t and D_t are the vectors of endogenous and exogenous variables respectively, Γ and C are the coefficient matrices of dependent and independent variables respectively. The matrices Π control the long-run co-integration relationships, while the short-run dynamics are captured by the matrix Γ. The term μ_t denotes the error term.

Table-2. Descriptive statistics and pair-wise correlations.

Variable	CDW	EXP	IMP	GINI	GDPP	POPD
Mean	86.989	26.252	22.584	42.952	8207.354	141.302
Std. Dev.	4.070	5.445	3.846	3.498	3922.144	4.014
Min	80.393	19.584	17.310	38.500	2920.561	134.493
Max	92.846	36.035	28.444	49.000	14344.420	147.674
CDW	1					
EXP	-0.2298	1				
IMP	0.2606	0.948	1			
GINI	-0.1633	0.4126	0.303	1		
GDPP	0.9892	-0.3542	-0.3767	-0.2281	1	
POPD	0.9978	-0.2522	-0.2812	-0.1587	0.9898	1

The results reported in Table 2 display the descriptive statistics of the variables and pair-wise correlations. The empirical analysis of pair-wise correlations indicates a negative correlation between the degree of export dependence and clean drinking water. The correlation between the Gini coefficient and clean drinking water is also negative. The degree of import dependence, the levels of national income, and population density are positively correlated with clean drinking water. The standard deviation of the variables is slightly higher.

Figure 1 illustrates the preliminary test results to explain the relationships between the variables. The scatterplot matrix graph indicates the existence of linear relationships between the degree of import dependence (IMP), the levels of national income (GDPP), and population density, and clean drinking water (CDW). However, the relationship between the degree of export dependence (EXP), Gini-Index (GINI), and clean drinking water (CDW) has obvious nonlinear characteristics and hence encourages us to utilize the semi-parametric regression model for studying the access to clean drinking water (Lin & Xu, 2020). On the face of it, these results appear to provide evidence that clean drinking water is negatively related to the degree of export dependence and income inequality in China.

Equation 2 is transformed into a semi-parametric regression model as follows:

$$LnCDW_t = \beta_0 + \beta_1 LnIMP_t + \beta_2 LnGDPP_t + \beta_3 LnPOPD_t + \int_1 (LnEXP_t)$$
$$+ \int_2 (LnGINI_t) + \upsilon_t + \varepsilon_t \tag{7}$$

Where the functional form of $\int_i (.)$ denotes a non-parametric function, the other parts in Equation 7 are the same as those in Equation 2.

187

Furthermore, to compare the estimation results of the parametric method with (FMOLS) and semi-parametric method, we will apply an additional traditional regression model with (FMOLS) in a quadratic model for the target independence variable "the degree of export dependence (EXP)", the regression model is given by:

$$LnCDW_t = \beta_0 + \beta_1 LnEXP_t + \beta_2 (LnEXP_t^2) + \beta_3 LnIMP_t + \beta_4 LnGDPP_t + \beta_5 LnGINI_t$$
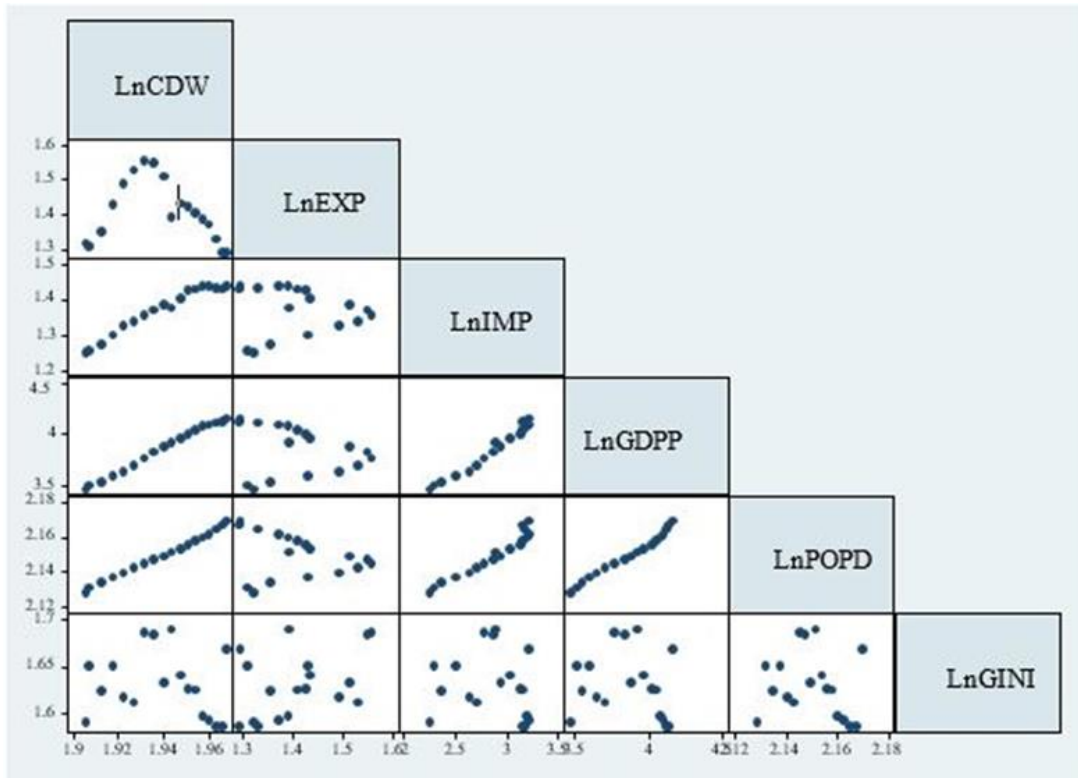$$+ \beta_6 LnPOPD_t + \varepsilon_t$$

(8)

Figure-1. Relationships between clean drinking water (CDW) and their influencing factors.

5. EMPIRICAL RESULTS

5.1. Unit Root Test

The present empirical analysis examines the stationarity properties of the variables included in the model, the study tested the stationarity of three different unit root tests namely; the ADF test, the PP test, and the Zivot-Andrews structural break tests (ZA). All three tests assume that the null hypothesis (H₀) of a unit root (Non-stationary series), versus alternative hypothesis (H₁) stationary series.

Table 3 display the results of the unit root tests of ADF and PP tests for variables in the level and the first differences, indicates that all factors are stationary in the first differences I (1) except CDW, GDPP, GINI, and POPD which are stationary in level. Thus, if there is a co-integration relationship between the variables, we can be estimated our model without any anxiety of spurious regression.

The existence of the stationarity indicates the presence of co-integration and causality relationship between the variables, depend on the VAR and VECM representations. In this regard, Engle and Granger (1987) revealed that, if two variables are integrated individually in order one and then co-integrated, in this case at least one direction relationship may exist between the variables.

Table-3. Unit root tests without structural break.

Variables	ADF		PP	
	Level	1st Difference	Level	1st Difference
CDW	-2.733*	-3.357**	-2.741*	-2.825*
CDWu	1.648	-149.092**	1.708	-95.32***
CDWr	0.470	-15.345***	0.496	-10.074***
EXP	-0.923	-5.391***	-1.292	-5.881***
IMP	-1.190	-2.739*	-1.484	-2.743*
GDPP	-3.516***	-2.721*	-2.494	-2.663*
GINI	-2.974*	-5.257***	-3.013**	-3.833***
POPD	-4.358***	-4.75***	-3.017***	-3.833***

Notes: ***, ** and * indicates statistical significance at the 1%, 5% and 10% level, respectively. All variables are tested with intercept and trend.

The Zivot-Andrews unit root test is also used to make up for the deficiency of the other unit root test methods, and it is more robust to solve the issue of structural breaks in the series than ADF and PP tests (Cook & Manning, 2005; Rafindadi & Mika'Ilu, 2019). Table 4 reported the results from the Zivot-Andrews unit root test with intercept and trend, the results indicate the existence of structural break in 2011, 2003, 2003, 2009, 2006, and 2004 for the series of clean drinking water, the degree of export dependence, the degree of import dependence, the levels of national income, income inequality, and population density respectively at level with intercept and trend. Stationarity is found for all variables at the first difference, this indicates that these variables are stationary at the first difference in the presence of structural breaks. It entails that integrating order of the variables are I (1) and confirms the results of ADF and PP unit root tests. Thus, based on the mixed test outcomes, we can use the FMOLS model, which requires that variables should be either I(1) or I(0), to examine unbiased estimates. In the next section, the empirical results provided by the FMOLS technique are presented.

Table-4. Zivot-Andrews structural break unit root tests.

Variables	level		1st Difference	
	t-Statistic	Break year	t-Statistic	Break year
CDW	-14.339***	2011	-86.645***	2006
CDWu	-1510.95***	2008	9421.378***	2008
CDWr	-167.675***	2008	-174.988***	2009
EXP	-3.291	2003	-7.410***	2010
IMP	-3.891	2003	-5.045**	2010
GDPP	-2.328	2009	-5.444*	2008
GINI	-4.666*	2006	-8.096*	2008
POPD	-1.487	2004	-6.719*	2007

Note: The optimal lags included in the models are selected with the Schwarz Bayesian Criterion. ***, ** and * Indicates statistical significance at the 1%, 5% and 10% level, respectively.

5.2. Co-Integration Test

The relationship between economic variables displays two types of links, linear and nonlinear relationships. In this regard, the traditional co-integration method assumes to exist linear form relationships between the variables, which do not show the actual relationship between the variables. Therefore, the present empirical analysis uses the FMOLS technique to examine the co-integration vector for heterogeneous co-integrated series (Lin & Xu, 2020).

The results for the long-run relationship among the estimated variables under the FMOLS and CCR framework have been shown in Table 5. We applied the FMOLS model to explore the long-run relationship among the variables, while the CCR is used to check the robustness of the FMOLS model. We note that when the degree of export dependence rises by 1%, this will cause the clean drinking water to decrease by 0.019%. Thus, there is a direct relationship between exports and clean drinking water for the case of China. Also, we notice the same result in the case of income inequality, if it rises by 1%, this will cause the clean drinking water to decrease by 0.070%. The linear impacts of the degree of import dependence, the levels of national income, and the population density on clean drinking water are positive, their regression coefficients are 0.048, 0.030, and 1.290 respectively, indicating

that these variables have a significant linear long-run relationship with clean drinking water. The CCR results represent comparable results to FMOLS when clean drinking water is taken as the dependent variable. Thus, the estimation results of all independent variables included in the model passed the significance test. This clarifies exists a nonlinear long-run equilibrium relationship between clean drinking water and their main influencing factors.

Table-5. FMOLS long-run co-integration estimations.

Variables	FMOLS	CCR
LnEXP	- 0.019***	-0.022**
LnIMP	0.048***	0.013***
LnGDPP	0.030***	0.031***
LnGINI	- 0.070***	-0.020***
LnPOPD	1.290***	3.137***
Constant	-0.873	-4.839
R²	0.98	0.99
Adjusted R²	0.97	0.98

Notes: The p-values are based on the bootstrapped distribution. ***= significant at 1% and ** = significant at 5% level.

To examining the standard linear Granger causality/Granger non-causality tests, we reported the p values using Schwarz Information Criterion (SIC) and selected order 1 as an optimal order of the VAR model.

Table 6 gives the estimation results of the linear Granger causality test. The null hypothesis which state that the degree of export dependence and income inequality does not Granger cause clean drinking water cannot be rejected at standard levels of significance. The results indicate that the degree of export dependence and income inequality have no predictive power for clean drinking water in the entire period. Analogously, in examining the causality linkage from clean drinking water to the main independent variables, the results also fail to reject the null hypothesis of clean drinking water does not Granger-cause the degree of export dependence and income inequality at any conventional significance levels. Thus, the absence of a causal link between the degree of export dependence, income inequality, and clean drinking water has been indicated. This result supports the earlier mention that ignoring the semi-parametric technique from this study will lead to misspecification errors. This argument is confirmed by the theoretical analysis of Diks and Fang (2020) which claimed that Granger's non-causality lays the first stone to use the nonparametric test of the model. Therefore, this evidence and the results bring us to the next part of the study, in which we aim to employ a semi-parametric regression model to investigate clean drinking water relationships, to explore the linear and nonlinear effects of independent variables on clean drinking water.

Table-6. Standard linear Granger causality test.

Null hypothesis	F statistic	p-Value
The degree of export dependence does not Granger cause clean drinking water	0.507	0.493
Clean drinking water does not Granger cause the degree of export dependence	0.257	0.623
Income inequality does not Granger cause clean drinking water	3.570	0.088
Clean drinking water does not Granger cause income inequality	0.140	0.717

Note: The reported F-statistics are performed using a linear vector autoregressive (VAR) model of order one. The order of the VAR is selected by the Schwarz information criterion (SIC).

5.3. Semi-Parametric Regression Model Estimation

5.3.1. The Results of Parameter Estimation

The study depends on Equation 2 to estimate the linear and nonlinear Equation 7 effects of explanatory variables on clean drinking water. The linear estimation results of Equation 2 appeared in Table 7, while the nonparametric (nonlinear) estimation results of Equation 7 are shown in Figure 2 and Figure 3 for the degree of export dependence and income inequality respectively.

The study depended on the following justification in the selection of the semi-parametric model:

First; the scatterplot matrix graph in Figure 1 shows that the regulation between clean drinking water and these two variables (the degree of export dependence and income inequality) is mainly nonlinear. Second; it can be seen from the results of the standard linear Granger causality test in Table 6 that the absence of a causal relationship between these variables.

Thus, the evidence proves that it is appropriate to use the nonparametric method Equation 7 in our estimation regression.

The results of the semi-parametric regression model are displayed in Table 7. The results show a positive linear effect of the degree of import dependence on clean drinking water in the national and rural levels, while it is displayed a negative effect in the case of the urban level. However, the results do not have significant effects.

The impact coefficient of the level of national income on clean drinking water in the national and rural levels are 0.039 and 0.053 respectively. This means that for every 1% increase in national income, the access to clean drinking water will increase by 0.039 and 0.053 percentage points. However, the impact coefficient of national income on clean drinking water in the urban level plays less role in improving clean drinking is only 0.0013, significantly lower than the impact coefficient in the other levels.

Table-7. The estimation results of the parametric part of the semi-parametric regression model.

Variables	National Level	Urban Level	Rural Level
LnIMP	0.002	–0.0013	0.035
LnGDPP	0.039**	0.0013**	0.053***
LnPOPD	–0.920***	–0.040***	1.329***
R^2	0.99	0.99	0.99
RooT MSE	0.0006	0.000	0.0013
Observation	18	18	18

Notes: *** and ** mean passing the significance test at a level of 1% and 5% respectively. RooT MSE represents the standard deviation of the residuals.

Population density has a negative statistically significant impact on clean drinking water at the national and urban levels. Their regression coefficients are –0.920, –0.040 respectively, indicating that population density in those levels has often reduced the access to clean drinking water. The main reason is that the relationship between access to clean water with national and urban population's density supports the view that high population density puts pressure on existing water facilities, and also increases the cost of providing more water facilities (Munamati, Nhapi, & Misi, 2016). However, the coefficient of the population density at the rural level is positive (1.329), which means that population density has significantly contributed to their clean drinking water.

5.3.2. The Results of Nonparametric Estimation

To access the significance of the nonlinearity ($\int i \, (.)$) of the degree of export dependence and income inequality, we present graphical results along with their wild-bootstrapped 95% confidence intervals in Figure 2 and Figure 3 respectively; we reported the results of the two nonlinear variables.

The function of the degree of export dependence shows an inverted "U-shaped" nonlinear impact on clean drinking water at the national and urban levels. This indicates that exports share firstly exerts a considerable positive influence on clean drinking water. Then, when the exports share percentage exceeds a certain extent the effects of the increase of exports share on the clean drinking water change into negative. This is mainly because, in the later stage, the urban level actively developed the infrastructural, and clean drinking water gradually replaced traditional culture.

In the other words, the function of the degree of export dependence at the rural level is close to a positive "U" shape such that its negative partial effect slightly diminishes with the degree of export dependence less than approximately 1.5%, then barely increases further afterward. Thus, the downward sloping and upward parts of the slops of the functions are due to the dominating effect of export share. These results support our argument

hypothesis by displaying different nonlinear impacts of exports, which go beyond semi-parametric function according to the p-value of the tests.
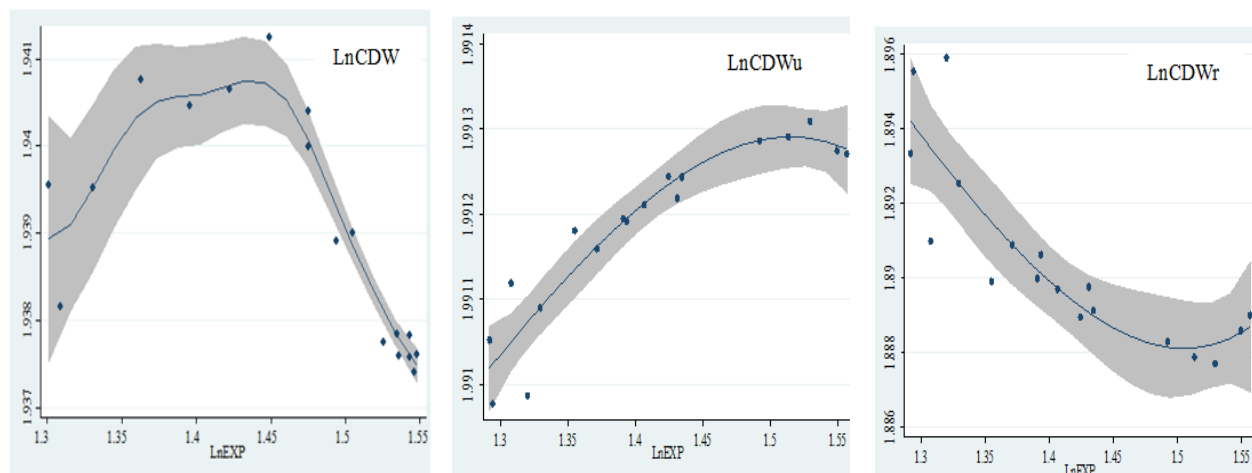

Figure-2. The nonlinear effect of the degree of export dependence on clean drinking water (National, Urban, and Rural levels). Notes: The maroon curve with a gray area is a confidence interval with a 95% confidence level. The blue dots in the figure represent the linear fit values. The blue curve in the figure is a B-spline smooth curve, which indicates the nonlinear effect of the explanatory variable on clean drinking water.

The impact of income inequality on China's clean drinking water also shows a significant nonlinear characteristic. The impact for the national level shows a positive "U-shaped" pattern Figure 3. This means that the income inequality in the early stages leads to a decrease in clean drinking water whereas the continuously minimized income inequality in the later stages promotes access to clean drinking water. We noticed that from the nonlinear graph of income inequality at the national level, the related scattered points between income inequality and access to clean drinking water are mainly concentrated on the left side of the graph (in the downward trend stage), and there are only four scattered points on the right of the graph, this result support our hypothesis regarding with the role of income inequality. But, income inequality exerts a gentle a positive "N-shaped" nonlinear effect on access to clean drinking water at the urban level and passed the significance test. This indicates that at the early stages, income inequality in the urban promotes access to clean drinking water. But this promotion has gradually disappeared over time in the mid-term. Then in the later stage, the urban level actively developed the regulation income, and equity circumstances gradually replaced the old situation has significantly promoted access to clean drinking water.

In contrast, we observe the difference in estimated impact at the rural level. Income inequality has shown an inverted "N-shaped" impact on access to clean drinking water. It indicates that the role of income inequality in rural level in promoting clean drinking water in the medium term has not reflected, and the clean drinking water promoting effect gradually diminishes at the later stage. For instance, in the long-run, the continuous income inequality will constraint access to clean drinking water.

6. DISCUSSION

The supply of clean drinking water in China is different between urban and rural communities due to concentrating the sources of water resources far from the population density areas (Wu, 2020). The urban and rural disparity is also embodied in income inequality and technology. Furthermore, urban communities have the advantage to access clean drinking water than rural communities, due to exit advanced water treatment technology in the urban area, and a large number of investments, whereas it cannot afford the same in the rural. On the other side, increasing the rapid urbanization in China is put more pressure on access to clean drinking water. Also, the recent change in the lifestyle of the community inwards to urban regions will increase the demand for clean water.
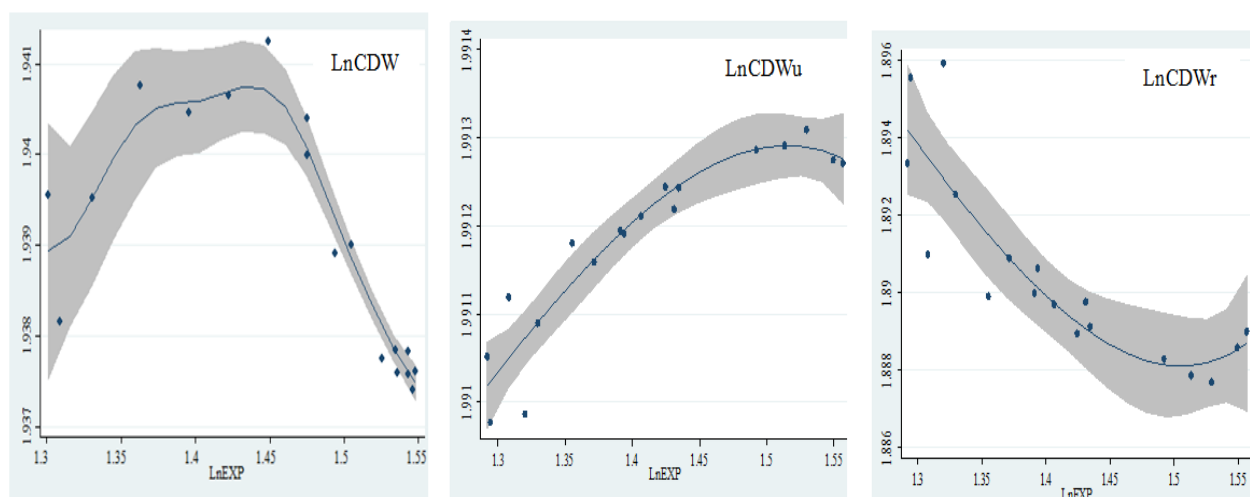
Figure-3. The nonlinear effects of income inequality on clean drinking water (National, Urban, and Rural levels).

As displayed in Table 7, the estimation results of the parametric model in this special regression dealt with "the control variables", which indicates that national income is the most important factor for access to clean drinking water, have a positive statistically significant effect in all three levels. For which the coefficients indicate that a 1 percent increase in a country's GDP per capita is associated with an estimated 3.9, 0.13, and 5.3 percent increase in the population with access to water in the overall country, urban, and rural levels respectively.

Clean drinking water also is affected positively significant by population density and import variables, especially in rural areas where industrialization is usually lack Ebenstein (2012). Thus, understanding the factors affecting clean drinking water is useful.

Thus, depending on these facts, in the present section, we will discuss focused on the results of the main independent variable and mainly concentrated on the semi-parametric regression output.

6.1. Impacts of Exports on Clean Drinking Water

The nonlinear impact of dependence on exports in clean drinking water in the national and urban levels is an inverted "U-shaped" pattern. While the rural level has a positive "U-shaped".

This indicates that in the early stages, the degree of export dependence in the overall country and urban levels led to a significant positive increase in clean drinking water; in the next stages, the pattern of effects has gradually narrowed, and become strongly negatively significant in the long-run.

This is mostly due to many reasons for instance. With the growing number of industrial products of the exports goods such as machinery and transport equipment, textile products, electronic components, and chemicals and related products, Most of these products are located in the urban area, many contaminated have been emitted into aquatic environments and generate various wastes (Lei, Su, & Zheng, 2018). On the other hand, there are also burdens and high environmental costs induced by producing export goods resulting in water pollution. As a result, water quality deteriorated in the long-run (the inverse relationship between exports and clean drinking water), these seriously will be reflected in the sustainable development of China.

Despite the massive increase in the number of the urban population using improved sources such as piped drinking water increased from 86.9 % of the urban population in 2000 to nearly 93% in 2017 (WHO/UNICEF.. 2019). Provision of clean water, however, has not guaranteed positive long-run access to safe urban clean drinking water supplies and the increasing urban population is putting immense pressure on clean water suppliers (Gong et al., 2012). Because urban per capita clean water use has risen only slightly, despite the substantial increase in urban incomes, but total urban clean water supply has remained somewhat constant (Browder et al., 2008).

These results are consistent with those of Rudra (2011) who found that trade has a negative significant effect on access to clean drinking water. Besides, the negative long-run relationship between clean water successes with

dependence on exports supports the view that the highest exporters in water-intensive industries tend to be developing countries (WTO, 2007). In contrast, Figure 2 shows a fairly strong downward-sloping relationship between exports and access to clean drinking water in the earlier period at rural level, indicating strong reduces effects. However, in the long-run become strongly positive significant.

Thus, our main findings is that the impacts of exports, specifically (total exports of goods and services measured as % of GDP), build the foundation on which country, urban, and rural levels can expand clean water provision whether in short-run or in the long-run.

6.2. Impacts of Income Inequality on Clean Drinking Water

Besides the challenges mentioned above, the existence of large differences in the income among people whether in urban or in rural communities also threaten access to clean drinking water.

The nonlinear impact of the income inequality on clean drinking water in national, urban, and rural levels has appeared different results; positive "U-shaped", positive "N-shaped" and inverted "N-shaped" pattern respectively.

We notice that income inequality in the urban community has a stronger, better impact on access to clean drinking water than in the rural community, this result can be explained by the following reasons. First, richer citizens and more politically vocal income groups concentrated in urban areas tend to prefer safe and secure clean drinking water, by supporting policies that provide more types of public projects investments, and actively resist plans to change the rules and status quo. Therefore, their impact in the most period of study is positive statistically significant, exactly in the early stages, and in the long-run effects (Easterly, 2007). Second, poorer groups favor that the government offers more comprehensive project access, for example, prefer the government investments in water infrastructure projects in rural communities, and government policies that aim to offer subsidies for clean water. Therefore, as fewer income groups, the poor area face difficulties in access clean drinking water compared with an urban area, thus, it has long-run adverse effects in more stages in earlier and long-run stages (Conceição, 2019). Also, some evidence examined that, richer rural dwellers have less access to clean drinking water than the urban poor nation. For instance, the second richest rural quintile in Sub-Saharan Africa has less access to clean water than the poorest urban quintile (WHO/UNICEF, 2011).

7. CONCLUSIONS

Access to clean drinking water in urban and rural communities has fundamental significance for the economy, ecology, and society which receiving increasing attention in China. To provide a better understanding of clean drinking water patterns in national, urban, and rural levels in China, the present study employs both a co-integration approach and a semi-parametric regression model to explore the effects of the degree of export dependence and income inequality in clean drinking water. However, the theoretical framework which offers an unambiguous implication in this field may not exist, therefore, the empirical evidence of the effect of dependence on exports and income inequality on access to clean water anticipates further empirical analysis to explore the causes applicable for overall country and levels.

Our findings across the two different regression models are strongly consistent with our hypotheses. While the scatterplot matrix graph and FMOLS long-run co-integration estimations also detect the nonlinearity of the model, rejections of model specification tests indicate that our method without model restriction should be estimated. The results from the nonlinear analysis revealed that while exist an inverted "U-shaped" relationship between clean drinking water and exports might be clear in the overall country and urban level, there exist opposite relationships between the variables in the rural case, indicating that, in overall country-level exports will reduce clean drinking water in the long-run. However, income inequality exhibited a positive long-run impact on clean drinking water in the overall country and urban level.

7.1. Implications

Overall, our results have implications for the literature.

We contribute to environmental economics literature on the empirical effects of international trade variables and analyze how the effects of the variables can be conditioned by domestic variables (clean drinking water). Thus, our analysis adds on the factors of access to clean water and helps in the formulation of appropriate interventions to improve clean drinking water in China.

Clean drinking water should be given priority in government programs. As clean water benefit for promotes good health and socio-economic development, which will facilitate to achieve sustainable development.

Future researches on the same topic could also examine the relationships between the factors determinants and clean drinking water at the provincial level. Likewise, other econometric regressions might be used to explore the existence of other forms of relationships such as the general equilibrium model or quantitative spatial-temporal analysis of exports and income inequality on clean drinking water. However, our belief that the existing gap in the literature on the role of trade in access to clean drinking water that no known papers address these issue puts policymakers in a tough situation when deciding about mechanisms to endeavor this sort of policy. Recently, access to clean drinking water stands among key known barriers that hinder communities from moving out of low levels of development and poverty.

7.2. Limitations

The use of country-level data restrict the ability of our study to identify the underlying causes of how exports and income inequality affect clean drinking water differently in China provinces, we used national, urban, and rural levels data due to the unavailability of disaggregated data for provinces levels for the dependent variable (clean drinking water). It is necessary to find provinces' clean drinking water data so that the findings can be more accurate and reliable. Therefore, future research must focus on the impacts of the factors on clean drinking water at provinces or city levels where data might be available.

Under these circumstances, we estimated the semi-parametric regression with relatively small observations were from 2000 to 2017, while the consistency estimation required larger observations. Furthermore, the nonlinear effects of exports and income inequality, even so being significant, but still lack a base theoretical underpinning that justifies the underlying nonlinear relationship channel.

REFERENCES

Allan, J. A. (2003). Virtual water-the water, food, and trade nexus. Useful concept or misleading metaphor? *Water International, 28*(1), 106-113. Available at: https://doi.org/10.1080/02508060.2003.9724812.

Amountzias, C., Dagdeviren, H., & Patokos, T. (2017). Pricing decisions and market power in the UK electricity market: A VECM approach. *Energy Policy, 108*, 467-473. Available at: https://doi.org/10.1016/j.enpol.2017.06.016.

Baltagi, B. H., & Li, D. (2002). Series estimation of partially linear panel data models with fixed effects. *Annals of Economics and Finance, 3*(1), 103-116. Available at: https://doi.org/10.1111/ectj.12011.

Bosch, C., Hommann, K., Rubio, G. M., Sadoff, C., & Travers, L. (2001). *Water, sanitation and poverty. Draft chapter*. Washington DC: World Bank.

Browder, G. J., Xie, S., Kim, Y., Gu, L., Fan, M., & Ehrhardt, D. (2008). Improving the performance of China's Urban Water Utilities. Water Sector Board of the Sustainable Development Network of the World Bank Group. Washington, DC 20433, 11.

Cesar, S. (2019). Privatization of water: Evaluating its performance in the developing world. *Annals of Public and Cooperative Economics*, *90*(1), 5-23. Available at: https://doi.org/10.1111/apce.12221.

China Statistical Yearbook. (2015). Beijing: China Statistics, Press. Retrieved from: http://www.stats.gov.cn/tjsj/ndsj/2015/indexeh.htm.

China Water Resources Bulletin. (2015). *Ministry of water resources of the people's republic of China*. Beijing: China Water Power Press.

Conceição, P. (2019). Human development report 2019: beyond income, beyond averages, beyond today: Inequalities in human development in the 21st century: United Nations Development Programme, United Nations Development Programme (UNDP), Retrieved from: http://hdr.undp.org.

Cook, S., & Manning, N. (2005). Unobserved heterogeneity in Markovian analysis of the size distortion of unit root tests. *Journal of Statistical Computation and Simulation*, *75*(9), 709-729. Available at: https://doi.org/10.1080/00949650412331299111.

Dalin, C., Konar, M., Hanasaki, N., Rinaldo, A., & Rodriguez-Iturbe, I. (2012). Evolution of the global virtual water trade network. *Proceedings of the National Academy of Sciences*, *109*(16), 5989-5994. Available at: https://doi.org/10.1073/pnas.1203176109.

Dalin, C., Hanasaki, N., Qiu, H., Mauzerall, D. L., & Rodriguez-Iturbe, I. (2014). Water resources transfers through Chinese interprovincial and foreign food trade. *Proceedings of the National Academy of Sciences*, *111*(27), 9774-9779. Available at: https://doi.org/10.1073/pnas.1404749111.

De Fraiture, C., Cai, X., Amarasinghe, U., Rosegrant, M., & Molden, D. (2004). Does international cereal trade save water?: The impact of virtual water trade on global water use. Comprehensive Assessment Research Report 4. Colombo, Sri Lanka: Comprehensive Assessment Secretariat.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*(366a), 427-431. Available at: https://doi.org/10.2307/2286348.

Dickey, D. A., Jansen, D. W., & Thornton, D. L. (1994). A primer on cointegration with an application to money and income cointegration (pp. 9-45). London: Palgrave Macmillan.

Diks, C., & Fang, H. (2020). A consistent nonparametric test for granger non-causality based on the transfer entropy. *Entropy*, *22*(10), 1-27. Available at: https://doi.org/10.3390/e22101123.

Dilekli, N., & Cazcarro, I. (2019). Testing the SDG targets on water and sanitation using the world trade model with a waste, wastewater, and recycling framework. *Ecological Economics*, *165*, 106376-106376. Available at: https://doi.org/10.1016/j.ecolecon.2019.106376.

Dos Santos, S., Adams, E., Neville, G., Wada, Y., De Sherbinin, A., Bernhardt, E. M., & Adamo, S. (2017). Urban growth and water access in sub-Saharan Africa: Progress, challenges, and emerging research directions. *Science of the Total Environment*, *607*, 497-508. Available at: https://doi.org/10.1016/j.scitotenv.2017.06.157.

Easterly, W. (2007). Inequality does cause underdevelopment: Insights from a new instrument. *Journal of Development Economics*, *84*(2), 755-776. Available at: https://doi.org/10.1016/j.jdeveco.2006.11.002.

Ebenstein, A. (2012). The consequences of industrialization: Evidence from water pollution and digestive cancers in China. *Review of Economics and Statistics*, *94*(1), 186-201. Available at: https://doi.org/10.1162/rest_a_00150.

Emenike, C., Tenebe, I., Omole, D., Ngene, B. U., Oniemayin, B. I., Maxwell, O., & Onoka, B. (2017). Accessing safe drinking water in sub-Saharan Africa: Issues and challenges in South–West Nigeria. *Sustainable Cities and Society*, *30*, 263-272. Available at: https://doi.org/10.1016/j.scs.2017.01.005.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica: Journal of the Econometric Society*, *55*(2), 251-276. Available at: https://doi.org/10.2307/1913236.

Flendrig, L., Shah, B., Subrahmaniam, N., & Ramakrishnan, V. (2009). Low cost thermoformed solar still water purifier for D&E countries. *Physics and Chemistry of the Earth, Parts A/B/C*, *34*(1-2), 50-54. Available at: https://doi.org/10.1016/j.pce.2008.03.007.

Gong, P., Liang, S., Carlton, E. J., Jiang, Q., Wu, J., Wang, L., & Remais, J. V. (2012). Urbanisation and health in China. *The Lancet, 379*(9818), 843-852.

Granger, C. W. (1988). Some recent development in a concept of causality. *Journal of Econometrics, 39*(1-2), 199-211. Available at: https://doi.org/10.1016/0304-4076(88)90045-0.

Hoekstra, A. Y. (2003). *Virtual water trade: A quantification of virtual water flows between nations in relation to international crop trade.* Paper presented at the Paper Presented at the Proceedings of the International Expert Meeting on Virtual Water Trade 12, Delft.

Hoekstra, A. Y., & Chapagain, A. K. (2011). *Globalization of water: Sharing the planet's freshwater resources.* UK: John Wiley & Sons. Blackwell Published Ltd.

Hopewell, M. R., & Graham, J. P. (2014). Trends in access to water supply and sanitation in 31 major sub-Saharan African cities: An analysis of DHS data from 2000 to 2012. *BMC Public Health, 14*(1), 1-12. Available at: https://doi.org/10.1186/1471-2458-14-208.

Infographics (AQUASTAT). (2014). *AQUASTAT website.* Rome: Food and Agriculture Organization of the United Nations.

Landrigan, P. J., Fuller, R., Acosta, N. J., Adeyi, O., Arnold, R., Baldé, A. B., . . . Breysse, P. N. (2018). The Lancet Commission on pollution and health. *The Lancet, 391*(10119), 462-512.

Lei, Y., Su, L., & Zheng, M. (2018). Water pollution footprints induced by industrial import and export in China. *Chinese Journal of Population Resources and Environment, 16*(2), 149-158. Available at: https://doi.org/10.1080/10042857.2018.1471850.

Lim, S., & Prakash, A. (2020). How the opposing pressures of industrialization and democratization influence clean water access in urban and rural areas: A panel study, 1991–2010. *Environmental Policy and Governance, 30*(4), 182-195. Available at: https://doi.org/10.1002/eet.1883.

Lin, B., & Xu, B. (2020). Effective ways to reduce CO_2 emissions from China's heavy industry? Evidence from semiparametric regression models. *Energy Economics, 92*, 104974. Available at: https://doi.org/10.1016/j.eneco.2020.104974.

Marques, A. C., Fuinhas, J. A., & Menegaki, A. N. (2014). Interactions between electricity generation sources and economic activity in Greece: A VECM approach. *Applied Energy, 132*, 34-46. Available at: https://doi.org/10.1016/j.apenergy.2014.06.073.

Munamati, M., Nhapi, I., & Misi, S. (2016). Exploring the determinants of sanitation success in Sub-Saharan Africa. *Water Research, 103*, 435-443. Available at: https://doi.org/10.1016/j.watres.2016.07.030.

Murshed, M., & Dao, N. T. T. (2020). Revisiting the CO_2 emission-induced EKC hypothesis in South Asia: The role of export quality improvement. *GeoJournal*, 1-29. Available at: https://doi.org/10.1007/s10708-020-10270-9.

OECD. (2018). *Is the last mile the longest? Economic Gains from Gender Equality in Nordic Countries.* Paris: OECD Publishing.

Paarlberg, R. L. (1992). Managing pesticide use in developing countries. *Environment: Science and Policy for Sustainable Development, 34*(4), 17-17.

Pedroni, P. (2001). Purchasing power parity tests in cointegrated panels. *Review of Economics and Statistics, 83*(4), 727-731.

Perron, P. (1989). The great crash, the oil price shock, and the unit root hypothesis. *Econometrica: journal of the Econometric Society, 57*(6), 1361-1401. Available at: https://doi.org/10.2307/1913712.

Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika, 75*(2), 335-346.

Phillips, P. C., & Hansen, B. E. (1990). Statistical inference in instrumental variables regression with I (1) processes. *The Review of Economic Studies, 57*(1), 99-125.

Pradhan, R. P., & Bagchi, T. P. (2013). Effect of transportation infrastructure on economic growth in India: the VECM approach. *Research in Transportation Economics, 38*(1), 139-148. Available at: https://doi.org/10.1016/j.retrec.2012.05.008.

Rafindadi, A. A., & Mika'Ilu, A. S. (2019). Sustainable energy consumption and capital formation: Empirical evidence from the developed financial market of the United Kingdom. *Sustainable Energy Technologies and Assessments, 35*, 265-277. Available at: https://doi.org/10.1016/j.seta.2019.07.007.

Robinson, P. M. (1988). Root-N-consistent semiparametric regression. *Econometrica: Journal of the Econometric Society, 56*(4), 931-954.

Rudra, N. (2011). Openness and the politics of potable water. *Comparative Political Studies, 44*(6), 771-803.

Smith, L., & Hanson, S. (2003). Access to water for the urban poor in Cape Town: Where equity meets cost recovery. *Urban Studies, 40*(8), 1517-1548. Available at: https://doi.org/10.1080/0042098032000094414.

Stock, J. H., & Watson, M. W. (1993). A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica: journal of the Econometric Society, 61*(4), 783-820.

UNDESA. (2015). *United Nations, Department of economic and social affairs.* Paris: UNESCO.

UNU-WIDER. (2020). World income inequality database. Retrieved from: https://www.wider.unu.edu.

Vörösmarty, C. J., Green, P., Salisbury, J., & Lammers, R. B. (2000). Global water resources: Vulnerability from climate change and population growth. *Science, 289*(5477), 284-288. Available at: https://doi.org/10.1080/0042098032000094414.

Whitford, A. B., Smith, H., & Mandawat, A. (2010). Disparities in access to clean water and sanitation: Institutional causes. *Water Policy, 12*(S1), 155-176.

WHO/UNICEF. (2011). *Water, sanitation and hygiene ladders: Global baseline report 2015.* Geneva, Switzerland: WHO.

WHO/UNICEF. (2015). *Joint water supply, sanitation monitoring programme-2015 update.* Geneva, Switzerland: WHO.

WHO/UNICEF. (2019). *Water, sanitation and hygiene ladders:* WHO/UNICEF.

World Bank. (2019). World development indicators: The world bank. Retrieved from: https://www.worldbank.org.

WTO. (2007). *World trade report 2007: Six decades of multilateral trade cooperation: What Have We Learnt?* Geneva: WTO.

Wu, J. (2020). Challenges for safe and healthy drinking water in China. *Current Environmental Health Reports, 7,* 292–302. Available at: https://doi.org/10.1007/s40572-020-00274-5.

Xu, Z., Yao, L., Zhang, Q., Dowaki, K., & Long, Y. (2020). Inequality of water allocation and policy response considering virtual water trade: A case study of Lanzhou city, China. *Journal of Cleaner Production, 269,* 122326. Available at: https://doi.org/10.1016/j.jclepro.2020.122326.

Yahia, A. A., & Li, Z. (2021). Spatial econometric analysis on the exports-PM2. 5 emissions nexus: Evidence from the Chinese smog provinces. *Open Access Library Journal, 8*(4), 1-22. Available at: https://doi.org/10.4236/oalib.1107358.

Yahia, A. A., Li, Z., Ebaidalla, E. M., & He, J. (2021). Exploring the impact of exports on clean energy consumption in China: An empirical study. *Asian Development Policy Review, 9*(1), 44-56. Available at: https://doi.org/10.18488/journal.107.2021.91.44.56.

Yang, H., Reichert, P., Abbaspour, K. C., & Zehnder, A. J. (2003). A water resources threshold and its implications for food security: ACS Publications. *Environmental Science & Technology, 37*(14), 3048–3054. Available at: https://doi.org/10.1021/es0263689.

Zivot, E., & Andrews, D. W. K. (2002). Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business & Economic Statistics, 20*(1), 25-44.