EFFECT OF MULTI-REGIONAL WATERWORKS ON THE OPERATION EFFICIENCY OF LOCAL WATERWORKS

By

BANG, Jeehun

CAPSTONE PROJECT

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

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Committee in charge:

Professor Jongyearn LEE, Supervisor ________________________

Professor Junesoo LEE ________________________

Professor Nahm Chung JUNG ________________________

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Executive summary

There have been several studies for developing policies that can promote the efficiency of the underdeveloped local waterworks in Korea. The studies can be divided into two parts. First, there are some studies of economies of scale through the integration of waterworks by each municipality(Choi, 2005). The others are several studies that compared the improvement of operation management index when the operation management work of each municipal waterworks was entrusted to water specialist institution(Won, 2010).

According to each study, it has been suggested that commissioning of waterworks management to specialized agencies is more effective in some indicators than direct management. The Korea Water Resources Corporation, a specialized water agency, has been operating 22 local governments since 2004. However, local consignment commissioning projects are limited by the local government's decision-making and cost burdens as a policy to improve the overall conditions of domestic waterworks. As it reflects this, the deployment of domestic local waterworks consignment projects has been stopped since 2013. Second, the integration plan of local waterworks confirms that economies of scale occur according to characteristics of network industry of local waterworks through various studies. However, according to the domestic laws, it is practically impossible for local governments to jointly operate and manage the local waterworks by integrating a part of the water supply facilities between the respective localities as management bodies. Therefore, it is not reasonable to establish a policy for improving the efficiency of domestic waterworks operation on the basis of it

Therefore, this study was carried out to establish a feasible policy direction for improving the poor water supply in Korea. For this purpose, this study analyzed the effect of multi-regional

waterworks on the operation efficiency of local waterworks in each municipality. The reason for the analysis based on the multi-regional waterworks is as follows. First, the multi-regional water means the water supply to more than two municipalities. Therefore, it is possible to indirectly analyze the influence of the integrated water supply assumed in the previous studies. Second, it is possible to establish a viable policy because the role of the regional waterworks is the largest in order to improve the operation efficiency of domestic local waterworks. In other words, if the municipality receiving the multi-regional water is more efficient than the municipality that does not receive it, then it indirectly proves the integrated effect of the waterworks. In addition, it is expected that the present domestic water system which is physically divided into multiregional waterworks by the goverment and the local waterworks that is operated and managed by the local government, is able to be evaluated efficiently and indirectly.

The results of the regression analysis are as follows, First, the regression analysis between the ratio of the multi-regional waterworks and the operation costs per total water supply of the local governments showed that there was a negative relationship at the 95% statistical significance level. In other words, the higher the ratio of the multi-regional water supply, the lower the cost per total supply which is quantitatively that the expenditure per water supply will decrease by 72won /m^3 as the ratio of multi-regional water increases by 10%. This is different from the common sense that each municipality purchasing a lot of the multi-regional water will cost more than other municipalities that do not. The reason that the municipalities that have their own water intake and purification facilities cost more than the municipalities that receive the multi-regional water are that the cost of their own water resource is low but the other expensive costs are incurred because of facility investments and maintenance costs for water treatments.

Second, as a result of analysis of the regression between the supply of the multi-regional water and the rate of revenue water, it was found that the local governments with a high ratio of the multi-regional water efficiently manage the revenue water at the 95% statistical significance level. This is because the municipalities that receive the multi-regional waterworks can concentrate on the relatively easy water supply work without the water treatment and management work that requires expertise. Lastly, the result of analysis of the regression between the supply of wide area water supply and the municipal operating workforce showed that the operational workforce decreased as the multi-regional water was supplied due to the integration effect. Quantitatively, as the multi-regional water ratio increased by 10%, the number of operators decreased by one.

Based on the results of this analysis, the following policy directions can be established. It is considered that it is not efficient in terms of workforce management to entrust all the water supply facilities and customer business of each local government collectively to a specialized agency like K-water. In other words, even though a specialized institution is entrusted with the management and administration of waterworks of various municipalities, it is difficult to expect economies of scale in terms of workforce management as the workforce is mainly determined according to the total water supply.

Instead, it is considered more efficient to adjust the scope of responsibility for the multi-regional and local water supply, which is divided into geographical boundaries between local governments. In detail, there may be an integrated management plan by expanding the business scope to the water treatment business of the municipality by the multi-regional water service provider. In this case, each municipality can concentrate only on supplying the tap water to each customer, which will lead to efficient operation of the whole local waterworks.

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I. Introduction

Korea's water supply system is divided into local waterworks run by local governments and multi-regional waterworks managed and operated by the government, which is K-water. In the same way, the management subject is divided into several organizations, resulting in inefficiency and redundant investment in production. In addition, since it is managed by an administrative unit rather than a watershed unit, it is practically not easy for a local government to take charge of the demand and supply of water, which may vary depending on the region, to be managed in a comprehensive manner.

In addition, local waterworks business in Korea are facing difficulties due to financial difficulties, imbalance of local water supply service, and shortage of professional manpower. Small-scale waterworks of the 161 local governments in the nation, are more inefficient due to the small water supply population and the small size of waterworks production costs. The municipalities in the country are compensating for the shortage of production costs by supplementary income amounting to 932.1 billion won including the subsidies for national treasury and general accounting as of 2016. In addition, the average capacity of the multi-regional area in terms of facility capacity is 1,556,000m^3 per day, but the other local governments have 862,000 m^3 per day, which is big according to the size of local governments. The most of the total water pipes, more than 20 years old, twenty-five thousand kilometers, are leaking more than 200 million tons annually, resulting in an economic loss of more than 100 billion won. This is not only a waste of resources but also a cause of management deterioration and cost increase. In order to overcome these limitations, the waterworks law was revised and it became possible to entrust it to professional organizations such as K-water and Korea Environmental Management Corporation (KEC), away from the direct management of local governments.

Many studies have evaluated the effectiveness of commissioned waterworks management by specialized agencies such as K-water. In addition, there have been a lot of studies that expect the economical effect of scale through horizontal integration of municipalities. However, since 2014, entrustment by specialized agencies has been stopped, and there is a difficulty in realizing horizontally through the municipalities due to the mutual interest relationship between the municipalities.

Therefore, this study intends to carry out research to establish a feasible policy direction for the improvement of the poor waterworks in Korea. For this purpose, this study will analyze the effect of the multi-regional waterworks on the operation efficiency of local waterworks by each municipality. First, this study will analyze the correlation between the supply of multi-regional waterworks and the operating costs of each local waterworks. This will look at whether the municipalities purchased from the multi-regional waterworks cost more than the municipalities where they take their own water free of charge. Next, this study will look at the correlation between the supply of the multi-regional waterworks and the rate of revenue water in each local waterworks. In general, it is a common belief that there is no relation between the supply of the multi-regional water and the rate of revenue managed by each municipality. Finally, this study examines the correlation between the supply of the multi-regional waterworks and the municipal administration workforce. Local governments that receive the multi-regional waterworks are expected to operate fewer manpower because they do not need the manpower to collect and purify water by themselves.

The reason for the analysis based on the multi-regional waterworks is as follows. First, the multi-regional water means the water supply to more than two people. Therefore, it is possible to indirectly analyze the influence of the integrated water supply assumed in the previous studies. Second, it is possible to establish a viable policy because the role of the regional waterworks is the largest in order to improve the operation efficiency of domestic local waterworks. In other words, if the municipality receiving the multi-regional water is more efficient than the municipality that does not receive it, then it indirectly proves the integrated effect of the waterworks. In addition, it is expected that the present domestic water system which is physically divided into multiregional waterworks by the government and the local waterworks that is operated and managed by the local government, is able to be evaluated efficiently and indirectly.

II. Literature Review

1. Reasons for the validity of integration or cooperaton of waterworks

The reason for installing the wide-area waterworks is that it is more effective to install one line on a larger scale and supply it to each local government, rather than having the same water source and several municipalities taking individual water intake facilities. In particular, when installing a dam to secure a stable water source, it is more cost-effective for the various municipalities to be supplied through large-scale pipes than to install individual water pipes. Kwon, Hyung-joon (2009) has set up a large-scale pipeline from a water source to each local government area, rather than establishing a pipeline from a water source to four local governments individually, And that it is a way to reduce the transaction cost by distributing water to the pipe and supplying it to the area. In the case of water purification plants, it is more efficient to use a joint water purification plant than to construct and operate each water purification plant (Kwon, 2009).

2. Preliminary Study on the Analysis of Local Waterworks Efficiency

The previous studies related to the efficiency of the water service business can be classified into the analysis of the efficiency of local public corporations using data envelope analysis and the study of economic analysis of scale.

The study on the efficiency of the local waterworks public corporations is mainly focused on whether there is a difference in the efficiency between the trusting institution and the direct agency. Ko, Kwang-hung (2008) analyzed the efficiency using data envelopment analysis and analyzed the efficiency difference according to the characteristics of local waterworks. As a result, there was a difference in efficiency depending on the size of the workplace and the degree of supply of the wide - area waterworks. Kim, Sang-moon (2012) analyzed the efficiency by analyzing the probability production change analysis, and compared the difference in efficiency between the direct agency and the fostering agency. As a result, the improvement rate of the technical efficiency of the delegation agency was higher than that of direct agency. Won, Koo-Hwan (2010) analyzed the difference in efficiency between direct and contracted institutions through T verification and analyzed the factors influencing efficiency by using logistic regression analysis. As a result of the analysis, it was found that there was a relative efficiency with respect to the trusting organization, and the general management cost had an effect on the efficiency. Overall, the results of several studies show that entrustment to specialized agencies is efficient.

The study of the economies of scale in the local waterworks business is followed including Kim, Eui-joon (1997), Park Sang-in (2005), Kim Ji-young (2008), Choi Han-ju (2013) . Kim, Eui-joon (1997) analyzed the economies of scale using the data of the 4th river basin regional waterworks project. Based on the results, he argued that to improve the efficiency of the local waterworks project, it should integrate the municipal water supply organization. Park Sang-in (2005) analyzed the economies of scale of 166 local waterworks projects in Korea in 2001 using regression analysis and found that economies of scale exist in labor input. Kim Ji-young (2008) analyzed the economies of scale and cost elasticities of 104 local waterworks projects in 2005 using the translog cost function. As a result, economies of scale existed only in the multi-regional area and some metropolitan areas . Choi Han - ju (2013) analyzed the economic existence of the scale through the data envelope analysis in the Chungbuk area and confirmed that there is economies of scale in the waterworks in Chungbuk province. These prior studies have confirmed the existence of economies of scale in the water supply industry, the network industry.

III. Research Method

1. Correlation analysis

Correlation analysis is a statistical technique for analyzing the degree of mutual linear relationship between variables. It is generally an important analytical process that is performed before regression analysis. Correlation coefficients used in the correlation analysis are those between -1.00 and +1.00, which are indicators of the change of one variable among the two variables above the isometric scale. In general, the higher the absolute value of the correlation coefficient is the higher the relationship between the two variables.

In correlation analysis, two measures of correlation coefficient and crystal number are used to measure the relationship between two variables. The correlation coefficient is a number indicating the direction and strength of the linear relationship between the dependent variable (y) and the independent variable (x). If r is positive, y and x are positive. As x increases, y also tends to increase. If r is negative, y and x have a negative relationship, and if x increases, y tends to decrease. The larger the absolute value of r, the stronger the linear relationship between y and x is.

2. Regression analysis

Regression analysis refers to the analysis of data as a model that can explain or predict the value of other variables using one variable. In other words, regression analysis can be thought of as making a relation between several variables, and if there is a relation between variables, it can be utilized for various prediction or explanation.

2.1 Independent and dependent variables

The variables described for analysis are called independent variables (or explanatory variables), and the predicted variables are called dependent variables (or response variables). If there is one independent variable, it is called simple regression analysis. If more than two independent variables are called multiple regression analysis. The first step in regression analysis is to distinguish between independent and dependent variables.

For normal functions, we use y = f (x), where x is an independent variable and y is a dependent variable. Here, we use the function f (x) to explain or predict how y will change as x varies. It is regression analysis to find f (x). In most cases, the value we can manipulate or set as desired is x (independent variable), and the result to be obtained through calculation of function f (x), that is, the value we want to know, is y (dependent variable).

2.2 Significance level and significance (p-value)

The significance level means the magnitude of the probability of rejecting the null hypothesis. Generally, it is often expressed as $\alpha = 0.05$ or $\alpha = 0.01$. If the significance level is too high ($\alpha > 0.05$), the probability of rejecting the null hypothesis becomes too high, which can lead to a false-positive error that makes it too easy to accept the hypothesis.

On the other hand, if the significance level is too small ($\alpha < 0.01$), the probability of choosing the null hypothesis becomes high, and the false hypothesis that the research hypothesis is correct may be negated. That is, the level of significance is a level that can be arbitrarily set. It is not necessarily set to 0.05 or 0.01, which is set to a level that reduces errors of Type 1 or Type 2.

The probability of significance is calculated by calculating the statistic that can be used to determine whether to reject the null hypothesis by the probability of the relevant area. In most cases, the hypothesis rejection is determined by comparing it with the significance level $\alpha = 0.05$. The probability of significance is a value that indicates the probability that the value of the opposite hypothesis is greater than the sample mean obtained in the null hypothesis. It is different from the 'significance level' which is the type 1 error.

3. Waterworks statistical analysis

3.1 Revenue Water Ratio

When evaluating the efficiency of the management of water facilities in a region both domestically and internationally, it is generally evaluated based on how much water loss is reduced. Assessment of water loss management can be used to assess the efficiency of water service operation management using the ratio of the quantity received by the water service provider to the area and the flow rate supplied to the area. It is also an indicator of the degree to which the state of water supply in the area is estimated.

The ratio of the amount collected as a charge to the value of the supplied quantity is called the Revenue Water Ratio and is expressed as follows.

- RWR (%) = [RW] / [TWC] X 100

Here, RWR: Revenue Water Ratio

RW: Revenue Water

TWC: Total Water Consumption

3.2 Waterworks Statistics

This study analyzed whether the supply of multi-regional waterworks had an impact on the operation of local waterworks using the waterworks statistics (Ministry of Environment) data in 2016. The purpose of the waterworks statistics is to provide basic data on the policy establishment for the proper installation and management of the waterworks facilities. Therefore, it can be said that it is the most statistically and objectively indicator of waterworks status in Korea. In this analysis, out of 161 municipalities in Korea, 152 municipalities except 9 metropolitan cities were used. This is because, in the case of metropolitan cities, the supply of waterworks and the budget are so large that the influence of the supply of the multi-regional waterworks is negligible in terms of operation management, but it can affect the statistical analysis.

The average size of the 152 municipalities to be analyzed was 610 square kilometers and the population was an average of 185,000. The average multi-regional supply ratio was 46%, and the revenue water ratio was 71.7% on average. The average cost for each municipality was 252 million won for supplying water per 1,000 households.

Table 1 Overview of Local Governments to be Analyzed

Variable	N	Mean	SD	Min	Max
area	152	610.75	339.87	33.00	1818.00
pop	152	185.81	238.97	10.28	1221.97
mtratio	152	0.46	0.41	0.00	1.00
rwr	152	71.72	13.19	36.82	96.20
crew	152	38.51	31.16	4.00	161.00
experson	152	2.52	1.97	0.25	12.06

IV. Analysis and findings

1. Impact of multi-regional waterworks on operating costs by local governments

In the case of the municipalities that the government provides water with the multi-regional waterworks, the government charges the municipalities with an average of 233 won per ton according to relevant laws. Therefore, it is recognized that the waterworks operating cost of a municipality purchasing the multi-regional water is more than that of the municipality that has own water resource and provides it to the tap water by themselves.

In order to confirm whether this common hypothesis is true, there are three models established and regression analysis will be conducted.

In Model 1, the ratio of multi-regional water to total water supply is set as an independent variable and the operating cost of the municipality is set as a dependent variable.

Model 2 added the area size and population of the municipality as explanatory variables that could affect operation costs to Model 1.

Model 3 added the revenue water ratio and the resident workforce as explanatory variables that could affect operating costs to Model 2.

Variable	model1	model2	model3
mtratio	-876.56319**	-604.99153*	-721.90116*
area		.36236145	.52303579
pop		-1.3897616**	-.1539721
rwr			-.85973989
crew			-10.520479
_cons	2434.4328***	2345.4735***	2538.682**
N	152	152	152
r2_a	.06096415	.11976167	.12326916

legend: * p<.05; ** p<.01; *** p<.001

The meaning of each variable is as follow,

- exp(won/m^3) : Expenditure per water supply (total expenditure / total water supply)
- mtratio(%) : Multi-regional water ratio (multi-regional water / total water supply)
- area(km^2) : Area

- pop(thousand) : Population
- rwr(%) : Revenue water ratio
- crew(persons) : The resident workforce

Variable	Obs	Mean	Std. Dev.	Min	Max
mtratio	152	.4635076	.4072791	0	1
aexp_persu~y	152	2028.139	1377.355	466.3036	8545.73
rwr	152	71.72347	13.19242	36.81599	96.20038
crew	152	38.50658	31.16332	4	161
area	152	610.75	339.8705	33	1818
pop	152	185.8078	238.9729	10.279	1221.975

As a result of the analysis, the ratio of multi-regional water on the operation cost was robust in all three models. Since the R-square value of model 3 is the highest, the model 3 is adopted as this analysis. And as a result of testing the heteroskedasticity of Model 3, the null hypothesis is rejected at significance level 0.05.

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(9)      =     20.28
         Prob > chi2  =    0.0163

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	20.28	9	0.0163
Skewness	14.33	3	0.0025
Kurtosis	2.47	1	0.1164
Total	37.08	13	0.0004

Therefore, it is adjusted the standard deviation for heteroskedasticity as following.

Table 2, regression analysis of municipal administration costs according to the multi-regional water ratio

```
Linear regression                               Number of obs     =        152
                                                F(5, 146)         =       7.32
                                                Prob > F          =     0.0000
                                                R-squared         =     0.1523
                                                Root MSE          =     1289.7
```

aexp_persu~y	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
mtratio	-721.9012	281.9029	-2.56	0.011	-1279.039	-164.7635
area	.5230358	.4192216	1.25	0.214	-.305491	1.351563
pop	-.1539721	.665885	-0.23	0.817	-1.469991	1.162047
rwr	-.8597399	9.634292	-0.09	0.929	-19.90043	18.18095
crew	-10.52048	5.357652	-1.96	0.051	-21.10905	.0680941
_cons	2538.682	788.96	3.22	0.002	979.4244	4097.94

Based on this result, it is estimated that the expenditure per water supply will decrease by 72won /m^3 as the ratio of multi-regional water increases by 10% for each municipality. This is a contradiction to the common sense that costs of municipalities purchasing the multi-regional water will be higher than the others that do not due to the cost of purchasing the multi-regional water. The reason is assumed that the high fixed costs due to facility investment (Park, 2005) and the continuous improvement and replacement cost of the invested tangible assets in the case of local governments that have their own water sources and water purification facilities.

2. The effect of multi-regional waterworks on the revenue water ratio of local governments

It is a general view that the proportion of multi-regional water per municipality is not directly related to the management of the revenue water ratio of the municipalities. This is because the revenue water ratio management is an indicator of how well the local governments manage their water supply facilities such as the pipelines in the process of supplying water to consumers after the production of tap water and reduce leakage.

In order to confirm whether this common hypothesis is true, there are three models established and regression analysis will be conducted.

In Model 1, the ratio of multi-regional water to total water supply is set as an independent variable and the revenue water ratio is set as a dependent variable.

Model 2 added the area size and population of the municipality as explanatory variables that could affect the revenue water ratio to Model 1.

Model 3 added the aggregate expenditure and the resident workforce as explanatory variables that affect the revenue water ratio to Model 2.

Variable	model_b1	model_b2	model_b3
mtratio	11.391342***	6.8731886**	5.338894*
area		-.00525767	-.00331174
pop		.02522636***	.02676045**
crew			-.13679648*
aexp			.00010882*
_cons	66.443496***	67.061561***	67.880714***
N	152	152	152
r2_a	.11783384	.34822719	.38311979

legend: * p<.05; ** p<.01; *** p<.001

The meaning of each variable is as follow,

- rwr(%) : Revenue water ratio
- mtratio(%) : Multi-regional water ratio (multi-regional water / total water supply)
- area(km^2) : Area
- pop(thousand) : Population
- crew(persons) : The resident workforce
- aexp(thousand won) : Aggregate expenditure

As a result of the analysis, the ratio of multi-regional water on the revenue water ratio was robust in all three models. Since the R-square value of motel 3 is the highest, the model 3 is adopted as this analysis. In the heteroskedasticity test of Model 3, heteroskedasticity does not appear due to failure to reject the null hypothesis.

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(9)      =      8.07
         Prob > chi2  =    0.5273
```

Source	SS	df	MS			
				Number of obs	=	152
				F(5, 146)	=	19.76
Model	10605.2023	5	2121.04047	Prob > F	=	0.0000
Residual	15674.8126	146	107.36173	R-squared	=	0.4035
				Adj R-squared	=	0.3831
Total	26280.0149	151	174.039834	Root MSE	=	10.362

rwr	Coef.	Std. Err.	t	P>|t|	Beta
mtratio	5.338894	2.328403	2.29	0.023	.1648235
area	-.0033117	.0028415	-1.17	0.246	-.085319
pop	.0267604	.008986	2.98	0.003	.4847498
crew	-.1367965	.0525249	-2.60	0.010	-.3231426
aexp	.0001088	.0000489	2.23	0.028	.2940475
_cons	67.88071	2.649045	25.62	0.000	.

Based on this result, the following can be interpreted. In general, the more the population, the more the revenue that makes the revenue water rate high. In addition, the more workforce and the cost to manage and operate, the higher the management capacity of waterworks facilities for the revenue water ratio. Finally, it is estimated that the revenue water ratio will increase by 0.5% as the ratio of multi-regional water increases by 10%. This is contrast to the general common hypothesis that there is no relationship between two variables.

The result seems to be due to two main causes. First, in case of municipalities that receive multi-regional water, water supply task becomes relatively easy. In the case of local governments, it is possible to concentrate on the task of providing relatively easy water supply (management of network, improvement of revenue water ratio) with fewer water purification services that require expertise. Second, as the amount of purchasing the multi-regional water is reported on a monthly basis, it seems that the local governments will be tempted to reduce leakages of the tap water to decline the purchasing cost.

3. The effect of multi-regional waterworks on the management workforce of each local government

When a municipality receives the multi-regional water, it does not need to operate the own water intake and water treatment plant, so it can reduce its operators. As a result, the general belief is that municipalities with the high proportion of the multi-regional water will have fewer workforce of management. This may be supported by previous studies claiming that there are economies of scale in labor input when the local waterworks are integrated (Park 2005)

In order to confirm whether this common hypothesis is true, there are three models established and regression analysis is conducted.

In Model 1, the ratio of multi-regional water to total water supply is set as an independent variable and the resident workforce is set as a dependent variable.

Model 2 added the area size and population of the municipality as explanatory variables that could affect the resident workforce to Model 1.

Model 3 added the aggregate expenditure and the total water supply as explanatory variables that could affect the resident workforce to Model 2.

Variable	model_c1	model_c2	model_c3
mtratio	-3.3943453	-11.674258**	-11.774324***
area		.01570219***	.01069824**
pop		.11540363***	-.02985496
tsupply			1.2459362***
aexp			-.00002972
_cons	40.079884***	12.884682**	15.711672***
N	152	152	152
r2_a	-.00468562	.72430898	.76798845

legend: * p<.05; ** p<.01; *** p<.001

The meaning of each variable is as follow,

- mtratio(%) : Multi-regional water ratio (multi-regional water / total water supply)
- area(km^2) : Area
- pop(thousand) : Population
- tsupply(million m^3) : Total water supply
- crew(persons) : The resident workforce
- aexp(thousand won) : Aggregate expenditure

As a result of the analysis, Model 1 seems to be insignificant because p-value is higher than 0.05, and Model 2 and Model 3 show the robustness of the influence of the multi-regional water rate on the workforce. Since the value of Motel 3 is highest in R-square, Model 3 is adopted for this analysis. In the heteroskedasticity test of Model 3, heteroskedasticity does not appear due to failure to reject the null hypothesis.

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(20)     =     66.55
         Prob > chi2  =    0.0000
```

```
Linear regression                               Number of obs     =        152
                                                F(5, 146)         =      51.52
                                                Prob > F          =     0.0000
                                                R-squared         =     0.7757
                                                Root MSE          =     15.011
```

crew	Coef.	Robust Std. Err.	t	P>|t|	Beta
mtratio	-11.77432	3.063996	-3.84	0.000	-.1538808
area	.0106982	.0035605	3.00	0.003	.1166762
pop	-.029855	.0376283	-0.79	0.429	-.2289399
tsupply	1.245936	.351201	3.55	0.001	1.153139
aexp	-.0000297	.0000842	-0.35	0.725	-.0339918
_cons	15.71167	3.326974	4.72	0.000	.

As a result of analysis, it was found that the operating workforce increased as the supply amount increased and as the management area increased. In addition, as in the previous study, it was found that the operational workforce decreased as the multi-regional water was supplied due to the integration effect. Quantitatively, as the multi-regional water ratio increased by 10%, the number of operators decreased by one.

V. Policy or Administrative Recommendations

The purpose of this study is to analyze the effect of the multi-regional waterworks on the operation efficiency of the local waterworks in each municipality in order to establish a feasible policy direction for improvement of domestic waterworks in Korea. First, the regression analysis between the supply of the multi-regional waterworks and the operation costs of the local waterworks showed that there was a negative relationship at the 95% statistical significance level. This is different from the common sense that each municipality purchasing a lot of the multi-regional water will cost more than other municipalities that do not. The reason that the municipalities that have their own water intake and purification facilities cost more than the municipalities that receive the multi-regional water are that the cost of their own water resource are low but the other expensive costs are incurred because of facility investments and maintenance costs for water treatments.

Second, as a result of analysis of the regression between the supply of the multi-regional water and the rate of revenue water, it was found that the local governments with a high ratio of the multi-regional water efficiently manage the revenue water at the 95% statistical significance level. This is because the municipalities that receive the multi-regional waterworks can concentrate on the relatively easy water supply work without the water treatment and management work that requires expertise. Lastly, the result of analysis of the regression between the supply of wide area water supply and the municipal operating workforce showed that the operational workforce decreased as the multi-regional water was supplied due to the integration effect. Quantitatively, as the multi-regional water ratio increased by 10%, the number of operators decreased by one.

Based on the results of this analysis, the following policy directions can be established. It is considered that it is not efficient in terms of workforce management to entrust all the water supply facilities and customer business of each local government collectively to a specialized agency like K-water. In other words, even though a specialized institution is entrusted with the management and administration of waterworks of various municipalities, it is difficult to expect economies of scale in terms of workforce management as the workforce is mainly determined according to the total water supply.

Instead, it is considered more efficient to adjust the scope of responsibility for the multi-regional and local water supply, which is divided into geographical boundaries between local governments. In detail, there may be an integrated management plan by expanding the business scope to the water treatment business of the municipality by the multi-regional water service provider. In this case, each municipality can concentrate only on supplying the tap water to each customer, which will lead to efficient operation of the whole local waterworks.

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