A Study on the Improvement of Water Price Normalization Policy in Korea

By

KO, Gijun

CAPSTONE PROJECT

Submitted to

KDI School of Public Policy and Management

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Committee in charge:

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EXECUTIVE SUMMARY

In 2014, the Ministry of Interior and Safety (MOIS) promoted a water price normalization policy in order to solve problem of low cost recovery ratio, which is a chronic problem of water management in Korea. However, MOIS's policy to increase water price has failed eventually. The reason why MOIS's policy failed was due to the fact that, first, it did not take into account the various conditions of each local water service and applied uniform criteria in setting goals and promotion periods. Second, MOIS used cost covering ratio and water production cost as criteria to classify policy targets, but this classification criteria had some problems.

This paper suggests policy target regrouping, goal level differentiation, and implementation period differentiation as an policy alternative to increase water price effectively. The research results show that factors related to economies of scale, such as length of water pipe, are significant factors to consider when classifying policy targets. In addition, a 75% of revenue water ratio was suggested as a factor to consider when deciding the timeline for raising water prices.

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CHAPTER I. INTRODUCTION

Water service is one of the most important public services in Korea and directly affects the welfare level and quality of life of citizens. Due to rapid global climate change, management for stable water resources and clean water quality is becoming increasingly important. Nevertheless, Korea's water cost covering ratio is only 80.6%. In other words, only 80.6% of the total costs invested to produce water are recovered on water prices. In particular, small-scale local governments in rural areas have difficulty in financing and improving services for waterworks management because the cost covering ratio is low. Failure to recover the cost of water can cause quantitative and qualitative problems in supplying water as it is difficult to maintain the water facilities properly. The low water price causes depletion of investment funds, making it difficult to invest facilities in time. Then the production and operation efficiency of the water supply will be reduced, resulting in high overall costs. This leads to a vicious cycle of lower cost covering ratio.

Recognizing the importance of the water cost covering policy, central and local governments have implemented various research and policies, but have not yet achieved any specific results. In 2014, the Ministry of the Interior and Safety (MOIS) pushed for a water price normalization policy. MOIS has assigned the goal of achieving an average 91.6% of cost covering ratio by 2017 for 114 local public companies operating the local water supply facilities. Considering that the average ratio was 83.8% at the time of policy implementation, 91.6% was a very challenging goal.

However, despite these efforts, the result was disappointing. In 2017, according to an analysis of the results of achieving the goal of water cost covering ratio, only 21 out of 114 local governments achieved the goal, while the remaining 93 local governments failed. The average cost covering ratio was 71.3%, which is a big difference from the goal of 91.6% (Integrated Disclosure System of Local Public Institution: CLEAN EYE).

The purpose of this report is to analyze the problems of the water price normalization policy that has been promoted in Korea and suggest ways to improve it. Following Chapter I Introduction, Chapter II will examine the current situation of Korea's public water service. Chapter III will cover what policies have been implemented in Korea to raise water prices, and the problem of the water price normalization policy will be looked into. Chapter IV will discuss previous studies related to water price normalization policy, and Chapter V outlines policy directions. Chapter VI will focus on statistical analysis of data to reveal what is the most important factor in the policy, and the policy direction will be presented in more detail. Lastly, Chapter VII will suggest the final conclusion and further directions for future water price normalization policy.

CHAPTER II. WATER SERVICE IN KOREA

According to 2018 Statistics of Waterworks published by the Ministry of Environment in 2020, a total of 161 local governments provide water service in Korea. However, the average cost covering ratio is 80.6%, which does not recover the total cost of water service. Cost covering ratio means the ratio of average water price divided by average cost. Therefore, the

100% of cost covering ratio means that the water price and cost are same. If the ratio is less than 100%, it means that the price is lower than the cost. The following table shows the difference in water service cost, water price, and cost covering ratio according to the size of local government.

Table 1. Water Cost Covering Ratio (2018)

Region	Total (161)	Metropolitan (8)	City (76)	County (77)
Cost(won/㎥)	914.3	767.6	1,167.4	2,053.2
Price(won/㎥)	736.9	707.7	873.9	900.6
CCR(%)	80.6	92.2	74.9	43.9

• arithmetic mean by local government

While the average cost covering ratio for all local governments in Korea is 80.6% in 2018, 77 county areas have only 44% of the ratio. The reason why small local governments have lower cost covering ratio is because small local governments have much higher water costs than large local governments. Despite these differences in the cost levels of each region, small local governments have failed to impose proper water prices, so cost covering ratio vary by region.

Small local governments with poor financial conditions cannot make enough investments in water facilities because they cannot charge proper water prices. As water supply facilities become aging, the revenue water ratio decreases, resulting in a vicious cycle in which water costs continue to rise. The table below clearly illustrates this fact.

Table 2. Revenue Water Ratio by Region.

Region	Total (161)	Metropolitan (8)	City (76)	County (77)
Water Supply Ratio(%)	97.0	99.1	95.1	81.1
Revenue Water Ratio(%)	84.9	91.0	79.8	65.9

• water supply ratio : percentage of population receiving water services to total population

• revenue water ratio : percentage of total amount of water that reaches the household compared to the total water produced

• arithmetic mean by local government

While the average revenue water ratio in Korea is 85%, that of the county area is only 66%. In other words, only 66% of the total water produced in the water plant is delivered to the customer, and the other 44% is lost for reasons such as leaks in the county area. In the case of the water supply ratio, only 81% of the residents of the county areas are supplied with water, although 97% of Korea's population receives water service. The other 19% of people in county area depend on other water resources such as small village waterworks and groundwater.

Therefore, small local governments are receiving more fiscal assistance than metropolitan cities to cover water cost.

Table 3. Financial Structure of Water Management (2018, billion KRW)

Region	Total (161)	Metropolitan (8)	City (76)	County (77)
Total Income	9,207(100.0%)	2,683(100.0%)	5,279(100.0%)	1,245(100.0%)
Capital Income	8,132(88.3%)	2,613(97.4%)	4,820(91.3%)	698(56.1%)
Subsidy Income	1,049(11.4%)	64(2.4%)	440(8.3%)	545(43.8%)
Bond issue	26(0.3%)	6(0.2%)	18(0.3%)	2(0.2%)

• capital income = water charge + transfer of the last year + etc.

• subsidy income = subsidy from central government + subsidy from province government + assistance from general account + etc.

• bond issue = fiscal loan + public bond + etc.

Metropolitan cities and general cities cover more than 90% of their total income with capital income, including water charges. On the other hand, county areas make up only 56%. The other 44% are subsidized by central government or general accounts.

CHAPTER III. WATER PRICE NORMALIZATION POLICY IN KOREA

1. Comprehensive Water Saving Plan (The Ministry of Environment, 2000)

Water price normalization policy in Korea first began in March 2000 with a comprehensive water saving plan established by the Ministry of Environment. In the late 1990s, Yeongwol Dam, which the government was trying to build in Donggang River in Kangwon province, was thwarted by issues such as environmental problems. Since then, new water resource development policies have faced limitations. The necessity to utilize limited water resources efficiently by strengthening water demand management has emerged. In response, the Ministry of Environment established comprehensive water saving plan to prepare for future water shortages and overcome the limitations of existing supply-oriented policies such as dam construction.

The Ministry of Environment set a basic goal for water conservation in this policy. The goal was to save 790 million tons by 2006, 13.5% of the total 5.84 billion tons of water production in 1998. The government has used various policy measures to spread the water-saving atmosphere throughout society. The water saving policy measures included various measures such as installing water saving equipment, replacing old water pipes, reuse of waste water and etc. Increase of water price was also one of the main policy measures.

As a result of the water price normalization policy, the cost covering ratio increased by 8.7% point from 74.1% in 1999 to 82.8% in 2005. However, after the end of comprehensive water saving plan, the water price normalization policy was not promoted actively. The government seems to believe that the water saving effect from additional price increase is insignificant. According to a study on developing comprehensive plan for water demand management in December 2006, it was concluded that maintaining the current level of water price was reasonable because the correlation between water price and water consumption is flexible and uncertain depending on the conditions, although the actualization of water pricing is essential in terms of recovering the production cost of water.

2. Management Improvement Plan of Local Water and Local Waste Water (The Ministry of the Interior and Safety, 2014)

In 2014, the central government resumed its water price normalization policy. The policy target was 114 local governments that run water public companies. In Korea, local governments with a daily production capacity of more than 10,000㎥ are required to establish and manage water companies under Local Public Company Act. Due to the low price compared to the cost, local public companies were in a chronic deficit. The financial conditions of local governments also worsened as some of the investment and operating costs of local public corporations are supported by the general accounts of local governments.

In Korea, MOIS is responsible for the overall management of local public companies. MOIS set a goal of achieving the cost covering ratio of 83.8% in 2012 to over 90% by 2017. MOIS promoted the policy by classifying 114 local public companies managing local water supply into four groups according to the cost covering ratio and cost level.

Table 4. Policy Target Grouping

Cost \ CCR	above average	below average
below average	Group 1 goal : 100% (23 companies)	Group 2 goal : 100% (2 companies)
above average	Group 3 goal : 90% (19 companies)	Group 4 goal : 80% (71 companies)

The group of local governments with low cost and high ratio of cost covering was given a goal to achieve 100% ratio by 2017. On the other hand, local governments in group 4 which have high costs and low ratio of cost covering were given a goal to achieve 80% ratio by 2017. Group 2 was given a goal of 100% and group 3 of 90%.

However, the upper limit of the pricing was set at 1,400 won/㎥, considering the conditions of small local governments with poor management conditions. For example, in the case of local governments in group 4, if the water price was raised to 1,400 won/㎥ by 2017, the goal was considered to be achieved even though the cost covering ratio was less than 80%. Finally, the annual goals of each group were set as follows.

Table 5. Water Price Increase Plan of MOIS

Target		**'14 Goal**	**'15 Goal**	**'16 Goal**	**'17 Goal**
Group 1 (23 Local Gov.) Cost (below 750.5won) CCR (above 83.81%)	Price	574.8	585	595.1	605.3
	CCR	95.40%	97.00%	98.70%	100%
Group 2 (2 Local Gov.) Cost (below 750.5won) CCR (below 83.81%)	Price	581.2	604.4	627.6	650.8
	CCR	89.30%	92.90%	96.40%	100%
Group 3 (19 Local Gov.) Cost (above 750.5won) CCR (above 83.81%)	Price	835.5	837.7	839.9	842.1
	CCR	95.90%	96.10%	96.40%	96.60%
Group 4 (71 Local Gov.) Cost (above 750.5won) CCR (below 83.81%)	Price	761.5	782.3	803.2	824
	CCR	70.10%	72.10%	74.00%	75.90%
Total	Price	652.5	664.2	675.9	687.6
	CCR	86.90%	88.50%	90.10%	91.60%

• Overall, an average 91.6% goals of the 114 local public companies have been set.

In addition, MOIS has changed the management performance evaluation system of local public companies, which affects the incentive performance pay of employees of local public companies, so that they can actively engage in water price increasing. In particular, the portion of cost covering ratio in the performance evaluation index was significantly increased from 2% (2 out of 100 points) to 8% (8 out of 100 points).

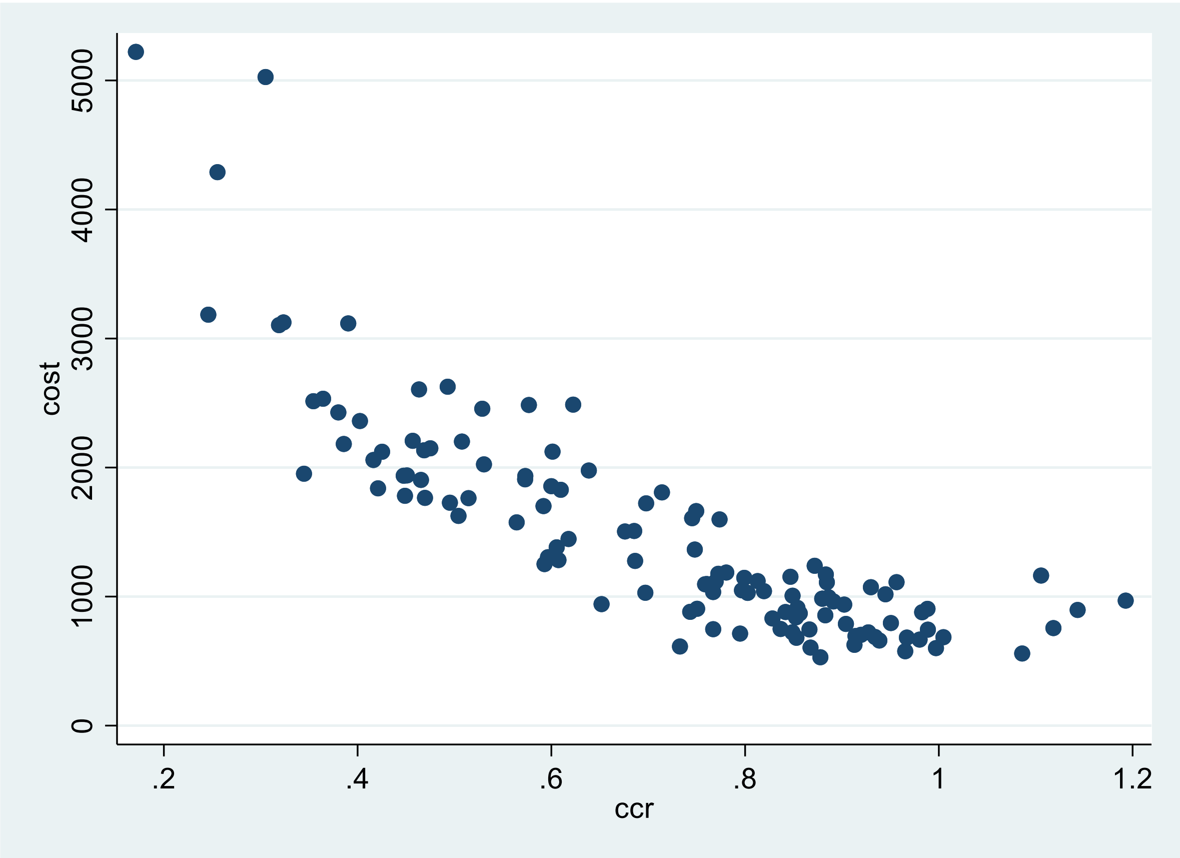
3. Policy Assessment

Despite these policy efforts, the result was disappointing. In 2017, according to an analysis of the results of achieving the goal of water cost covering ratio, only 21 out of 114 local governments achieved the goal, while the other 93 failed. The average cost covering ratio was 71.3%, which was a big difference from the original goal of 91.6% (Integrated Disclosure System of Local Public Institution: CLEAN EYE).

The first reason why the water price normalization policy failed is because the government set a very short period of time to achieve goal, even though the goal of each policy target was unrealistic. For example, Cheolwon county in Kangwon province, a typical rural area, was given 80.0% as its goal for 2017 despite 53.3% cost covering ratio at the time the policy was established. It is almost impossible for local governments which have various problems in managing water facilities with a small population to raise water price by about 30% point over five years. In order to raise water price, the local governor must have the strong will and local councils must agree to increase price. However, in the real world, it is very difficult to raise prices sharply because of resistance from local residents and political reasons.

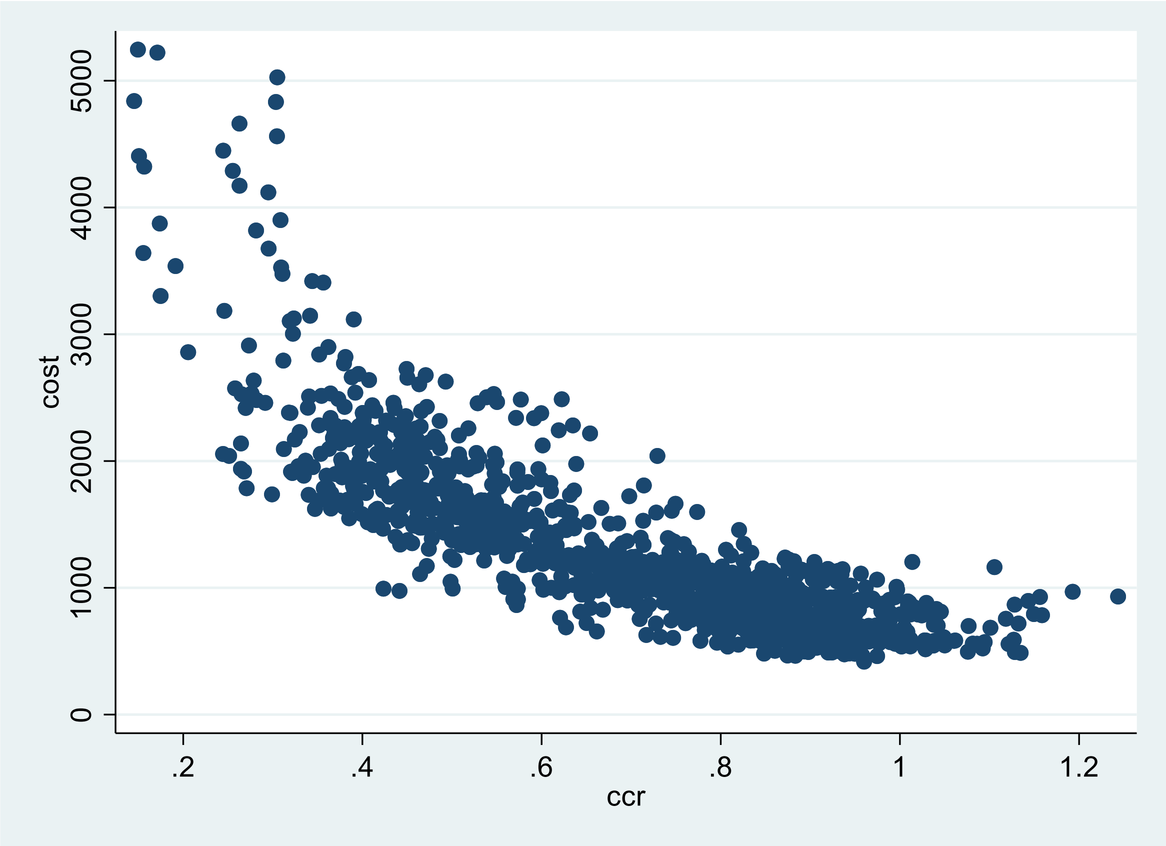
The second reason why the policy failed was because MOIS set up the policy target group incorrectly. MOIS used cost level and cost covering ratio as the criteria for classifying local public companies. However, cost and cost covering ratio are highly correlated. Cost covering ratio is the price divided by the cost. It is difficult for local governments to raise the price immediately to the level of production cost as mentioned earlier. Analysis of the correlation between the cost covering ratios and water costs of 120 local public companies in 2018 showed that the correlation ratio was –0.8412.

Scatter Plot: Cost and CCR (2018)



Similarly, the analysis of the correlation on cumulative data over the 10 years from 2009 to 2018 was very high at -0.8237.

Scatter Plot: Cost and CCR (2009 ~ 2018)



In promoting the water price normalization policy, local governments with similar conditions should be put together to implement policies. Fundamentally, there has been an error in setting up the group. Therefore, it is necessary to explore policy improvement to rationalize the target group and to set a realistic level of goal.

CHAPTER IV. LITERATURE REVIEW

There are many studies to solve the water pricing problem in Korea. Jeong, Cho, Hyun and

Bae (2012) studied empirically the factors that affect the production cost and price of water. Analyzing the water management data from 2000 to 2009, Jeong et al. (2012) found that supply-side factors, demand-side factors, financial and institutional factors had a significant impact on water production cost and price.

According to the research, the higher capacity of water facilities and population density, the lower the cost of water production costs. And the higher water supply ratio, the leakage water ratio, and the amount of debt of water business, the higher the cost of water production (Jeong et al., 2012)

Jeong et al. (2012) also found out that the variables that negatively affect the water price were water facility capacity, population density, financial independence ratio, while the variables that positively affect water price were the length of water pipes and the amount of debt of water business. Jeong et al. (2012) argued that leakage water ratio represents inefficiency of the water management, and suggested to reduce the leakage water ratio in order to efficiently operate the waterworks and reduce production costs.

Kim (2015) analyzed that water prices are low in large cities with high population density and relatively large water facility capacity. In other words, Kim (2015) argued that the economy of scale affects cost reduction and low water prices. Kim (2015) suggested a plan to expand the water management by integrating two or more local governmental water managements as a policy alternative, because the key to reforming the water financial system is raising water price.

In this study, Kim (2015) also said that the reason why Korea's water price is so low is that the economic value of water is not included in the cost estimation. In other words, the cost of damaging resources, the cost of opportunities to limit the availability of the next generation, and the cost of positive or negative external effects from the installation of water facilities were not estimated. Kim (2015) pointed out that the government's inclination to maintain low prices of public utilities is also one of the reasons. Since water price is included in the government's public price management target, it is difficult to raise water price in time.

Cho, Kim and Huh (2018) also mentioned the necessity of integrating water managements of local governments. Cho et al. (2018) argued that regional integration is necessary to improve the sustainability of water management because Korea has a large gap in water services by region. Cho (2018) suggested that the water operating system should be integrated first because it would be difficult to find consensus among local governments, such as budget allocation, profit distribution, and water price decision. Ultimate suggestion of Cho et al. (2018) was to integrate water prices in all local governments. Cho et al. (2018) also argued that it is necessary to estimate water price including the total economic value considering external costs, opportunity costs, and environmental costs of the waterworks in order to persuade residents and reach an agreement between regions.

However, previous studies also have limitations. The policy alternative to integrating water management of local government to reduce the water production cost is not realistic. The Ministry of Environment has already tried to integrate water management of local government since 2010 by providing subsidies to 46 local governments in 11 regions. However, the policy did not work. According to the report of National Assembly Budget Office in 2013, the reason why the integration policy of regional water management failed is that the interests of local governments conflicted in the process of integrating operations of water facilities, despite differences in the conditions of water facilities, financial conditions, costs and price level of water of each local government.

Some studies have emphasized improving operational efficiency in order to improve the management efficiency of water services. Lee, Kim, Kim and Kim (2016) argued that decreasing the leakage water ratio is a priority in order to increase efficiency of local water management. Lee at al. (2016) said that central government should first pursue policies to reduce water leakage in rural areas where the conditions of water management are not good compared to other local governments.

Kim et al. (2017) analyzed that local governments with lower revenue water ratio have higher maintenance costs and the maintenance cost stabilize at 75% of revenue water ratio. Kim et al. (2017) said local government with a revenue water ratio of less than 75% invests heavily to maintain water supply networks, but if the ratio exceed 75%, the costs will be reduced. This is because local governments with low revenue water ratio have more aged water pipes, which are relatively costly to operate and maintain (Kim et al., 2017). Therefore, Kim et al. (2017) suggested that local governments with low revenue water ratio should first achieve the 75% goal. In other words, it is most efficient strategy to increase the revenue water ratio to a certain level in the short term in order to secure stability of water management and gradually increase the ratio (Kim et al., 2017).

In summary, the implications of previous research in planning the water price normalization policy are as follows. First, important variables that affects the cost and price of water are environmental factors such as facility capacity, pipe length and population density. Second, in order to improve the financial conditions of local waterworks, it is also necessary to consider the improvement of operational efficiency of water facilities, such as reducing water leakage. The previous studies suggest that in designing policies for normalizing water prices, the operating environment of water service of local governments and the reduction of water leakage should be considered in the long term.

CHAPTER V. POLICY DIRECTION FOR WATER PRICE NORMALIZATION

Previously, this paper pointed out that the criteria adopted by MOIS, cost and cost covering ratio, are substantially the same and it is necessary to set more realistic indicators. As stated in the previous study, it is necessary to consider the indicators related to economies of scale that affect the cost of water production when implementing the cost-covering policy. Local governments with economies of scale will be able to achieve high goal of cost covering ratio because they have relatively good water service environment and low water production cost. On the other hand, small local governments that don’t have economies of scale should be given relatively low-level goals.

In addition, as analyzed in the previous study, the achievement of the 75% of revenue water ratio could be suggested as another criterion because the water supply network operation and maintenance costs will be different based on the 75% of revenue water ratio. Local governments with low revenue water ratio not only spend a lot of maintenance costs, but also are fundamentally threatened by an unstable water supply. Therefore, local governments that fail to achieve 75% of the revenue water ratio must first achieve the 75% and be granted a long period of time to achieve goal. This is because if the local governments invest in their facilities to increase the revenue water ratio, it is expected that production cost of water will rise temporarily. On the other hand, local governments that have achieved 75% of revenue water ratio will be given a relatively short period of time to achieve the goal of cost covering ratio.

Applying the above classification criteria, local government groups can conceptually be set up as follows.

Table 6. Policy Target Regrouping

Goal \ Factor		Economies of Scale	
		High	Low
75% RWR	Achieved	< Group 1 > Goal : high Period : short term	< Group 2 > Goal : low Period : short term
	Not Achieved	< Group 3 > Goal : high Period : long term	< Group 4 > Goal : low Period : long term

CHAPTER VI. DATA ANALYSIS AND POLICY IMPLICATIONS

Statistical analysis of data was conducted to analyze factors affecting the production cost of water. The target units are 120 local governments where water public companies are established. The reason for analyzing only 120 local governments with local public companies, not analyzing the total 161 local governments, is because it is assumed that there would be a difference in data reliability.

According to the Local Public Company Act in Korea, if a water production capacity is more than 10,000㎥, a local public company must be established and operated (Article 2 of the Enforcement Decree of Local Public Company Act). Local public companies are required to be audited annually (Article 35 of Local Public Company Act). They are also strictly monitored by the government for their management performance evaluation (Article 68 of the Enforcement Decree of Local Public Company Act). Therefore, in the statistical analysis of the data, it is assumed that the data of the water service operated by local public companies are more reliable than the data of the water service directly operated by local governments.

Dependent variable is the water production cost per ㎥. Independent variables are total water production per day, daily water production per person, total water pipe length, total water pipe length per person, revenue water ratio, leakage water ratio, water supply ratio, size of population, population density, and financial independence ratio.

Table 7. Variable List

Variable Type	Variable Name	Explanation
Dependent	Cost (won/㎥)	total cost of water for production and supply
Independent	tpop	total population
	wpop	water service population
	tpoparea (people/㎢)	total population density (total population/area)
	wpoparea (people/㎢)	water service population density (water service population/area)
	pro (㎥/day)	average of daily water production (total water production of a year/365 day)
	prowpop (㎥/day/person)	average of daily water production divided by water service population
	pl (m)	total pipe length
	plwpop (m/person)	total pipe length divided by water service population
	splr (%)	water supply ratio (water service population/total population)
	rwr (%)	revenue water ratio (amount of revenue water/total water service production)
	lwr (%)	leakage water ratio (amount of leakage water/total water production)
	fi (%)	financial independence ratio (local tax income/total budget size)

The above data were derived from the Statistics of Waterworks published by the Ministry of Environment, the Summary of Local Governments' Integrated Finances published by MOIS (website : Local Finance 365), and the Account Settlement of Local Public Companies published by MOIS (website : MOIS).

The analysis period is for the previous 10 years based on the recently released 2018 Statistics of Waterworks (Ministry of Environment, January 2020). First, a regression analysis was performed on the 2018 single-year data, and the results were obtained. Next, panel regression analysis was performed on the cumulative data of 10 years to analyze the results more precisely. Analyzing the cross-sectional time series panel data over a decade can better explain the dynamic changes. For example, it is possible to check whether the change of specific data is due to the property of the local government (local area) or the flow of time.

1. Regression Analysis on 2018 Single-Year Data

Stepwise regression of 2018 single-year data resulted in two models.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.720[a]	.519	.515	593.034813581434700
2	.772[b]	.596	.589	545.851259812264000

a. Predictors: (Constant), plwpop

b. Predictors: (Constant), plwpop, splr

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	681.729	88.817		7.676	.000
	plwpop	85.561	7.582	.720	11.284	.000
2	(Constant)	3601.008	623.827		5.772	.000
	plwpop	69.656	7.750	.587	8.988	.000
	splr	-3003.469	636.283	-.308	-4.720	.000

a. Dependent Variable: cost

For Model 1, the independent variable is the water pipe length per person and the adjusted R-squared is 0.515. In other words, the water pipe length per person explains 51.5% of the cost change. In Model 1, the cost increases by 86 won/㎥ as the length of water pipe per person increases by 1m.

For Model 2, an independent variable water supply ratio is added and the adjusted R-squared is 0.589. In other words, the water pipe length per person and water supply ratio account for 58.9% of the cost change. In Model 2, 1m increase in pipelines would lead to a cost increase of 69.7 won/㎥ and 1% increase in water supply ratio means 30 won/㎥ decline. (100% increase in water supply ratio shows 3,003 won/㎥ decline in the table.)

Based on the 2018 single-year data regression analysis results, the policy target group can be simply classified into the following table.

Table 8. Policy Target Group (2018 Data Regression Analysis)

Goal \ Factor		Length of water pipe per person (Economies of Scale)	
		Below Average (Good Condition)	Above Average (Bad Condition)
75% RWR	Achieved	< Group 1 > Goal : high Period : short term	< Group 2 > Goal : low Period : short term
	Not Achieved	< Group 3 > Goal : high Period : long term	< Group 4 > Goal : low Period : long term

2. Pooled Regression

Before analyzing panel data, accumulated data for 10 years were analyzed at a cross section level. In other words, 10-year data were combined into a single table for regression analysis. A stepwise regression analysis resulted in eight models.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.723[a]	.523	.523	484.427828424819040
2	.760[b]	.578	.577	456.112382321116000
3	.773[c]	.598	.597	445.142258215698230

4	.777[d]	.603	.602	442.425210382008600
5	.788[e]	.621	.620	432.435868452583200
6	.796[f]	.633	.631	425.640063452503060
7	.799[g]	.638	.636	423.131229074480640
8	.800[h]	.640	.637	422.248567997173040

a. Predictors: (Constant), plwpop

b. Predictors: (Constant), plwpop, splr

c. Predictors: (Constant), plwpop, splr, lwr

d. Predictors: (Constant), plwpop, splr, lwr, pl

e. Predictors: (Constant), plwpop, splr, lwr, pl, wpop

f. Predictors: (Constant), plwpop, splr, lwr, pl, wpop, tpop

g. Predictors: (Constant), plwpop, splr, lwr, pl, wpop, tpop, tpoparea

h. Predictors: (Constant), plwpop, splr, lwr, pl, wpop, tpop, tpoparea, prowpop

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	613.246	24.137		25.407	.000
	plwpop	88.380	2.486	.723	35.556	.000
2	(Constant)	2154.228	128.439		16.772	.000
	plwpop	74.783	2.593	.612	28.845	.000
	splr	-1607.807	131.894	-.259	-12.190	.000
3	(Constant)	1859.566	131.138		14.180	.000
	plwpop	64.168	2.886	.525	22.234	.000
	splr	-1398.257	131.606	-.225	-10.625	.000

	lwr	1091.712	142.760	.178	7.647	.000
	(Constant)	1802.892	131.147		13.747	.000
	plwpop	63.998	2.869	.524	22.309	.000
4	splr	-1272.562	134.722	-.205	-9.446	.000
	lwr	1029.961	142.771	.168	7.214	.000
	pl	-3.084E-005	.000	-.077	-3.896	.000
	(Constant)	1674.623	129.353		12.946	.000
	plwpop	69.934	2.916	.572	23.979	.000
	splr	-1106.993	133.568	-.178	-8.288	.000
5	lwr	1068.999	139.647	.174	7.655	.000
	pl	.000	.000	-.366	-8.400	.000
	wpop	.000	.000	.324	7.399	.000
	(Constant)	2446.529	178.598		13.699	.000
	plwpop	62.246	3.130	.509	19.888	.000
	splr	-1835.115	176.754	-.295	-10.382	.000
6	lwr	1055.436	137.470	.172	7.678	.000
	pl	-9.568E-005	.000	-.239	-5.039	.000
	wpop	.007	.001	10.660	6.354	.000
	tpop	-.007	.001	-10.438	-6.163	.000
	(Constant)	2451.781	177.551		13.809	.000
	plwpop	60.237	3.155	.493	19.090	.000
	splr	-1747.444	177.199	-.281	-9.862	.000
7	lwr	975.877	138.231	.159	7.060	.000
	pl	.000	.000	-.304	-6.060	.000
	wpop	.008	.001	11.818	6.972	.000
	tpop	-.008	.001	-11.485	-6.733	.000
	tpoparea	-25.766	6.731	-.107	-3.828	.000
	(Constant)	2492.171	177.972		14.003	.000
8	plwpop	61.694	3.206	.505	19.241	.000
	splr	-1695.580	178.135	-.273	-9.518	.000

lwr	1167.745	159.295	.190	7.331	.000
pl	.000	.000	-.313	-6.236	.000
wpop	.008	.001	11.664	6.891	.000
tpop	-.007	.001	-11.321	-6.645	.000
tpoparea	-27.002	6.736	-.112	-4.008	.000
prowpop	-322.397	133.864	-.057	-2.408	.016

a. Dependent Variable: cost

In the first model, the independent variable is the length of water pipeline per person. In next models, water supply ratio, leakage water ratio, total length of water pipe, water service population, total population, total population density, and daily water production per person were added in order.

3. Panel Data Analysis

For a more accurate analysis that takes into account the effects of time effects, Regression analysis was performed on panel data from 2009 to 2018. A fixed effects model was applied among the panel data analysis models. A fixed effects model is a method of controlling variables that do not change over time or variables that are not observed by researchers when estimating the effects of X (independent variables) for Y (dependent variables). In other words, it controls the potential effect on the x-y relationship of variables that the researchers could not observe or measure.

In the panel data analysis, the variables related to the economy of scale in the water service area were used as independent variables such as water production per person, pipe length per person, and population density. The results of analyzing the cumulative data over 10 years show that significant variables are the water pipe length per person and the revenue water ratio.

```
Fixed-effects (within) regression               Number of obs     =      1,155
Group variable: name                            Number of groups  =        120

R-sq:                                           Obs per group:
     within  = 0.2632                                         min =          2
     between = 0.5419                                         avg =        9.6
     overall = 0.5095                                         max =         10

                                                F(6,1029)         =      61.26
corr(u_i, Xb)  = 0.1705                         Prob > F          =     0.0000

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     prowpop |   60.06085   141.8311     0.42   0.672    -218.2504    338.3721
      plwpop |   63.08493   3.839609    16.43   0.000     55.55057    70.61929
         rwr |   557.4372   182.3812     3.06   0.002     199.5556    915.3189
         lwr |   241.3277    157.838     1.53   0.127    -68.39337    551.0487
   tpoparea  |  -31.28391   54.11536    -0.58   0.563     -137.473    74.90516
          fi |  -246.1041   171.7413    -1.43   0.152    -583.1073    90.89914
       _cons |   449.5484   190.7813     2.36   0.019     75.18357    823.9131
-------------+----------------------------------------------------------------
     sigma_u |  475.33782
     sigma_e |  181.94778
         rho |  .87220667   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(119, 1029) = 53.43                  Prob > F = 0.0000
```

However, the above analysis results may include distortions that may occur due to different units of variables. For example, measurement unit of the pipe length is meter, whereas the revenue water ratio is percent. In order to avoid interpretive misunderstandings caused by different units of measurement of variables, it is necessary to analyze the panel data based on the change ratio of variables. In other words, panel data was analyzed again after converting original data into log values.

The analysis results show that water production per person, length of water pipe per person, and revenue water ratio are significant variables.

```
Fixed-effects (within) regression               Number of obs     =      1,155
Group variable: name                            Number of groups  =        120

R-sq:                                           Obs per group:
     within  = 0.1604                                         min =          2
     between = 0.6456                                         avg =        9.6
     overall = 0.6169                                         max =         10

                                                F(6,1029)         =      32.77
corr(u_i, Xb)  = 0.1179                         Prob > F          =     0.0000
```

cost	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
prowpop	.1925962	.0431445	4.46	0.000	.107935	.2772574
plwpop	.2105854	.0211472	9.96	0.000	.1690888	.252082
rwr	.2887411	.0563939	5.12	0.000	.178081	.3994013
lwr	.0053862	.0101512	0.53	0.596	-.0145332	.0253055
tpoparea	-.1014476	.0532986	-1.90	0.057	-.206034	.0031387
fi	-.0372753	.0304698	-1.22	0.221	-.0970653	.0225147
_cons	6.8249	.0979847	69.65	0.000	6.632627	7.017172
sigma_u	.28478439					
sigma_e	.10397902					
rho	.88237199	(fraction of variance due to u_i)				

```
F test that all u_i=0: F(119, 1029) = 53.23                  Prob > F = 0.0000
```

The above analysis suggests that if water production per person increases by 1%, water production cost increases by 0.19%, and also if the length of water pipes per person increases by 1%, water production cost increases by 0.21%. Therefore, policy makers can create a table below with additional criteria if they want to classify the target groups in detail when promoting the water price normalization policy.

Table 9. Policy Target Group (2009 - 2018 Panel Data Analysis)

<table>
<tr><td colspan="2" rowspan="5">Factor
Goal</td><td colspan="4">1. pipe length per person</td></tr>
<tr><td colspan="2">Below Average</td><td colspan="2">Above Average</td></tr>
<tr><td colspan="2">2. water production per person</td><td colspan="2">2. water production per person</td></tr>
<tr><td>Below Average</td><td>Above Average</td><td>Below Average</td><td>Above Average</td></tr>
<tr><td>Good Condition</td><td colspan="2">Normal Condition</td><td>Bad Condition</td></tr>
<tr><td rowspan="2">75% RWR</td><td>Achieved</td><td>< Group 1 >
Goal : high
Period : short term</td><td colspan="2">< Group 2 >
Goal : normal
Period : short term</td><td>< Group 3 >
Goal : low
Period : short term</td></tr>
<tr><td>Not Achieved</td><td>< Group 3 >
Goal : high
Period : long term</td><td colspan="2">< Group 2 >
Goal : normal
Period : long term</td><td>< Group 3 >
Goal : low
Period : long term</td></tr>
</table>

The first criterion is to classify local governments based on whether the pipeline length per person is longer or shorter than the average, and the second criterion is to classify whether amount of water production per person is above or below average. This research paper analyzed panel data that converted both dependent and independent variables to log values at the end. However, for example, another analysis may be attempted by converting only a part of the variable into a log value.

CHAPTER VII. CONCLUSION

Increasing water price is a very difficult task due to external factors such as political considerations of local governments and the impact of public prices on inflation. Some local governments, which have absolutely high cost levels with problems economies of scale, should raise water price step by step because the cost recovery process requires a long period of time. As an policy alternative for water price normalization policy, this research paper proposed reclassification of target local governments, adjusting of goals and time frame considering operational factors.

The data analysis shows that the factors related to economies of scale are statistically significant indicators for the classification of local governments. It is important for policy makers to classify policy targets and determine policy goals according to those factors. In setting the goal achieving period, important point is 75% of revenue water ratio. Local governments that have failed to achieve a 75% of revenue water ratio should focus on achieving that point by facility investment. In order to implement the policy more precisely, it is necessary to differentiate the achieving period by calculating the appropriate revenue water ratio for each local area. However, a model for calculating the detailed revenue water ratio for each local area has not been developed yet. If further research in this field is developed in the future, it will be a great help to improve water service in Korea.

If central government in Korea differentiates policy targets, goals and achieving period by taking into account the operational factors of local water services, it is expected that equity between policy targets and driving force of policy will improve.

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