Applying Incentives to Increase Revenue Water in Urban Systems

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Abstract:

The study utilises cross-section data from utilities of National Water and Sewerage Corporation (NWSC) of Uganda to test application of extrinsic incentive theory on non-revenue water reduction. Applying a multiple regression model, we find that the effect of level of incentive payments on revenue water (billing efficiency) depends on the amounts of staff inputs, service coverage and water supplied per connection. Accordingly, utilities with higher levels of promised incentive payments have a higher likelihood of improving their billing efficiencies, depending on the number of staff employed, level of service coverage and production per connection. The evidence also suggests that other extrinsic factors of incentive theory like coercion and threat of punishment may be useful modulators of incentive payment effects. The study creates more understanding about the use of incentive theory in the design of non-revenue water reduction plans and how corresponding incentive policies can be structured.

Key Words: Non-Revenue Water, Incentive Theory, Water Utilities, Interractions, Billing Efficiency.

1. BACKGROUND TO INCENTIVE THEORY

Incentive theory has been more widely known as the principal-agent problem, especially when applied to the corporate world. In the corporate world, the principal is the employer and the agent is the employee. According to Locke and Latham (1990), the theory points out that the interests between the principal and the agent may not necessarily be aligned, and hence the agent might not wholeheartedly pursue the interests of the principal. Various mechanisms have been devised to align interests like commissions, profit sharing, stock options, efficiency wages and even a disincentive like firing. All the above mechanisms and many more try to address the principal-agent problem. Closely related to the incentive theory is the cognitive theory of goal setting, which means that individuals' behaviors can be driven by a clearly expected outcome (Locke and Latham, ibid). Sometimes, the expected outcome is in itself the reward. The time you set for the achievement of a goal, the level of complexity/difficulty of the goal and the specificity of the goal determine success in its achievement. An ideal goal is one where initiation of action and achievement time is close. A goal must neither be too hard nor too easy to attain. Too hard might discourage effort while too easy does not bring the satisfaction that adds to self-esteem. Finally, a goal should be precise. The theory has been supported in over 1,000 studies with employees from all sorts of organisations, and there is strong support that setting goals is related to performance improvements (Miner, 2003).

The purpose of this paper is to use a set of crossectional quantitative data to investigate how incentive theory can help understand the relationships between different levels of production input variables in water organisations and non-revenue water. According to MacLeod (1995), the standard agency model of incentives is concerned with the optimal contract that a principal will choose to induce effort from her employees, given a number of constraints on the information available and the alternatives available to employees. Alchian and Demsetz (1972) highlight the importance of measurement problems as the basis of incentive theory. A production process often entails an element of teamwork that cannot be mediated by markets, and therefore require an entrepreneur who can provide direct incentives. Research shows that companies that

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pay for incremental performance actually achieve improved staff committment and hence higher productivity, profits, and customer service (Cadsby et al., 2007; Peterson and Luthans, 2006; Salamin and Hom, 2005; Heneman et al., 1988). Williamson (1975) observes that in every organisation there is the possibility of opportunism that raises organisational costs and therefore requires a careful design of the governance structure to deal with this problem. Mugisha (2007) investigates the effects of financial incentives on efficiency and finds a positive relationship between the two variables. However, Mugisha uses limited environmental variables and obtains a statistically insignificant result. There is need for a follow study, which is the intention of this investigation. From the literature on incentive theory we are able to make the following observations:

1. We have a poor understanding of the magnitudes of the incentive effect. At the moment, there is no consistent way to link the levels of promised incentive payments with a return on performance like non-revenue water[2] reduction in water organisations.
2. The effect of application of different levels of incentives on performance is likely to be modulated by a number of input variables in the production process of a water supply chain. There is limited information on the interraction effects involved, especially in production technology involving non-revenue water management, which has received significant focus recently.

These are the gaps that this paper attempts to address, by providing empirical evidence from Uganda's water utilities.

2. INCENTIVE SYSTEMS IN UGANDA'S NWSC

National Water and Sewerage Corporation (NWSC) is a publicly owned state corporation operating on an autonomous basis. Currently the corporation operates in twenty three (23) largest urban towns of Uganda. The corporation's activities are guided by the NWSC Act, which empowers it to operate in any way possible to ensure self-financial sustainability. Operationally, the NWSC Board and management have a performance contract (PC) with the Government of Uganda (GoU), which stipulates roles of and responsibilities of each party. The PC also incorporates performance targets, a monitoring system and an incentive plan that rewards positive performance and penalises regression. The PC is operationalized through sets of internally delegated area management contracts (IDAMCs) with individual Area/regional management teams. The contracts also stipulate obligations, targets, incentive mechanisms and a performance monitoring framework. Targets/goals are set on annual basis through a protracted negotiation procedure between representative teams from NWSC Head Office (Principal) and Area/regional teams (Agents). Box 1 and Box2 show examples of financial incentive plans used in one of the sub-utilities of NWSC under delegated contract framework and the PC, respectively. Clearly, in both cases, reduction of non-revenue water (reverse of billing efficiency) carries a financial incentive/reward.

[2] According to Lambert (2003) defines non-revenue water as the difference between system input water volume and authorised billed water consumption.

Box 1: Incentive Formula for Kampala Water, NWSC-Uganda (2006-2009)

In this regard, the incentive fee[3] for Kampala Water is computed as follows:

General Formula

$$IF = B_{IF} * (P/N) + \{X\% * (OM_E – OM_O) * [aWR_{pa} + bNRW_{pa} + cCE_{pa}]\} + YTA_{pa}$$

Specific Formula

$$IF = 139{,}037{,}000 * (P/N) + \{15\% * (OM_E – OM_O) * [0.4WR_{pa} + 0.3NRW_{pa} + 0.3CE_{pa}]\} + 10{,}000{,}000TA_{pa}$$

where:

B_{IF} = Ushs.139, 037,000 is the Base Incentive

P = the weighted number of minimum service standards that have been achieved for the given month

N = 100, is the total weighted number of minimum service standards to be achieved

X% = 15% is the agreed proportion (%) of the improvement in operating margin (OM) to be retained by the Operator as bonus

OM_O = Minimum cash operating margin based on the agreed operating expenditure (Base Fee + Performance Fee) and the set Minimum Standard for revenue collections

OM_E = the achieved cash operating margin during the month being evaluated

WR_{pa} = Percentage incremental achievement in the improvement of the *Working Ratio*

NRW_{pa} = Percentage incremental achievement in the reduction of *Non-Revenue Water*

CE_{pa} = Percentage incremental achievement in the increase in *Connection Efficiency*

TA_{pa} = Percentage incremental achievement in the reduction of *Total Arrears*

Z = Ushs.10, 000,000 is the agreed incentive attached to reduction of arrears (debts)

a, b, & c = Area specific weights for Parent Targets for computing Incentive Fees where a+b+c=1.

The percentage incremental achievement (PIA) is computed as follows:

$$PIA = [(Ia – Im)/(It – Im)]*100$$

Where:

Im = the minimum performance standard for a given indicator

It = the desired target performance standard for a given indicator for the month or quarter in question

Ia = the actual achieved performance level for a given indicator for the month in question.

Source: Kampala Water IDAMC, NWSC (2006-2009), in Mugisha (2011)

Box 2: Incentive Formula for NWSC-Uganda/Government Contract (2009-2012)

The Reward/Penalty structure shall include a maximum performance incentive of 12% of Annual Gross Salary (AGS) on the achievement of all the agreed performance targets (equivalent to a Composite Aggregate Score (CAS) of 2), no incentive and no penalty on achievement of all the agreed base performance targets (equivalent to CAS of 1), a maximum penalty of 12% of AGS for failure to achieve all the agreed base performance targets (equivalent to CAS of 0) and a prorated percentage of AGS for any performance between CAS of 0 and 2.

The reward/penalty shall be computed as follows;

$$\mathrm{Re}\,ward / Penalty = 12\% * (AGS) * (CAS - 1)$$

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[3] The Incentive Fee (IF) is paid to the Operator on a prorated and weighted basis once the Operator exceeds the Minimum Performance Standards (MPS) for the parent indicators. The IF computation is prorated between the MPS and the desired target Performance Standards for parent indicators at the end of the Contract duration or the end of the respective months as the case may be. The improvements in a parent indicator that contribute to the IF are capped and are limited to the achievement of the desired target performance standard. If the Area improves performance beyond the desired target performance standards, that improvement beyond the desired performance standard, except for the cash Operating margin, does not contribute to the IF. The IF is capped.

$$CAS = \begin{pmatrix} 0.05X_{RCE} + 0.125X_{WS} + 0.075X_{RCD} + 0.10X_{CW} + 0.05X_{NRW-KW} + 0.1X_{NRW-OA} + 0.05X_{NSC} \\ + 0.125X_{NWC} + 0.07X_{WCP} + 0.1X_{PAR} + 0.05X_{EDC} + 0.05X_{CSI} + 0.05X_{WQ} \end{pmatrix}$$

Where:

CAS =	Composite Aggregate Score
X_{RCE} =	Performance Score on Return Capital Employed
X_{WS} =	Performance Score on Water Sales
X_{RCD} =	Performance Score on Receivable Collection Days
X_{CW} =	Performance Score on Capital Works
$X_{NRW\text{-}KW}$=	Performance Score on Non-Revenue Water-Kampala Water
$X_{NRW\text{-}OA}$=	Performance Score on Non-Revenue Water – Other Areas
X_{NWC} =	Performance Score on New Water Connections
X_{NSC} =	Performance Score on New Sewerage Connections
X_{NWC} =	Performance Score on New Water Connections
X_{WCP} =	Performance Score on Water Consumed by the Poor
X_{PAR}=	Performance Score on Percentage of Audit Recommendations Implemented.
X_{EDC} =	Performance Score on Effluent Discharge Compliance
X_{CSI} =	Performance Score on Customer Satisfaction Survey
X_{WQ} =	Performance Score on Water Quality

Notes : A performance score of 2 shall equate to achievement of the Agreed Performance Target (APT), 1 to achievement of the Base Performance Target (BPT) and zero for failure to achieve all the agreed Base Performance Targets. The performance score shall be computed as follows;

Indicators	**Actual Performance (AP)**	**Performance Score (X_i)**
RCE, WS, CW, NWC, NSW,WCP,PAR,ED,CSI &WQ	$AP \neq APT$	$1+\left(\frac{AP-BPT}{APT-BPT}\right)$
	$AP = APT$	2
RCD & NRW	$AP \neq APT$	$1+\left(\frac{BPT-AP}{BPT-APT}\right)$
	$AP = APT$	2

Source: NWSC-Uganda/Government Performance Contract (2009-2012), in Mugisha (2011)

3. MODEL SPECIFICATION AND HYPOTHESIS

We use a multiple regression model to assess the relationships between revenue water and a number of variables defined by the general production input/output theory. Under this theory we have a set of inputs consisting of labour, capital and "other" giving rise to a certain set of output(s). In this study, we specify the output (dependent variable) as billing efficiency (reverse reverse of non-revenue water). The choice of this output is based on the direct correlation with the overrall commercialisation objective of NWSC utilities, which is to maximise billings through improving billing efficiencies and hence increased revenue collections. The input variables are selected as labour (number of staff employed); service coverage (proportion of population served with water to total target population); water production density (system water input per service connection) and level of available incentive payments (maximum incentive payable as a proportion of employee related costs). The input variables are chosen in such a way that scale differences in utilities do not bias the analysis. According to Sykes (2011), multiple regression analysis is a technique that allows more than one factor to enter the analysis separately so that the effect of each can be estimated. It is valuable for quantifying the impact of various simultaneous influences upon a single dependent variable. Further, because of omitted variables bias with simple regression, multiple regression analysis is often essential even when the investigator is only interested in the effects of one of the independent variables. Multiple regression analysis will select a plane so that the sum of squared errors—the error here being the vertical distance between the actual value of the dependent variable and the estimated plane—is at a minimum.

In our case, we specify a general form of a multiple regression model as shown in equation (1):

$Y = f(X_S, X_C, X_P, X_I, t)$ .... (1)

Where:

$\boldsymbol{Y}$ denotes level of revenue water (measured by proportion of billed water to total system input volume

$\boldsymbol{X_S}$ denotes number of staff employeed

$\boldsymbol{Xc}$ denotes service coverage

$\boldsymbol{X_P}$ denotes water production density

$\boldsymbol{X_I}$ denotes level of proportion of promised incentive payments to employee related costs per utility

$\boldsymbol{t}$ is the time trend to capture the seasonality/time-series nature of the data

In this case, allowing for possible two-way, three-way and four-way interractions, between the input (independent variables), the regression model can take various forms. The most common one is the linear function model, shown in equation (2):

$$Yi = \beta_0 + \beta_1 X_{Si} + \beta_2 X_{Ci} + \beta_3 X_{Pi} + \beta_4 X_{Ii} + \beta_5 t_i + \beta_6 X_{Si} X_{Ci} + \beta_7 X_{Si} X_{Pi} + \beta_8 X_{Si} X_{Ii} + \beta_9 X_{Ci} X_{Pi} + \beta_{10} X_{Ci} X_{Ii} + \beta_{11} X_{Pi} X_{Ii} + \beta_{12} X_{Si} X_{Ci} X_{Pi} + \beta_{13} X_{Si} X_{Pi} X_{Ii} + \beta_{14} X_{Ci} X_{Pi} X_{Ii} + \beta_{15} X_{Si} X_{Ci} X_{Pi} X_{Ii} + e_i \quad \ldots\ldots (2)$$

Where $\boldsymbol{\beta_0}$ is the intercept – the value of the dependent variable when all the independent variables are zero; while other $\boldsymbol{\beta's}$ represents regression coefficients/elasticities with respect to the all independent variables; the mulplicative terms indicate interractions between the independent variables, and $\boldsymbol{e_i}$ represents the error term. The subscript '$\boldsymbol{i}$' denotes the utility. Both the linear multiple regression model function calculates the best straight line that fits the data. From equations (2), if the value of the dependent variables predicted by the estimated regression equations is $\boldsymbol{\tilde{Y_i}}$, then we can solve the equation by choosing values of $\boldsymbol{\beta's}$ that minimize: $\sum_{i=1}^{n} (\boldsymbol{Y_i} - \boldsymbol{\tilde{Y_i}})^2$ where subscript $\boldsymbol{i}$ denotes the utility and $\boldsymbol{n}$ is the number of utilities in the sample.

According to Mansfield et al. (2002), the robustness of a multiple regression model can be checked through a number of tests. First is *multicollinearity*, which is a situation in which two or more independent variables are very highly correlated – if two independent variables are highly correlated, there is no way to tell how much effect each has separately. Second is *serial correlation* in which the error terms (values of $\boldsymbol{e_i}$) are not independent (as required by regression analysis) but are serially correlated. One way to check whether serial correlation exists is to use Durbin-Watson test (Farebrother, 1980; Mansfield et al., ibid.). If $\boldsymbol{e_i}$ is the error term, to apply the Durbin-Watson test, we compute the statistic, $\boldsymbol{d}$, as follows:

$$\boldsymbol{d} = \frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (3)$$

Durbin and Watson have provided tables (see Farebrother, 1980), that show whether *d* is so high or so low that the null hypothesis that there is no serial correlation should be rejected. The third test is the *linearity* of the relationship between dependent and independent variables – a regression model must be fitted in data that is linearly related. The other important tests are *hemoscedacity* (constant variance) of errors and *normality* of residuals/errors.

We are now in position to make propositions for this paper. From equation (2) and the gaps indentified in section (1), this paper seeks to test the application of extrinsic incentive theory on management of non-revenue water (billing efficiency) for water utilities in developing countries using two hypotheses. The hypotheses are in line with Braumoeller (2004) who points out that when a statistical equation includes multiplicative terms in order to capture interractive effects, the statistical significance of the lower order coefficients is largely useless if interpreted alone for hypothesis testing. Therefore, in this paper, we propose that, in a given production process, aimed at improving billing efficiency output:

I. *The nature of the effects of incentive payments on non-revenue water (as a proportion of water supplied) depends on the interractive effects of staff inputs, service coverage and water supplied per connection.*
II. *In addition to incentive payments, water coverage and production density are significant drivers of revenue water improvements.*

4. DATA AND EMPIRICAL RESULTS

The study uses data on revenue water (billing efficiency, which is the reverse of non-revenue water), number of staff employed, service coverage and water supply per service connection, from NWSC-Uganda's 19 sub-utilities over the period 2004-2010. Overall, a cross-sectional data set consisting of 88 utility data points are used. Only authenticated data from the NWSC's monitoring and evaluation department is used because of reliability issues.The selection of the dependent variable revenue water (reverse of NRW) is due to its importance in determining financial and operational sustainability of utilities in developing countries. There is growing interest in mapping out infrastructure policies to improve revenue water in order to improve input resource allocation efficiencies. On the other hand, the independent variables selected constitute some of the most prominent predictors of revenue water in developing countries. The choice is also in line with economic production theory that specifies inputs as labour, capital and "other". Water production is a good physical proxy measure of capital, since the more investments they are in the water system, the more the water production capacity. In addition, they are key considerations in designing infrastructure policies required to optimise network performance, forming part of typical performance management system to control NRW in most developing country utilities (Mugisha, 2011). Understanding their relationship with revenue water levels helps utility managers to design meaningful NRW reduction programs. Table 1 and Table 2 list the regression model variable specification and summary statistics respectively.

Table 1: Dependent and Independent Variable Specification

Description	Indicator
Dependent Variable	Revenue Water (%)
Independent Variables	Number of Staff (No.)
	Service Coverage (%)
	Water supplied per connection (cubic.m/connection)
	Max. Available incentive payments as a percentage of employee related costs (%)
	Time trend

Table 2: NWSC Summary Statistics 2004-2010

Statistic	***Dependent variable***	***Indipendent_variables***				
	Revenue Water (%)	No_of staff	Service coverage (%)	Production density (cubic.m/conn.)	Max. Available incentive/employee costs (%)	Time
Mean	82.026	65.886	6.409	220.987	53.951	4.29
Stand. Dev.	8.771	139.268	14.142	72.267	26.654	2.24
Minimum	57.100	10	36.000	128.981	8.499	1
Maximum	94.900	715	90.000	432.497	134.396	8

From equation (2) above, we see that the effect of a certain independent variable, say X_{Si} on Y is given by; $\beta_1 + \beta_6 X_{Ci} + \beta_7 X_{Pi} + \beta_8 X_{Ii} + \beta_{12} X_{Ci} X_{Pi} + \beta_{13} X_{Pi} X_{Ii} + \beta_{15} X_{Ci} X_{Pi} X_{Ii}$; namely all the coefficient terms of X_{Si} in equation (2). Clearly, we obtain the effect β_1, mathematically, when the other variables in the expression are equal to zero. This is meaningless in real life – it is not possible to have zero values of service coverage and water production density and still talk of revenue water, in a practical sense. Because of this reason, we convert the variables into deviations from some values, greater than zero and evaluate the effects around them. According to Coelli et al. (2003), it is preferrable to use mean values. In this case, we use deviations from the mean values for staff, service coverage and production density. For the incentive variable, deviations are computed against a minimum value of 15% to minimise serial correlations of residuals. Furthermore, in order to ensure that the model complies with the assumptions of a regression model, various other transformations of the regressors are carried out. These included taking natural logarithms of variables other than time trend and those already in percentages (Battese and Coelli, 1995). In this way, the model becomes a log linear specification that reduces potential problems with hetereoscadicity. The variables affected in this process are staff numbers and production density.

Furthermore, before proceeding to apply all the cross-section data to the multi-variate equation (2), we first check possible *multi-collinearity*, taking into consideration all the single variables and multiplicative terms. Applying cross-correlation tests, we reduce the regressors, after eliminating those that are higly correlated (combinations with a correlation coefficient ≥ 0.7). Appendix 1 shows a correlation matrix of reduced regressors. Consequently, the reduced multi-variate equation (without the intercept) becomes:

$$Yi = \beta_1 x_{Si} + \beta_2 x_{Ci} + \beta_3 x_{Pi} + \beta_4 x_{Ii} + \beta_5 t_i + \beta_6 x_{Si} x_{Ci} + \beta_7 x_{Si} x_{Pi} + \beta_9 x_{Ci} x_{Pi} + \beta_{12} x_{Si} x_{Ci} x_{Pi} + \beta_{15} x_{Si} x_{Ci} x_{Pi} x_{Ii} + e_i \quad \text{.........................} (4)$$

It should be noted that the regressors in equation (4) have been redefined to conform to a log linear specification (see explanations above) as follows:

* $x_{Si}'s$ are staff input deviations from the mean ($lnX_{Si} - lnX_{Si}^{mean}$)

* x_{Ci}'s are deviations of service coverage (%) from the mean ($X_{Ci} - X_{Ci}^{mean}$)
* x_{Pi}'s are deviations of production density from the mean ($lnX_{Pi} - lnX_{Pi}^{mean}$)
* x_{Ii}'s are maximum incentive payment proportions (%) from a minimum value of 15% used by NWSC ($X_{Ii} - X_{Ii}^{min}$).
* t's are time trends

Empirical Results

We are now in position to compute the equation (4). In order to establish the role played by the multiplicative terms, we first estimate the reduced form of equation (4), including oly lower order regressors. Using a computer-aided **LINEST** model (on EXCEL program), we obtain results of this specification as shown in table 3 below. The definitions of results in third-fifth rows are shown in the footnotes. The t-observed values help to determine whether the observed relationships occur by chance. Given that the computed critical value, t_c ($p < 0.01$, df = 79) is 2.64, the null hypothesis that the observed relationships between revenue water (%) and the four regressors in the reduced equation (with exception of incentive variable) occur by chance is rejected at p= 1%. The incentive coefficient, β_4 , is small and insignificant in this reduced form. However, when the Durbin-Watson statistic is computed for the rediduals of this model, we obtain a value, d = 0.064; an indication of serious violation of independence of residual errors. Therefore, the reduced model cannot be used to make rational inferences about the slope coefficients.

Table 3: Model 1 - Regression results (without interactive terms)

Statistics	x_{Si}	x_{Ci}	x_{Pi}	x_{Ii}	t
1. Coefficients ($\boldsymbol{\beta_j}$)	11.616	0.461	67.158	0.009	-15.331
2. Standard error of coeffs.	1.032	0.091	8.034	0.270	3.056
3. t-values[4]	11.251*	5.076*	8.359*	0.033	-5.016*
	0.925[5]	21.79[6]	na	na	
	195.1[7]	79[8]	na	na	
	528,312[9]	42,782[10]	na	na	

**significant at p = 0.01*

When the interraction terms are included as depicted in equation (4), after controlling for multi-collinearity, we obtain results as shown in table 4. A computation of Durbin-Watson statistic ***d,*** yields a value of 2.19 for the latter model results. According to Farebrother (1980), when there is no intercept in the regression equation, the Durbin-Watson value for n = 84 and K = 10, at p = 0.01 should be between 1.24 and 2.23. Therefore, this specification is more reliable in defining the slope coefficients. Table 4 results show that the regressors explain about 94% of the variations in the dependent variable (R-squared of 0.94), which is a strong statistical goodness-of-fit. The **FDIST** is used to calculate the probability of a larger F-value occurring by

[4] t-values are computed by dividing the slope coefficient by the corresponding estimate of standard error of coefficient
[5] R-squared
[6] Standard error of dependent value estimate
[7] F-statistic or F-observed value that determines whether the relationships between dependent variable and independent variables occurs by chance
[8] Degrees of freedom
[9] Regression sum of squares
[10] Residual sum of squares

chance in table 4. The statistic for an F-value of 112.8 with df_1 = 10 and df_2 = 74 is 1.25415*10E-40. Therefore, the null hypothesis that the observed F-value occurs by chance is strongly rejected. In other words, the regression equation (4) is useful in predicting the assessed the effects of the given regressors on level of revenue water.

Table 4: Model 2 - Regression results (with interactive terms)

Statistics	x_{Si}	x_{Ci}	x_{Pi}	x_{Ii}	t	$x_{Si}x_{Ci}$	$x_{Si}x_{Pi}$	$x_{Ci}x_{Pi}$	$x_{Si}x_{Ci}x_{Pi}$	$x_{Si}x_{Ci}x_{Pi}x_{Ii}$
1. Coefficients (β_j)	-0.04	0.23	-2.21	30.96	1.82	7.40	0.49	67.91	1.74	-27.8128
2. Standard error of coeffs.	0.05	2.39	1.44	9.02	0.58	1.53	0.09	7.84	0.57	4.538698
3. t-values[11]	(0.76)	0.09	(1.54)	3.43*	3.13**	4.83*	5.14*	8.66*	3.03**	(6.13)*
	0.94[12]	21.79[13]	na	na	na	na	na	na	na	na
	***112.8[14]	74.00[15]	na	na	na	na	na	na	na	na
	535,945[16]	35,148[17]	na	na	na	na	na	na	na	na

**significant at p = 0.01*

***significant at p=0.025*

****FDIST function value is 1.25415E-40*

Other Tests of Model Assumptions: We also test the assumption of linearity of the relationship between dependent and regressor variables. By plotting the residual values versus the predicted values, we find that the points are symmetrical and there is no evidence of a "bowed" pattern. When the residual values are plotted against time and the predicted values, we did not detect a systematic pattern of residuals getting smaller or larger - an indication of limited heteroscadacity of the residuals. The normality of the residuals and predicted values is also tested using "kurtosis" and "skewness" statistics. We obtain kurtosis; skewness (K; S) values of (0.486; 0.340) and (0.480, -0.338) for residual and predicted values respectively. Both values lie within a range of -2 to 2 and hence normality can be assumed (Van Dijk et al., 2011).

5. RESULTS DISCUSSIONS

The thrust of discussions in this paper derive from a theory imbedded in extensive research, demonstrating that companies who pay for incremental performance actually achieve improved staff committment and hence higher productivity, profits, and customer service (Cadsby et al., 2007; Peterson and Luthans, 2006; Salamin and Hom, 2005; Heneman et al., 1988). The results in table 4 show that the effect of level of incentives on revenue water is given by $31.0{-}27.8x_{Si}x_{Ci}x_{Pi}$ .This expression suggests that the level of promised incentive payments has a significant positive effect on revenue water (at p = 0.01), at mean values of staff inputs, service coverage and production density. On the other hand, the interactions suggest that the multiplicative variables have a significant reducing impact (at p = 0.01) on the incentive payment effects. On the other hand, a comparison of results of table 3 and table 4 shows that when the

[11] t-values are computed by dividing the slope coefficient by the corresponding estimate of standard error of coefficient
[12] R-squared
[13] Standard error of dependent value estimate
[14] F-statistic or F-observed value that determines whether the relationships between dependent variable and independent variables occurs by chance
[15] Degrees of freedom
[16] Regression sum of squares
[17] Residual sum of squares

interactive terms are incorporated in the analysis, the combined explanatory power of the regressors on variations in revenue water is improved. In addition, the significance of the incentive effects is greatly enhanced. As a result, the null hypothesis that *"the nature of the effects of incentive payments on revenue water (as a proportion of water supplied) depends on the interractive effects of staff inputs, service coverage and water supplied per connection"* is accepted by our evidence. According to this evidence, utilities with higher levels of promised incentive payments have a higher likelihood of reducing their non-revenue water, depending on the number of staff employed, level of service coverage and production per connection.

In addition, the results show that the effects of staff inputs on revenue water depend on the level of water production density, service coverage and incentive payments. Specifically, using only statistically significant terms, the effect is computed from $7.4x_{Ci} + 0.49x_{Pi} + 1.74x_{Pi}x_{Ci} - 27.8x_{Ii}x_{Ci}x_{Pi}$. From the latter, clearly, it is not easy to discern a self-explanatory relationship between changes in staff numbers and improvements in revenue water. The situation varies based on unique production inputs of utilities. Typically, the positive relationship between high billing efficiency and low service coverage can be true in NWSC's Kampala Water Supply Area (KWSA) where coverage is high and billing efficiency is relatively low. The relationship between high service coverage and NRW could be due to dry zones. High levels of leakage coupled with high demand for water creates a supply-demand deficit in the service area. Although potential customers are in the service area, contributing to high service coverage, they depend on other alternative sources of water such as boreholes that are on the increase within the KWSA. In addition, this situation is due to inappropriate/inadequate NRW reduction strategies, which are characterised by limited waste metering districts (DMAs). This means that when service coverage is increased, this effort, most likely, contributes to increased scale of illegal connections in the water distribution network, more water leakages and increased unbilled connections. The latter could be due to laxities in capturing connections in the billing system. In other words, a positive relationship between increased service coverage and NRW is due to inadequate asset management. On the other hand where increased service coverage has a positive impact on reduction of non-revenue water may be related to increased availability of water supply and hence reduced vending activities that usually enhance illegal consumption – a "free-rider" issue.

The negative effects associated with staff inputs could be attributed to increased numbers without a specific focus and clarity on NRW reduction activities. It could also be an indicator that employees[18] are, themselves, involved in facilitating illegal connections. For example, a recent investigation by George and Company Ltd. (2011) into illegal consumption in Kampala Water Supply Area implicates a significant number of the corporation's staff involved in aiding customers to carry out illegal consumption in form of meter bypasses, meter tempering/reversal and under-reading. The corporation has handled this plague by zoning the city into smaller supply areas, appointing territorial teams made up of three people and making them fully accountable for all operational activities. In this regard, if any incidence of illicit consumption is found in any supply area, the team members are personally held responsible and disciplined. This approach has created a sense of seriousness and reduced complacency. In addition, the corporation uses a set of "amnesty" calls for both its employees and customers to, voluntarily, disclose illegal consumption. In one of the branches where illicit consumption was rampant, more than 20 percent of the accounts were voluntarily surrendered as suspected illegal connections by staff. According to KWSA (2011), this approach contributed towards reduction

[18] These are employees that are motivated by greed and even if incentives are made, they will still be involved in rent-seeking activities, like illegal connections.

of non-revenue water from 40% as at June 2010 to 37% as at June 2011. On the other hand, the positive effects associated with increased staff inputs would be, partly, due to streamlining non-revenue water strategies so that more staff are involved. This is what happens in small towns of NWSC when there is a specific target to maximise incentive payments.

Lastly, the effects of water production density on revenue water also depend on levels of incentive payments, staff inputs and coverage. A negative effect would be a disappointing result, given that the tendency in most utilities is to invest in increasing supply to meet ever-increasing demand. This would mean that increasing water supply increases water loss, which is not economically efficient. Therefore, for water companies where NRW is a key performance target to earn incentive payment like in KWSA (see intentive formular in box 1), there can easily be tendencies to deliberately cut-back on water supply irrespective of whether supply reliability is assured or not. Where this situation is being experienced in some NWSC utilities, it is attributed to the fact that increasing water supply either only helps to reach those areas where consumption is not captured in the billing system or increases supply reliability for premises where billed consumption is simply kept constant through meter reading connivance/tempering by the corporation's meter readers/marketing assistants. On the other hand, increased water production per connection also increases hydraulic pressures and results into increased leakages and bursts which increases NRW. Moreover some types of meters used in the network are sensitive to flow velocities and when water supply increases and fills overhead domestic tanks, the small flows pass without being registered in the domestic meters, which cumulatively leads to increased NRW (Mutikanga, et al., 2011).

6. CONCLUSIONS

This study has tested application of fundamentals of extrinsic incentive theory in the management of non-revenue water. Our evidence suggests that the effect of level of incentive payments on revenue water (billing efficiency) depends on the amounts of staff inputs, service coverage and water supplied per connection. According to this evidence, utilities with higher levels of promised incentive payments have a higher likelihood of improving their billing efficiencies, depending on the number of staff employed, level of service coverage and production per connection. Given a certain level of promised incentive payments, utilities with higher levels of staff numbers, service coverage and production density will have a high likelihood of high non-revenue water (%). The theory also alludes to use of coercion and threat of punishment as measures of performance improvement. From our observations, we see that these aspects of the theory are being extensively used in Kampala Water Supply Area, in tandem with financial incentives and may been contributing to behavioural change towards better management of NRW. However, managers need to be convinced that the generated performance indicators (PIs) will not be used for penalising them. Otherwise, managers often corrupt data and produce numbers they are asked to deliver (Mutikanga et al. 2010).

In addition, the paper shows that higher levels of promised incentives promote the reduction of NRW. However, it must be noted that higher levels of actual incentive payments must involve a smart balance between the benefits of NRW reduction and the associated costs (incentive payments and the actions taken by managers). If excessive amounts of effort (and resources) are devoted to NRW reduction, the result may be a tilt in the economic balance of the utility business – it is always important to compute the economic level of leakage as a guide to emphasis on NRW reduction efforts. Currently, this analysis eludes NWSC. May be if such analyses were being carried out, water scarce areas would be required to pay more attention to water leakages than regions where water is abundant. Similarly, such analyses would show that theft in very poor communities may have different cash flow implications than theft in well-to-do communities. Of course, promoting a culture of payment (often via targeted subisidies) has a positive impact over the long run – so it is hard to assert that managers should ‘look the other way’ when NRW is driven by illegal connections. Furthermore, a culture of bribe-taking by emplyees has implications that go beyond NRW; it tantamounts to overall poor governance of the utility. More research should be directed in this area.

The evidence has implications for theory and infrastructure policy. It creates more appreciation and understanding of the role of using incentive payments to finding solutions of incomplete contracting in water utilities – a structural problem which is pointed out by MacLeod (1995). The study also distils out additional extrinsic factors (of coercion and threat of punishment) of incentive theory that may be useful modulators of effects of incentive payments on revenue water. More work is needed to better understand the nature of such interraction effects and how their understanding can be used to find solutions to the incomplete contracting problem. For policy, the study reinforces the need to strengthen the use of extrinsic incentives, which include payments, coercion and threat of punishment; in non-revenue water reduction programmes. Liemberg (2002) points out that properly designed incentive contracts can potentially reduce NRW in utitilies. This study suggests that the design of such incentive plans needs to take cognisance of possible interaction effects of staff inputs involved, levels of service coverage and amounts of water production densities applied. More work is needed, in different utility settings, to understand the nature of the interaction effects involved and how they impact on the design of practical incentive plans. There are many other factors that influence the levels of NRW (Skipworth et al. 1999). For instance, system pressures, system age, customer density etc. have a positive relationship with NRW and have not been used in the study. Future research should explore the effects of these factors on NRW.

REFERENCES

Alchian, Armen A. and Harold Demsetz (1972). Production, Information Costs and Economic Organisations. *American Economic Review*, 62:777-795

Battese, G.,E. and Coelli, T., J (1995). A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data. *Empirical Economics,* 20: 325-332

Braumoeller F. Bear (2004). Hypothesis Testing and Multicative Interraction Terms. *International Organization* , 58: 807-820

Cadsby, C. B., Song, F., & Tapon, F. (2007). Sorting and incentive effects of pay for performance: An experimental investigation. *Academy of Management Journal*, *50*, 387–405

Tim Coelli, A.Estache, S.Perelman & L.Trujillo (2003). A Premier on Efficiency Measurement for Utilities and Transport Regulators. WBI Development Studies. World Bank, Washington DC.

Farebrother, R. W. (1980). The Durbin-Watson test for serial correlation when there is no intercept in the regression. *Econometrica,* Vol. 48 (6), 1553-1563

George and Company Ltd. (2011). Illegal Use Reduction Project Report, June-August, 2011. National Water and Sewerage Corporation, Plot 39, Jinja Road, Kampala.

Heneman, R. L., Greenberger, D. B., & Strasser, S. (1988). The relationship between pay-for-performance perceptions and pay satisfaction. *Personnel Psychology*, *41*, 745–759.

KWSA (2011). Kampala Water Supply Area, Quartely Report, July-September, 2011. National Water and Sewerage Corporation, Plot 39, Jinja Road, Kampala.

Lambert A. (2003). Assessing non-revenue water and its components: a practical approach. Water 21, August, 2003.

Liemberger, R. (2002). "Performance target based non-revenue water reduction contracts: a new concept successfully implemented in southeast Asia." *Water science and Technology: Water Supply*, 2(4), 21-28.

Locke, E. A., & Latham, G. P. (1990). *A theory of goal setting & task performance*. Englewood Cliffs, NJ: Prentice Hall.

MacLeod W. Bentley (1995). Incentives in Organisations: An Overview of Some of the Evidence and Theory. Published in *Trends in Business Organisation*, Horst Siebert (ed.), the Kiel Institute of World Economics.

Manfield, E., Bruce, W. A., Doherty, N.A and Weigelt, K.(2002). Managerial Economics: Theory, Applications and Case Studies. W.W. Norton and Company, Inc., 500 Fifth Avenue, New York, N.Y. 10110. ISBN 0-393-97677-7

Miner, J. B. (2003). The rated importance, scientific validity, and practical usefulness of organizational behavior theories. *Academy of Management Learning and Education*, *2*, 250–268

Mugisha Silver (2011). Utility Benchmarking and Regulation in Developing Countries: Practical Application of Performance Monitoring and Incentives. IWA Publishing, UK, ISBN-10: 1843392577 ISBN-13: 978-1843392576

Mugisha, S. (2007). "Effects of incentive applications on technical efficiencies: Empirical evidence from Ugandan water utilities." *Utilities Policy*, 15, 225-233.

Mutikanga, H., Sharma, S. K., Vairavamoorthy, K., and Cabrera Jr, E. (2010). Using performance indicators as a water loss management tool in developing countries. Water Supply: Research and Technology—AQUA, **59 (8), 471–481**

Mutikanga, H.E; Sharma, S.K; Vairavamoorthy, K. (2011). Assessment of apparent losses in urban water systems. *Water and Environment Journal*. 25 (3), 327-325Peterson, S. J., & Luthans, F. (2006). The impact of financial and nonfinancial incentives on business-unit outcomes over time. *Journal of Applied Psychology*, *91*, 156–165

Salamin, A., & Hom, P. W. (2005). In search of the elusive U-shaped performance-turnover relationship: Are high performing Swiss bankers more liable to quit? *Journal of Applied Psychology*, *90*, 1204–1216.

Skipworth, P.J., Saul, A. J., and Machell, J. (1999). The effects of regional factors on leakage levels and the role of performance indicators. Water and Environment Journal, 13 (3), 184-188

Van Dijk M.P., Bas Koch and Matthijs Soeterbroak (2011). Is the Number of Business Start-ups a function of agglomeration economies and the local knowledge economy? Evidence from the Netherlands. Working Research paper, Erasmus University, Rotterdam, Netherlands.

Williamson. O (1985). The Economic Institutions of Capitalism. N.Y., Free Press

Appendix 1: Multi-collinearity test for reduced regressors, including multiplicative variables

	x_{Si}	x_{Ci}	x_{Pi}	x_{Ii}	t	$x_{Si}x_{Ci}$	$x_{Si}x_{Pi}$	$x_{Ci}x_{Pi}$	$x_{Si}x_{Ci}x_{Pi}$	$x_{Si}x_{Ci}x_{Pi}x_{Ii}$
x_{Si}	1									
x_{Ci}	0.20061	1								
x_{Pi}	0.42543	-0.1693	1							
x_{Ii}	-0.1227	0.08728	-0.2207	1						
t	0.07473	0.33939	-0.6374	0.20851	1					
$x_{Si}x_{Ci}$	0.36956	-0.6854	0.26188	-0.1821	-0.0985	1				
$x_{Si}x_{Pi}$	0.34683	0.07752	-0.2079	0.0075	0.3223	-0.0239	1			
$x_{Ci}x_{Pi}$	0.29836	0.06609	0.31639	0.02624	-0.1667	0.23055	-0.0015	1		
$x_{Si}x_{Ci}x_{Pi}$	0.14223	0.06077	-0.1087	-0.1345	0.19163	0.03209	0.23078	-0.584	1	
$x_{Si}x_{Ci}x_{Pi}x_{Ii}$	0.03477	0.16327	-0.1987	0.12717	0.18905	-0.1523	0.26142	-0.5676	0.61972	1