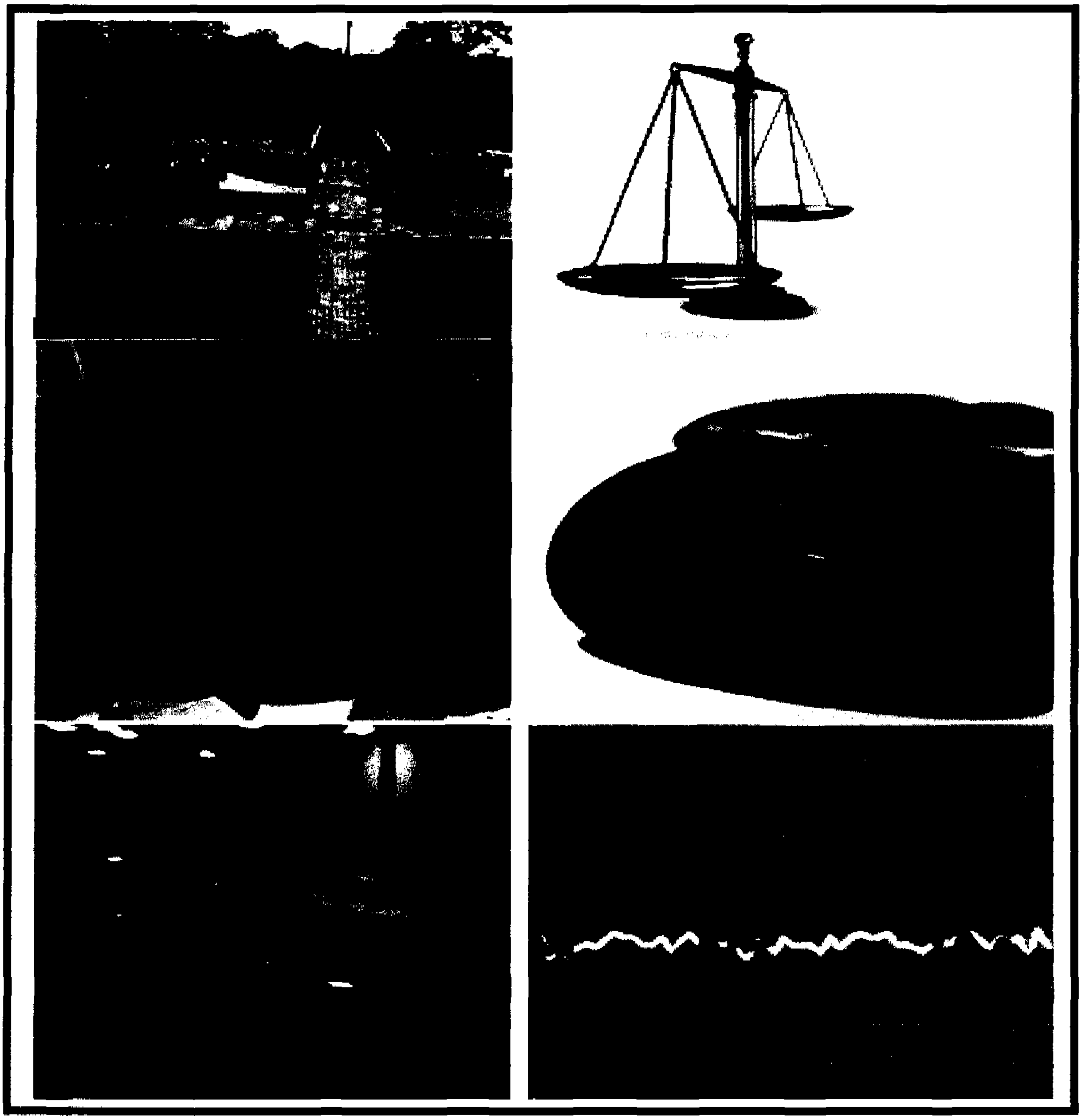
UNESCO-IHE **UNESCO-IHE** MSc Thesis-4/2008

INSTITUTE FOR WATER EDUCATION



Investigating the “Double Jeopardy” Issue in the Water Sector The Limited (Applicability) of Partial “Metric “Benchmarking”

Doan Van Minh

MSc Thesis: 08.26
April 2008

UNESCO-IHE
Institute for Water Education

UNESCO-IHE
Institute for Water Education

INVESTIGATING THE "DOUBLE JEOPARDY" ISSUE IN THE WATER SECTOR THE LIMITED (APPLICABILITY) OF PARTIAL "METRIC" BENCHMARKING"

Master of Science Thesis
By
Doan Van Minh

Supervisors
Prof. Dr. Meine Peter Van Dijk (UNESCO-IHE)
Mentor
Marco Schouten (UNESCO-IHE)

Examination committee
Prof. Dr. Meine Peter Van Dijk (UNESCO-IHE), Chairman
Marco Schouten (UNESCO-IHE)
Peter Ryan (IRC)

This research is done for the partial fulfilment of requirements for the Master of Science degree at the UNESCO-IHE Institute for Water Education, Delft, the Netherlands
Delft
April 2008

Table of Contents

List of figures

List of tables

List of appendices

Abstract

Currently, "metric" benchmarking has been widely applied in the water service sector. It is argued being a managerial tool to boost the efficient performance of water service sector in the absence of market mechanism in the sector.

At the same time, a consistent method in application of "metric" benchmarking in the sector is still on discussion. Some advocate the partial cost indicator method while others use the total cost indicator method. In addition, in relation with the indicator selection, a term so called "double jeopardy" issue has received series of concerns by various authors on literature.

The uncompleted benchmarking approaches together with the "double jeopardy" issue raises a problem in efficient measurement of benchmarking practice. This problem is the distortion of efficient benchmarking results by the "double jeopardy".

In this research, an analysis is made on the relation between capital costs and operational indicators using three cases located in the Netherlands water supply companies in four years, and the UK over seven years and Vietnam in one year in order to firstly examine the real existence of "double jeopardy" in the selected water sector, secondly get insight into the vulnerability of different benchmarking results to the "double jeopardy" issue, lastly test the consistence of different benchmarking results in a selected case.

Relationship between the capital and operational costs of the three selected cases is analyzed by application of regression model. The consistence between benchmarking results is carried on by the application of comparative analyses.

The results from the regression model suggest that "double jeopardy" really exist in the selected cases and the results of partial benchmarking scheme are more vulnerable to the "double jeopardy" issue. The comparative analysis shows that there is inconsistent between the partial and total cost benchmarking results. These research results comply with the current knowledge about the issues.

Within the findings of the research at hand, it enables the benchmarking initiatives to select appropriate financial indicators to measure the efficiency of water utilities.

Acknowledgements

I would like to extend my sincere gratitude to organizations and individuals who helped me to complete my M.Sc. study.

I would like to express my sincere gratitude to my supervisor Prof. Dr Meine Peter Van Dijk for his overall supervision of this work with the clear guidance, and constant support.

My mentor Marco Schouten, to whom I sincerely acknowledge my hearted gratitude, encouraged me to think independently and in a scientifically disciplined manner, and weekly side by side in a half of year supported me to make this work possible.

I am also graceful to Dr. Klaas Schwarts, who organized the working in progress workshop whereby the study received various useful comments. My special thanks are given to all of my colleagues in Water Service Department who contributed valuable suggestions for the thesis.

I would like to thank the librarian staffs for their supports in achieving peer reviewed articles and couching in the referral method.

I want to give my truly thanks and appreciations to Foreign Affairs of the Netherlands Government through the Netherlands Fellowship Programme (NFP) and Unesco-IHE financially supported for making my study possible.

I would like to thank my employer-the Development Strategy Institute, ministry of Planning and Investment of Vietnam for nominating me to study and complete my M.Sc. at Unesco-IHE, the Netherlands.

Finally, I deeply excavated my acknowledgment to all my family members who sent their sympathies and mental encouragement during my resident in Holland to complete this work, especially to my youth sister who cared for the routine activities of my family during my absence.

Chapter 1 Introduction

The purpose of this chapter is to introduce generally the research topic. First, it shows that benchmarking has been used widely in the public sector especially in water sector. Second, it presents different benchmarking methods used to measure efficiencies in public utilities. Lastly, the chapter raises a problem resulting from different benchmarking indicator selection by two benchmarking approaches.

I. Background

In 1979, competitiveness of the Xerox's copiers was in extreme low position in comparison with those of its Japanese competitors. The costs for producing Xerox's copying machines were equal to the price of those Japanese companies. This triggered out a new management tool which was applied to boost the competitiveness of Xerox. Such a tool is called "benchmarking". The benchmarking tool has two main types. One

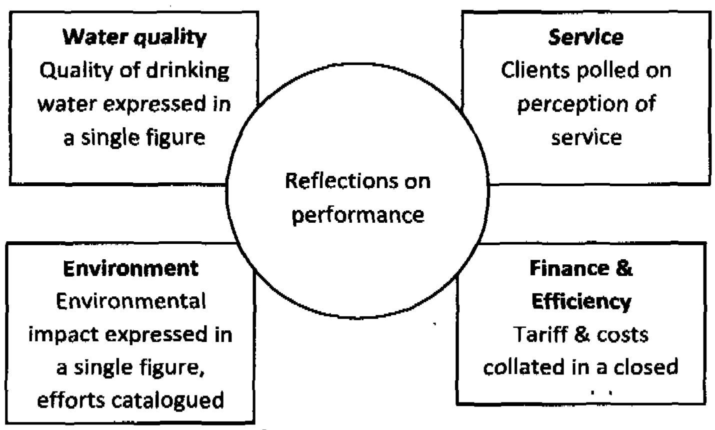


Figure 1: Main areas of "metric" benchmarking
Source: Larsson et al. (2002)

is Process Benchmarking, whose comparisons are based on the process of benchmarked organizations. The other is the "metric benchmarking" whose comparisons are based on performance indicators.

Specifically, "Metric benchmarking" is the quantitative measurement of performance of a utility against other utilities or the industry over time, using key performance indicators (KPIs) which are not versatile to apply in any benchmarking schemes but each initiative will tailor its own KPIs set. One example of KPIs by The International Benchmarking Network for Water and Sanitation Utilities (IBNET) is presented in annex 1.

In "metric" benchmarking there are four areas needed to be measured as shown in ***Figure 1***. Here the water quality complies with drinking water standards set by authorities. The quality of service is the extent to which expectations of customers are met. It is represented by indicators like *reliability, responsiveness and consideration* etc.

The environmental area is to estimate the impacts of water production and distribution on environment. This estimation is done by the application of environmental Life Cycle

Analysis according to Eco-Indicator method which was tailored by Kiwa to use in water sector. Lastly, the finance and efficiency area take into the revenue and all costs presented on balance sheets of water utilities.

In "metric" benchmarking as mentioned by Diewart and Nakamura (1999) the core of a benchmarking exercise is the selections of a set of indicators which measure given aspects of a water company. Hence, careful selection of indicators allows the benchmarking scheme to reflect closely the real performance of a water company.

Returning to the Xerox's story, after the application of benchmarking two years, in 1981 the performance of Xerox achieved big improvement. Its labour costs reduced 30 percentage and the defected machines also decreased by 90 percentages. Since then the application of benchmarking has been widely expanded over other giant corporations like Motorola, General Motor, and AT&T. According to Ed Boyce, a vice president of Vienna, Virginia-based Kaiser Associates, 60 to 70 per cent of the largest US companies are undertaking some kind of benchmarking programs (Fong 1998).

The successful story of benchmarking application in private sector also conquers the public sector. Shleifer (1985) suggested a method of application of benchmarking in the public sector. The author's idea is to compare the costs of a public utility with an efficient utility in the industry. From the onset, around the world, benchmarking has been receiving many promotions by various regulatory bodies and other initiatives such as regulators use benchmarking to set revenue requirements in public sectors (Irastorza 2003). They consider benchmarking an incentive to promote efficiency in the absence of market mechanism in the public domain (Giannakis et al. 2004). Donors use benchmarking to give loans to the utilities. Thus, objectives of benchmarking are to improve performance and to implement new methods and processes that help to increase the efficiency and competitiveness of an organization. It finds a "best practice" or frontier organizations, whereby both private and public sector can learn from these frontiers to improve their performance.

Though benchmarking is a useful management tool, its application in public sectors has not been straightforward yet. This is because of the fact that the application of benchmarking in public sector is very young (Kouzmin et al. 1999)

Moreover consistent theory of benchmarking in public sectors has not been well developed. Thus, the methodology of benchmarking needs to be developed and verified for practical application (Giannakis et al. 2004)

Like the other public sectors, benchmarking are also popular in water service sector, The International Benchmarking Review (2001) identified some 160 benchmarking schemes covering at least 700 water/wastewater utilities in 110 countries. The main motivation to initiate metric benchmarking is that utilities may learn from another. The idea is that not all problems and solutions of monopolistic providers are locally dependent, but standard solutions may be available elsewhere (UKWIR 2001). However, benchmarking exercises are not solely executed to enhance companies to learn from another. Benchmarking is also executed to increase overall insight in the performance of the sector, to set price levels, or to assess the eligibility of companies to access loans and grants. In many cases, one benchmarking scheme serves many of these purposes (see table 1).

One of the main challenges for water service benchmarking engineers is to tailor a set of performance indicators to the purpose of the benchmarking scheme (Kouzmin 1999) and (Diewart 1999). Even more, apart from the purpose, the set of performance indicators also needs to be adjusted to other contextual factors, like the benchmarking partners and the accessibility of data (*Drew* 1997). Consequently the performance indicators of the various benchmarking schemes vary considerably.

Table 1 shows that in all cases the purpose is for utilities to learn from another. However, some schemes have more ambitious goals. They also want to use the benchmarking for setting prices (like in the UK), or to judge the eligibility to access loans (like in Vietnam). The Vietnam case is interesting since the World Bank has agreed to make two kinds of credit accessible to individual water utilities based on their benchmarking ranking. A higher ranking in the benchmark would enable utilities to access to higher level of debt (*Sharifian* 2002). Another observation from the Table is that in case the goal is primarily to learn from another, the OPEX benchmarking approach seems to suffice. Only in the cases when additional purposes are served also TOTEX benchmarking is applied. Interestingly this does not apply for the Vietnamese benchmarking which uses an OPEX benchmarking approach.

Table 1: Different approaches to "metric" benchmarking by various initiatives

Region	**Benchmarking scheme**	**Benchmarking Purpose**				**Benchmarking approach**		
		Learning	**Insight**	**Price**	**Loans**	**CAPEX**	**OPEX**	**TOTEX**
Euro	The UK Office of Water (OFWAT)	+	+	+		X	X	
	The Association of Dutch Water Companies (VEWIN)	+	+				X	X
	Norwegian association of water and wastewater works (NORVAR)[1]	+				X	X	X
	Finnish benchmarking model[1]					X	X	X
	Danish Water and Waste Water Association[1]	+	+					X
America	American Water Work Association (AWWA)[2]	+	+				X	
	The PERU water regulator (SUNASS)[3]	+	+				X	
Asia	Indian model[4]	+	+		+	X	X	
	Vietnam Water and Sewerage Association (VWSA)	+	+		+		X	
	South East Asian Water Utilities Network (SEAWUN)	+					X	
Arica	The Water Utility Partnership (WUP) for capacity building in Africa	+					X	
Australia	Australian model[5]	+	+			X	X	X
International	The World Bank	+					X	
	The international benchmarking network for water and sanitation utilities (IBNET)	+					X	

[1] Presented in Comparison and evaluation of the Northern European Benchmarking systems
[2] http://www.awwa.org
[3] Corton, M. L. (2003), Benchmarking in Latin Water Sector; the case of Peru, *Utility Policy*, *11*, 133-142.
[4] *2007 Benchmarking and Data Book of Water Utilities in India*
[5] Australian National Performance Report 2005-06

In metric benchmarking, a broad division can be made in two alternative approaches for selecting performance indicators (*Fong et al.* 1998). One way is to include only the partial performance indicators, which are not set up based on the total cost. One popular approach to partial benchmarking is to include operational costs. The main argument for selecting only operational indicators is that utilities are able to manipulate them in the short term. The main indicator to assess the operational financial performance is in the OPEX (Operational Expenditures) benchmarking approach the working ratio[6]. Capital expenditures (CAPEX) are excluded from the benchmarking due to their more fixed character. Besides, partial benchmarking also means to include merely the CAPEX indicators. In fact, CAPEX benchmarking is not executed independently but it is a part of a total benchmarking scheme like in the UK water benchmarking. The alternative approach is to include the full costs performance indicators. This approach is referred to as TOTEX (total expenditures) benchmarking and is based on the argument that the TOTEX indicators provide a more accurate reflection of the entirety of the costs of service provision. The main performance indicators in the TOTEX relate the total costs to the total output of the utility (like water delivered number of connections). The table 1 above presents the approaches used of selected benchmarking schemes in the water supply and sanitation sector. This argument is strengthened by the sector's capital intensity[7] (Table 2), making the weight of the CAPEX in the full costs for water high.

Since this study is to focus on the efficiency area of "metric" benchmarking, the costs mentioned above should be broken down in more detail. These costs include three elements; cost of capital, depreciation and operational costs.

There are different methods to classify costs; in this study the method mentioned by Larsson et al. (2002) is used. The full cost of water utilities is separated in the following groups:

Operational costs (OPEX): these costs are related to daily operation of water utilities, they are totally transferred into the value of water produced. Examples of these costs are labour, materials, communication etc.

Capital costs (CAPEX): these costs are connected with the capital used by water utilities. Any water utilities need capital to operate. When employed capital brings with itself costs. This cost is divided in sub-categories, which are:

- Depreciation: this cost is associated with the fixed assets of water utilities. It is a part of fixed asset value that is transferred gradually into the value of water produced. It should be make clear here that in accounting term, depreciation is considered operational cost. However, due to its strong link to investment and constant over time, then for the purpose of this study, depreciation is put in the capital cost group.
- Cost of loan capital: a part of the total capital investment is borrowed and this needs interest payment for the lenders.
- Cost of equity capital: investors also invest by their own money, and when doing this, they require a rate of return on the investment amount.

[6] Working ratio is calculated by dividing the operational costs by the operational revenues.
[7] CAPEX in the water industry accounts for 65 to 80% of the full costs of supplying the service (Kessides, 2003; Noll, 2000).

The table 2 shows cost items of water utilities in the UK. The capital costs accounts for almost more than haft of the full cost of supplying water.

Table 2: Cost break down of a water companies

Items	Dwr Cymru Cyfydedig Utilities[8]		Dee Valley Water PLC[9]	
	Amount (£000)	Percentage in total costs (%)	Amount (£000)	Percentage in total costs (%)
Employment costs	1,372	7.30	13049	4.88
Power	1,244	6.62	13661	5.11
Hired and contracted service	166	0.88	9354	3.50
Materials and consumables	503	2.68	4292	1.61
Service charge	722	3.84	8781	3.29
Bulk supply imports	28	0.15	-	-
Other direct costs	203	1.08	-	-
General and supported expenditures	2,471	13.15	20326	7.60
Customer services	-	-	10757	4.02
Scientific service	-	-	7556	2.83
Local authority rates	947	5.04	13636	5.10
Doubtful debts	418	2.22	4789	1.79
Third party service	1,885	10.03	9256	3.46
Total operating expenditures	9,959	[illegible]	115457	43.20
Infrastructure renewals charge	3,058	16.27	29819	11.16
Current cost depreciated	2,474	13.16	73734	27.59
Business activity current cost depreciated	504	2.68	-	-
Third party service	-	-	1380	0.52
Interest payables	2,799	14.89	46900	17.55
Total capital costs	8,835	[illegible]	151833	56.80
Total costs	**18,794**	**100.00**	**267290**	**100.00**

II. Problem identification, its significances

1- Problem identification

As mentioned earlier, "metric" benchmarking is popular in water sector. It has specific purposes by different initiatives and the benchmarking methodology is not straightforward. All these raise the issue of how "metric" benchmarking is used in efficient measurement of water utilities?

In fact, "metric" benchmarking exercise uses financial indicators or variables to measure the efficiency of water utilities (Kouzmin 1999). And also according to him (1999) and Diewart (1999) the selection of these indicators is the major issue in a benchmarking.

[8] Dwr Cymru Cyfydedig Utilities, Regulatory account 2007

[9] Dee Valley Water PLC, Regulatory Financial Statements 2007

There are two approaches to choose the financial indicators, which are partial or total cost approaches. In the first situation, benchmarking initiatives can choose either operational cost or capital cost variables. Like in the UK, partial approach has been existing (Giannakis et al. 2004) and Graham (2005) while Dutch and Norwegian regulators have preferred to use the total cost benchmarking Ajodhia (2004). Under specific regulatory purposes, the issue of choosing different indicators is that which one (partial or total cost indicators) are the best to measure the real efficiency of water utilities and what are the regulated utilities' behaviours under defined set of indicators .

The behaviours of benchmarked utilities first are concerned by Ajodhia et al. (2005) when the authors mentioned about the "double jeopardy" issue. "Double jeopardy" is a terminology used to describe the allocating and accounting trade-off between the capital and operational costs. The allocating trade-off relates to the investment decision. The utilities may use different capital and labour ratio to produce the same amount of output. In this trade-off there may be inefficient if the utilities want to meet regulatory standards by using suboptimal capital and labour ratio. The accounting trade-off is the way that the utilities dealing with its costs. Utilities may re-name the operational cost by capital costs to meet the regulatory standards in benchmarking. These authors conclude that to eliminate the trade-off, full cost benchmarking should be used and it can achieve more consistent outcomes than building-blocks benchmarking".

Moreover, the issue of "double jeopardy" is also examined by Jamasb et al. (2004) in other term which is called "Gaming". In incentive benchmarking regulation, Gaming is the type of behaviours that aims to increase profits without achieving real efficiency gains. These authors also defined two types of Gaming. One does not have a material effect on the efficient operation of the utilities and is intended to present the performance of the firm in a more favourable light like the case of shifting operational costs into capital costs. The other is to distort the efficient level of the utilities by increasing of the utilities' cost base (suboptimal capital and labour ratio) or delaying efficient improvement.

The important note about the "double jeopardy" and Gaming terminology is that the two terminologies in some extend are overlapped each other. Specifically, the accounting trade-off and a part of allocating trade-off, which increases the cost base in the "double jeopardy" is the "Gaming" activities. Because in both the two situations, there is an endeavour to make benefit without improvement in the efficiency. On the other hand, activities not mentioned by the "double jeopardy" such as firms try to influence the choice of methods, variables, and the definition of variable during the consultation period etc (Jamasb et al. 2003) are parts of "Gaming". In contrast, the optimal allocating trade-off in the "double jeopardy" is not a "Gaming" activity. Thus, the two terminologies are partial overlapped.

The implication behind both "double jeopardy" and Gaming in some extend is the trade-off between the capital costs and operational costs of water utilities.

The philosophy to explain for the trade-off between operational and capital cost refers to the Cobb-Douglas function.

$$\boldsymbol{Q = AK^{\alpha}L^{1-\alpha}} \qquad \textbf{0-1}$$

Where A is a positive constant, α is positive fraction, K and L are the amount of operational and capital cost consumption respectively, and lastly Q denotes to the

quantity produced. This function has a characteristic that its isoquants has negative slopes. Imply that there is a trade-off between the two variables.
To proof this, taking the natural log of both sides of the equation 2-1

$$\ln A + \alpha \ln L + (1 - \alpha) \ln L - \ln Q = 0 \qquad \text{0-2}$$

Which implicitly define L as a function of K. Application of implicit derivation rules to the 2-2 equation, and then we have

$$\frac{dK}{dL} = -\frac{\partial F/\partial L}{\partial F/\partial K} = -\frac{(1 - \alpha/L)}{(\alpha/K)} = -\frac{\beta K}{\alpha L} < 0 \qquad 2-3$$

If this function is considered a production function of water utilities, and K and L are capital costs and operating costs respectively, then due to the downward slope of the iso-quantity curve there is always a sacrifice operating costs for capital costs. The driver for this trade-off is to hide specific costs in order to provide unreal efficient level. Because of this activity, partial cost benchmarking may be inconsistent in its results.

The trade-off mentioned in Cobb-Douglass function reflects the law of reducing marginal benefit of capital and operational costs. This trade-off is exponential function and the natural behaviour of a utility under a normal environment.

High and varied CAPEX are also characteristics of water service industry. This could be seen in the Table 2 where the CAPEX accounts for 47% (the first company) and 57% (the second company) of the full cost for supplying water. In addition, (*Kessides* 2003) and (*Noll et al.* 2000) also mentioned that capital costs of potable water industry accounts for 65 to 80% of cost for supplying the service This large proportion of fixed costs in water industry makes it possible to transfer its operational cost to its fixed costs without a big notice by regulators. This transfer has severe effects on the operational costs while small increases in the fixed part. Thus, when a benchmarking uses operational cost variables, the benchmarking organization with incentives to reduce operational costs may hide them in the fixed cost parts. Moreover, the fixed or capital costs accounts for a large part of full cost of water provision. If it does not use in benchmarking scheme, then that benchmarking practice has omitted the majority and taken into account only the minority of the costs for supplying water. Within this respect, the real efficient performance is not reflected wholly in the benchmarking results.

One of the risks emerging in using OPEX benchmarking is that providers may be tempted either to purposely manipulate the data, or to boost their operational performance at the cost of higher CAPEX. To boost their operational performance they may categorize OPEX costs under a CAPEX cost category. To have a higher capital cost allowance, providers may have inefficient investment decision or delay the efficient improvement. This possibility for manipulation may implicate that there is a trade-off between the CAPEX and the OPEX performance of water providers. This trade-off between OPEX and CAPEX is also referred to as the "double jeopardy" issue (Ajodhia et al., 2005) and Gaming (Jamasb et al., 2004).

In conclusion, the selection of either the OPEX or the TOTEX approach in metric benchmarking under the existence of "double jeopardy" issue is likely to result in the difference in the efficient measurements of each benchmarking approach.

2- Significance of the study

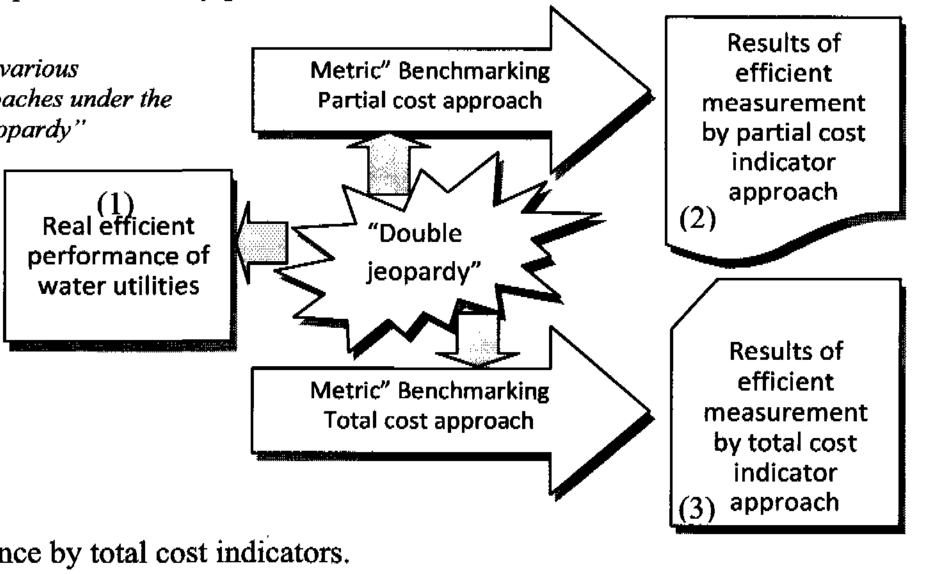
This research is importance since it expands the test of "double jeopardy" issue to two more cases which are the Dutch supply sector and Vietnam water service sector. In this sense, it contributes to the body of "double jeopardy" knowledge two empirical results. That before is mainly discussed in the UK water service sector and the other public sectors.

Additionally, this study contributes to the benchmarking methodology in water service sector in a way that it points out benchmarking initiatives with their specific objectives should carefully address either partial or total cost indicators in relation with the objectives otherwise it may lead to the their unachievable objectives.

III. Research objectives

Figure 2 visualizes the problem of benchmarking results under different benchmarking approaches and the effects of "double jeopardy" issue. Regarding the shapes of the boxes as the efficiencies performance, the box 1 is the real performance, the box 2 is the measured efficient performance by partial cost indicators, and the box 3 is the measured

Figure 2: Results of various benchmarking approaches under the effects of "double jeopardy"



efficient performance by total cost indicators.

The research at hand is dedicated to gain insight into this trade-off or the "double jeopardy issue" under benchmarking regulatory regimes. Such is conducted by comparing relative performance of capital base outcomes and operational based outcomes. In this respect, the research complies with the call of Giannakis, Jamasbb and Pollitt (2004) and Larsson (2002) to conduct further research on the methodology of benchmarking.

To better understand the effect of the trade-off on the partial benchmarking results and total benchmarking results. In this sense, the research is first to analyze the vulnerability of different benchmarking approaches to the "double jeopardy" and second to compare the overall partial cost based benchmarking outcomes with overall total cost based benchmarking outcomes.

IV. Outline of the research

This thesis is structured into five chapters. The introduction chapter is to present the relevance of this research with the reality of water service sector and raise the problem currently exists.

The second chapter comes with the aim of getting insight into the current knowledge about the research problem by reviewing specific peer reviewed articles. Specifically, it focuses on the roles of the indicator selection in benchmarking practice and the "double jeopardy" currently occurring in the public sector.

The chapter three is to develop the analytical framework for this study. First the chapter presents the research questions and hypotheses. Second, basing on the three research questions and hypotheses, it is structured into three stages. Each stage focuses on one research question and hypotheses and has its own research method, data and. The first two stages apply regression model and use the data from the three cases. The last stage use comparative method and use the data from Vietnam one case.

Chapter 4 is to present the results of each stage as mentioned in the chapter 3. The results of the first two stages are developed in the same order. Fist, the regression model results and testing the significant of regression parameters are shown, and then the analysis and conclusion come in. In the results of the last stage, the comparison charts are presented together with their analyses.

Lastly, chapter 5 is about the recommendations and limitations of the study.

Chapter 2 Survey of prior research

The purpose of this chapter is to analyze critically the use of variables and their effects on "metric" benchmarking outcomes through summary, classification, and comparison of prior peer reviewed articles. Moreover, it also refers to the issue of trade off between the capital costs and operational costs of public utilities.

I) Introduction

As mentioned in chapter 1, "metric" benchmarking which uses cost indicators has been employed for various objectives by different initiatives in public sector. A benchmarking exercise is able to take either total cost indicators or partial cost indicators depending upon specific initiatives and objectives of that benchmarking exercise. However, the fact is that the selection of indicators or variables is crucial for a benchmarking exercise. Applying different set of indicators or variables may produce inconsistent benchmarking outcomes and the trade-off between them. This issue has received concerns by various authors. This literature survey is conducted to define an overview of this issue. First, it would review the implication of total or partial cost benchmarking for efficiency purpose. Second, it focuses on effects of indicators selection on benchmarking outcomes. Lastly, it shows the trade off in the capital and operational cost of public utilities. The reviewed articles are both qualitative and quantitative base.

II) Review

1 The selection of variables

To develop the arguments for the integration of price and quality in a benchmarking exercise in electrical sector, Giannakis et al. (2004) presented the dependence of model results on (1) the number of variable use, (2) the technology structure specification and (3) the choice of input output sets. The model mentioned here is DEA[10] model which is used to calculate the efficient level of regulated firms.

For the purpose of this part, it only focuses on the number of variable usage in a model and choice of variables.

Firstly, it should be clear when mentioning about variables of a model. As described by the author, the variables are used to measure firm's performance by monetary, physical units and quality of service. The monetary variables are the total and operational costs. The physical variables are (1) total number of connection (CUST), (2) units of products delivered (ENGY) and (3) the total of network length. Lastly, the service quality variables are security of supply (NINT), reliability of supply (TINT).

The author selected four models as shown in the column (2, 3, 4, and 5) of the table 3. Each model uses different variables presented in column (1). For example the model 1

[10] DEA is a non-parametric method that uses piecewise linear programming to calculate (rather than estimate) the efficient or best-practice frontier in a given set of decision-making units (Fare et al 1985)

is operational cost model. It uses four variables, the operational costs as input, the CUST, ENGY and NETL as output.

The data used in these models are taken from 14 distribution network operators in the UK electricity sector over 1991/1992 to 1998/1999.

Table 3: Specification of DEA models[11]

VARIABLE (1)	MODEL			
	MODEL 1 (OPEX MODEL) (2)	MODEL 2 (CAPEX MODEL) (3)	MODEL 3 (QUALITY MODEL) (4)	MODEL 4 (TOTEX-QUALITY MODEL) (5)
OPEX	Input			
TOTEX		Input		Input
NINT (security of supply)			Input	Input
TINT (reliability of supply)			Input	Input
CUST (total number of customers)	Output	Output	Output	Output
ENGY (units of energy delivered)	Output	Output	Output	Output
NETL (total network length)	Output	Output	Output	Output

Applying the data to the various models, although the author presents some results, here only the results related to the research at hand are mentioned.

Firstly, the average efficient scores of companies by different DEA models are shown in Figure 3 below. This figure is drawn after the data having been sort by the OPEX column. If considering OPEX line is a base line, then the implication of this chart is that efficiency scores can depend on the choice of variables. For example, consider the line of TOTEX and OPEX. If the result scores are consistent, one line should be above or below completely the other line. As in the figure in the left-hand side the OPEX line is above the TOTEX line, further on the TOTEX line is above the CAPEX line. This is also more confirmable since the score correlation of CAPEX and OPEX is 0.67 and shows a low functional relationship between the two benchmarking models.

Thus, the selection of indicators is crucial for the results of benchmarking exercises.

The author also concludes that the more variables are in a model, the higher the performance is. However, the variation is the same direction or the curve representing the less variable model lies below the one representing the more variable model. The lesson is that if the two curves are not parallel, there may be a contradiction between variables.

[11] *Source: Giannakis et al. (2004)*

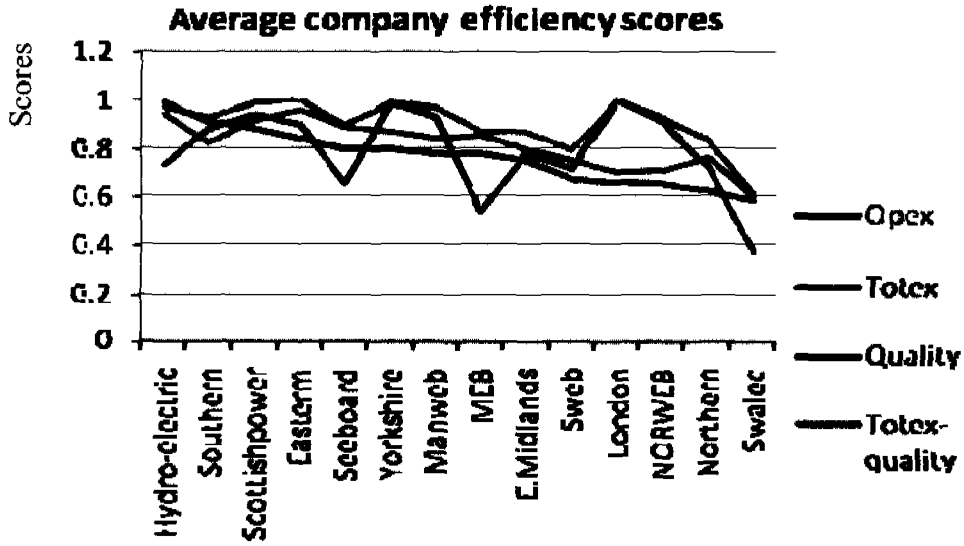


Figure 3: Company average scores by different models
Source: Giannakis et al. (2004)

Basing on the variation of the OPEX and TOTEX score results, the author cites the conclusion from other study. This conclusion is that, because of the variation, there may a trade-off between the CAPEX and OPEX cost in distribution operators. This conclusion has not been well developed and given clear understands for readers.

Moreover, the methodology of this article is mathematical intensive. This may not easy for everyone to understand and check the reliability of the method. The data set of the article is from distribution network operators of electricity sector. This also raises the question that what is the reality of indicator selection and trade-off of CAPEX and OPEX in the water service sector.

2 The trade-off between the capital and operational costs

This part is to have overview about the trade-off between capital costs and operational costs available in the current literature.

Burns and Riechmann (2004) focus on the issue of trade-off between the capital and operational expenditure as well as the measurement of capital cost.
Their article focuses on the monopolistic network industries. Its main objective is to examine the key drivers of investment behaviour in regulatory regimes. In addition, how these drivers affect the investment behaviour.

The article shows four dimensions of investment that would be affected by regulatory regimes. These include:

- Investment and output delivery, especially delivery of quality of service;
- The choice of inputs, in particular between labour and capital;
- Cyclical investment and cyclical cost reductions; and
- Investment in cases of network externalities

The second and third are valuable for this thesis so that they will be reviewed in detail.
In the "choice of input part", firstly the author shows that under the revenue regulatory regimes, when the actual costs of companies are the base for set company's revenue, the

companies have strong incentive to cut operational cost rather than capital cost since companies desire more short term profit than long term one. On the other hand, if consider the total cost of water service a pie, then the operational costs account for small part since this sector is said to be capital intensive, then when operational benchmarking is undertaken, it will not show the efficient of the whole efficient picture. This idea support for the implementation of total cost benchmarking.

The author took the case of UK electricity distribution sector and mentioned that companies have incentives to move costs that are set up in a benchmarking into other specific costs of the companies. This process is to meet the cost saving regulation. For example if benchmarking establishes a level of operational cost that companies are not allowed to overcome, the companies will move the operational costs into the other cost blocks.

The author explains this empirical result by a hypothesis situation where there are two firms producing the same quantity of outputs q.

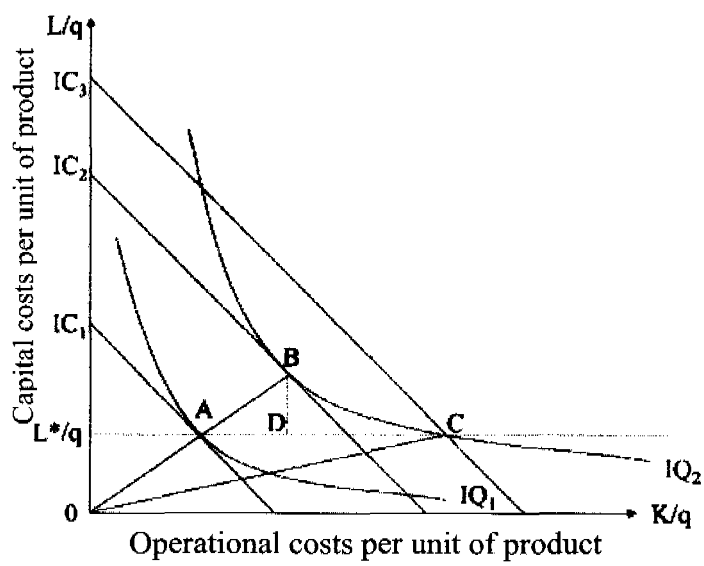


Figure 4: Capitalization in response to regulatory signals
Source: Burns and Riechmann (2004)

This process shows in the Figure 4 where labour is on horizontal axis and capital on the vertical axis.

The assumption is that at the beginning, the regulator allows both firms to charge at their actual costs and they are flexible to transfer costs between capital and labour groups. In this situation, firm A is more efficient than firm B since it operates at lower at both labour and capital.

When the regulators change their policy, they base on operational cost benchmarking to set the limit of this cost at L*/q level. Firms are allowed to recovery the operational costs at this level. In this situation, firm A does not change its cost structure since it is efficient while firm B may carry on two options:

First, it may move to the point A but in this option, it has to cope with many management efforts so it may discard this possibility.

Second, it may move to point C. In this process, it has to trade-off labour for capital costs. While following this option firm B has two possibilities to act with the surplus labour cost. It can either re-label labour cost as capital cost or reduce the actual capital cost by reducing the investment. The latter case is harmful for quality issue.

The above contention of the author presents a clear explanation for the behaviour of firms under regulation based on cost benchmarking. However, the weak point of the author is that there is no an empirical test for this idea. The chart, as shown in

Figure 4, is a visualization of the Cobb-Douglas function in the previous chapter.

Moreover, on this article, the author presents cyclical cost reductions. The main idea of this is the regulated operators can also past the cost saving across regulatory periods. Figure 5 shows the big boost of productivity in the year after the regulatory price review then before the new period, the productivity greatly fall.

	Operating expenditure productivity	Total cost productivity
1991–1992	1.81	0.99
1992 1993	6.14	3.49
1993 1994	1.36	1.66
1994–1995	3.67	1.65
1995 1996[a]	27.59	13.7
1996–1997	7.07	2.82
1997–1998[b]	−7.72	−4.19
1991–1998	4.85	2.66
1992 1988	5.4	2.95

Figure 5: Productivity change over time amongst the utilities
Source: Burns and Riechmann (2004)
a: year following price review
b: year before new regulatory announcement

The implication for this idea is that since operational costs are short-term cost, it is more flexible for firm to manoeuvre across years than the long-term capital costs. Consequently firms are likely to put more effects on the operational benchmarking outcomes than capital ones.

Although operational benchmarking has received critical concerns, it does exist. So why do not people undertake total cost benchmarking? There are clues for this concern presented in a report by (*Frontier Economics* 2003).

The report was implemented within the context that the Office of Gas and Electricity Markets (OFGEM) in the UK wanted to improve the framework of price control and to set the foundation for the next regulatory period. It dealt with four issues of price control that are incentives in regulation, capitalization of operating expenditure, Periodicity, and regulating quality. The capitalization of operating expenditure subsection is reviewed in detail since it is relevant to writer's theme.

In this subsection, first the author presents the approach of Water Services Regulation Authority (OFWAT) to benchmarking. This benchmarking is partial cost method. Meaning OFWAT benchmarks the capital and operational costs of utilities separately. OFWAT recognized problem at the review of 1999 that some companies seemed to perform well in operating benchmark while less well in capital benchmark. To address this problem OFWAT made an informal adjustment to force reduction in capital expenditure through a banding system. The author also portrays the two strategies that companies may act to response to the benchmarking as mentioned in the previous article. The implication of this problem is that firstly due to the contra-variant between the operating cost benchmarking and capital cost benchmarking results, there is likely a trade-off between the two variables in some utilities.

To eliminate the problem arisen during separated block benchmarking, the author proposes the total cost benchmarking and raises the issue relating to define the capital costs. Thus, up to now, the question at the beginning of this report has been answered or separated block/ operating benchmarking is preferable since it is likely to overcome the issues of capital cost estimation.

To support for total cost benchmarking, the report describes two capital cost-estimating models.

In another article, when criticizing the benchmarking as a subjective efficient measurement, *Shuttleworth* (2005) stated a problem that "a partial approach can give a misleading impression of the scope for cost reduction" and explained this problem is more severe when regulators apply benchmarking to sub-set of total cost like capital and operational costs. For each subset, companies may save in this sub-set by spending more on other sub-set. For example, companies may reduce operational costs by invest in new capital assets. Although the author does not state clearly about the trade-off between the operational and capital costs, by reasoning, this issue is obvious. In this article, when implying about the trade-off, the author referred to only two specific companies in the UK to support for the statement. This could not represent the whole sector.

Although the idea that there is a trade-off between capital and operational costs is more popular in literature, other authors considered there is not a trade-off between the two cost blocks. This stance could be found in the OFWAT's report (*Byatt* 1995). In this report, OFWAT accepted that it had not found reasonable evident for the trade-off between the two cost groups. The variety of cost structure in different utilities is because of other reasons other than the intention of management boards.

Lastly, the issue of trade-off was also mentioned by Jamasb et al (2003). These authors use the terminology called "Gaming" to describe a situation where firms can get benefit without real efficient improvement. The authors give various kinds of "Gaming". In the cost aspect, one way to "gaming" is firms shift costs among different cost groups. The results survey by these authors of 8 regulators shown that when the operational cost benchmarking is employed, there is tendency of shifting operational cost into the regulated activities. On the other hand, when total cost benchmarking employed, the same tendency apply for both capital costs and operational costs.

The implication here is that due to the asymmetric information between regulators and regulated firms, firms can manipulate costs without notice of regulators. This "Gaming" results in unreal efficient performance of regulated utilities.

III) Conclusion

Several conclusions come out after the review of some articles. First, variable selection is crucial for a benchmarking. It may produce inconsistent results when different set of indicators is used. However, this conclusion comes out from a research that its methodology is mathematically advanced and the sample size is small. Second, although various authors mention the trade-off between the capital costs and operational costs, the idea is mainly come from theoretical analysis. The empirical testing raises its weak voice in this issue except some evidences from the UK case where OFWAT mentions the transfer among cost groups. Third, companies are more likely to manoeuvre in partial benchmarking than in total benchmarking that why total benchmarking is promotable. When total benchmarking is in use, it raises some issues related to capital cost calculation.

Most reviewed articles when mentioned about the trade-off between the capital and operational cost have referred to the regulatory reality in the UK. This raise other concerns that whether the trade-off between the capital and operational cost is typical of a country or every country.

Contribution to the understanding of the trade-off between various set of costs, benchmarking results under the selection of different cost indicators, this research takes the case of Benchmarking in Dutch, the UK and Vietnam to verify the two issues.

Chapter 3 Research design

The study of this research expands across three stages which mainly apply the quantitative approach. Besides, the last stage presents some interviewing results to well explain the large variability of capital costs in Vietnam case.

Research questions and hypotheses

As mentioned in chapter 1, the existence of "double jeopardy" are concerning by various authors and there are two popular approaches to benchmarking. Both of these are contributing to a problem that is the distortion of benchmarking results. With the problem and the aims of the research, this study focuses on the following questions and hypotheses:

Research questions:

Does the "double jeopardy" issue exist in water service sector?

When executing the two benchmarking approaches under the effects of "double jeopardy", each approach creates its own efficient outcomes. In this aspect, the second research question is that is there a difference in the occurrence of the "double jeopardy" issue between alternative benchmarking approaches (partial versus total cost approaches)?

The third research question is to investigate the alignment between the results of total cost benchmarking approach and those of operational cost benchmarking approach. It includes sub-questions;

- Is there a consistence between the total cost benchmarking results and operational cost benchmarking results?
- Additionally, benchmarking also measures other operational performance of water utilities such as the unaccounted for water and the number of staffs per thousand connections. In this meaning, the third research question also examines if capital and operational ratios coincide with other operational performance of water utilities?
- Why do capital costs vary in water companies?

Research hypotheses:

These above research questions are converted into the following research hypotheses:

"Double jeopardy" issue exists in the water service sector.

Within the boundary of the second research question, the second hypothesis is that operational benchmarking outcomes are more influenced by the "double jeopardy" than those of total cost benchmarking outcomes.

In the comparison between the capital and operational ratio with other operational performance of water utilities, the third hypotheses are that total cost benchmarking results are more consistent with the other operational performances of water utilities and that the capital ratio performance is more aligned with other operational aspects of water utilities.

Scope of the research

This study places itself within the context of benchmarking in water service sector. There are two popular benchmarking methodologies in the sector. However, this research focuses on only the "metric" benchmarking method.

This research focuses on case study. It selects data from three cases to get insight into the research questions and conclude the research hypotheses. The findings from the three cases are typical for the selected cases. However, if any cases which are similar to the selected cases, the results may be applied with care.

I. Background of the selected cases

This study inquires three cases. The criteria to select a case are firstly the purposes of the benchmarking, secondly the indicators used in the benchmarking and lastly the timeframe of the benchmarking. The first and the second criteria are of important since there is a argument that where the partial benchmarking is undertake by the economic regulators or under the economic motivation, the "double jeopardy" is the most likely to occur. In addition, the data available to collect by using internet are also important.

The purposes of Dutch are to get insight and to learn from each other. And it uses the total, operational and capital cost indicators. The UK case has the characteristic that the benchmarking scheme is used to set price and takes the partial cost indicators. Data of these two cases are both available on the internet. The benchmarking in Vietnam is to give loans to the utilities. This will promote the utilities to be the best regardless of the way to achieve this target. The timeframe of the three benchmarking is also distinguished. Benchmarking in the UK has long history from its privatization in 1989, the Vietnam case is undertaken the first time and the Dutch case is in the middle. It started in 1997 to 2006.

1 Dutch cases

In the Netherlands water service sector, benchmarking has been undertaken by the initiative of Vewin- the Association of Dutch Water Companies. Up to now, there have been four benchmarking exercises implemented in the country. Each benchmarking was taken every three years, starting from 1997. The main purposes of doing this benchmarking are to get insight into the activities of the companies and to learn from each other. The indicators used to assess the efficiency in the benchmarking are the capital, operational and full cost of water utilities.

2 The UK case

In England and Wales, Ofwat (Office of the Water Services), an economic regulator, has been assessing relative efficiency for the water industry since privatization in 1989. The sectors of Scotland and Northern Ireland are separately organized and still publicly owned (Dassler et al. 2006). The aim of this organization is to set price limits in a way that will create incentives for water companies to improve capital efficiency and deliver real price benefits to customers (Allan 2006). Though there have been various benchmarking methods undertaken to cross checking, the main cost indicators to measure efficiency of water utilities are the Capital costs and operational costs. The organization implements a five year periodical review to set the revenue for the regulated utilities.

3 Vietnam case

There was a benchmarking exercise undertaken in Vietnam in 2002 by Vietnam Water and Sewerage Association funded by the World Bank. This benchmarking has taken the form of "metric" benchmarking and taken the data from the year 2000 of 67 water companies in the country. It has employed partial cost variables to measure the efficient aspect of water utilities.

In the meantime, the Vietnam Urban Water Supply Development Project was proposed. This project had two main objectives. The first one was to expand the water service financially and environmentally sustainable to un-served households both in large cities and in small district towns. The second one was to improve the technical, financial and commercial performance of water utilities. The project would provide two kinds of credit to water utilities basing on their benchmarking ranges. The higher performance result would enable utilities to access to higher level of debt. (*Sharifian* 2002). Thus, performance, derived from partial benchmarking results, is a crucial criterion to give loans to water companies.

In addition, water service in Vietnam is capital intensity and capital proportion in total cost of Vietnam water supply industry varies notably due to the historical investment. According to a report by Vietnam Water and Sewerage Association (VWSA)(*Ton et al.*, 2003) repayment to build water infrastructure accounts from 60% to 80% of total annual cost of a water company. Moreover, low performance companies need as three times capital requirement as high performance companies to own the same amount of asset. This creates more concerns that the operational variables, which capture only short-term cost aspect of companies, are unable to represent fully the efficient performance of water companies. Consequence, if loans are granted for companies by their operational cost benchmarking results, there is risk that loans are likely to be given to unreal efficient companies.

II. Stage 1 – Existence of "double jeopardy" in water supply sector

This part is designed to do the research on the question that whether the "double jeopardy" really exists. It starts with the establishment of the indicators to assess the performance of efficient aspects of water utilities. Then it presents the augment to use the Cobb-Douglas function to depict the "double jeopardy" issue. Next, to apply the linear regression model to examine the trade-off, the Cobb-Douglas function needs to be transformed into the linear form. Lastly is to build arguments and assumptions to apply the slope of the regression line in relationship analysis.

The input in this part is the data collected in the reality at the benchmarking in the three selected case studies.

1 Indicator formulation of stage 1

As "metric" benchmarking is the comparison of different performance indicators. Building a system of indicators is crucial for such a kind of "metric" benchmarking type. There are various ways to select financial indicators as mentioned earlier. For the purpose of this stage, the only the following indicators are selected.

Indicators for measuring OPEX efficiency:

$$Working\ ratio = \frac{Operational\ costs}{Operational\ revenue}$$

Indicators for measuring CAPEX efficiency:

$$CAPEX\ ratio = \frac{Total\ CAPEX}{reveneu}$$

An integrated indicator results from the sum of the two individual indicators above. The reason to create the integrated indicator is that, as mentioned above, Vietnam benchmarking result took only working ratio to measure efficient aspect, so that this aspect in the new method should also use one indicator to be compatible with the old method. However, the integrated indicator is distinguished from working ratio since it accounts for the total cost.

2 Analysis framework and assumptions of stage 1

This part presents arguments to apply linear regression tools in relationship analysis and the implication of regression, correlation and hypothesis testing presented by Douglas et al (2003). This knowledge builds the basic fundamentals for analyzing the relationship between the capital based and operation based indicators.

All the arguments are based on the assumption that the technology and labour skills of the examined periods are constant.

The idea of this stage is that all the data of the three cases is combined to feed in a linear regression model. The result of this regression model is a regression line whose slope's sign will represent the relationship between the two input variables (the capital and operational ratios). If the sign is minus, then there is a "double jeopardy" otherwise there is not a "double jeopardy".

To compatible among the three cases, this stage leaves out the country specific factors which influence on the level of efficiency of each case. This means that the efficient level of each case is compared only within one country, and then the relative efficient levels of different utilities in each country are brought together in the same scale. Such a correction is carried on by the Indexing method as presented in the later part.

Followings are the detail of the application of the linear regression in relationship analysis and the data correction method.

2.1 Application of linear regression in relationship analysis of stage 1

Cobb-Doulas function as mentioned in the first chapter is merely to depict the behaviour of firms under the effects of only law of reducing marginal benefit of capital and operational costs in ideal conditions. This function is a signal to suggest about the negative relationship between the capital and operational costs of utilities.

Under the real condition with the effect of regulations, the "double jeopardy" issue occurs. The functional form of "double jeopardy" is not obvious. Hence, the assumption is that the "double jeopardy" has a linear form.

Under this assumption, the linear regression of capital costs and operational costs is executed. When the results of the regression come out, they will be test the suitability of the model to explain the data. If the model is adequate in term of statistics, its slope will be used to make conclusion about the trade-off relationship or "doubled jeopardy" issue. The T-statistic parallel with P-value are used to test the adequate of the regression model. This testing method will also supplemented by the R-square and Pearson-r coefficient. The detail of application of this testing method is elaborated in the continuous parts.

The above argument builds the fundamentals for the application of linear regression to investigate the "double jeopardy" issue. The method here is that first the regression model will be established based on capital and operational ratio. The slope of the found regression line is the indicator to evaluate the trade-off relationship.

2.2 Implication of the regression line slope and testing its parameters of stage 1

As arguments and assumptions on the previous step, capital costs and operational costs of water utilities relate to each other by the linear equation. So do the capital and operational ratios. The form of a linear function is: $Y = \beta_1 . X + \beta_2$. Here Y denotes capital ratio, which is dependent variable and X is equal to operational ratio, which is the explanation or regressor variables. The other the constant parameters β_1-β_2- are the slope and the intercept of the regression line, respectively.

In this equation the slope of the regression line has a meaningful value for interpreting the relationship between the capital and operational ratio. This slope shows three types of linear relationship between the two variables. These types of relationship are depended on the slope's sign. If the slope is negative, it shows a contra variant relationship between capital and operational costs. If its value is zero, then there is no linear relationship between the two variables. Lastly, if the slope is positive value, meaning capital and operational costs have covariant relationship.

β_1 is called the trade-off coefficient. This figure shows that if the operational ratio increases 1 unit, there is β_1 unit of capital ratio scarified.

To investigate whether there is a trade-off between the capital and operational costs of water utilities, then the zero slope value is meaningless in showing this relationship. Thus, statistical hypothesis testing about the zero value of the slope will be executed. If there are statistical evidences to reject the zero value of the slope, then there is a relationship between the two variables.

Chapter 4 will implement the following testing procedure to test the existence of a non-zero slope value:

Pair of hypothesis: $\begin{cases} H_0: \beta_1 = 0 \\ H_1: \beta_1 \# 0 \end{cases}$

The above pair of hypothesis is translated into the following hypothesis in term of linear relationship between capital and operational costs of water utilities:

Pair of hypothesis: $\begin{cases} \text{Null hypotheis: No trade} - \text{off} \\ \text{Existance of negative linear relationship} \end{cases}$

The statistic used: $T_0 = \dfrac{\hat{\beta}_1 - \beta_{1,0}}{\sqrt[2]{\hat{\delta}^2 / \sum_{i=1}^{n}(x_i - \bar{x})^2}}$

This statistic follows T-distribution with n-2 degree of freedom. At the critical value of 5%, the hypothesis H_o would be rejected if$|t_0| > t_{\frac{\alpha}{2},(n-2)}$.

When rejecting H_0, it also means that the real relationship between capital and operational exists.

The other method parallel with T-test is P-value. The P-value test is simpler than T-test since it compares the P-value of a sample with the critical value (a popular critical value is 5%). If the P-value of the sample is small than the critical number, then the regression model is statistically significant to the whole population.

R-square is also employed to show the goodness of the model. In this sense, it indicates the percentage of the observations related by the regression line. Or the percentage of the water utilities which have the capital and operational costs relates by the linear regression line. This is equivalent to the percentage of the water utilities having the trade-off or "double jeopardy" issue.

2.3 Durbin-Watson test

As mentioned by Durbin-Watson (Durbin and Watson 1951), in the regression model, there always exists the error terms. And there is likely to exist auto-correlation of the error terms across time periods. If the autocorrelation occurs, it makes the independent residuals/errors assumption collapse. This situation results in the unsuitability of the regression model to explain the data.

Because this study investigates the data of the UK and Dutch water service sector over several periods of time. It is likely that the auto-correlation of the errors may occur in the regression models. Application of Durbin-Watson helps to solve this possibility.

The pair of hypothesis test: $\begin{cases} H_0: \textit{The error terms are independent} \\ H_1: \textit{The error terms are dependent} \end{cases}$

The "d"-statistic is used to test the hypothesis:

$$d = \frac{\sum(\Delta Z_{i,j})^2}{\sum(Z_{i,j})^2}$$

The "d" value from the above equation then is compared with the lower d_L and upper d_U bound value. If the "d" higher than the upper value, then the value is not significant and the H_0 is unable to reject or we must accept that the errors of the regression model are independent while if observed "d" is smaller than d_L, then it is significant to reject H_0 or the error terms of the regression models are dependent.

3 Data and input variable for stage 1

Inputs for the regression model of the stages

The inputs of this stage are the data collected through each selected case as stated earlier. These data are used to calculate the operational and capital ratio for each case. Then the capital ratio and operational ratios are corrected by indexing method. After correction, these data are fed into the regression model.

Data correction

As mentioned earlier, the data from the three cases with two from developed countries and one from developing countries. This results in many country specific factors making the absolute efficient levels the three cases different such as productivity, opinions of the government about the water business and the geographical characteristics. To remove the factors, first the efficient level of each case is calculated within the countries, and then the relative efficiencies for each country are fed into the regression model.

The method to remove the factors is making the index of capital and operational ratios in each case by the following formulas:

$$Corrected\ ratio = \frac{Ratio - Min(ratio)}{Max(ratio) - Min(ratio)} * 100\%$$

In the above equation:

Corrected ratios are used to feed into the regression model

Ratio is the capital ratios or operational ratios for each observation in each case

Min (ratio): is the minimum value of capital or operational ratios in a case

Max (ratio): is the maximum value of capital and operational ratios in a case

In this part, first the data requirement is presented, next is the sources of the data, and lastly is method of data collection.

Data requirement

The data needed for the first stage of the current study are drawn based on the already formulated indicators.

The first sort of data is the benchmarking results of Vietnam water benchmarking in 2002. This data include working ratio and results of performance based on operational costs. This report was published in 2002 with the employment of the data of the year 2000.

The second sort of data is to measure the total cost performance of water companies. This includes:

- The elements of CAPEX which contain depreciation, interest payment,
- The operational costs of supplying water, the total amount of water supply
- The total revenue of water supply

Data sources

Vietnam data are collected through two sources. The first one was presented in the Vietnam benchmarking reports, which were acquired in the World Bank office in both electronic and paper files.

The Ministry of Construction supplied data related to total cost and capital cost. This data were available at the ministry since there was a survey implemented under the official document No. 146 issued on 11 August 2003 about reality of water service production and supply. Whereby, all 67 water supply companies in the country were obliged to supply their data on various aspects of their business, which also included depreciation, benefit, and total cost of water supply, total revenue and total assets of water companies.

The data of the UK water service sector are achieved through the regulatory accounts under the requirement of Ofwat. Every company in the England and Wales under the regulation of Ofwat has to report its regulatory accounts to this economic regulator. At the same time, such a kind of report is also available in the each utility's website. These reports on the websites are downloaded and filtered to pick out the required data.

Data of Dutch water service sector were acquired in the same manner as that of the UK. The difference is these kinds of data are shown in the benchmarking undertaken by Vewin from 1997 to 2006.

Sample size requirement

To be statistically significant, in selected cases if the data of the whole population are unachievable fully, then this step is to calculate the sample size requirement.

$$n = \frac{N}{1 + N * (e)^2}$$

Source: Yamane (1967:886) **0-1**

Normal distribution of costs of water utilities, a 95% confidence level and P = 0.05 are assumed for selection of sample size. To give the study a statistical significant, two statistical formulas are applied to estimate the sample size.

In the equation 3-3, n denotes for the sample size, N-population and e-error of the estimation.
In addition, because observations in small and finite population give more information than in large population, finite population correction formula can be used to correct the sample size. In this formula, n is the corrected sample size, n_0-the sample size calculated from previous step.

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

Source: http://edis.ifas.ufl.edu/PD006

0-2

The study at hand is to target to three cases. Among the three cases, the data from Vietnam and the UK are unachievable for the whole sector for the studying periods, that why the above steps are applied to calculate the sample sizes. In contrast, data of the Netherlands case are able to collect for all water companies. Hence, sample size calculation for this case is avoidable.

Applying these formulas is to calculate the sample size for Vietnam and the UK cases.
For the Vietnam case, the targeted population of this case is the data of 67 water companies in 2000 in the country. Then the sample size for this case is calculated as the following.

$$n = \frac{67}{1 + 67 * (0.05)^2} = 57\ Observations$$

Replacing numbers, the corrected sample size is:

$$n = \frac{57}{1 + \frac{(57 - 1)}{67}} = 31\ observations$$

For the UK case, the targeted population is the data of 22 water utilities in the country over 2001 to 2007 periods. This turns out that the number of total targeted observations is 154. Applying the same calculating procedure of Vietnam case, the sample size for the UK case is 66 observations.

This means that if the number of observation is higher than 31 for Vietnam case and 66 for the UK case, then results are statistical adequate.

Results of data collection

The result of the collection from the Vietnam construction ministry turned out that several companies did not fulfill their obligation to supply the data. The total numbers of companies, whose data meet the requirement of this research, are 31 companies. However, as mention in the sample size, this figure is sufficient for making conclusion for the whole population.

The other data including data from the World Bank office and the Dutch water-benchmarking sector are fully accessible for the purpose of this research. Data from World Bank is a complete set of data collected by the survey in 2000 and 2 main benchmarking reports. Data from Dutch water-benchmarking sector are achievable from the web site of Vewin over four year 1997, 2000, 2003 and 2006.

The results of data collection from the UK water sector happened as not expected. There were 104 observations achievable in comparison with 154 observations as expected in the all utilities over 2001 to 2007 periods.

III Stage 2-The Vulnerability of benchmarking results to "double jeopardy"

This research stage aims at examining the vulnerability of different benchmarking results by the "double jeopardy" issue. As mention earlier, there are two benchmarking approaches, which use partial or total cost indicators. This stage is to examine in such two benchmarking approaches under the existence of "double jeopardy" which approaches' results are more likely to be distorted.

1. Indicators formulation of stage 2

Similar to the stage 1, this stage uses two indicators which are the capital ratios and operational ratios.

Indicators for measuring OPEX efficiency:

$$Working\ ratio = \frac{Operational\ costs}{Operational\ revenue}$$

Indicators for measuring CAPEX efficiency:

$$CAPEX\ ratio = \frac{Total\ CAPEX}{reveneu}$$

2. Analytical framework of stage 2

The arguments to apply linear regression and to test its significant are the same as the arguments developed in stage 1. For avoiding repetition, this part does not re-present these arguments.

Differently, this stage applies two analytical approaches based on the three established regression lines of the three selected cases. The first one is to use the R-square of the regression model to investigate the situation of the "double jeopardy" in the three specific cases basing on the history data. The second approach is to use the slopes of these lines to analyze the future occurrence of "double jeopardy" in the three selected cases if their current methods of benchmarking are continued to carrier on in the future.

Firstly, to use the R-square in the analysis of the current situation, this analysis applies the argument in statistics that the R-square is to show the variability of the observations which are likely to be depicted by the regression line. In this sense, the R-square of each linear regression model shows the percentage of the water utilities which are related to each other by the regression lines. The higher the value of the R-square, the more occurrence of the "double jeopardy" in that selected cases.

Secondly, for analyzing the future effects of "double jeopardy" on the benchmarking schemes of the three cases, the slope of each linear regression line is used as the indicator. The argument for the application of the slope in future analysis is that the slope is typical for each country and is defined by the current development of technology and the price of labour. At the same time, these two factors are not dynamic in short-term. Hence, the value of the slope is suitable for the future analysis.

The three selected cases have the characteristics that; Dutch water benchmarking selected total costs, operational costs and total cost as variables. The UK has employed partial indicators which are capital costs and operational costs separately. Lastly the Vietnam benchmarking also took partial benchmarking indicators with only the operational costs. Each benchmarking method in a specific case is related to the value of the R-square and the regression slope of that method to show the effects of "double jeopardy" on different benchmarking approaches.

Similar to stage 1, the error term of UK and Dutch are tested for auto-correlation since these sets of data are taken over time series by Durbin-Watson test. The test does not apply for Vietnam case due to the single year data collected.

The regression model without auto-correlation in its error term will be considered suitability for analysis.

After the model passes the Durbin-Watson test, the T-test is employed to test the magnitude of the slope against zero. When these models pass the Durbin and Watson test and the slopes pass the T-test (p-value) at the critical value of 5%, then the slope is applicable to analyze in this stage.

Two considerations are carried on in the stage. First is the analysis of the slope of each case in relationship with the "double jeopardy" issue to get insight into the effects of "double jeopardy" on benchmarking results. Such a research is implemented by analyzing each component of "double jeopardy" separately under the existence of slope of each case.

Secondly, efficiency of each case is compare to reveal the less efficient one. Then possibilities resulting in the less efficiency are presented up. If these possibilities include the components of "double jeopardy", and if the case use partial benchmarking approach, then there is high possibility of less efficiency resulting from "double jeopardy". Or the benchmarking approach used by the less efficient case is more vulnerable to the "double jeopardy".

To measure efficiency of each case in comparison with each other, all the three cases are plotted on the same chart. The distance from the origin to the regression line shows the level of efficiency of the case. The assumption is that all utilities are following minimizing cost strategy. Hence, all try to keep the capital ratios and operational ratios as low as possible. This is equivalent with the situation where the regression line of each case tries to be as close as the origin of the coordinate.

3. The inputs for this stage 2

Data requirement

The data needed for the stage 2 of the current study are drawn based on the already formulated indicators.

The first sort of data is the benchmarking results of Vietnam water benchmarking in 2002. This data include working ratio and results of performance based on operational costs. This report was published in 2002 with the employment of the data of the year 2000.

The second sort of data is to measure the total cost performance of water companies. This includes:

- The elements of CAPEX which contain depreciation, interest payment
- The operational costs of supplying water
- The total revenue of water supply

Data sources

Data from Vietnam case were acquired firstly at the World Bank office in the country through Vietnam benchmarking reports in 2000.

Secondly, the Ministry of Construction supplied data related to total cost and capital cost. This data were available at the ministry since there was a survey implemented under the official document No. 146 issued on 11 August 2003 about reality of water service production and supply. Whereby, all 67 water supply companies in the country were obliged to supply their data on various aspects of their business, which also included depreciation, benefit, and total cost of water supply, total revenue.

The data of the UK water service sector are achieved through the regulatory accounts under the requirement of Ofwat. Every company in the England and Wales under the regulation of Ofwat has to report its regulatory accounts to this economic regulator. At the same time, such a kind of report is also available in the each utility's website. These reports on the websites are downloaded and filtered to pick out the required data.

Data of Dutch water service sector were acquired in the same manner as that of the UK. The difference is these kinds of data are shown in the benchmarking undertaken by Vewin from 1997 to 2006.

Results of data collection

The result of the data collection from the Vietnam construction ministry turned out that several companies did not fulfill their obligation to supply the data. The total numbers of companies, whose data meet the requirement of this research, are 31 companies.

The other data including data from the World Bank office and the Dutch water-benchmarking sector are fully accessible for the purpose of this research. Data from World Bank is a complete set of data collected by the survey in 2000 and 2 main benchmarking reports.

The reports of Dutch water benchmarking were collected in four year 1997, 2000, 2003 and 2006 through the website of Vewin, on which the required data were available.

The results of data collection from the UK water sector happened as not expected. There were 104 observations achievable in comparison with 154 observations as expected in the all utilities over 2001 to 2007 periods. However, the number of these observations is sufficient in comparison with the sample size requirement calculated in the previous part.

IV Stage 3-The consistence among performance of various benchmarking outcomes

This stage focuses on the third research question, which is specified in sub question as in the following:

- Is there a consistence between total cost benchmarking results and operational cost benchmarking results?
- Is there a consistence between the results of benchmarking based on the two approaches and other operational performance of water utilities like performance of uncounted for water and the number of staff per thousand connections?
- Which factors of "double jeopardy" issue make the diversification of capital costs in water utilities?

Among the three selected cases, the case of Vietnam is suitable for this stage of study since the benchmarking in this country was partial benchmarking which used only operational costs (working ratio indicator) to estimate the efficiency of water companies. The use of only working ratio is like to have the most distortion in benchmarking.

The data set from Vietnam case is used differently in this stage. They are used to calculate the total benchmarking results. These total benchmarking results then are compared with the partial benchmarking results available in Vietnam benchmarking in 2002.

Secondly, the research also compares the capital and operational ratio against other operational performance of water companies in Vietnam such as unaccounted for water and number of staffs per thousand connections. The idea is that if the results of comparison do not coincide with each other, there are two implications needed to be indicated. First partial indicator does not reflect the whole efficiency. Secondly, under the operational benchmarking in Vietnam, the capital and operational costs are treated differently, and then it results in the situation where capital and operational ratio do not both coincide with the other operational performance like unaccounted for water and the number of staffs per thousand connections. If the analysis results turn out that the operational ratios are less aligned with the other operating performance, while those of capital ratios are more coincided with the other operating performance, it is likely that the "double jeopardy" occurs in a way that the operational costs are favoured since they are used in benchmarking standard. One assumption here is that companies are unable to hide their overall performance. Or the other operating performance reflects the real situation of the companies.

Lastly, it is to investigate the factors influencing the capital diversity of water companies in Vietnam. Such a work is implemented by analyzing an interview results.

1. Indicator selection

Besides taking the efficient indicators in the stage 1 of the study, for the purpose of this stage, two additional indicators are selected. These indicators are those, which are popular in benchmarking exercise.

$$Uncounted\ for\ water = \frac{supplied\ volume - billed\ volume}{supplied\ volume}$$

$$Staffs\ per\ thousand\ connections = \frac{Number\ of\ staffs}{Number\ of\ connection} * 1000$$

Then the Unaccounted for water indicators is corrected by the size of companies through dividing itself by the number of connections of that company.

The two same indicators as the stage 1 also are used in this stage:

Indicators for measuring OPEX efficiency:

$$Working\ ratio = \frac{Operational\ costs}{Operational\ revenue}$$

Indicators for measuring CAPEX efficiency:

$$CAPEX\ ratio = \frac{Total\ CAPEX}{reveneu}$$

2. Analytical framework and indicator selection

Two methods are mainly carried out in this stage of the study. The first one is to apply the comparative and judgment method. The comparison and judgment are undertaken between the partial cost (working ratio) benchmarking outcomes against the total cost benchmarking outcomes as well as between unaccounted for water and the number of staffs per thousand connections against the working ratio and total ratio. The visualization or chart analysis will help in this method of study.

Supplementary for chart analysis, the differences between total cost benchmarking and operational benchmarking outcomes in each observation also are considered to give these differences in numerical values. The idea is that each observations or company in Vietnam has its own total cost benchmarking outcomes and operational cost benchmarking outcomes. If the two approaches are consistent, then all the results in one benchmarking approach should higher or lower than the other approach. For example, if all the operational benchmarking outcomes are lower than the total benchmarking outcomes, then these two benchmarking are consistent. This analysis examines the results of total cost benchmarking minus the operational benchmarking outcomes. If the values of this minus operation have the same sign, then the two benchmarking are consistent.

The operational benchmarking outcomes were acquired from Vietnam water service the benchmarking exercise in 2002. The total cost benchmarking outcomes are calculated based on the collected data and three indicators. The first two indicators are the same as those in Vietnam benchmarking in 2002. The third one is different from the one used in Vietnam benchmarking in 2002 as it is the total cost indicator (the Vietnamese indicator is operational costs or working ratio).

The method to calculate the performance of total cost benchmarking outcome is similar to the method which used to calculate the operational cost benchmarking outcomes in Vietnam in 2002. This method took three indicators (unaccounted for water, number of staffs per thousand connections and working ratio) to calculate the overall performance of water companies. The new total cost benchmarking will replace the working ratio by the total ratio. The other two indicators are kept the same.

The second method is to qualitative orientation. It analyzes the results of an interview to get insight into the diversification of capital costs in Vietnam. There is a concern that this diversification is due to the "double jeopardy". If the findings turn out that there are not other factors affecting on the diversification then one must accept that the diversification is due to the "double jeopardy". This method more likely is the exclusive approach.

For the qualitative method, interview was implemented with the questionnaires focusing on drivers that make capital costs of water companies various and the reason that makes capital costs excluded in calculating the overall performance.

The questionnaires are formulated to find out the main factors that effect on the diversification of capital ratios in Vietnam water sector. Then the next question is to focus on why the main factors influence the capital ratios of water companies.

3. Data collection and Inputs of this inquire stage

The data of the two indicators (Unaccounted for water and the number of staffs per thousand connections) were taken from a benchmarking exercise in Vietnam, which was published in 2002 and the data of this benchmarking were from the year 2000.

The 2002 Vietnam benchmarking reports published 61 observations of unaccounted for water per connection and the number of staffs per thousand connections. These data were collected to use in this stage of study.

The working ratios and capital ratios of this case are taken from the previous step.
The interview was carried out with Informants from six different organizations. These organizations are three from water companies (Bac Giang, Phu Tho and Tuyen Quang), one from the Ministry of Construction, one from Vietnam Water and Environment Company (VIWASA), and the last from Vietnam Water Supply and Sewerage Association (VWSSA), participated in the interview

Chapter 4 RESEARCH RESULTS AND ANALYSIS

First, this chapter introduces the results of regression model, which employs three different sources of data. It presents the results in the following order. First it gives the description of the specifications and the results of the regression model. Then it gives the judgments about the models. Lastly, based on the results and the judgments, the individual conclusions on various countries are drawn.

Secondly, it also presents the results of the comparison between the capital and operational ratios against the other operating performance of water utilities, and the results of the interview about the diversification of capital costs in Vietnam case.

1 Stage 1- the existence of "double jeopardy" in water supply sector

As mentioned in the previous chapter, this part is to examine the existence of the "double jeopardy" issue by the intention to feed the data of the three selected cases into a regression model. When doing like this, the regression slope is not significant to be different from zero. Hence, the slope of the model integrated all the three case data is not reliable for analysis.

To find the reason of unsuitability of the model, each data set of the three cases is tested separately by the T-test about the significant of the slope at 95% confident level.

The results of regression model with corrected integrated capital and operational ratios of the three cases are presented in Table 4.

The data in this model include 149 observations of corrected capital ratios and operational ratios of all the three cases.

Table 4: Summary outputs of integrated regression model

Data	**Corrected CAPEX and OPEX ratios of Dutch water sector in 2003, 2006, the UK over 2001-2007 and Vietnam in 2000**	
Regression variables	Corrected operational ratios and capital ratios	
Number of observations	149	
Statistical indicators of the slope:		
Durbin-Watson test: d value = 1.8	**D_L= 1.65**	**D_U= 1.69**
Auto-correlation:	No-autocorrelation in error terms	
Slope of regression line:	-0.44	
T-statistic	-5.89	$t_{\alpha/2,(n-2)}=t_{0.025,147}\sim 1.88$
P-value	$2.5*10^{-8}$	Significant value= 0.05
Correlation coefficient	0.437	
R-square	0.19	
Situation of null hypothesis of the slope	**The slope has the negative value at the critical value of 5%**	

The Durbin-Watson value is 1.88 which is greater than the upper bound value. So it is not significant to reject the statistical hypothesis about the independent of the error

terms of the regression model. Or we must accept that the error terms are independent. This is equivalent to no-autocorrelation in the error terms of the data set. This is equivalent to the conclusion that there is not auto-correlation at confident level of 5%. Thus, this model is suitable for describing the "double jeopardy".
The goodness of the model is shown by the correlation and R-square coefficients. Correlation shows there are 43.7% of the observations are relative. Among this with R-square 0.19, the linear regression model is able to describe 43% (0.19/0.437) of the observations which are related. Or almost haft of the related observations are explained by linear regression. This also means that there are other forms of relationship between the two variables. However, it goes further than the boundary of this study.

The next test is P-value (T-statistic equivalent) to test the significant of the slope against zero at 95% confident level. The result of this test is also shown in the table 4. It says that the P-value is much smaller than the critical value. Hence, it is conclusive that the slope is not zero and thus, it is adequate to depict the relationship between the capital ratios and operational ratios.

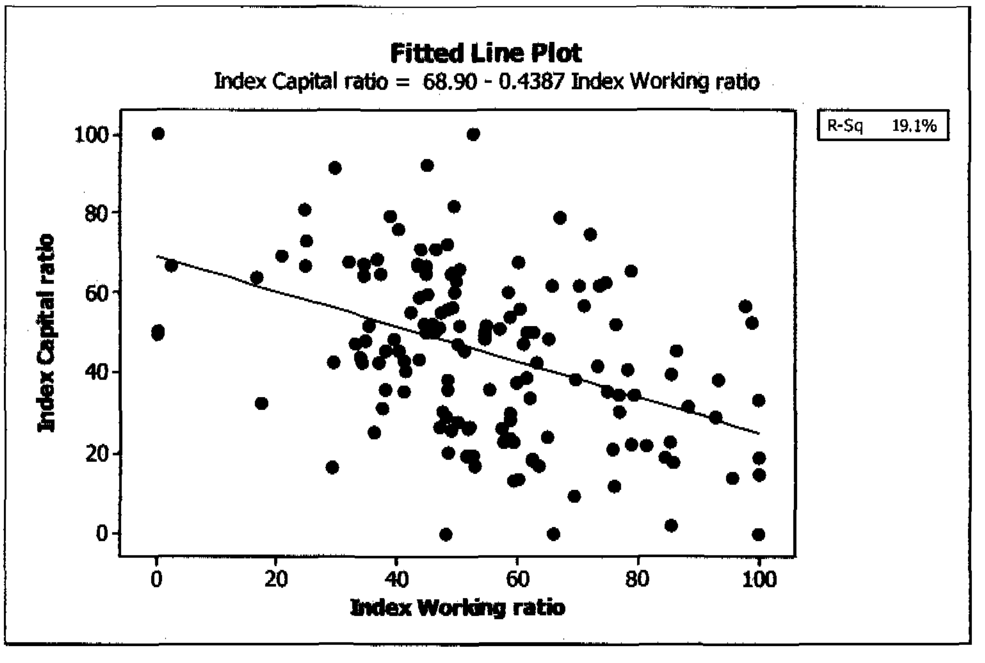


Figure 6: The Fitted line plot of index capital and index operational ratios in the three cases

As pointed out in the analytical frame work, the model and the slope are both sufficient to give conclusion about the "double jeopardy". As the value of the slope is -0.44, this mean that there is a trade-off between the capital and operational costs or "double jeopardy" issue exists in Dutch water supply companies, and the UK and Vietnam water service sector.

The Figure 6 above visualizes the results of the regression line between the index or the corrected capital and operational ratios in the three selected cases. Though the dots deviate far from their regression line, it is obvious that the cloud of the dots has a downward slope. This visually supplements for the value of the slope given in the table 4. The large deviations from the regression line of the corrected capital and operational ratios show wide range of both capital and operational ratios in the three selected cases.

In conclusion, for testing the existence of "double jeopardy" in the first research question, the answer is that there is "double jeopardy" in Dutch water supply companies, and the UK and Vietnam water service sector. However, this conclusion is not sector wide or applies for on every utility. This in some extend is contradicted with the Cobb-Douglas function which explains the behaviour of the two cost groups in exponentially functional form. Imaging, if there is a positive slope line drawing from the origin of the coordinate, then any dots belonging to or closing this line presents a utilities whose both capital and operational ratios of the water utilities could also increase or decrease. In fact, this situation occurs when water companies are able to achieve the efficiency in both capital and operational costs or there is a change in the scales of those companies. Thus, "double jeopardy" exists in the tested cases, it does not occur in every utility. However, it still distorts the benchmarking results though it happens partially in water sector.

II Stage 2 – Vulnerability of benchmarking results to "double jeopardy"

This part presents results to answer the second research question which is "what is the situation of "double jeopardy" when different benchmarking approach is applied?"
This part is structure in the order that firstly it displays the results of regression model of the three selected cases. Secondly, the regression parameters and Durbin-Watson value are examined to assess the goodness of the models. Lastly, the results are synthesized in a table and a chart to compare the differences.

1 Results of separated models

In this stage the inputs into the regression models are the capital ratios and operational ratios of each selected case.

The data of Dutch water supply sector are collected in four years (1997, 2000, 2003 and 2006). However, the data of the four years are failed in the Durbin-Watson test. Removal of 1997 and 2000 data helps the rest of the data set to pass the Durbin-Watson test. Hence, only the regression results of data in 2003 and 2006 are used in analysis in this case. The results of both two regression models are presented in the below tables.

The table 5 and table 6 are the results of the regression model of Netherland case. The table 6 shows the results in which the autocorrelation has been removed by Durbin and Watson test while the table 5 is the results with autocorrelation. Because the autocorrelation is indicator to show the goodness of the model, when there is auto correlation in a model, that model is rejected in analysis application.

The table 5 shows all the parameters of the regression model as well as the Durbin and Watson value in four year data. However, merely examining the Durbin and Watson value, it is obvious that this value is smaller than the lower bound value of Durbin and Watson statistics at the critical level 5% and 51 observations. Because this value is smaller than the D_L value, it is significant to reject the independent of error terms in the model[12]. This is equivalent with the conclusion that the error terms are auto-correlative.

Table 5: Summary output of Dutch regression model (four year data)

Data	CAPEX and OPEX data of Dutch water sector in four year 1997, 2000, 2003 and 2006	
Regression variables	Corrected capital ratio and working ratio	
Number of observations	51	
Statistical indicators of the slope:		
Durbin-Watson test: **d value = 1.41**	**D_L= 1.5**	**D_U= 1.59**
Slope of regression line:	0.579	
T-statistic	-6.48	$t_{\alpha/2,(n-2)}=t_{0.025,49}= 2$
P-value	$4*10^{-8}$	Significant value= 0.05
Correlation coefficient	0.68	
R-square	0.46	
Situation of null hypothesis of the slope	**The slope has the negative value at the critical value of 5%**	

Moreover, Table 6 is the results of the regression model employing the data in 1997 and 2000. This parameters show that the data set passed the Durbin-Watson test with d-value of 1.6 higher than the upper bound value at the critical level of 5% or there is not autocorrelation in this data set. However, the p-value shows that the regression slope is not reliable to be different from zero at the critical level of 5%. Thus the slope could not be used in the analysis. This data set will be excluded from the collected data in later analysis.

Table 6: Summary output of Dutch regression model (data in 1997 and 2000)

Data	CAPEX and OPEX data of Dutch water sector in 1997 and 2000	
Regression variables	Capital ratio and working ratio	
Number of observations	31	
Statistical indicators of the slope:		
Durbin-Watson test: d value = 1.6	**D_L= 1.3**	**D_U= 1.49**
Slope of regression line:	0.44	
T-statistic	1.42	$t_{\alpha/2,(n-2)}=t_{0.025,29}= 2.045$
P-value	0.16	Significant value= 0.05
Correlation coefficient	0.255	
R-square	0.06	
Situation of null hypothesis of the slope	**Not significant to reject the slope is zero at critical value of 5%**	

[12] Referring to the analytical framework of this stage for the pair of statistical hypotheses for Durbin and Water test

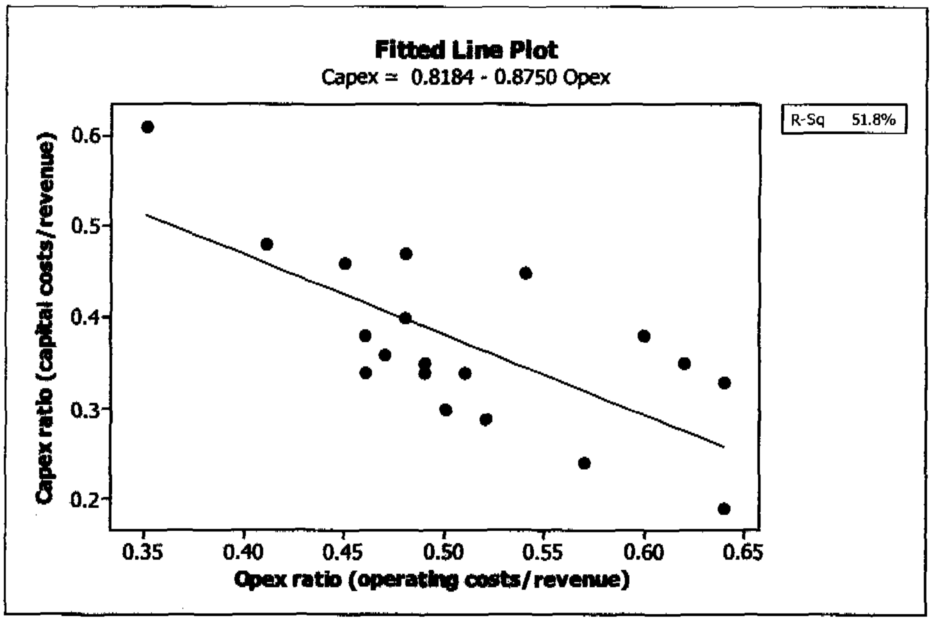


Figure 7: The Fitted line plot of capital and operational ratios in Dutch water supply

In Table 7, after removal of data in 1997 and 2000 the Durbin-Watson value is 2.74. This value is higher than the upper bound of the test. So it is not significant to reject the hypothesis that the error terms are independent or there is not auto-correlation in this model.

Table 7: Summary output of Dutch regression model (data in 2003 and 2006)

Data	**CAPEX and OPEX data of Dutch water sector in 2003 and 2006**	
Regression variables	Capital ratio and working ratio	
Number of observations	20	
Statistical indicators of the slope:		
Durbin-Watson test: d value = 2.74	**D_L= 1.08**	**D_U= 1.28**
Slope of regression line:	-0.87	
T-statistic	-4.4	$t_{\alpha/2,(n-2)}=t_{0.025,\,18}=2.1$
P-value	0.000348	Significant value= 0.05
Correlation coefficient	0.72	
R-square	0.51	
Situation of null hypothesis of the slope	**The slope has the negative value at the critical value 5%**	

T-statistics and P-value are to examine statistically the real existence of the slope value. The T-statistics and P-value are (-4.4) and 0.000348 respectively. These values are significant to reject the hypothesis (mentioned in previous part) that the value of the slope is zero at 95% confident level. Hence, the slope is reasonable to use in showing the "double jeopardy" issue.

Next is the correlative coefficient with the value of 0.72. This value indicates 72% of capital and operational ratios of Dutch water sector are related. This is also equivalent to 72% of the capital and operational costs of Dutch water sector related.

The R-square is to show that 51.7% of the capital and operational ratios are linearly related. Or this model is able to explain the "double jeopardy" at 51.7% of Dutch water sector. This equivalent to the existence of other relationship forms of the two variables.

The Figure 7 above visualizes the regression model of Dutch water sector. It is plotted by the operational ratios on the horizontal axis against capital ratio on the vertical axis. It is obvious that the dots distribute equally around the regression line.

Netherlands regression model is sound to describe the relationship between the capital and operation ratio in Dutch water service sector. The slope of the regression line is also good to use in relationship analysis.

As shown in the Table 8 below are regression parameters of the UK water sector.

The data of this case are intended to be collected at 22 water utilities in the country over 2001 to 2007 periods. However, several utilities did not publish their data for the whole research period. As such there are 98 observations taken into accounts.

Table 8: Summary output of the UK regression model

Data	**CAPEX and OPEX data of the UK water utilities over 7 years from 2001 to 2007 periods**	
Regression variables	Capital ratio and working ratio	
Number of observations	98	
Statistical indicators of the slope:		
Durbin-Watson test: d value = 1.81	**D_L= 1.59**	**D_U= 1.63**
Slope of regression line:	-0.51	
T-statistic	-4.71	$t_{\frac{\alpha}{2}(n-2)} = t_{0.025,(98)} \sim 1.99$
P-value	$8*10^{-6}$	Significant value= 0.05
Correlation coefficient	0.434	
R-square	0.188	
Situation of null hypothesis of the slope	**The slope has the negative value at the critical value 5%**	

The correlation among time series data are cleaned by the Durbin-Watson's method to ensure that there is no auto-correlation in the model. Here Durbin-Watson value is 1.81 which is higher than the upper critical value (D_u=1.63), ensuring that there is no auto-correlation in the data set.

T-statistic and P-value are a signal to test the real existence of the slope of the regression line. In this model, the T-statistic lies in the rejected area and so is P-value. Hence, the statistical hypothesis that the slope is equal to zero is rejected. Or the slope of this regression line is sufficient to use in relationship analysis.

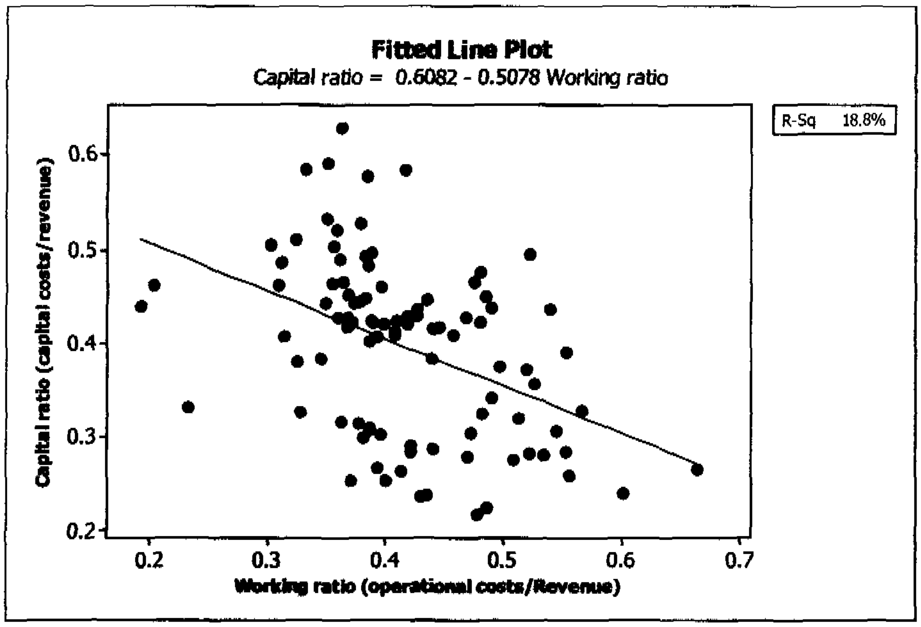


Figure 8: Fitted line plots between capital and operational ratio In the UK water sector

Figure 8 below visualizes the result of the UK regression model. It is valuable to investigate the notable dot having very high capital ratio and low operational ratio. This is Southern Water Services Ltd with capital ratio of 0.63 (average value equal to 0.42) and low operational ratio of 0.36 (average value equal to 0.39). This is likely to be a clue of "double jeopardy" in accounting trade-off since the capital cost of the utilities increased by 10% while the operational cost reduced 5% in comparison with the previous year (2005 and 2004). To conclude this issue, more investigation needs to be executed in the investment activity of the companies.

The next parameter is correlative coefficient. This parameter shows that there is 43.4% of the capital and operational ratios are correlative.

Further on is the R-square parameter, it indicates that 18.8% of the variability of the observations is explained by the linear regression model.

All the statistical test of this model is significant at level of 95%. This model and the slope are suitable in application for analysis.

In conclusion, though the regression model is able to depict only 18.8% of the variability of the observations, the other statistical parameters of the model are satisfactory at 95% significant level. Thus, this model is reasonably used to analyze the "double jeopardy" in the UK case.

Lastly, regression parameters of the Vietnam water sector are shown in the Table 9. Specifically, the variables in this model are the working ratio and capital ratio of the Vietnam water sector. The data were collected through the benchmarking report in 2000 and the Ministry of Construction. After merging the two set of data, there are 31 observations available for feeding in the regression model.

Table 9: Summary output of the Vietnam regression model

Data	**CAPEX and OPEX data of Vietnam water sector in 2000**	
Regression variables	Capital ratio and working ratio	
Number of observations	31	
Statistical indicators of the slope:		
Slope of regression line:	-0.32	
T-statistic	-1.48	$t_{\frac{\alpha}{2}(n-2)} = t_{0.025,(29)} \sim -1.99$
P-value	0.148	Significant value= 0.05
Correlation coefficient	0.265	
R-square	0.07	
Situation of null hypothesis of the slope	**Not significant to reject the slope is zero at 95% level of confident**	

Because the data in Vietnam case were collected in a single year, there is not likely to have an auto-correlation in these set of data. Thus, the Durbin-Watson test is avoidable in this case.

Unfortunately, T-statistic and P-value are not significant at the confident level of 95% to reject the zero slope value. These values are -1.4 and 0.158 respectively.

The correlative and R-square coefficients (26.5% and 7% respectively) also show that the goodness of the model is not able to explain the "double jeopardy" issue in Vietnam.

In conclusion, the model poorly describes the "double jeopardy" in Vietnam case. In fact, it is actually inconclusive about the "double jeopardy" in this case.

Though the results of the Vietnam case are not statistical significant for judging the "double jeopardy" in Vietnam, the results and the collected data are still use for comparative purposes in the later parts.

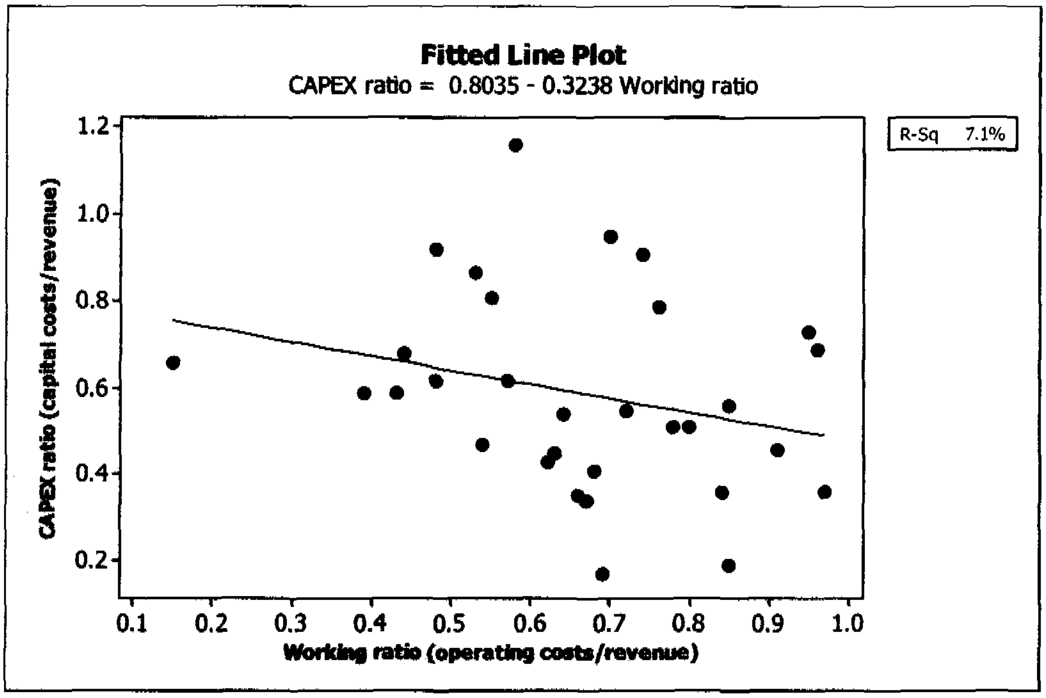


Figure 9: Fitted line plots between capital and operational ratio In the Vietnam water sector

Figure 9 visualizes the result of the regression model of Vietnam. Each dot presents working ratio and capital ratio of a specific water utility in 2000 in Vietnam.

There are two outliers in the figure. One represents Hanoi Water Supply Company No.2 with capital ratio and operational ratio equal to 0.19 and 0.85 respectively and the other is Quang Ninh Water Supply Company whose capital and operational ratio are 0.17 and 0.69 correspondently.

The main reason that capital ratio of Hanoi No. 2 Water Company was low at such a level since there was a new project which fixed assets had not shown on balance sheet to be depreciated while the operational still incurred.

The reasons for the Quang Ninh Company are firstly due to its high labour usage (the number of staffs per m^3 produced of the company is 3.83 in comparison with 2.9 of the national average). Secondly, the depreciation method also contributed to the low capital costs of the company. There are five treatment plants operated by the company. Al these plants were constructed in 1978. Hence, there was fixed assets which are no longer depreciated while they are still in operation. These activities still result in operating costs. Lastly, the treatment plants use surface water which needs more operating cost to treat than ground water sources.

2 Assess the synthesis results of the three cases

This part presents the results and analysis of the three regression models. The analysis focuses on the vulnerability of different benchmarking results to the "double jeopardy".

Figure 10 below illustrates the results of the three regression models for the analytical purpose. The empirical regression lines of the three cases have their own legends on the figure.

Firstly, the current situation of different benchmarking approaches under effects of "double jeopardy" is analyzed based on the values of the R-square of each regression model.

Table 10: Comparison of R-square and correlation of different regression models

Case	Benchmarking approach	R-square value	Correlation coefficient
Dutch	Total, operational and capital costs	0.51	0.72
The UK	Capital and operational costs separately	0.188	0.434
Vietnam	Only operational costs	0.07	0.265

As shown in Table 10, Vietnam case with its operational cost benchmarking has lowest both R-square and correlation coefficient. This also means that the capital and operational costs in Vietnam is at low level of correlation in comparison with the other two cases. In this sense, the "double jeopardy" happened least in Vietnam. On the other hand, Dutch case had the highest value for both R-square and correlation coefficient showing that it was the case with the most occurrence of "double jeopardy".

The above results seem to be contradicted with the idea that where the partial benchmarking executed, the "double jeopardy" is more likely to occur. However, some issues should be considered. First is about the inputs in each model since different models did not use the same time series data (Vietnam in 1 year, Dutch in 2 years, and the UK in 7 years). This could result in the large deviation of the observations. In addition, the quality of data also contributes to the magnitude of the parameters. Specifically, the low correlation and R-square in Vietnam is due to the large fluctuations of the capital costs in the country. This will be presented in the stage 3 of the research. Second is about the effects of the "double jeopardy" on the benchmarking results. The high degree of "double jeopardy" issue does not necessarily mean the bad effects on benchmarking since "double jeopardy" has two elements. Only the accounting trade-off and the suboptimal usage of capital costs in allocating trade-off elements put adverse effects on the benchmarking results.

Secondly, the future distorting effects of "double jeopardy" on benchmarking results are executed by analysis the magnitude of the regression slopes. In this sense, the slopes are related differently to two components of "double jeopardy", which are the accounting trade-off and allocating trade-off.

In accounting trade-off, the slope shows the ability to hide a given kind of costs into the other cost blocks. For example, in the case of Dutch water sector in the figure 10 below, capital ratios and operational ratios are related by the equation: $Y=-0.875*X + 0.814$ with the slope equal to -0.875. The figure (-0.875) means that one unit decrease in the operational ratio results in 0.875 unit reduction in capital ratio. In this implication of the slope to the trade-off, the comparison of the three cases shows that Vietnam regression line has the lowest slope (-0.32). This slope makes it harder to detect the whether the companies shift operating costs into capital costs since one unit reduction in operational ratio leads to only 0.32 units in capital ratio. Applying the same interpretation shows that in Dutch case, it is easier to detect the accounting trade-off since this case has the largest slope, and the UK case stands in the middle with slope of -0.5.

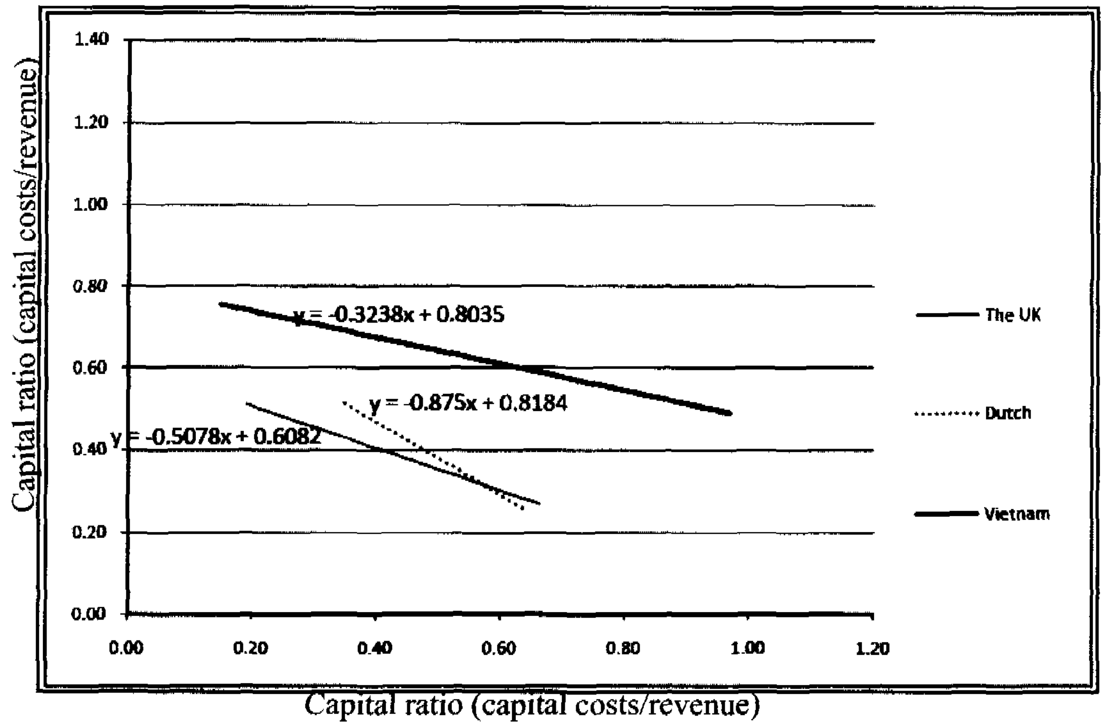


Figure 10: Regression of the three cases between capital and operational ratio

In relation with benchmarking approaches, in case of partial benchmarking, the lower value of slope shows higher possibility of accounting trade-off and this results in the higher distortion in partial benchmarking results.

The slope is also related to the allocating trade-off of "double jeopardy" issue. The allocating trade-off means that how much capital costs a company invests in relation with the amount operational costs consumed. Within this respect, the slope shows how expensive the trade-off is. Like in the Dutch equation (Y=-0.875*X + 0.814) shows that if the operational reduces 1 unit, the capital cost needs to increases 0.87 units. This is the most expensive one in comparison with the other two cases -0.5 and 0.32 for Vietnam and the UK correspondently. Because of the expensiveness, the water utilities in Dutch case are less incentive to make the trade-off.

Thus, slope analysis shows that the Vietnam water service sector with operational cost benchmarking results is more vulnerable to the "double jeopardy" issue since the low slope value indicates the less expensive and difficult to detect the trade-off.

Noting that, the above analysis does not mention the cause and effect relationship between the benchmarking approaches and magnitude of the slopes. It only intends to show the sensitivity of "double jeopardy" to different benchmarking approach under a specific slope.

The magnitude of the slope is a different issue. It is the nature of the sector depending on the technology development and price of labour in the specific sector. Technology development shows the amount of labour to exchange with capital investment. The more advanced technology is, the steep slope is. For example, Vietnam case is low technology development, and then the slope is lower than the other two cases. Similarly, the slope is also high in the case where the labour price is high.

Secondly, efficiency level of each case is also a signal for the suboptimal allocating trade-off. The efficiency is expressed by the distance from the regression line represented for the case to the origin of the coordinate. The closer the line to the origin is, the more effective the case is since this owns a capital and operational ratio as low as possible.

Referring to the figure 10 above, the distance from the Vietnam' regression line to the origin is the largest. Hence, the efficiency of this case is the lowest among the three cases.

Consider the Dutch and the UK cases separately, these two cases are intercepted each other at the point with capital ratio and operational ratio equal to 0.32 and 0.57 correspondently (the arrow in the figure 10). In term of capital ratio, when Dutch water sector employs a capital ratio above 0.32, it is more efficient than the UK case. The question here is that "why is the efficient level of the UK lower than that of the Dutch case at the high capital ratio"? There are two explanations for the situation of the UK in comparison with Dutch case. Firstly, the price of labour (operational costs) is cheaper in relation with capital in the UK case. Hence, the UK utilities prefer to use labour instead of capital. Secondly, there is possibility that overinvestment occurs more frequently in the UK than in Dutch water sector that make the capital less efficient.

Moreover, in reality the Dutch water sector is more effective than the UK sector. By investigating the data set of operational ratio shows that 97.96% observations from the UK employed operational ratios lower than 0.57 while the UK is more efficient than the Dutch case only if the operational ratio is above 0.57.

Thus, in term of efficiency, the Dutch case is most efficient, second is the UK and last is Vietnam case.

Returning to the point of benchmarking approaches in relation with efficiency, Vietnam is the lowest efficient case and its benchmarking approach is only operational indicator. However, in this case it is unable to claim the low efficiency by Vietnam's partial benchmarking approach since both capital and operational of the case are less efficient than that of the other two cases. The lower efficient level is due to the other factors from developing countries distinguishing from developed countries.

On the other hand, the Dutch and the UK case are more compatible in term of technology development and the mature of the water supply sector. Hence, comparison between the two cases is able to reveal the effects of "double jeopardy" on the efficiency.

The lower capital efficiency of the UK in comparison with Dutch case has two possibilities to explain as above. One of them is the over-investment. And over-investment could results from the accounting trade-off and physically over-invested. These two issues are "double jeopardy" elements. In combination with benchmarking approaches, Dutch's benchmarking scheme uses total, operational and capital costs while the UK benchmarks capital cost and operational costs separately. Thus, there is high possibility that the lower efficiency in the UK is due to the partial benchmarking indicator selection. Partial indicators lead the water utilities to treat operational and capital costs differently. Or partial benchmarking approaches are more sensitive to "double jeopardy". This sensitivity may lead to distortion in benchmarking results.

In conclusion for this part:

As the analysis of the R-square and correlation coefficient, the pass data show that the "double jeopardy" occurred more in the total cost benchmarking approaches. However, this observation is facing limitations of the data.

Analysis for the future application of different benchmarking approaches shows that partial benchmarking approaches are more sensitive to "double jeopardy" than total benchmarking approach. Especially, in the situation where the trade-off coefficient between the capital costs and operational costs is low (developing countries), partial benchmarking together with the Agent-Principle problem (hiding costs) make it easier for "double jeopardy" to distort the benchmarking results. Lower efficiency in tested case shows high possibility that it is influenced by partial benchmarking approaches under the influence of "double jeopardy".

The remark of this section is about the assumption of cost minimizing of water utilities on which the above analyses are executed. The assumption is built on the ideal case where the price of capital and labour is treated equally. In this situation every company will try to be as close as possible to the origin of the coordinate.

III Stage 3 The consistence among various performance benchmarking outcomes

This part presents the results of a comparison of total cost against operational cost benchmarking outcomes as well as the capital ratios and operational ratio against the other operating performance of water companies in Vietnam. This examination helps to strengthen the "double jeopardy" issue in the case where operational benchmarking indicator is selected.

1 Total cost vs. operational cost benchmarking outcomes

Figure 11 shows the overall performance scores of operational cost based model and total cost based model of 28 water companies in Vietnam in 2000. The horizontal axis presents the water companies, while the vertical axis is the overall performance scores. Comparing the TOTEX with OPEX performance in the chart shows that there are points where the TOTEX performance is higher than that of CAPEX performance and vice versa. Also the two trend lines representing the TOTEX and OPEX performance intercepts each other. This means the results from the operational benchmarking do not coincide with those from the total model.

Referring to chapter 3, where Giannakis et al. (2004) presents two statements. The first statement is that the benchmarking outcomes are sensitive to the selection of indicators.

This statement is applicable for the case of Vietnam since different indicators result in various performance outcomes.

The degree of inconsistence between the two approaches could be illustrated in the

Figure 12 is drawn by taking the difference between the TOTEX minus OPEX performance scores. The figure shows that 72.22 percentages the differences are higher than zero. Or 72.22% of the TOTEX benchmarking scores are higher than those of OPEX. This means that 27.78% of the TOTEX benchmarking outcomes do not coincide with those of OPEX.

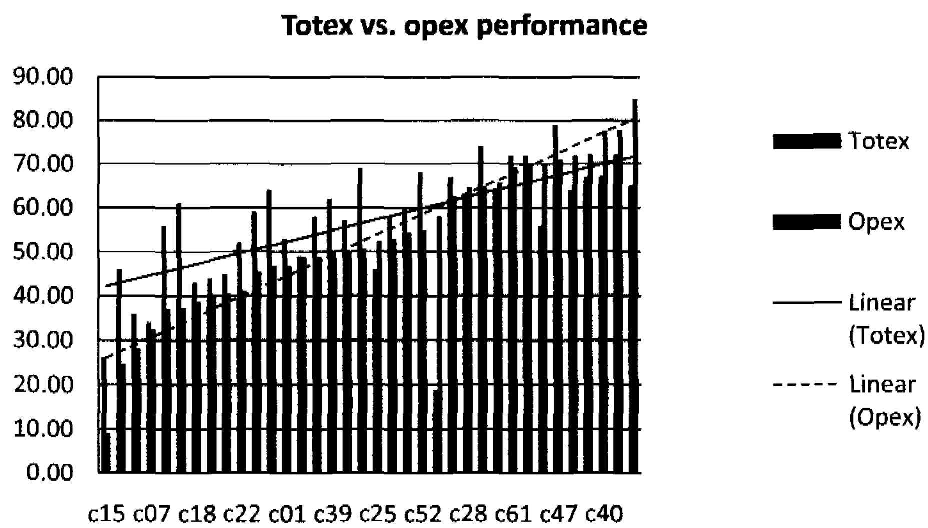


Figure 11: Performance scores of water companies under different approaches

Thus, the results shows that total cost benchmarking results are not aligned with the operational cost benchmarking results. The total cost benchmarking outcomes have higher score than the operational one. All also comply with two issues mentioned by Giannakis et al. (2004) in chapter 2, which are the inconsistence in benchmarking results when employing different benchmarking variables and the more variables in a benchmarking, the higher the scores are.

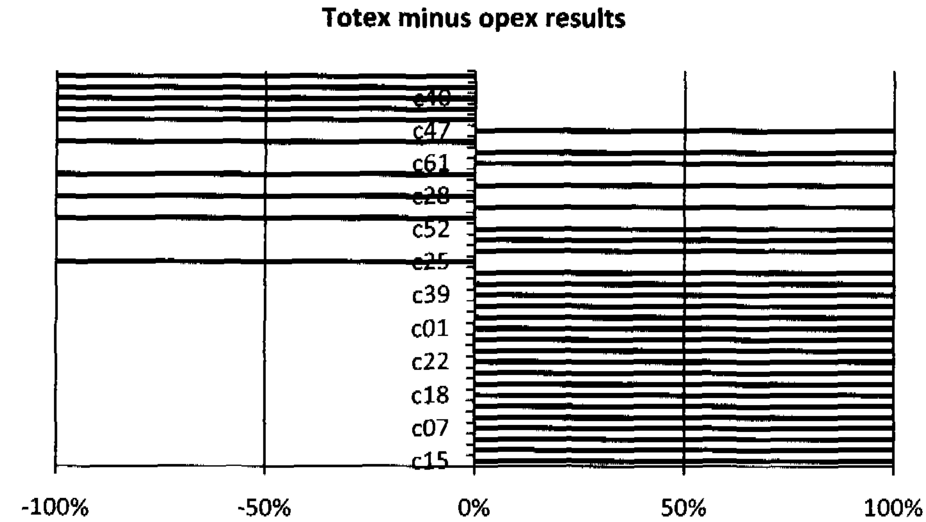


Figure 12: The difference between TOTEX and OPEX performance

2 UFW vs. total and operational cost benchmarking performance

Figure 13 shows the unaccounted for water vs. the capital and operational cost performance of 28 Vietnamese water supply companies in 2000. To eliminate the effects of the scale of the companies on the UAF, this indicator has been corrected by the number of connections of observed companies.

The three lines in the chart are the trend of the three investigated variables; unaccounted for water, working ratio and total ratio. These lines show that the trends of UFW and total ratio are more coincided than those of UFW and operational ratio. This means that a company with high capital ratio also has high UAF indicators. This seems contradict with reality since in reality companies invest more capital with the intention that they will have more advanced technology or better asset systems. However, if the companies invest more in asset but they lack a good maintenance system and labour force to detect the leakage or burst, then the pipe systems are not cared sufficiently. Especially in the Vietnam, the asset systems have been invested long ago. As a result, the UFW is likely to occur at high level.

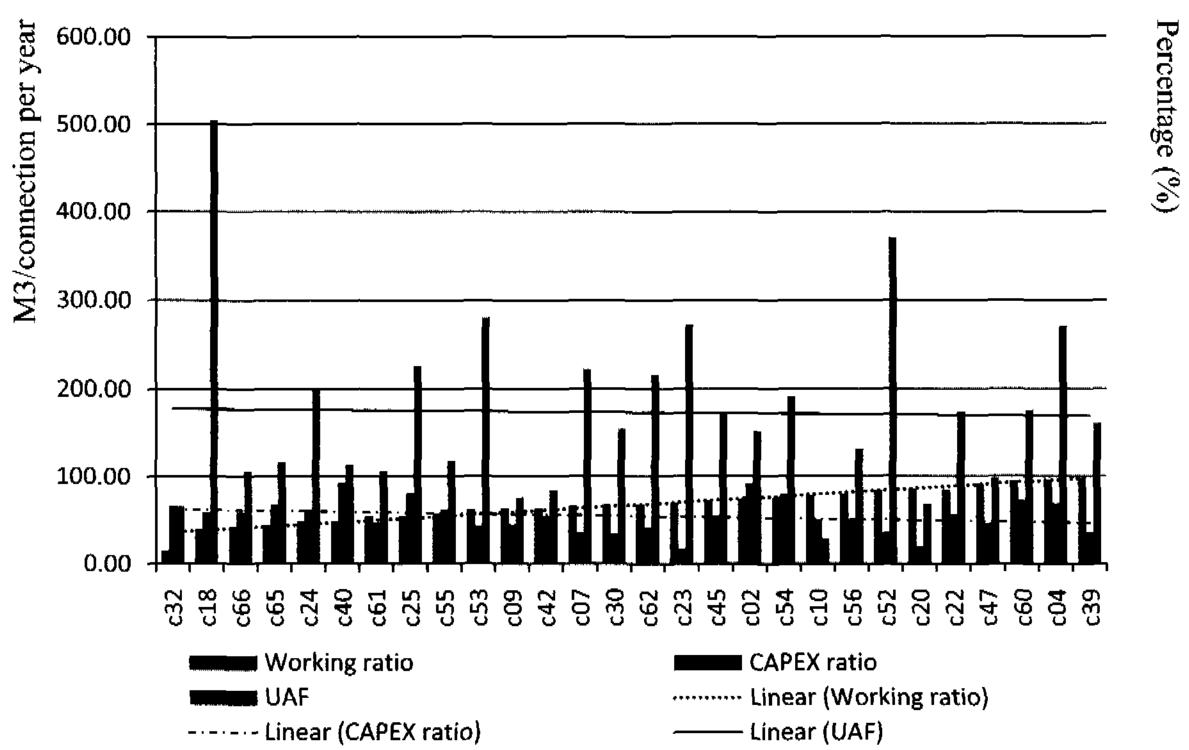


Figure 13: *UFW vs. Capital and working ratios*

On the other hand, the UFW and operational trend are contradicted with each other. The companies with high UFW have low operational ratio. This situation reflects the reality in water companies in Vietnam. When the companies save the operational costs, they must spend in UFW or this ratio is high. Why do they do this? This is likely to be the operational benchmarking approach in Vietnam. This discrimination between capital costs and operational costs trigger out a problem for operational benchmarking results. On the benchmarking results, the companies look high efficient performance in operational costs while their investment is not used properly, the high performance in operational ratio is paid by the high UFW. If they are given loans, are the loans given to a real high efficient performance companies in term of total cost?

3 Number of staffs per thousand connection vs. total and working ratio

Figure 14 shows the number of staffs per thousand connections vs. the total and operational cost performance of 28 Vietnamese water supply companies in 2000.

The three lines in the chart are the trends of the three investigated variables; number of staffs per thousand connections, working ratio and total ratio.

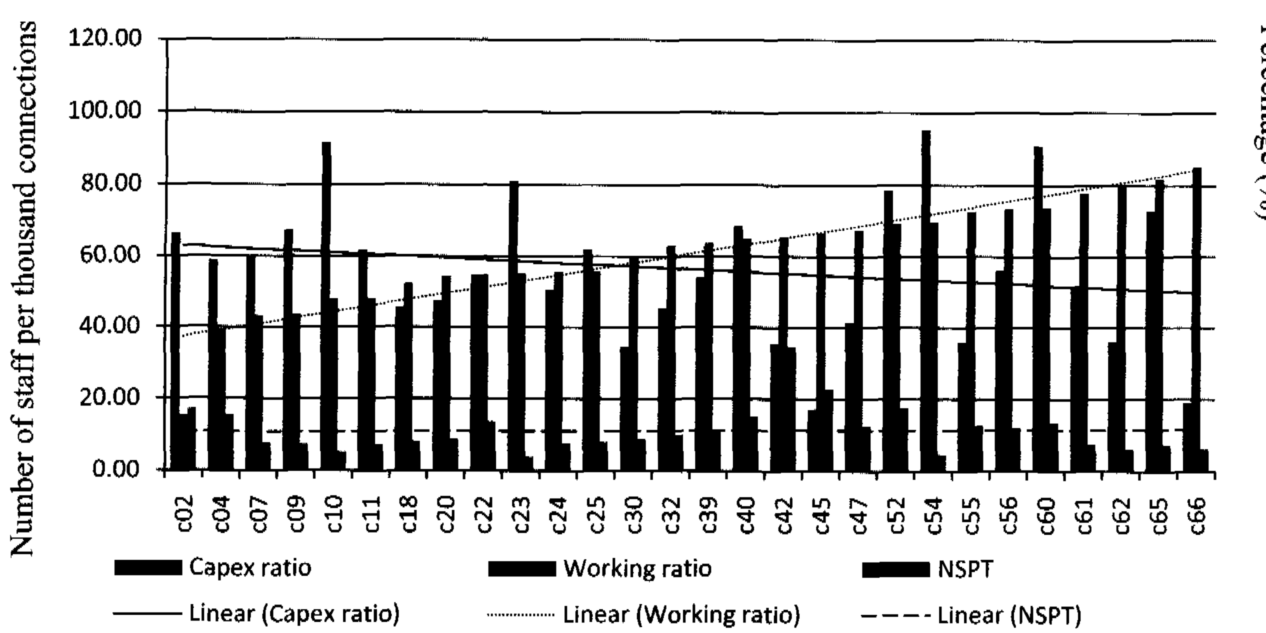


Figure 14: Number of staffs per thousand connections vs. capital and working ratio

The figure shows that the trend of NSPT (the number of staffs per thousand connections) is located at the lowest level of the three lines and it is not coincided with both total and working/operational ratio's trends. There are companies in which their capital ratios are high while there are also companies in which operational ratios are high.

4 Results of interview

This part presents the results of respondents from interview. It shows three issues, which are historical investment of water companies, source of capital investment, the depreciation method applied by companies, are the main factors which are affecting on the capitals cost of water companies.

Firstly, the history investment of water companies affects the capital costs in a way that water companies with their assets invested long in the past face complexity in defining the remained values of the assets. These remained assets are the base for calculating the amount of depreciation in the companies.

Secondly, the sources of investments are one of the drivers making diversification in capital costs in the sector. The sources of capital to invest in assets of water companies in Vietnam are mainly come from donors like the World Bank, the Asian Development Bank. When the donors give loans to the companies, their conditions on the level of interest payment, time of repayment of the loans and the assets which have to buy from specific countries are different. These factors are all the elements of capital costs that why later in the operating process, the capital costs of water companies are varied.

Lastly, the depreciation method is the one which influence on the depreciation amount of the capital costs. There are two issues in the depreciation method affecting the capital costs. Firstly, in the accounting systems currently applying on the water companies, it has regulation on the percentage applying to depreciate a specific kind of fixed assets. The fixed assets of water companies are divided into four differences groups including:

the water collecting system, the treatment plan system, the distribution system and the other fixed assets. However, companies faces the controversy in category their assets into the four above groups to apply the depreciating percentage. As a result of this, the capital costs are varied. Secondly, the depreciation of assets in a water companies also gets influence from the donors. In some loaning contracts, the donors also define the level and time of depreciation of the assets funded by their loans.

Chapter 5 Conclusion and recommendation

Conclusions

Basing on the results in chapter 4, this part presents the conclusion about the research questions. It also shows the weaknesses of this research as well as some issue which are not able to research within the boundary of this study. Lastly, basing on the conclusion, it gives the recommendations.

The first research question: Is there a "double jeopardy" in water service sector? The answer is that there is "double jeopardy" in water service sector by testing the data of Dutch and the UK.

The second research question: Under the existence of "double jeopardy", which benchmarking outcomes (total or partial approaches) are more likely to be distorted? The conclusion for this research question is categorized into the sub-group as follow:

In Vietnam case, where only operational indicator is employed to measure the efficiency and the low slope of trade-off between the capital and operational ratio, the efficient benchmarking outcomes are more likely to be distorted than the two other cases with higher slope of trade-off. This is because of the fact that low trade-off slope make it easier for companies shifting costs from one to another block (the Agent-Principle problem is easier to occur). This also equivalent to that the operational benchmarking indicator selection is more vulnerable to the "double jeopardy".

Relatively, the efficiency of the water utilities in Dutch is higher than that of the water utilities in the UK. The lower efficiency is likely to be result from the partial benchmarking approach currently existing in the country. Or efficiency in partial benchmarking is likely to be distorted. This make the results of partial benchmarking are also more vulnerable to the "double jeopardy".

The answer for the second research question is that partial benchmarking either operational indicator is used or both the operational and capital indicator are employed, is always more vulnerable to the "double jeopardy" issue. Especially in the case of developing countries, in which the slope of trade-off is normally low, the benchmarking results are more severely vulnerable to the "double jeopardy".

The third research question: The third research question is structured into three sub-questions. The first one deals with the consistency between the operational and total cost benchmarking outcomes. The conclusion for this question is that the total cost benchmarking outcomes are not coincided with the operational cost benchmarking outcomes. The second one deals with the comparison of other operational performance of water utilities against the working and capital ratio. In this aspect, the UFW are more coincided with the capital ratio than with operational ratio while it is inconclusive about the comparison of number of staffs per thousand connections against the operational and capital ratio. The last one is about three main drivers that make the capital costs in Vietnam case diversification, which are the historical investment of water companies, source of capital investment, the depreciation method applied by companies.

Recommendations

From the conclusion of the first and the second question of this study the first recommendation for the selection of benchmarking indicator is that the total cost benchmarking indicator selection is likely to face less distortion for benchmarking outcomes. Thus, benchmarking scheme should apply the total cost indicator instead of partial cost indicators. This will avoid the accounting trade-off and increasing in cost base. Both help to use benchmarking properly in meaning that it boosts the efficiency of the public sector due to lack of market mechanisms.

Application of total benchmarking scheme faces the challenges of measuring the capital costs which is difficult as pointed out in the literature review chapter and the diversification of capital costs like in Vietnam case. These challenges are able to make the total cost benchmarking unachievable in developing countries. In this situation, if the partial benchmarking is used, the financial activities of water companies should be made transparency and standardization to minimize the distortion of partial benchmarking outcomes by the "double jeopardy" issue.

Limitations of this study

The first limitation of this study happens at the case of Vietnam. The results of regression model are not statistical significant at the confident level of 95%. This problem is likely to occur due to two factors. The first is the sample size of the collected data has not sufficient. Second is the accuracy of the collected data. To avoid this problem, the future study should increase the sample size and pay more attention to the accuracy of data by checking directly with the data providers to confirm some doubtful figures.

The current research with its analytical framework is unable to delineate the effects of different "double jeopardy" components on benchmarking results. This research merely regards all components of the issue as factors making the distortion in the benchmarking outcomes. However, the optimal allocating trade-off of "double jeopardy" does not distort the benchmarking outcomes. Hence, the new analytical framework should be developed to estimate the effects of different trade-off on the benchmarking results.

Lastly, within the boundary of this research, it is unable to estimate the most likely suitable form of the relationship between the capital and operational costs of water utilities. Hence, the assumption about the linear relationship between the capital and operational costs based on which the linear regression model is applied has been formulated. As in the regression model of the three separate cases, the R-square values are much low than the correlation coefficients. This implies that the capital and operational costs also relate to each other in another form rather than only the linear form. The future research could also expand the test of "double jeopardy" issue by apply the other regression models such as the exponential forms.

Reference

Allan, G. (2006). "Assessing capital efficiency in the water and sewerage industry in England and Wales: Ofwat's approach." Utilities Policy 14: 224-233.

Ajodhia, V., Kristiansen, T., and Petrov, K. (2004) INTEGRATED COST AND QUALITY BENCHMARKING IN ELECTRICITY DISTRIBUTION.

Brealey, R. A., et al. (2001), *FUNDAMENTALS OF CORPORATE FINANCE*, Third Edition ed., 639 pp., The McGraw-Hill, San Francisco.

Burns, P., and Riechmann, C. (2004) Regulatory instruments and investment behaviour. Utilities Policy, 12(4), 211-219.

Byatt, I. C. R. (1995), The costs of water delivered and sewage collected, OFWAT, Birmingham.

Corton, M. L. (2003), Benchmarking in Latin Water Sector; the case of Peru, *Utility Policy, 11*, 133-142.

Dassler, T., Parker, D., and Saal, D. S. (2006) Methods and trends of performance benchmarking in UK utility regulation. Utilities Policy, 14, 166-174.

Diewart, W. E., and Nakamura, A. O. (1999) Benchmarking and the Measurement of Best Practice Efficiency: An Electricity Generation Application. The Canadian Journal of Economics / Revue canadienne d'Economique, 32(2), 570-588.

Douglas C. Montgomery, G. C. R. (2003), *Applied Statistics and Probability for Engineers*, 3 ed., John Wiley & Sons, Inc, United States of America.

Drew, S. A. W. (1997), From Knowledge to Action: Impact of Benchmarking on the Organizational Performance, *Long Range Planning, 30*, 427-441.

Fare, R., Grosskopf, S., Lovell, C.A.K., 1985. The Measurement of Efficiency of Production. Kluwer-Nijhoff Publishing, Boston.

Durbin, J., and G. S. Watson (1951) Testing for Serial Correlation in Least Squares Regression. II. Biometrika, 38(1/2), 159-177.

Fong, S. W., Cheng, E. W. L., and Ho, D. C. K. (1998) Benchmarking: a general reading for management practitioners. Management Decision 36(6), 407–418.

Fox, P. (2000), Capital works unit costs in the water industry, 24 pp, OFWAT, Birmingham.

Frontier Economics (2003), Balancing incentives, Frontier Economics, London.

Giannakis, D., Jamasbb, T., and Pollittc, M. (2004) Benchmarking and incentive regulation of quality of service: an application to the UK electricity distribution networks. Energy Policy, 33(17), 2256-2271.

Hendrikx, J. A. M., and T. J. J. Schmitz (2007), Reflections on performance 2006, Vewin, Rijswijk.

Irastorza, V. (2003), Benchmarking for Distribution Utilities: A Problematic Approach to Defining Efficiency, *The Electricity Journal.*

Jamasb, T., Nillesen, P., and Pollitt, M. (2003) Gaming the Regulator: A Survey. The Electricity Journal, 16(10), 68– 80.

Kessides, I. (2003), Reforming Infrastructure: Privatization, Regulation and Competition, World Bank, Washington D.C.

Kouzmin, A., Loffler, E., Klages, H., and Kakabadse, N. K. (1999) Benchmarking and performance measurement in public sectors: Towards learning for agency effectiveness. The International Journal of Public Sector Management, 12(2), 121-144.

Larsson, M., Parena, R., Smeets, E., and Troquet (2002) Process Benchmarking in the Water Industry, IWA Pulishing, London.

Noll, R., Shirley, M. M., and Cowan, S. (2000) Regulatory reform: Economic analysis and British experience. SIEPR Discussion Paper No. 99-32, Stanford Institute for Economic Policy Research, Stanford.

Sharifian, J. (2002), Benchmarking the Urban Water Sector Vietnam, The World Bank, Hanoi.

Shleifer, A., (1985) A theory of yardstick competition. Rand Journal of Economics,16 (3), 319-327.

Shuttleworth, G. (2005), Benchmarking of electricity networks: Practical problems with its use for regulation, *Utilities Policy*, *13*, 310-317.

Ton, N., et al. (2003), Main report; Capital cost section, Vietnam Water and Sererage Associassion, Ha Noi.

Voulgaris, F., et al. (2000), On the Evaluation of Greek Industrial SMEs' Performance via Multicriteria Analysis of Financial Ratios, *Small Business Economics*, *15*, 127–136.

Warford, J. L. F. J. J. (1969), Cost Functions for the Water Industry, *The Journal of Industrial Economics*, *18*, 53-63.

Appendices 1 Key indicators of performance or "metric" benchmarking

Indicator	Definition	Unit
Water Coverage	Population with access to water services (either with direct service connection or within reach of a public water point) as a percentage of the total population under utility's nominal responsibility	%
Water Production	Total annual water supplied to the distribution system (including purchased water, if any) expressed by	liters/person/ day
	Population served per day and Connection per month.	M3/conn/month
Total Water Consumption	Total annual water sold expressed by population served by	Liters/person/ day
Total Water Consumption	Population served per day Connection per month	M3/conn/month
Residential Consumption	Shows the average water consumption per person per day by customer category	liters/person /day
Non Revenue Water	Difference between water supplied and water sold (i.e. volume of water "lost") expressed as a percentage of net water supplied	%
	Volume of water "lost" per water connection per day	m3/conn/day
Metering level	Total number of connections with operating meter/ total number of connections, expressed in percentage	%
% sold that is metered	Volume of water sold that is metered/ Total volume of water sold, expressed in percentage	%
Pipe Breaks	Total number of pipe breaks per year expressed per km of the water distribution network	breaks/km/yr
Unit Operational Cost of Water	Total annual operational expenses/Total annual volume sold.	US$/m3 sold
Staff/ 000 connections	Total number of staff expressed as per thousand connections	#/'000 conn
Labor Costs vs. Operational Costs	Total annual labor costs (including benefits) expressed as a percentage of total annual operational costs	%
Contracted-out service costs as percentage of operational costs	Total cost of services contracted-out to the private sector expressed as a percentage of total annual operational costs	
Continuity of Service	Average hours of service per day for water supply	Hrs/day
Customers with discontinuous supply	The percentage of customers with a water supply that is discontinuous during normal operation	% of # required
Average Revenue	Total annual W&WW operating revenues expressed by annual	US$/m3 water sold
Operating Cost Coverage	Total annual operational revenues/Total annual operating costs	Ratio
Debt Service Ratio	Cash income / Debt service * 100	%
Total revenues per service pop/GNI	Total annual operating revenues per population served/National GNI per capita; expressed in percentage	% GNI per capita

Source: The International Benchmarking Network for Water and Sanitation tool kits

This system of indicators is to measure the overall performance of water utilities. Since this study focus on the efficient issues, it will room in to have a close look at the financial rations and cost classifications.

Appendices 2: Types of "metric" Benchmarking

The consensus on classification of benchmarking has not been adopted. However, this classification gives insight into the benchmarking (*Fong and al* 1998). And the insight view helps to set up principle goals of benchmarking. It depends upon; (1) the nature of the object being benchmarked, (2) the partners with whom comparisons are being made (*Drew* 1997). The typologies of benchmarking in general are categorized as follow;
The table 3 shows the mapping of all benchmarking based on different criteria, which are the referent partners and the object of benchmarking. For the purpose of this study, "metric" benchmarking is classified by this table as follow.

Classification of benchmarking and its objectives

Classification	*Type*	*Meaning*
Nature of referent partner	*Internal*	Comparing within one organization about the performance of similar business units or processes
	Competitors/peers	Comparing with direct competitors, catch up or even surpass their overall performance
	Industry	Comparing with company in the same industry, including non-competitors
	Global	Comparing with an organization where its geographical location extends beyond country boundaries
Object of benchmarking	*Process*	Pertaining to discrete work processes and operating systems
	Functional	Application of the process benchmarking that compares particular business functions at two or more organizations
	Performance	Concerning outcome characteristics, quantifiable in terms of price, speed, reliability, etc.
	Strategic	Involving assessment of strategic rather than operational matters like organizational structures, management practices and business strategies.(*Drew*, 1997)

Source: Modified from *Fong and al*, (1998)

In term of nature of referent partner, "metric" benchmarking is considered competitor/ peer benchmarking, in which different utilities compare their indicators (working ratio, UFW) against each others. Or, "metric" benchmarking also means industrial benchmarking, in which a specific water utilities compares their performance indicators against the average of indicators for the whole water sector.
On the other hand, when consider the object of benchmarking, "metric" benchmarking is performance benchmarking, which compares quantified outcome indicators.

Financial ratio

In "metric" benchmarking, the application of financial ratios is very popular like in Vietnam, Peru or World Bank, the initiatives promote the use of working ratio in benchmarking. That why it necessitates to present briefly the financial ratios.

Appendices 3: Summary of financial indicators

Leverage ratios

$$\text{Long-term debt ratio} = \frac{\text{long-term debt}}{\text{long-term debt} + \text{equity}}$$

$$\text{Debt-equity ratio} = \frac{\text{long-term debt}}{\text{equity}}$$

$$\text{Total debt ratio} = \frac{\text{total liabilities}}{\text{total assets}}$$

$$\text{Times interest earned} = \frac{\text{EBIT}}{\text{interest payments}}$$

$$\text{Cash coverage ratio} = \frac{\text{EBIT} + \text{depreciation}}{\text{interest payments}}$$

Liquidity ratios

$$\text{NWC to assets} = \frac{\text{net working capital}}{\text{total assets}}$$

$$\text{Current ratio} = \frac{\text{current assets}}{\text{current liabilities}}$$

$$\text{Quick ratio} = \frac{\text{cash} + \text{marketable securities} + \text{receivables}}{\text{current liabilities}}$$

$$\text{Cash ratio} = \frac{\text{cash} + \text{marketable securities}}{\text{current liabilities}}$$

$$\text{Interval measure} = \frac{\text{cash} + \text{marketable securities} + \text{receivables}}{\text{average daily expenditures from operations}}$$

Efficiency ratios

$$\text{Total asset turnover} = \frac{\text{sales}}{\text{average total assets}}$$

$$\text{Average collection period} = \frac{\text{average receivables}}{\text{average daily sales}}$$

$$\text{Inventory turnover} = \frac{\text{cost of goods sold}}{\text{average inventory}}$$

$$\text{Days' sales in inventories} = \frac{\text{average inventory}}{\text{cost of goods sold}/365}$$

Profitability ratios

$$\text{Net profit margin} = \frac{\text{net income} + \text{interest}}{\text{sales}}$$

$$\text{Return on assets} = \frac{\text{net income} + \text{interest}}{\text{average total assets}}$$

$$\text{Return on equity} = \frac{\text{net income}}{\text{average equity}}$$

$$\text{Payout ratio} = \frac{\text{dividends}}{\text{earnings}}$$

$$\text{Plowback ratio} = 1 - \text{payout ratio}$$

$$\text{Growth in equity from plowback} = \text{plowback ratio} \times \text{ROE}$$

Source: *Brealey and Meyer* (2001)

Financial ratio is a ratio of selected values on an enterprise's balance sheet. It measures the efficient aspect of corporate performance. They provide meaningful quantitative results of the internal decisions and external conditions of companies. Recently financial ratios have been considered a measure of corporate performance and viability (*Voulgaris et al.*, 2000). Financial ratios comprise a set of indicators, which cover most aspects of corporate finance. An example of financial ratio is shown in Appendices 3. It presents many financial indicators since "metric" benchmarking is the comparison of performance results. Narrower, in financial aspect, there are only the efficient financial ratios employed in a benchmarking scheme.