

12-2009

## The Impact of Computerisation on Productivity: The Case of Two State Utility Corporations in Botswana

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### Recommended Citation

Ojedokun, A., and Moahi, K. (2009). An Empirical Study of The Impact of Computerisation on Productivity: The Case of Two State Utility Corporations in Botswana. *The African Journal Of Information Systems*, Volume 1, Issue 3, pp.29-66.

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# THE IMPACT OF COMPUTERISATION ON PRODUCTIVITY: THE CASE OF TWO STATE UTILITY CORPORATIONS IN BOTSWANA

## Research Paper

Volume 1, Issue 3, December 2009, ISSN 1936-0282

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*(Received Jan 2009, Accepted Nov 2009)*

## Abstract

The study investigated the impact of computer technology on productivity improvement as reflected in the billing process and total quality bills invoiced per month in the Gaborone headquarters of Botswana Power Corporation and Water Utilities Corporation. It examined the input-output relationship with computers as one of the inputs. The other input is labour represented by the Meter Reading Hours and the Supervisory Hours. The study drew on the economic production theory and time series approach to determine the contributions of the inputs to output. The study relied on unpublished information and interviews rather than the use of publicly or commercially available data as the primary data source.

The results as evidenced by the regression parameters suggest that inputs and their characteristics satisfactorily explained the productivity improvement of the billing process in the two corporations. The results, however, show no significant statistical evidence that computer technology is positively linked to improvement in total quality bills invoiced per month. Interview conducted revealed that some aspects of the workplace practices within the two corporations also exerted significant influence on the inputs. This suggests that computer technology alone is an insufficient predictor of productivity improvement.

The study extends research on information technology (IT) impact on productivity improvement to public sector in Africa, and perhaps, is the first attempt to compare the impact of computer technology on productivity improvement among government utility corporations in Africa. The study would assist African governments in fashioning appropriate policies on investments in IT and to review existing ones.

## Keywords

IT Impact, IT Investments, Computerised Billing, Computer Technology, Botswana

# THE IMPACT OF COMPUTERISATION ON PRODUCTIVITY: THE CASE OF TWO STATE UTILITY CORPORATIONS IN BOTSWANA

## INTRODUCTION

The Republic of Botswana, with a population of about 1.9 million, is located in Southern Africa. It shares a border with South Africa in Mabato. Botswana, with a significant capital investment, has created one of the most dynamic economies in Africa. Through fiscal discipline and sound management, Botswana transformed itself from one of the poorest countries in the world to a middle-income country with a per capita GDP of \$13,300 in 2008 (Central Intelligence Agency – The World Factbook-Botswana, 2009).

In its strategic plan for 2003-2006, the government acknowledged the importance of Information and Communications Technology (ICT) to improving public access to information and services, and to national development. According to the Government Computer Bureau (2003), the aim of the plan was to provide facilities that could support quicker and easier public access to services and information. Further, it aimed to strengthen existing infrastructure and to build human capacity for government use of ICTs. The Botswana Government's ICT Vision for development of Information Technology (IT), "IT strategy 1996-1997: Vision 2003" is to the effect that Botswana must recognise the importance of information and of developing efficient information systems and networks for the support of research, education, development and communication with the rest of the world.

The strategy's roadmap for reaching the above vision include becoming a regional leader in the exploitation and use of IT in the achievement of national objectives; developing a well trained IT workforce; improving the implementation of data communications in both public and private sectors; using IT to improve government services; implementing quality IT Systems; each Ministry developing and generating its own information database; ensuring government is less dependent on paperwork and more on electronically stored and communicated information; and promoting private IT Service and Industry (Government Computer Bureau, 2003).

The objectives according to Bose et al. (2002) were to improve budgeting, *productivity*, and public service; remove bottlenecks to development; improve capacity to implement and monitor projects; as well as improve relationship with the private sector. As a result, there has been increased spending by government Ministries and Corporations on ICT projects (Government Computer Bureau, 2003; Sebetela, 2002).

Empirical studies in the IT value literature have attempted to quantify the benefits and/or payoffs from IT investments by analysing data collected at the different levels of study - economy level, industry level, firm and/or organisation level, and application (or process or activity) level (e.g. Devaraj and Kohli, 2000; Good and Stone, 2000; Dewan and Kraemer, 2000; Lee and Menon, 2000; Sircar, Turnbow, and Bordoloi, 2000; Stratopoulos and Dehning, 2000; Thatcher and

Oliver, 2001; Banker, Chang and Kao, 2002; Santhanam, 2003; Mukhopadhyay, Rajiv, and Srinivasan, 1997; Lehr and Lichtenberg, 1998; Lee and Perry, 2002).

Most of these studies have used either large United State (U.S.) firms or firms that are known to be the best performers in the industry. Some use public or commercially available data as the primary data source, the quality of which has been questioned on various grounds (Gordon, cited in Barua, Kriebel and Mukhopadhyay, 1995), rather than data specifically collected through surveys, interviews and unpublished organisation information sources for the purpose of assessing IT contributions.

However, while literature is replete with works on IT impact on productivity and/or performance, there has been little investigation into specific impact of IT in Africa (Adam and Wood, 1999, p.307). Except for a few studies, all of the empirical studies on the impact of IT on productivity are outside of Africa, an environment different from the developed and the newly industrialised countries (NIEs). Results from these studies according to Adam and Wood are not applicable to developing countries as they cover only a small portion of the problems that face developing countries.

Empirical studies about the impact of IT in public sector organisations are rare (Kraemer and Dedrick cited in Lee and Perry, 2002). Examination of literature further revealed that only a few studies have been carried out in the public sector (e.g. Mukhopadhyay, Rajiv, and Srinivasan, 1997; Lehr and Lichtenberg, 1998; Lee and Perry, 2002), yet the public sector is argued to be more computer-intensive than the private sector (Bretschneider and Wittmer cited in Bretschneider and Heintze, 2000).

Lubbe (2000) notes that the use of IT is neither fully understood nor studied *enough* in developing countries in order to yield meaningful insight. Lubbe's (2000) study of IT investment approaches in Namibia particularly revealed that organisations are not investigating returns on IT investment because they think it is too difficult. The calculation of the return on IT investment according to Lubbe could be complex as no real cash flow is available, with the problem of intangible costs compounding the problem. While government Ministries and Corporations in Botswana continues to massively inject funds into computerisation in order to find solutions to the problem of low productivity, its contribution to productivity movement has not been empirically investigated and ascertained.

The above underscores the need for this study on the contribution of computer technology to productivity improvement in the public sector in Africa. The objective therefore is to investigate the impact of computerisation on the billing process (i.e. in bills invoiced per month) in two state utility corporations in Botswana - the Botswana Power Corporation (BPC) and the Water Utilities Corporation (WUC). This study investigates the impact of computerisation on productivity by examining the input-output relationship with computer technology as one of the inputs.

The rest of the paper is structured in eight sections, as follows. The first section is the introduction. The second section provides brief information about the Corporations under study and the description of the meter reading process in the two Corporations. The third section

reviews the literature on attempts at identifying productivity gains from investment in IT. The fourth presents the study's research framework followed by the detailed description of the research methods. The fifth section presents a detailed analysis of the study's findings. The sixth section presents the discussion of the findings. The seventh section presents the conclusion and implications of the findings. The eighth section presents the future research directions from the study.

## **THE CORPORATIONS AND THEIR BILLING SYSTEMS**

Computer use in BPC began with a Government Computer Bureau (GCB) mainframe with dumb terminals at its Head Office in 1983/1984. The main application was COBOL-based billing system. In 1986, the Corporation introduced a Novell-based Local Area Network. Then in 1991, it introduced a Wide Area Network (WAN) which was extended to Morupule Power Station and Francistown Distribution Centre. Again, in 1995, BPC acquired a new billing system from Harris Computers in Canada. This was installed in June 1996 to improve revenue collection, customer relations and decentralization of the existing billing system. Currently, BPC uses wireless network within Gaborone (the Country's Capital). This allows it to provide customer pay points anywhere within Gaborone. The Data Control and Meter Reading Department is responsible for billing customers for monthly consumption of electricity and uses the Harris and the Consolidated Africa Technology System (CATS) for this purpose.

WUC began computerisation in 1987. It started with 'Mentor (Legacy) System' for billing. This was partially manual. Meter reading books are used to indicate the history and water consumption of plot. The shortcoming of this system was that meter readers were able to estimate consumptions without a visit to the site. In other words, it allowed falsification of meter readings. In addition, during rainy seasons, meter-reading books were always returned wet. In 1999, a SAP enterprise resource planning system was purchased and implemented as a new billing system to overcome the above shortcomings as it allows the use of handheld devices for data capture and upload. It came with the following modules: financial, materials management, human resources, IS-U/CCS, cost controlling, plant maintenance and real-time data management. This system facilitated the integration of all the applications in WUC.

### **The Meter Reading Process**

Except for the differences in the billing systems, bill processing in BPC and WUC are the same. While BPC uses Harris System and the CATS, WUC uses SAP. Metre readers use handheld devices. Bill processing begins after the creation of consumer accounts. Consumer data are downloaded from the computer into the handheld devices. The data is then used for metre reading. Metre readers work for 7 hours 45 minutes per day in BPC and 6 hours per day in WUC for 5 days a week. In both corporations, they also work for at least two weekends in a month as overtime. This is about 54 hours 15 minutes in BPC and 42 hours in WUC per week (inclusive of hours spent during the weekends). This is on the average, about 46 hours 30 minutes in BPC and 36 hours in WUC per week per month. Each metre reader is expected to record between 150 to 300 metres per day, depending on the terrain and/or the routes assigned. The results are later uploaded from the handheld devices into the Route Master (RM) in the computer for bill processing.

## LITERATURE REVIEW

The use of computers and information systems (IS) in organisations is increasingly becoming a widespread phenomenon. The availability of even cheaper and more powerful personal computers has put increasing computing power into the hands of a greater number of people. Computer use in the public sector is particularly heavy and growing (Kraemer and Dedrick, 1996). Its ability to store, retrieve and manipulate large amounts of data rapidly and cheaply has led to its widespread use in managing many clerical, accounting and service documentation functions in organisations. Some of the benefits are quite obvious (e.g. use of spreadsheet for financial planning, typing of documents on computers, distribution of memos through emails, keeping of records in electronic databases, etc.) while others are less obvious, but possibly more significant in their impact. Thus, organisational investments in ITs have increased dramatically both in the developed and the developing world. Investments in computerisation have particularly increased exponentially not only in the private sector but more especially in the public sector. Arguably, the public sector organisations according to Bretschneider and Wittmer cited in Bretschneider and Heintze (2000) now have a deeper penetration of computer technology than the private sector organisations.

Almost every government and business around the world believes that computer technology is the key to the future and many have invested a lot of money in it. A survey of the government ministries and public sector organisations in Ghana (Republic of Ghana, National ICT and Plan Development Committee, 2005) for example, found all the organisations involved computerised. Comparative analysis further indicates 100% of the public sector organisations have computer systems in place; while the corresponding figure for the government ministries was also 100%. Government and businesses, no doubt, expect to see benefits and returns from their enormous investments. These massive investments in IT were as a result of the growing recognition among economic development specialists that investment in technology can play a critical role in stimulating economic growth and productivity. For example, during the 1990s, according to Stiroh (2001), the United States of America enjoyed remarkable upsurge as unemployment declined, inflation remained in check and labour productivity growth accelerated to rates not consistently seen since the 1960s.

A number of empirical studies have attempted to find the benefits of IT expenditure, but the results have been conflicting. Earlier studies for example, including some fairly recent ones, failed to find positive payoffs (e.g. Roach, 1988; Bailey and Gordon, 1988; Wolff, 1991; Parsons, Gotlieb, and Denny, 1993; Loveman, 1994; Wolff, 2002). These studies used financial measures (using publicly or commercially available data) and failed to capture intangible costs/benefits and/or assets such as on-the-job training, improvement on employee's human capital to estimate payoff from investment in IT. The intangible costs/benefits, which may be considered productivity measures, are capable of producing excess returns on investment but fail to appear as assets in the balance sheet. This may have been responsible for the lack of statistical evidence of the impact of IT on productivity. Thus, since the 1980s, the lack of statistical evidence of the impact of computer technology has been a subject of debate as a result of the growing gap between expectations of the use of computers and the realisation of its benefits. This has resulted in what is known as the "productivity paradox". Although, the so called "productivity paradox"

concept, which started in 1987 with Robert Solow (Peslak, 2004) questions the extent and impact of IT investment (Mukhopadhyay, Rajiv and Srinivasan, 1997 and Lee and Perry, 2002), it does not deny the possibility of productivity improvements from the use of IT (Kraemer and Dedrick, 1994).

Available literature shows that most of the fairly recent studies are reporting positive payoffs from computerisation. The studies, among others, include those conducted by Adam and Wood (1999), Dewan and Kraemer (2000), Good and Stone (2000), Devaraj and Kohli (2000), Lee and Menon (2000), Sircar, Turnbow, and Bordoloi (2000), Stratopoulos and Dehning (2000), Thatcher and Oliver (2001), Banker, Chang and Kao (2002), Lee and Perry (2000) and Santhanam (2003). The studies have analysed data collected at the economy level, industry level, firm and/or organisation level, and application (or process or activity) level. They have used both financial (and/or profitability or economic) measures (e.g. return on assets, return on equity, return on investment, gross profit margin, net profit margin, etc.) to assess IT contributions. Some of them, including the few that were carried out in the public sector (on government services), have also incorporated productivity measures, and have identified productivity gains from investments in IT. These include: improved quality of product and services (Devaraj and Kohli, 2000), increased capacity utilisation and inventory turnover (Barua, Kreibel, and Mukhopadhyay, 1995), reduced production time (Kelley, 1994), meeting budget target and handling increased workloads and reducing worker's propensity to make mistakes (Lehr and Lichtenberg, 1998), and increased mail sorting output (Mukhopadhyay, Rajiv, Srinivasan (1997)). The results of positive relationships are found to be independent of the unit of the analysis – economy/country, organisation and application levels. This corroborates Rai et al. cited in Chan (2000) who argue that if IT investments are conceptualised at the firm level, the value of IT needs to be measured at the firm level as well, and if conceptualised at the activity or department level, then measurements should be at these lower levels. It is however better to identify benefits at the lower levels to avoid the problem of aggregation of IT impact over multiple processes.

Except for a few studies which use qualitative techniques, (e.g. Adam and Wood, 1999), most of the studies use quantitative methods (e.g. correlation analysis, Canonical analysis, regression analysis, Cobb-Douglas production function, data envelopment analysis, business value linkage, hierarchical regression, structural equation, etc.) and various estimation techniques (ordinary least squares, two-staged least squares, generalised least squares, weighted least squares, stochastic production frontier, etc.) to estimate impact. Mukhopadhyay et al.'s (1997) public sector study for example, considered IT impact on both process output and quality and carried out their analysis at the application level. According to the authors, because it was often difficult to obtain market prices for outputs to account for differences in quality, they developed a physical measure to quantify the output of the sorting process and used standard measures for inputs (labour hours and machine hours). They measured output quality in terms of the timeliness of mail processing. In addition, they used a set of factors in their model to account for differences in input characteristics. They used the rate of absenteeism to capture the withdrawal behaviour of the work force and the extent of barcoded incoming mail as a measure of the quality of raw material. The authors employed the production function specification using the Cobb Douglas form, and the Stochastic Production Frontier (SPF) to estimate their model.

This study focuses on measures of productivity rather than business and/or financial performance. Mukhopadhyay et al.'s study provided the basis of the framework developed in this study. It considers both output quantity and quality. The study considers not only the level of inputs but also the characteristics of the inputs. Since the Cobb-Douglas production function has been found suitable and reliable and is widely used, the study attempts to establish its performance in the context of Botswana. The study relies on unpublished information from the corporations' departments, and interviews rather than the use of computer budget and/or publicly or commercially available data as the primary data source. It confines measurement of productivity to the application (i.e. utility billing) to which the computer technology is deployed based on the corporations computer technology investment objectives to avoid the problem of aggregation of impacts over multiple processes.

## **RESEARCH FRAMEWORK**

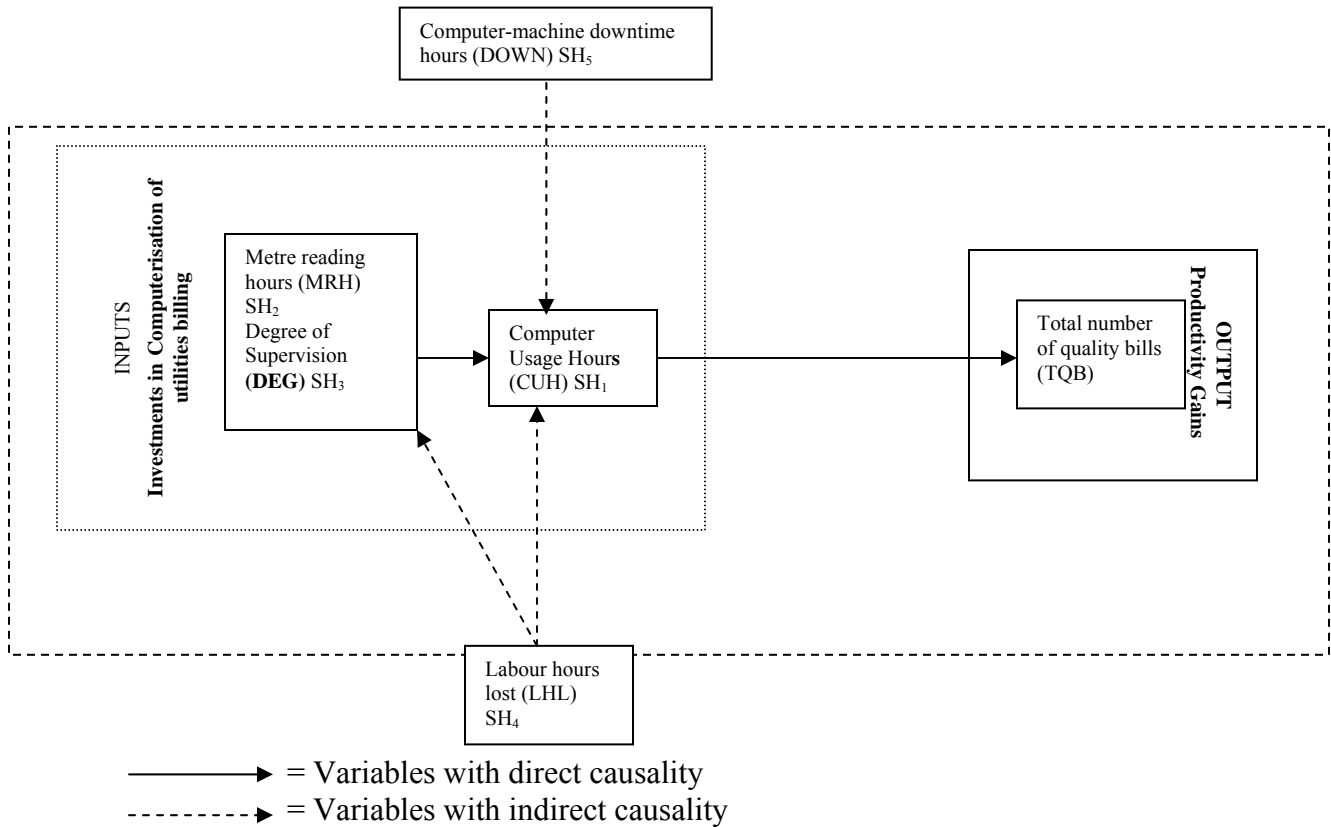
This study builds on a research stream that applies production theory to determine the contributions of various inputs to output. The approach uses microeconomic production theory to determine the set of relevant variables and to define the structural relationships among them. According to Barua et al. (1995), isolating economically and technologically distinct activities within a business helps to identify the value added by an input to individual products. The theory is therefore the appropriate choice to investigate the impact of computerisation on productivity and has been used in a number of IT productivity studies (e.g. Kelley, 1994; Brynjofsson and Hitt, 1996; Mukhopadhyay, Rajiv and Srinivasan, 1997; Lehr and Lichtenberg, 1998; Dewan and Kraemer, 2000; Banker, Chang and Kao, 2002; Lee and Perry, 2002). It is thus reliable to estimate the specified input-output relationship econometrically. The theory of production does not only posit a relationship among inputs and output, it also posits that this relationship may vary depending on particular circumstances.

The study applied the Cobb-Douglas production function which has been used in a number of IT productivity studies (e.g. Loveman, 1994; Lichtenberg, 1995; Brynjofsson and Hitt, 1996; Hitt and Brynjofsson, 1996; Mukhopadhyay, Rajiv and Srinivasan, 1997; Lehr and Lichtenberg, 1998; Lee and Perry, 2002) as a reliable base model. Gurbaxani, Melville, and Kraemer (2000) for example, considered Cobb-Douglas's assumption in previous empirical studies (cf. Hitt and Brynjofsson, 1996) as reasonable. Similar IS studies from developed countries (e.g. Lehr and Lichtenberg, 1998; Lee and Perry, 2000; Banker, Chang and Kao, 2002) have also well acknowledged the Cobb-Douglas function. Gurbaxani, Melville, and Kraemer's (2000) main result for example, show that information systems environment can be characterised by the Cobb-Douglas production function. Although this study is based on Cobb-Douglas production function, the variables are peculiar to Botswana.

The study uses a model at the application level but performs the analysis within an activity (bill processing) to study the impact of computerisation on productivity improvement. The application level computerisation impact does not suffer from the aggregation problem. It, however, requires a great deal of data. The analysis at the activity level is also likely to be useful for management control purposes. The study's model based on input-output relationships of a production (figure 1) is made up of three types of inputs variables – meter reading hour (MHR), degree of supervision (DEG) and computer usage hour (CUH); and two types of input characteristics variables –



computer machine downtime (DOWN) and labour hours lost (LHL) and an output variable total quality bills (TB).



**Figure 1: The study model based on the production theory**

These variables are as defined below:

*Total Quality Bills (TQB)*, is the dependent variable for the production function of computerised bill processing that measures the total number of quality bills invoiced per month (output). In this study, quality refers to the accuracy of meter readings, data entry into the computer, and calculations by the computer.

*Meter Reading Hours (MRH)* is an independent variable for the total number of hours of meter reading. With meter readers’ motivation, this variable is expected to be positive. The more hours they put into meter readings, the greater the number of metre readings (quantity) for bill processing should be. Motivation, through incentive compensation system, that rewards individuals encourages productivity. Motivation affects behaviour by reducing absence rate, leave rate, quit rate, and by increasing get-to-work speed.

*Degree of Supervision (DEG)* is an independent variable for the number of hours in supervision. It is a measure of the contribution of the supervisors in ensuring that work is carried out in a competent manner. DEG impacts on the efficiency of the billing process and hence the quantity and quality of bills invoiced per month. With motivation, supervisors ensure that meter readers work for the agreed number of hours, and that meter readings are accurately taken in order to assure quality of bills. This variable is expected to be positive.

*Computer Usage Hours (CUH)* is an independent variable for hours of computer use in the processing of bills. CUH is a measure of the intensity of the use of computers in the billing process. A computer that is used regularly would be significantly valuable than a computer in a box in the storeroom. It could also be a reflection of computerisation intensity in a corporation. As more hours are used and/or spent on computers for bills processing, the higher the quantity and quality of the output of the billing process (the bills). This is expected to be positive.

*Labour Hours Lost (LHL)* is an independent variable that measures withdrawal behaviour of employees through annual vacation and sick leaves, especially at unexpected times. It is expected to be negative. Long hours of work without rest, and under deadlines could lead to stress. The consequence is sickness, which could then lead to absenteeism at unexpected times. Absenteeism may retard productivity. This suggests that employees would not be able to work for the agreed number of hours. Stress could also result in inaccurate meter readings, which would then affect the quality of bills. In this case, the employee is present but performing below par. It is also widely known but little discussed, especially where morale is lagging such that most employees who call in sick to work are not always ill. Some claim paid sick days to tend an ailing child, run personal errands, or even just enjoy a weekday. Similarly, a concerted work stoppage where employees avail en mass of their paid leaves as a result of grievances can also impair productivity.

*Computer Machine Downtime (DOWN)* is the downtime hours of the computer system. The study expects DOWN to have a negative impact on billing output in terms of quantity due to its disruptive consequences. It is an independent variable. A prolonged computer downtime would necessitate reverting to the slow manual process, which is also prone to errors thereby affecting both the quantity and the quality of bills.

The theory of production from economics states that the inputs an economic entity consumes can be related to output through a production function ( $f$ ). That is, the output an organisation produces is a function of the inputs it uses. The study assumes that the two corporations produce a quantity of quality output via a production function ( $f$ ) whose inputs are labour and computer usage hours (CUH) as opposed to computer price/budget.

*Output equation:*

$$\text{Output} = f(\text{Inputs and input characteristics}) \quad \text{'Eq. (1)'}$$

The function  $f$  defines the technical relationship between the inputs and output. The study therefore estimated a Cobb-Douglas production function in which investments in computer technology was treated as an input, with the production efficiency of the billing process likely to be affected by inputs and their characteristics. Inputs for the computerized billing process include MRH and DEG; while capital i.e. computer technology capital is defined in terms of

CUH as opposed to computer price/budget. The input characteristics are LHL due to vacation and sick leaves taken at unexpected times, and the DOWN, defined in terms of the hours for which the computers remain unusable due to faults/breakdowns.

Incorporating these into the output equation (1), gives:

$$TQB_{at} = \beta_0 MRH_{at}^{\beta_1} DEG_{at}^{\beta_2} LHL_{at}^{\beta_3} CUH_{at}^{\beta_4} DOWN_{at}^{\beta_5} e^{\varepsilon}$$

‘Eq (2)’

Where a = 1 and 2 represents the corporations and t = 1, 2, ...5 denotes the 5 accounting periods (2000-2004).

This study hypothesises ( $H_m$ ) that the impact of computerisation on productivity improvement of the billing process is a function of the metre reading hours, the degree of supervision, the computer hours for bills processing, the labour hours lost (through annual vacation and sick leaves, at unexpected times), and the rate of computer downtime. It further draws on the following sub-hypotheses:

*Sub-Hypothesis (SH<sub>1</sub>):* An increase in the number computer hours used of computers for bill processing increases the number of bills invoiced per month.

*Sub-Hypothesis (SH<sub>2</sub>):* An increase in the metre reading hours increases the number of readings and consequently the number of bills invoiced per month.

*Sub-Hypothesis (SH<sub>3</sub>):* Efficient supervision (measured in the number of hours of supervision) increases work rate and consequently increases the number of bills invoiced per month.

*Sub-Hypothesis (SH<sub>4</sub>):* Labour hours lost through absences, due to annual vacation and sick leaves taken at unexpected times, reduces expected hours of work and consequently the number of bills invoiced per month.

*Sub-Hypothesis (SH<sub>5</sub>):* A prolonged delay in resolving computer faults (breakdowns) reported causes delay in bill processing and consequently reduces the number of bills invoiced per month.

## RESEARCH METHODS

The time series research design was used to examine changes in productivity over time, by using it to test the study sub-hypotheses. Since the focus of the study was on the utility corporations using the same task technology e.g. the hand-held devices for capturing data, the selection of the corporations and respondents was purposive (Aina and Ajiferuke, 2002; Tongco, 2007). This approach has been used in a number of IS studies (e.g. Olutimayin, 2002; Adewoye, 2007; Reddy, et. al., 2008).

The study draws from Mukhopadhyay et al. (1997) to examine the impact of computerisation on both process output and quality. It uses both qualitative and quantitative measures. It captures the differences in inputs across the two corporations under study: the BPC and WUC, models both process output and quality, and accounts for the differences in input characteristics. It then develops a physical measure to quantify the output of the billing process and uses standard

measures for inputs (Labour and Computer). The study assumes accuracy of metre readings and data entry into the computer and uses the computer processing of the metre readings as a measure of the quality of the bills.

The study was carried out at the application level and did not involve the aggregation of computerisation impact over multiple processes. 45 (April, 2001 – December, 2004) and 60 (January, 2000 – December, 2004) monthly data available for these periods were collected from BPC and WUC respectively (Appendices A and B). The study used two data collection instruments: self-designed data collection form, and interviews. Data collection form was used to elicit time series data to be included in the Cobb-Douglas equation. The instrument was used to collect data on the following variables: *TQB, MRH, LHL, DEG, CUH, and DOWN*.

The data collection procedure involved numerous site visits during the period January to March, 2005, first, to get educated on the operations of the corporations and second, to collect data for the study. Data for the quantitative variables were deduced from the examination of the unpublished corporation's records. Face-to-face and telephonic interviews were conducted with staff and unit heads before and following the results of analysis of data for purposes of seeking clarification and drawing appropriate conclusions.

For the purposes of data collection from the corporation's unpublished records, BPC granted the first author direct access to copies of "status of bills" containing bills invoiced per month for all locations from which the bills invoiced per month for Gaborone location were extracted and compiled for use. WUC did not allow direct access copies of "status of bills", instead an employee was detailed to extract and compile the data for the first author. The same was with leave records of employees. Whereas BPC granted direct access to the leave records of employees which enabled the LHL per employee or group of employees to be calculated, WUC detailed an employee from the Human Resources section to extract and compile the records for use in the study. The accuracy of data on these two variables from WUC is therefore suspect. Records however, show that employees do take leaves very often. In obtaining the MRH, the number of days worked by each meter reader was calculated. The number of weekends in each month was also calculated through the use of the yearly calendar. To calculate the number of hours worked per month by meter readers, the hours of work per day for the meter readers was obtained from each of the corporations and multiplied by the number of days worked per month. It was however, revealed that they are involved in other things such as looking for faults, problems, hazards, et cetera. This they confirmed has impact on normal hours for meter reading exercise. To obtain DEG, Supervisors (billing and meter reading) in the two corporations were asked to state, on the average, the number of hours devoted to supervision per day. The number of supervisory hours per month was then calculated from the number of days worked per month and the estimated number of hours of supervision per day. Interview revealed that although they do find time to carry out supervision, they are often too busy with other reports that had to be produced. There was also a general report of lack of motivation by the meter readers and supervisors. This appears more pronounced in WUC. To obtain the variable CUH, all employees who use the computer in the billing process (the billing officers/clerks, billing supervisors, and meter reader supervisors) in the two corporations were asked to state the number of hours devoted to such activity on the computer. The CUH was then calculated from the number of days worked per month and the estimated number of hours of computer use per day. Employees however, mentioned that they do use computers for other official and non-official duties such as

e-mailing, surfing Internet, and carrying out and submitting study assignments online. To obtain DOWN, the two corporations granted access to the records of fault call log-ins (indicating the request and closed times) from all sections of the two corporations. With the assistance of the IT personnel of the two corporations, the fault calls emanating from the billing section were identified, and the time taken (elapsed time) for faults to be corrected were calculated and taken as the DOWN. This exercise was a bit difficult as call log-in is by name of staff and not section. However, the IT personnel assisted in identifying call log-ins from the billing section of their corporation. Records show that there are delays in attending fault reports.

*Microfit for Windows* econometric package version 4.1 was used to analyse the time series data.

Four models (log linear, differenced log linear, error correction, and the log linear differenced) were tested before the best (i.e. *differenced log linear* for BPC and *error correction* for WUC) was finally chosen. The  $R^2$  and the Ramsey's RESET test were conducted to determine the most suitable model.

Since time series data display characteristics such as seasonality, trend and cyclical movements i.e. they are usually characterized by non-stationarity, the authors applied stationarity and cointegration tests in the estimation process. The Ordinary Least Squares (OLS) regression analysis was applied to the stationary time series variables. To allow application of the OLS regression analysis, the natural log of each side of equation 2 was taken so that the equation can be expressed in additive terms.

$$\ln (TQB)_{at} = \alpha + \beta_1 \ln (MRH)_{at} + \beta_2 \ln (DEG)_{at} + \beta_3 \ln (LHL)_{at} + \beta_4 \ln (CUH)_{at} + \beta_5 \ln (DOWN)_{at} + \mathcal{E}_{at} \quad (3)$$

Where  $\alpha = \ln \beta_0$ , the function (intercept or constant) which usually measures the shift parameter and  $\mathcal{E}_{at}$  = stochastic term satisfying all the classical assumptions.

Where  $\alpha$ ,  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$ ,  $\beta_4$ , and  $\beta_5$ , in equation 3 are parameters to be estimated. We expected  $\beta_1$ ,  $\beta_2$ ,  $\beta_4$  to be positive and  $\beta_3$ , and  $\beta_5$  to be negative.

The stationarity test was performed first by examining the time series plot of all the variables to be estimated (Appendices D & C) and second by performing the unit root tests using the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) (Table 1). The ADF helped to eliminate the problem of autocorrelation.

| Variables | <b>BPC</b><br>Dickey-Fuller (DF) | <b>BPC</b><br>Augmented Dickey-Fuller 1 (ADF1) | <b>WUC</b><br>Dickey-Fuller (DF) | <b>WUC</b><br>Augmented Dickey-Fuller 1 (ADF1) |
|-----------|----------------------------------|--|----------------------------------|--|
| LTQB      | -5.1084                          | -4.5303  | 0.64147*                         | 1.0173*  |
| LMRH      | -5.2993                          | -3.0166  | -5.0183                          | -3.7724  |
| LDEG      | -8.3018                          | -5.6125  | -9.7508                          | -6.4999  |
| LLHL      | -7.7057                          | -5.3655  | -8.5518                          | -6.4427  |
| LCUH      | -4.0576                          | -2.0454*                                       | -6.2442                          | -4.7334  |
| LDOWN     | -4.2390                          | -3.0860  | --2.3529*                        | -2.6873*                                       |

The Dickey-Fuller regressions include an intercept but not a trend

**BPC**: 95% critical value for the augmented Dickey-Fuller statistic = -2.9558

**WUC**: 95% critical value for the augmented Dickey-Fuller statistic = -2.9241

(\*) denotes that the non-stationary hypothesis cannot be rejected at the 5 percent level of significance.

H<sub>0</sub>: Unit Root

H<sub>1</sub>: Stationary process

**Table 1: Unit Root Tests (BPC & WUC results)**

The above results (Table 1) suggest that the null hypothesis of a unit root at 5% significance level (in log) cannot be rejected for variable CUH (in BPC time series) and variables TQB and DOWN (in WUC time series). These clearly demonstrate that for the time series, the variable CUH for BPC and, TQB and DOWN for WUC are all non-stationary. Since in both the DF and the ADF tests for WUC time series, the dependent variable (TQB) and the independent variable (DOWN) were non-stationary and were integrated of order one, it became appropriate for the series to be tested for the existence of a long run relationship between them.

And since only variable CUH was non-stationary for BPC, the cointegration test could not be performed. An OLS regression was therefore performed for the time series. However, for any analysis of data to be undertaken, the series had to be made stationary. The mean and variance stabilising transformation was therefore applied by differencing the log of all the variables. As indicated in Table 2, all the time series for BPC were now stationary in both the DF and ADF tests.

| Variables | <b>BPC</b><br>Dickey-Fuller (DF) | <b>BPC</b><br>Augmented Dickey-Fuller 1 (ADF1) |
|-----------|----------------------------------|--|
| ΔLTQB     | -7.7951                          | -6.0672  |
| ΔLMRH     | -10.5876                         | -6.1542  |
| ΔLDEG     | -11.6269                         | -7.8105  |
| ΔLLHL     | -10.8054                         | -7.7018  |
| ΔLCUH     | -10.8096                         | -6.2095  |
| ΔLDOWN    | -6.6163                          | -5.0725  |

The Dickey-Fuller regressions include an intercept but not a trend

95% critical value for the augmented Dickey-Fuller statistic = -2.9558

**Table 2: Unit root tests for BPC time series (differenced log)**

The unit root test results (Table 2) thus suggest that the differenced log linear model of equation 3 fits the time series for BPC better than any of the others.

$$\Delta \ln (TB)_{at} = \alpha + \beta_1 \Delta \ln (MRH)_{at} + \beta_2 \Delta \ln (DEG)_{at} + \beta_3 \Delta \ln (LHL)_{at} + \beta_4 \Delta \ln (CUH)_{at} + \beta_5 \Delta \ln (DOWN)_{at} + \mathcal{E}_{at} \tag{4}$$

| <b>BPC (R<sup>2</sup> = .31545)</b>        |                                  |                |
|--|----------------------------------|----------------|
|  | <b>β</b>                         | <b>P value</b> |
| Const.                                     | .022252                          | .638           |
| DLMRH                                      | -.76033                          | .336           |
| DLDEG                                      | 1.4347                           | .042           |
| DLLHL                                      | -.094710                         | .028           |
| DLCUH                                      | -.43104                          | .536           |
| DLDOWN                                     | -.041148                         | .614           |
| F-stst. = (.009)                           | Serial Correlation = CHSQ (.158) |                |
| DW-stat. = (2.2631)                        | Heteroscedasticity = CHSQ (.761) |                |
| B:Functional Form *CHSQ( 1)= .071983[.788] |                                  |                |

**Table 3: Regression Analysis Results for Botswana Power Corporation (BPC)**

The regression results (Table 3) shows that the estimated coefficients of all the variables had the expected signs except the variables MRH and CUH. Furthermore, all the variables were not statistically significant at the 5% level, except the variables DEG and LHL.

The diagnostic test results of the regression reveal that, using the Lagrange Multiplier (LM) test, we cannot reject the null hypothesis that there is no residual serial correlation (p = .158) in the model, implying that the error term is free from autocorrelation. The results, based on the Ramsey’s RESET test, also show that the model is correctly specified. Finally, the results indicate that the model does not suffer from heteroscedasticity (p = .761), implying that the variance is constant. The null hypotheses (of no residual serial correlation and freedom from heteroscedasticity) are accepted in each case because the probability value associated with the Chi-Square test statistic in each case is more than 5%.

As stated earlier, for WUC, the cointegrating tests had to be carried out. However, before the cointegration test on WUC time series data, the vector autoregressive (VAR) hypothesis testing was carried out to determine the order of the VAR (i.e. the order of lag). The highest order of VAR was used to avoid the problem of serial correlation. Two methods were used to determine the order of VAR – the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC) (Table 4-7). Because the value of SBC would lead to selecting a lower order of VAR (i.e. VAR (1) in this case), the value of AIC was used, as it was high enough for high-order VAR specification. We therefore chose the VAR (3) model.

| Order | AIC      | SBC      |
|-------|----------|----------|
| 3     | 100.4980 | -15.9559 |
| 2     | 98.3301  | 18.6511  |
| 1     | 92.1490  | 49.2450  |
| 0     | 13.8287  | 7.6995   |

**Table 4: Test Statistics and Choice Criteria for Selecting the Order of the VAR Model**

The Johansen cointegration test was then performed with all the variables included (Tables 5 & 6)

57 observations from 2000M4 to 2004M12. Order of VAR = 3.

List of variables included in the cointegrating vector: LTQB, LDOWN.

List of I(0) variables included in the VAR: LMRH, LDEG, LLHL, LCUH

List of eigenvalues in descending order: .23705 .010795

| Null   | Alternative | Statistic | 95% Critical Value | 90% Critical Value |
|--------|-------------|-----------|--------------------|--------------------|
| r = 0  | r = 1       | 15.4222   | 14.8800            | 12.9800            |
| r <= 1 | r = 2       | 0.61867   | 8.0700             | 6.5000             |

**Table 5: Cointegration LR Test based on Max. Eigenvalue of the Stochastic Matrix**

| Null   | Alternative | Statistic | 95% Critical Value | 90% Critical Value |
|--------|-------------|-----------|--------------------|--------------------|
| r = 0  | r >= 1      | 16.0408   | 17.8600            | 15.7500            |
| r <= 1 | r = 2       | 0.61867   | 8.0700             | 6.5000             |

**Table 6: Cointegration LR Test Based on Trace of the Stochastic Matrix**

The results from Tables 5 and 6 (maximal eigenvalue and trace statistic respectively) suggest that the hypothesis of no cointegration be rejected at 95% level of significance (i.e. r = 0). They however do not reject the hypothesis that there is one cointegrating relation between the variables (i.e. r = 1). In other words, both the Maximal Eigenvalue and Trace statistic support the presence of one cointegrating vector. Equation 3 therefore had to be re-specified into a dynamic Error Correction Model (ECM) (eqn. 5) for WUC time series, which include the variables in the cointegrating tests. Error correction modelling is based on the idea of incorporating both the long- and short-run effects in the empirical model structure.

$$\Delta Ln (TB)_t = \alpha + \beta_1 \Delta Ln (TB)_{t-1} + \beta_2 \Delta Ln (TB)_{t-2} + \beta_3 \Delta Ln (DOWN)_t + \beta_4 \Delta Ln (DOWN)_{t-1} + \beta_5 \Delta Ln (DOWN)_{t-2} + \beta_6 Ln (MRH)_t + \beta_7 Ln (MRH)_{t-1} + \beta_8 Ln (MRH)_{t-2} + \beta_9 Ln (DEG)_t + \beta_{10} Ln (DEG)_{t-1} + \beta_{11} Ln (DEG)_{t-2} + \beta_{12} Ln (LHL)_t + \beta_{13} Ln (LHL)_{t-1} + \beta_{14} Ln (LHL)_{t-2} + \beta_{15} Ln (CUH)_t + \beta_{16} Ln (CUH)_{t-1} + \beta_{16} Ln (CUH)_{t-2} + \gamma ECM(-1) + \mathcal{E}_t$$

‘Eq. (5) ‘

The cointegration test revealed the existence of a long-run equilibrium relationship among the variables involved in the productivity equation (Table 7). The estimated coefficients of the variables MRH, LHL, and CUH had unexpected signs. Only the long-run variable DOWN and



variable MRH were statistically significant at the 5% level of significance. The variable LHL was only statistically significant at 10% level of significance.

The ECM presents the relationship between the short term and the long term explanatory variables on the one hand, and changes in the explained variable on the other hand. In other words, the ECM presents us with the opportunity to determine the short run elasticity (a measure of the % change) of the quality of billing with respect to the explanatory variables (explanatory factors) in the model. In addition, the coefficient of error correction term shows the level of last period's disequilibrium error that is corrected in the succeeding period.

| WUC – R <sup>2</sup> = .54772               |                                  |         |
|---|----------------------------------|---------|
|   | $\beta$                          | P value |
| Intercept.                                  | .0093646                         | .972    |
| dLTB1                                       | -.59616                          | .000    |
| dLDOWN1                                     | -.0014485                        | .482    |
| dLTB2                                       | -.16746                          | .156    |
| dLDOWN2                                     | -.0071201                        | .003    |
| Ecm1 (-1)                                   | .019727                          | .435    |
| LMRH  | -.069409                         | .044    |
| LDEG  | .10567                           | .110    |
| LLHL  | .0070178                         | .075    |
| LCUH  | -.017015                         | .666    |
| F-stst. = (.000)                            | Serial Correlation = CHSQ (.966) |         |
| DW-stat. - = (1.8228)                       | Heteroscedasticity =CHSQ (.000)  |         |
| * B:Functional Form *CHSQ( 1)= .26212[.609] |                                  |         |

**Table 7: Regression Analysis Results for Water Utilities Corporation (WUC)**

The diagnostic test results reveal that, using the Lagrange Multiplier test, we cannot reject the null hypothesis that there is no residual serial correlation ( $p = .966$ ) in the model, implying that the error term is free from autocorrelation. The results based on the Ramsey's RESET test, also show that the model is correctly specified. However, the results show that the probability value associated with the Chi-Square test statistic for non-heteroscedasticity null is less than 5% ( $p = .000$ ). The null hypothesis is thus rejected, indicating that the model suffers from heteroscedasticity. This implies that the variance is not constant.

As shown in tables 3 and 7, the coefficient of the explanatory variables in the model,  $\beta$  (beta), and the *probability value*,  $p$ , provide us with information on the significance of the explanatory variables.

The coefficient of the error correction term estimated to be 0.019727 for WUC represents the magnitude of the adjustment of the disequilibrium error carried forward from the previous year. The implication is that if the total quality bills are disturbed (or at disequilibrium) in the previous period, the departure of the total quality bills from its equilibrium value is corrected by 1.9% in the succeeding period (Table 7).

## FINDINGS

As evidenced by the regression parameters in Tables 3 and 7, the F-statistic, in both cases, rejects the hypothesis that the coefficients of the variables are jointly equal to zero. This indicates that there is a significant relationship between the dependent variable on the one hand and the set of independent variables on the other. That is, jointly, the inputs - MRH, DEG, CUH, and their characteristics - LHL, and DOWN satisfactorily explains the productivity improvement of the billing process (the total quality bills). Therefore, any desired improvements of the billing process jointly and significantly depend on these five factors. The main hypothesis,  $H_m$ , is therefore accepted. In addition, some of the variables have the expected signs as well as being statistically significant.

The  $R^2$  (*R-squared*) shows that these explanatory variables account for about 32% and 55% of variance in productivity as reflected by total quality bills invoiced per month in both BPC and WUC respectively. In particular, as far as BPC is concerned, the following had a significant impact on productivity at 5% - DEG and LHL (Table 3). In the case of WUC, DOWN and MHR had a significant impact at 5% significance level and LHL at 10% level of significance (Table 7). The  $R^2$  further explains the variance of observations in each case. In both cases however, the Durbin-Watson (DW) statistic is acceptable, since it is within the acceptable boundaries of 1.6 to 2.4, indicating that the regression does not suffer from any serious problem of autocorrelation.

However, no significant statistical evidence exists to the effect that CUH (and hence, computer technology) is positively linked to improvement in total quality bills invoiced per month (i.e. productivity improvement) (BPC:  $\beta = -.43$ ; WUC:  $\beta = -.02$ ). Indeed, a 1% increase in CUH led to a decrease in total quality bills invoiced per month by 0.43 and 0.02 for BPC and WUC respectively. The relevant parameter was however not significant for the corporations ( $p = .54$  for BPC and  $p = .67$  for WUC) (Tables 1 & 2). Nevertheless, the study's sub-hypothesis,  $SH_1$  is rejected. Analysis of post data collection interviews reveal that employees in the two corporations have access to and use electronic mail, word-processor, and the Internet. The corporations granted access to the Internet to assist employees with study and research, and to e-mail for official communication. This suggests that to some extent significant usage of computers occurs in other official and non-official areas. The combination of the above activities may explain the loss of productivity impact of the computer technology on the billing process.

Likewise, no significant statistical evidence exists to the effect that MRH is positively linked to improvement in total quality bills invoiced per month (i.e. productivity improvement) (BPC:  $\beta = -.76$ ; WUC:  $\beta = -.07$ ). Thus, the study sub-hypothesis,  $SH_2$  is rejected. While in the case of BPC, it is not statistically significant ( $p = .34$ ), it is statistically significant ( $p = .044$ ) at 5% level of significance in the case of WUC. The results imply that a one percent increase in meter reading hours led to a decrease in total quality bills invoiced per month by 0.76 for BPC and 0.07

for WUC. Analysis of post data collection interviews reveal that meter reading is a labour-intensive activity. Meter readers in the two corporations also play the gatekeeper role of looking for leaks, problems, hazards, safety issues, and serve as the neighbourhood watch. Meter readers work long hours without rest (these include two weekends in a month as overtime), and under deadlines, and hence do not have enough time to rest and/or participate in social activities. The stress, resulting in unexpected employee absences from work, had a significant negative effect on MRH (and hence on meter readings available for bills processing) each month.

Conversely, the DEG is positively linked to improvement in total quality bills invoiced per month (BPC:  $\beta = 1.43$ ; WUC:  $\beta = 0.11$ ). That is, the higher the DEG, the greater the TQB. Thus, the study sub-hypothesis,  $SH_3$  is accepted. The result suggests that a 1% increase in DEG increased TQB invoiced by 1.4 and 0.1 for BPC and WUC respectively. While this is statistically significant for BPC at the 5% level of significance ( $p = .042$ ), it is not for WUC ( $p = .11$ ). Analysis of post data collection interviews reveal that supervisors in the meter reading section hardly have time as a result of too much paper work. The supervisors in many cases are required to produce additional reports manually. This is more pronounced in WUC. Interviews further reveal that they are not happy with their job. Many of the respondents reported lack of motivation and said that they are simply working to keep their jobs.

As expected however, LHL is negatively linked to total quality bills invoiced per month in BPC but unexpectedly positively linked in the case of WUC. (BPC:  $\beta = -.095$ ; WUC:  $\beta = .007$ ). Thus, sub-hypothesis  $SH_4$  for this study is accepted for BPC and rejected for WUC. The result is statistically significant for BPC ( $p = .028$ ) at the 5% level of significance and for WUC ( $p = .075$ ) at the 10% level of significance. For WUC, it suggests that absences at unexpected times led to increases in the total quality bills invoiced per month. The methodology of data collection, and hence the degree of accuracy of data may explain the result obtained for WUC. Rather than allowing the first author direct access to employee leave records, an employee in the Human Resources section was detailed to extract and compile the leave records of employees in the billing section. Analysis of post data collection interviews however, revealed that employees, especially in the two corporations do absent themselves from work (probably as a result of stress). This is significant among meter readers.

Similarly, the results show that computer downtime hours are negatively linked to improvement in total quality bills invoiced per month (BPC:  $\beta = -.041$ ; WUC:  $\beta = -.007$ ). Thus, sub-hypothesis  $SH_5$  is accepted. The results suggest that a 1% delay in correcting the faults led to a reduction of the total quality bills by 0.041 and 0.007 for BPC and WUC respectively. While this is significant for WUC ( $p = .003$ ) at the 5% level of significance, it is not significant in the case of BPC ( $p = .61$ ). The coefficient of error correction of this variable for WUC represents the magnitude of the adjustment of the disequilibrium error carried forward from the previous year. This implies that a disturbed computer downtime (by way of the departure of the downtime hours from its equilibrium value) in the previous year is corrected by 1.9% for the succeeding period. The result for WUC suggests prolonged delays in correcting faults, and is significant enough to negatively affect total quality bills invoiced per month. The result for BPC suggests that although there were delays, they were not significant as to negatively affect total quality bills invoiced per month.

## DISCUSSION

This study results from the production function model, pointing to lack of evidence of positive impact of computer technology on total quality bills invoiced per month (i.e. productivity improvement) is consistent with the findings from other studies on the productivity impact of IT (e.g. Bailey and Gordon, 1988; Brynjofsson, 1993; Dasgupta, Sarkis and Talluri, 1999; Wolff, 2002; etc.). Rather than relying on financial investments on computer technology (i.e. IT budgets) to assess its productivity impact, the computer use hours have been used. It is recognised that computer that is regularly used would be significantly valuable than a computer that is not used. In spite of this, the result still shows no significant statistical evidence of the computer technology's positive link to improved total quality bills invoiced per month (i.e. productivity improvement). It is however obvious that workplace practices and the characteristics of the inputs influenced the outcome of this study.

For example, this study's finding on the influence of workplace practices is in agreement with previous studies (e.g. White and Pearson, 2001; Gorman, 1998; King cited in Beard, 2002), which have found that organisations can lose countless hours of employee productivity due to personal use of computers during office hours. This study revealed that employees have access to computers for other official (i.e. outside of bills processing) and non-official activities, which may have resulted in loss of productivity impact of the computer technology. White and Pearson noted that up to 40 percent of the Web sites accessed from corporate networks during working hours are unrelated to the organisation business. Further, according to Gorman (1998), two companies discovered that only 23% of their employees' Internet usage was business related. King and Gorman reported that many managers polled said that employees' use of the Internet for non-business purposes undermines their effectiveness and productivity. This underlines the importance of ensuring that business objectives and added value drive computer technology investments. In other words, the significant use of computer technology other than for the purpose for which it was acquired can negatively affect its productivity impact.

The results relating to the statistical insignificance of the contribution of MRH, and the negative impact of LHL on total quality bills invoiced per month (i.e. productivity) are also consistent with previous studies (e.g. Shepard and Clifton, 2000; Ramanathan, 1992; Savery and Luks, 2000), that have found relationship between overtime and productivity, personal stress and employee productivity, hours worked and reported sickness and accident rates. This study revealed that meter readers work long hours without rest and under deadlines and sometimes work overtime, which may have resulted in stress and hence unexpected absences from work. According to Shepard and Clifton, the length of work week potentially influences productivity through effects on individual motivation and effort, physical wellbeing and work-related stress, as well as on absenteeism, turnover and off-job satisfaction. Lewis (2004) notes that employee absences, especially when not expected can leave work for others and impair productivity. Shepard and Clifton's empirical study show that the use of overtime hours lowers average productivity, measured as output per worker hour, for almost all of the 18 manufacturing industries studied. According to Savery and Luks, overwork often results in a loss of efficiency and more mistakes, but more importantly, stress-related physical and psychological injuries. Long working hours can mean increasing fatigue rather than increasing productivity (Beder, 2001). Reduced working hours bring better productivity. Employees will get proper rest, which means they will be refreshed and be more effective when they are at work. This study also

supports Wood's (1998) argument that high levels of absenteeism may constitute a form of industrial protest in response to unhappiness over wages and/or working conditions. Wood reports a general practice of employees using up any unused sick leave in the run up to the Christmas as they tended to see sick leave as an entitlement i.e. as part of their annual leave, rather than to be taken in extraordinary circumstances.

The finding of this study that the DEG is positively linked to improvement in total quality bills invoiced per month is also in agreement with previous studies (e.g. Burke, 2001; Latham, Gary and Kinne, 1973; Dubinsky, Yammarino and Jolson, 1994) that have found positive relationship between supervision and quality of service and products provided by organisations and that goal setting is correlated with high productivity and a low number of injuries only when it is accompanied by supervision. This study revealed that supervision does have positive impact on productivity, which is particularly significant in BPC. Latham, Gary and Kinne's study show that goal setting without immediate supervision was related to employee turnover. Dubinsky et al. found the use of close supervision to have more favourable impact on work outcomes than inactive or moderately active involvement. As observed, the service sector is facing the challenges of productivity improvement particularly as it relates to the delivery of quality services and products to clients and customers. Supervision therefore serves a critical role in the creation of a service culture that guarantees productivity improvement.

The results of this study showing that DOWNTIME is negatively linked to improvement in total quality bills invoiced per month is an indication of major time losses due to faults and/or breakdowns, thus affecting work processes. This study revealed that there are prolonged delays in correcting faults in the two corporations. The result is thus consistent with the study's sub-hypothesis. The study's finding is also consistent with other prior studies (e.g. Coltekin, Vartiainen, and Koc, 1999; Kundu, 2004) on the negative impact of computer downtime on productivity and motivation. Coltekin et al. for example, found that 11 working days were wasted among 17 scientists because of computer breakdowns while Kundu found that information management practices were adversely affected by the occurrence of computer disasters, which include hardware faults, software problems, et cetera. In other words, every minute of downtime can mean lower employee productivity, lost revenue and profit. Where the computer is central to the organisation's purpose, a computer failure can represent a very large cost.

Everyone works in expectation of some rewards and/or benefits. Many employees obtain satisfaction from recognition for personal achievement, satisfactory working condition, fair pay, career progression, etc. The degree of reward influences the quality and quantity of work, and in turn productivity. Reward is seen as a means of increasing employee morale, and of retaining and attracting qualified employees with significant impact on productivity. Employees in this study reported lack of motivation, which may have resulted in loss of morale and hence low productivity. The lack of motivation reported is consistent with previous studies (e.g. Hong et al., 1995; Tsai and Wang, 2005) that have found that employee benefit programmes have great impact on work-motivation with moderating effect on organisation productivity irrespective of industry or firm size. An incentive compensation system that rewards individuals according to Willis et al. (2004) is necessary for productivity improvement. Motivation is an internal state resulting from the influence of personal or situational factors, and affects behaviour such as

absence rate, leave rate, quit rate, get-to-work speed, etc. To sustain motivation over time according to Counsell (2002), employees need to be supported, challenged, and recognised for their contribution.

## **CONCLUSION**

It has been widely acknowledged that the spread of computing technology has had a major impact on the way work is done, decisions are made, organisations are structured and how people interact. This study has tried to get a better understanding of how computer technology could bring improvement on productivity. The study found input characteristics and workplace practices as significant factors in putting computer technology to productive use.

By using time series data from the head offices of two government utilities corporations in Botswana, Botswana Power Corporation and Water Utility Corporation that use the same task technology, the authors were able to determine the impact of the computer usage hours (as a measure of computer technology use), meter reading hours, labour hours lost, degrees of supervision and computer downtime on the total quality of bills invoiced per month. The authors were also, through post data analyses interviews, able to interpret the impacts (i.e. no significant statistical evidence that computer technology is positively linked to improvement in total quality bills invoiced per month). The results reveal that computer technology impact measurement is very much dependent on the characteristics of the inputs and workplace practices.

This study thus suggests that computer technology alone is an insufficient predictor of productivity improvement; workplace practices tend to influence the usage of computer technology and its impact on organisations. Care must therefore be taken by organisations and researchers not to over interpret findings on the impact of IT on productivity. This is because a shortfall of evidence is not necessarily evidence of a shortfall. In other words, the inability to demonstrate the existence of a positive correlation between investment in IT and productivity should not be interpreted as a reason to consider investment in IT as worthless. The findings from this study have important implications, not only for the two corporations under study, but also for similar organisations. The following recommendations are made:

Organisations should consider reducing and/or eliminating the use of computers on irrelevant tasks for productivity gains to show up. Computer technology in itself cannot increase or decrease productivity unless it is put to use. A total ban on personal usage of the Internet is not recommended as it may cause resentment and/or strong protest from employees. One strategy however could be the introduction of “acceptable computer use policy” that restricts use for unrelated and unofficial tasks to outside working hours. This can be accomplished only through management-employee negotiation.

Organisations should also consider reducing the working hours, especially for workers engaged in physical activities such as meter reading. Longer hours do not mean better results, quite the contrary. Explanations of improved productivity resulting from reduced hours include improved commitment and motivation of workers, reduced absenteeism and turnover, reduced stress and fatigue, and reductions in unproductive or idle work time.

Organisations should ensure close supervision of employees as this is critical to the creation of a service culture that guarantees productivity improvement. Further, they should work to reduce computer downtime hours in order to increase productivity. There is the need to carry out routine, planned maintenance. This can prevent problems or minimise the computer downtime. Maintaining information about hardware and software configurations, developing plans to deal with specific types of failure, and training personnel to handle recovery tasks can help to minimize the effects on computer systems and reduce productivity loss from downtime.

It is important for organisations to have a well-run reward programme that rewards employees adequately. Reward is one of the most powerful forms of human motivation. The benefits result in increased morale and productivity.

Apart from the substantive findings about the impact of computer technology on productivity improvement, in terms of the total quality bills invoiced per month, this study makes a few contributions to research about the impact of IT investments on productivity improvement. First, it expands research on IT impact on productivity improvement in Africa. Most research studies in this area have been conducted in countries outside of Africa. Second, it extends IT productivity research to the public sector (e.g. state utility corporations) in Africa. Third, this study, may be perhaps, the first attempt to compare the impact of IT on productivity improvement among utility corporations in Africa. Fourth, it confirms the importance of workplace practices in the context of Africa, in assessing the impact of IT investments on productivity improvement. The study shows that employee practices within an organisation may affect the way computer technology is converted into productive output. Finally, it contributes to the debate on whether IT investments add value in any way to productivity improvement. The findings add to the evidence that there is no significant *statistical* evidence of productivity improvement from the use of IT. However, the study does not deny the possibility of productivity improvements from the use of IT.

## **FUTURE RESEARCH DIRECTIONS**

There is obviously a need for more public-sector research on investments in computerisation in Africa as the use is not yet fully understood nor studied enough to yield meaningful insight. Although, this study focused on utility bill processing, future research could be directed towards identifying productivity impact in other applications (e.g. postal system, inventory control, etc.) in Africa.

The study, like the majority of others, has also focused on how computer technology impact organisational productivity resulting in the revelation of the influence of workplace practices by employees, and not on how computers impact organisation employees. However, computers have been considered a source of stress for employees (e.g. stress of having to learn new computer skills, thinking their job has become less secure and less interesting). The authors therefore further recommend that further research be directed towards investigating its impact on organisation employees especially in Africa as employees may be experiencing increased workplace problems because of the introduction of computers.

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## APPENDICES

**Appendix A: Summary time series data – BPC****Key:**

**Total Quality Bills (TQB)** = Total bills invoiced each month from the actual plot meters read.

**Meter Reading Hours (MRH)** - Total number of hours spent by meter readers reading meters per month.

**Degree of Supervision (DEG)** = Supervisory hours per month (i.e. number of working days multiplied by average hours of supervision per day), as well as education and experience.

**Labour Hours Lost (LHL)** = Labour Hours Lost = Hours lost to be deducted from records of leaves (sick and normal), and public holidays per month i.e. number of public holidays, sick and annual leaves multiplied by number of hours of work.

**Computer Usage Hours (CUH)** = Number of hours of use of computer for bill processing multiplied by the number of staff and/or staff (Account Supervisor, Account Clerk Meter Reading, Account Clerk Billing, Data Capture Clerk).

**Computer downtime (DOWN)** = Hours when computer(s) cannot be used for a particular process due to technical problems.

**2004**

|                  | <b>MRH</b> | <b>DEG</b> | <b>LHL</b> | <b>CUH</b> | <b>DOWN</b> | <b>TQB</b> |
|------------------|------------|------------|------------|------------|-------------|------------|
| <b>January</b>   | 2735.75    | 111        | 622.25     | 722        | 64          | 48275      |
| <b>February</b>  | 3115.5     | 140        | 62.5       | 868        | 136         | 46393      |
| <b>March</b>     | 3472       | 161        | 117.25     | 1241       | 72          | 46049      |
| <b>April</b>     | 3123.25    | 124        | 394.5      | 993.5      | 48          | 26045      |
| <b>May</b>       | 2906.25    | 128        | 415.75     | 978        | 32          | 31435      |
| <b>June</b>      | 3348       | 149        | 141.5      | 1160       | 80          | 40211      |
| <b>July</b>      | 2759       | 110        | 751        | 780        | 72          | 34584      |
| <b>August</b>    | 3262       | 150        | 226.75     | 1165       | 24          | 39778      |
| <b>September</b> | 3030.25    | 122        | 283.75     | 986        | 16          | 41508      |
| <b>October</b>   | 2921.75    | 133        | 440.25     | 957        | 0           | 37844      |
| <b>November</b>  | 3805.25    | 144        | 183.25     | 1076       | 40          | 30345      |
| <b>December</b>  | 3278.25    | 147        | 834.75     | 991.5      | 0           | 37304      |

**2003**

|                  | <b>MRH</b> | <b>DEG</b> | <b>LHL</b> | <b>CUH</b> | <b>DOWN</b> | <b>TQB</b> |
|------------------|------------|------------|------------|------------|-------------|------------|
| <b>January</b>   | 3224       | 133        | 625.25     | 797        | 304         | 31670      |
| <b>February</b>  | 3487.5     | 134        | 94.5       | 847        | 192         | 23845      |
| <b>March</b>     | 3479.75    | 140        | 82.25      | 871.5      | 208         | 44604      |
| <b>April</b>     | 3518.5     | 140        | 314.75     | 821        | 240         | 30468      |
| <b>May</b>       | 3224       | 126        | 454        | 758        | 400         | 18550      |
| <b>June</b>      | 3472       | 139        | 82         | 866.5      | 160         | 46497      |
| <b>July</b>      | 3069       | 119        | 673        | 718        | 272         | 43764      |
| <b>August</b>    | 3658       | 147        | 63.25      | 894        | 0           | 64389      |
| <b>September</b> | 3332.5     | 128        | 289        | 811        | 152         | 27754      |
| <b>October</b>   | 3642.5     | 147        | 322        | 847        | 176         | 21847      |
| <b>November</b>  | 3301.5     | 135        | 198.5      | 784        | 0           | 36191      |
| <b>December</b>  | 2976       | 122        | 823.5      | 692        | 0           | 45651      |

**2002**

|                  | <b>MRH</b> | <b>DEG</b> | <b>LHL</b> | <b>CUH</b> | <b>DOWN</b> | <b>TQB</b> |
|------------------|------------|------------|------------|------------|-------------|------------|
| <b>January</b>   | 3464.25    | 142        | 655.5      | 899        | 8           | 29302      |
| <b>February</b>  | 3465.25    | 125        | 93.75      | 850        | 0           | 30435      |
| <b>March</b>     | 3317       | 133        | 321        | 804        | 24          | 23345      |
| <b>April</b>     | 3479.75    | 128        | 321.5      | 837        | 136         | 26353      |
| <b>May</b>       | 3386.75    | 133        | 534.5      | 730        | 152         | 32519      |
| <b>June</b>      | 3495.25    | 138        | 62.75      | 864        | 160         | 30536      |
| <b>July</b>      | 3069       | 112        | 665        | 723        | 120         | 29758      |
| <b>August</b>    | 3782       | 152        | 78.5       | 946        | 0           | 56160      |
| <b>September</b> | 3317       | 119        | 377        | 763        | 64          | 32545      |
| <b>October</b>   | 3627       | 152        | 273.5      | 911        | 24          | 34403      |
| <b>November</b>  | 3572.75    | 152        | 184.5      | 861.5      | 40          | 29906      |
| <b>December</b>  | 3123.25    | 115        | 682.75     | 681        | 80          | 25765      |

**2001**

|                  | <b>MRH</b> | <b>DEG</b> | <b>LHL</b> | <b>CUH</b> | <b>DOWN</b> | <b>TQB</b> |
|------------------|------------|------------|------------|------------|-------------|------------|
| <b>January</b>   | 2650.5     | 129        | 617.5      | 800        | 8           |            |
| <b>February</b>  | 2976       | 130        | 48         | 842        | 40          |            |
| <b>March</b>     | 3208.5     | 154        | 15.5       | 968        | 24          |            |
| <b>April</b>     | 2487.75    | 117        | 524.25     | 712        | 0           | 17145      |
| <b>May</b>       | 2852       | 131        | 408        | 796        | 0           | 35971      |
| <b>June</b>      | 3014.75    | 132        | 137.25     | 884.5      | 8           | 34961      |
| <b>July</b>      | 2697       | 121        | 190        | 780        | 56          | 28878      |
| <b>August</b>    | 3185.25    | 155        | 182.75     | 998.5      | 56          | 33954      |
| <b>September</b> | 2968.25    | 135        | 15.75      | 867        | 0           | 36771      |
| <b>October</b>   | 3634.75    | 137        | 282.5      | 885        | 0           | 25120      |
| <b>November</b>  | 3774.25    | 149        | 206.25     | 842        | 56          | 38969      |
| <b>December</b>  | 2991.5     | 108        | 628.75     | 624        | 0           | 28008      |

## Appendix B: Summary time series data – WUC

### Key:

**Total Quality Bills (TQB)** = Total bills invoiced each month from the actual plot meters read.

**Meter Reading Hours (MRH)** - Total number of hours spent by meter readers reading meters per month.

**Degree of Supervision (DEG)** = Supervisory hours per month (i.e. number of working days multiplied by average hours of supervision per day), as well as education and experience.

**Labour Hours Lost (LHL)** = Labour Hours Lost = Hours lost to be deducted from records of leaves (sick and normal), and public holidays per month i.e. number of public holidays, sick and annual leaves multiplied by number of hours of work.

**Computer Usage Hours (CUH)** = Number of hours of use of computer for bill processing multiplied by the number of staff and/or staff (Billing officers, Billing supervisors & Meter Reading Supervisors).

**Computer downtime (DOWN)** = Hours when computer(s) cannot be used for a particular process due to technical problems.

### 2004

|                  | MRH  | DEG | LHL | CUH    | DOWN | TQB   |
|------------------|------|-----|-----|--------|------|-------|
| <b>January</b>   | 1488 | 132 | 696 | 787    | 0    | 36364 |
| <b>February</b>  | 1794 | 140 | 174 | 932    | 0    | 36131 |
| <b>March</b>     | 2412 | 161 | 276 | 1099   | 8    | 35876 |
| <b>April</b>     | 2130 | 140 | 358 | 944    | 176  | 35972 |
| <b>May</b>       | 2130 | 133 | 238 | 931    | 168  | 36400 |
| <b>June</b>      | 2286 | 154 | 214 | 1074.5 | 216  | 36070 |
| <b>July</b>      | 1734 | 111 | 698 | 765    | 176  | 36177 |
| <b>August</b>    | 2436 | 154 | 68  | 1066   | 176  | 36350 |
| <b>September</b> | 2094 | 133 | 262 | 817    | 176  | 36533 |
| <b>October</b>   | 2163 | 133 | 221 | 1046.5 | 128  | 37147 |
| <b>November</b>  | 2298 | 154 | 214 | 1077   | 0    | 37090 |
| <b>December</b>  | 2100 | 143 | 636 | 922.5  | 0    | 39654 |

**2003**

|                  | <b>MRH</b> | <b>DEG</b> | <b>LHL</b> | <b>CUH</b> | <b>DOWN</b> | <b>TQB</b> |
|------------------|------------|------------|------------|------------|-------------|------------|
| <b>January</b>   | 1614       | 126        | 784        | 716        | 152         | 34867      |
| <b>February</b>  | 1872       | 140        | 0          | 1020       | 384         | 34623      |
| <b>March</b>     | 1710       | 139        | 194        | 1001       | 512         | 35028      |
| <b>April</b>     | 1818       | 140        | 198        | 1013       | 528         | 34931      |
| <b>May</b>       | 1566       | 125        | 442        | 911        | 400         | 35532      |
| <b>June</b>      | 1830       | 140        | 66         | 999        | 152         | 34800      |
| <b>July</b>      | 1458       | 117        | 638        | 842        | 0           | 34865      |
| <b>August</b>    | 1830       | 147        | 120        | 1071       | 0           | 35292      |
| <b>September</b> | 1644       | 133        | 300        | 962        | 0           | 35743      |
| <b>October</b>   | 1782       | 144        | 366        | 1028       | 0           | 35284      |
| <b>November</b>  | 1584       | 140        | 192        | 1020       | 0           | 35202      |
| <b>December</b>  | 1386       | 118        | 974        | 630        | 0           | 35212      |

**2002**

|                  | <b>MRH</b> | <b>DEG</b> | <b>LHL</b> | <b>CUH</b> | <b>DOWN</b> | <b>TQB</b> |
|------------------|------------|------------|------------|------------|-------------|------------|
| <b>January</b>   | 1584       | 145        | 794        | 841        | 0           | 33615      |
| <b>February</b>  | 1794       | 140        | 104        | 880        | 160         | 33098      |
| <b>March</b>     | 1746       | 132        | 230        | 800        | 168         | 33158      |
| <b>April</b>     | 1818       | 140        | 196        | 873        | 328         | 33044      |
| <b>May</b>       | 1692       | 124        | 434        | 789        | 368         | 33237      |
| <b>June</b>      | 1818       | 140        | 74         | 862.5      | 320         | 32918      |
| <b>July</b>      | 1380       | 114        | 708        | 709        | 376         | 33110      |
| <b>August</b>    | 1980       | 154        | 80         | 949        | 368         | 33229      |
| <b>September</b> | 1710       | 133        | 234        | 822        | 416         | 34062      |
| <b>October</b>   | 2440       | 147        | 270        | 913        | 368         | 33982      |
| <b>November</b>  | 1878       | 147        | 88         | 917        | 184         | 33929      |
| <b>December</b>  | 1242       | 118        | 1102       | 522        | 64          | 35151      |

**2001**

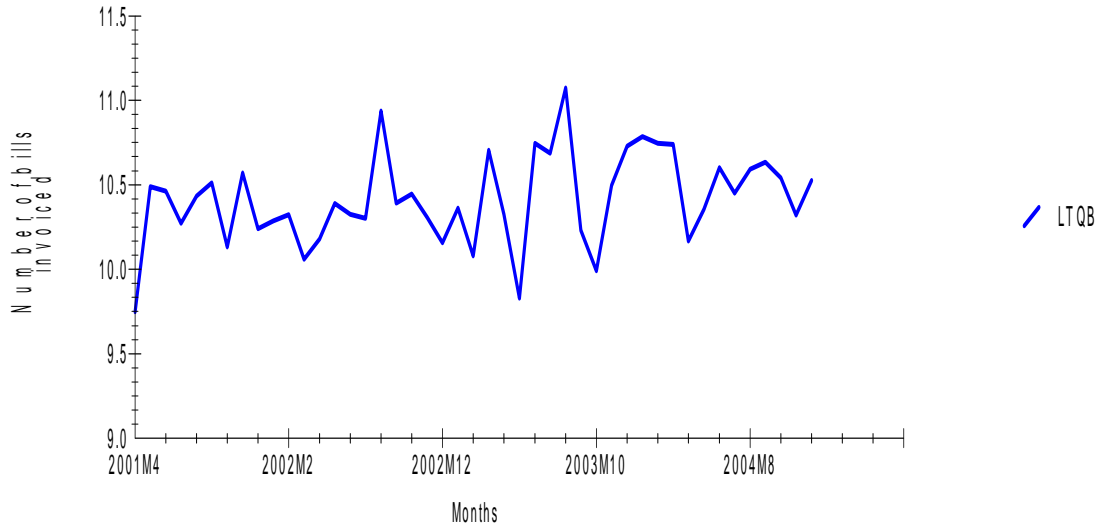
|                  | <b>MRH</b> | <b>DEG</b> | <b>LHL</b> | <b>CUH</b> | <b>DOWN</b> | <b>TQB</b> |
|------------------|------------|------------|------------|------------|-------------|------------|
| <b>January</b>   | 1734       | 114        | 822        | 722        | 0           | 32158      |
| <b>February</b>  | 1926       | 140        | 114        | 999        | 0           | 32611      |
| <b>March</b>     | 2148       | 152        | 76         | 1087       | 112         | 32255      |
| <b>April</b>     | 1686       | 119        | 414        | 841        | 168         | 32030      |
| <b>May</b>       | 1818       | 130        | 450        | 934        | 184         | 32223      |
| <b>June</b>      | 2088       | 147        | 20         | 1064       | 24          | 31990      |
| <b>July</b>      | 1746       | 126        | 414        | 904        | 0           | 32214      |
| <b>August</b>    | 2214       | 160        | 78         | 1152       | 0           | 32160      |
| <b>September</b> | 1986       | 140        | 46         | 1012       | 0           | 32208      |
| <b>October</b>   | 1998       | 146        | 282        | 1043       | 0           | 32088      |
| <b>November</b>  | 2142       | 146        | 106        | 1066       | 0           | 32223      |
| <b>December</b>  | 1428       | 102        | 992        | 582        | 8           | 32934      |



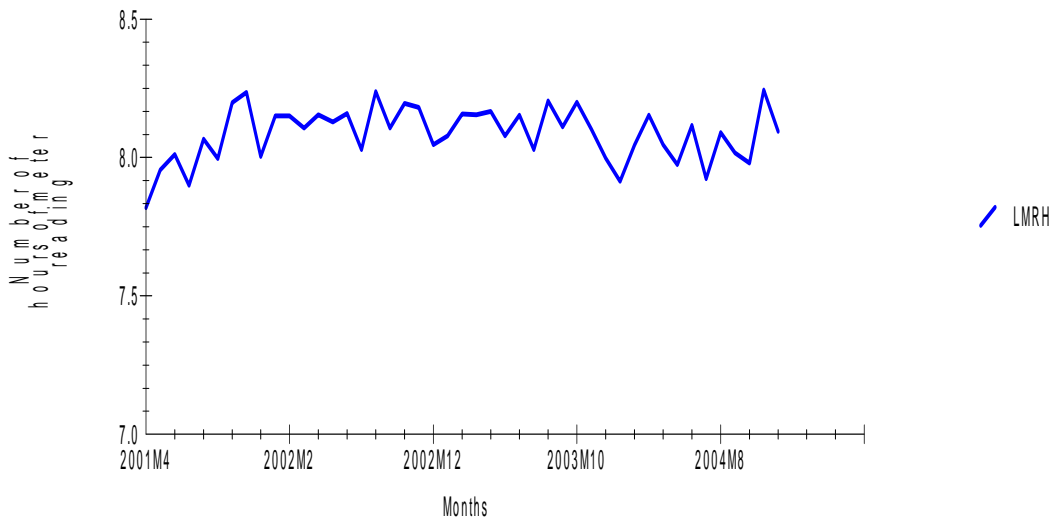
**2000**

|                  | <b>MRH</b> | <b>DEG</b> | <b>LHL</b> | <b>CUH</b> | <b>DOWN</b> | <b>TQB</b> |
|------------------|------------|------------|------------|------------|-------------|------------|
| <b>January</b>   | 1578       | 147        | 352        | 1036       | 344         | 32721      |
| <b>February</b>  | 1782       | 147        | 132        | 1050       | 672         | 32077      |
| <b>March</b>     | 2070       | 160        | 8          | 1166       | 784         | 31185      |
| <b>April</b>     | 1380       | 112        | 384        | 802        | 640         | 31504      |
| <b>May</b>       | 1890       | 147        | 162        | 1064       | 456         | 31035      |
| <b>June</b>      | 1752       | 140        | 210        | 1013       | 720         | 30582      |
| <b>July</b>      | 1524       | 119        | 330        | 853        | 1928        | 30800      |
| <b>August</b>    | 2022       | 161        | 64         | 1159       | 2344        | 31010      |
| <b>September</b> | 1890       | 146        | 40         | 1039       | 632         | 31141      |
| <b>October</b>   | 1938       | 154        | 50         | 1115       | 0           | 30923      |
| <b>November</b>  | 1860       | 154        | 136        | 1108       | 0           | 31053      |
| <b>December</b>  | 1008       | 114        | 934        | 776        | 8           | 37215      |

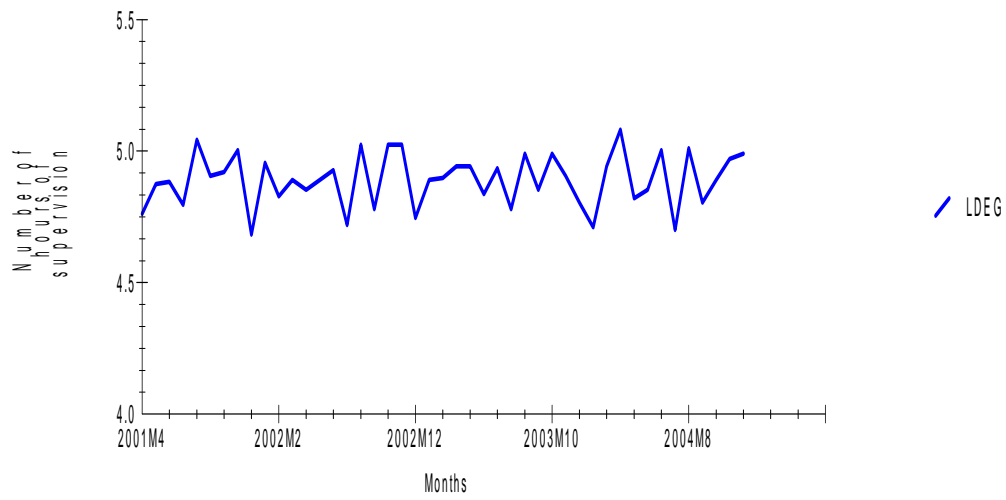
**Appendix C: Graphical display of the log form of the time series variables data from the BPC**



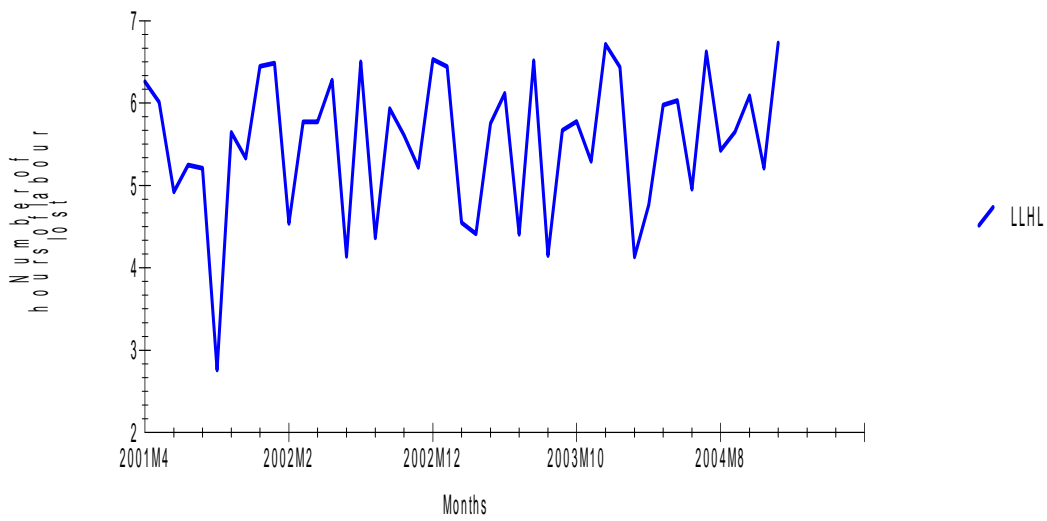
Plot of monthly bills invoiced (TQB) in natural log (BPC)



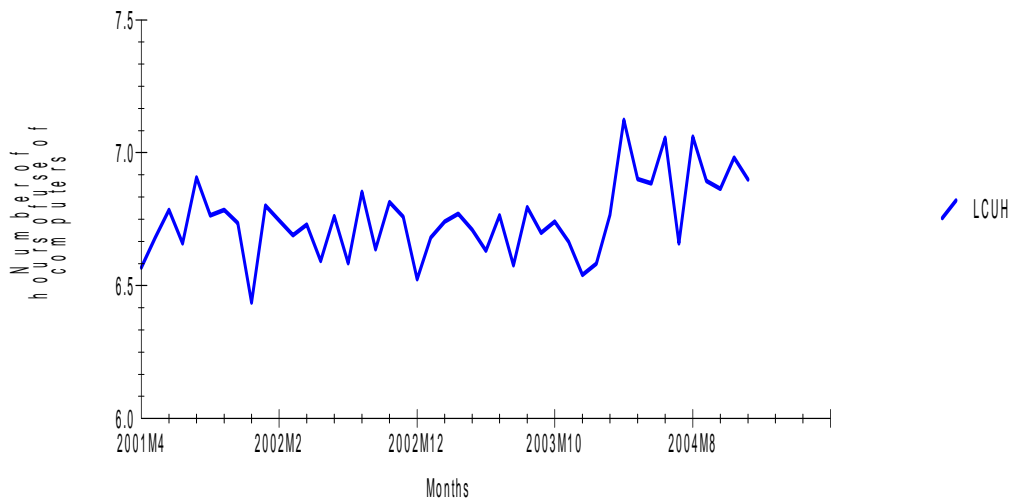
Plot of monthly meter reading hours (MRH) in natural log (BPC)



Plot of monthly hours of supervision (DEG) in natural log (BPC)



Plot of monthly hours of labour lost (LHL) in natural log (BPC)



Plot of monthly hours of use of computers (CUH) in natural log (BPC)

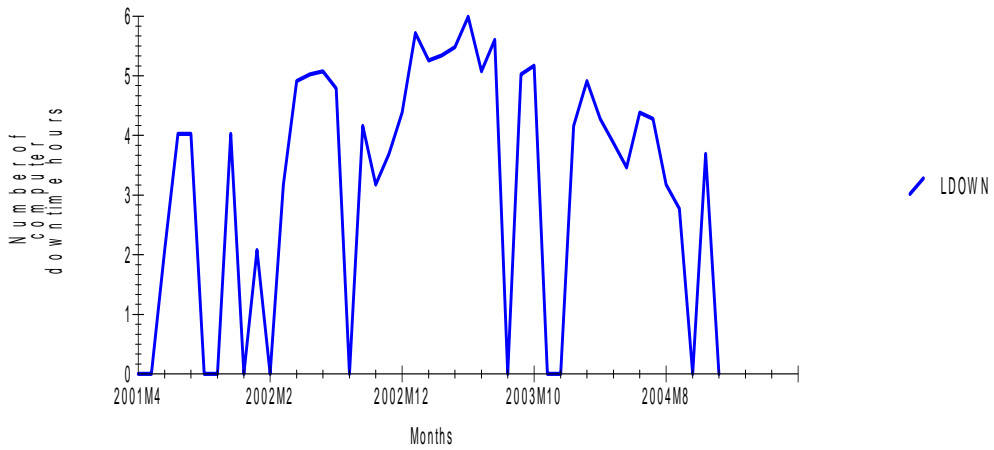
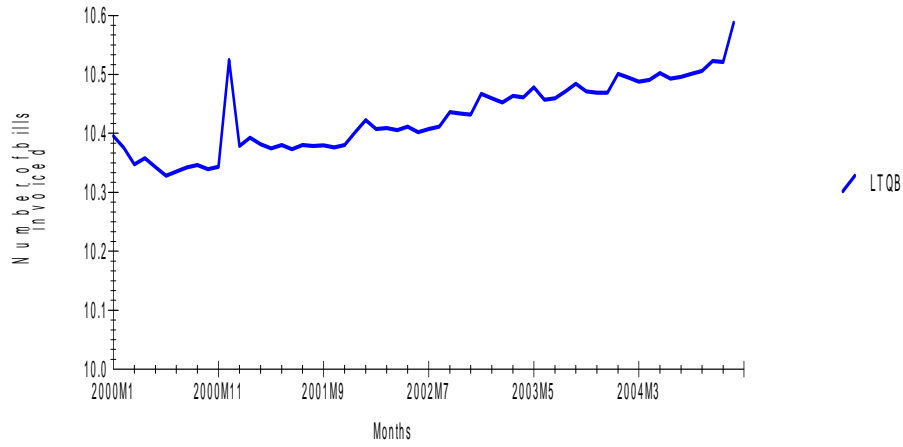
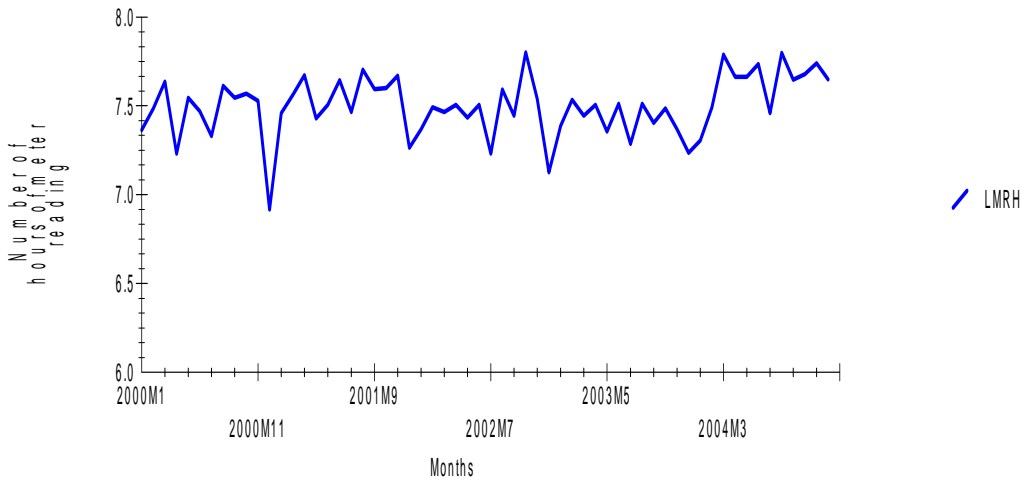


Figure 4f: Plot of monthly computer downtime hours (DOWN) in natural log (BPC)

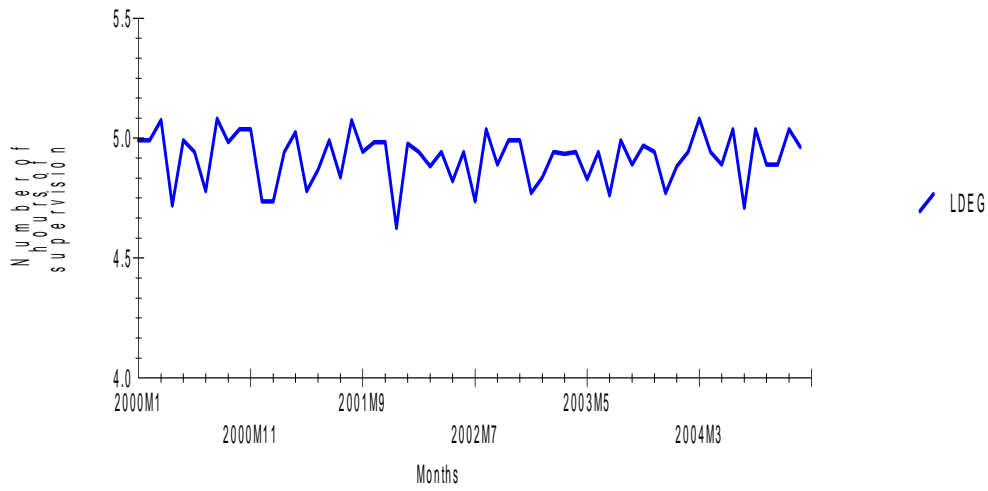
### Appendix D: Graphical display of the log form of the time series variables data from the WUC



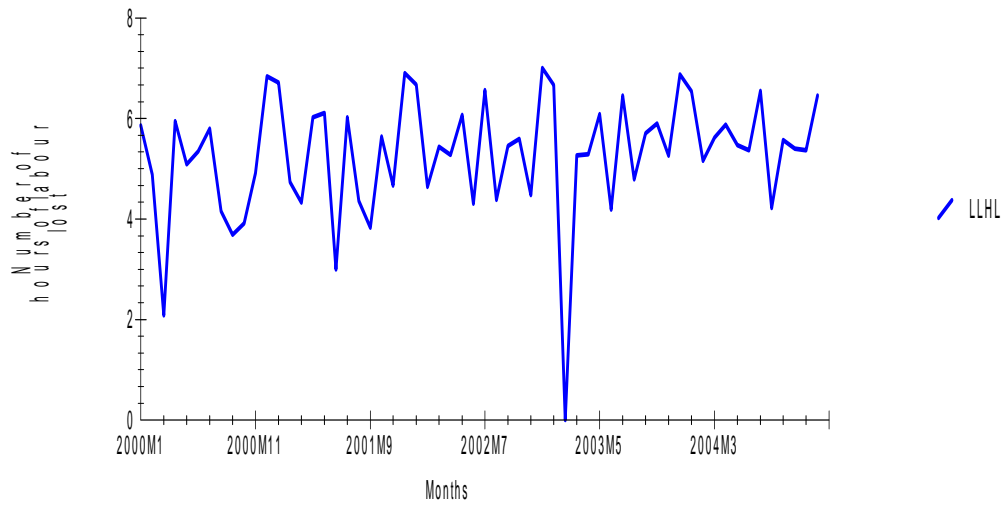
Plot of monthly total bills invoiced (TQB) in natural log (WUC)



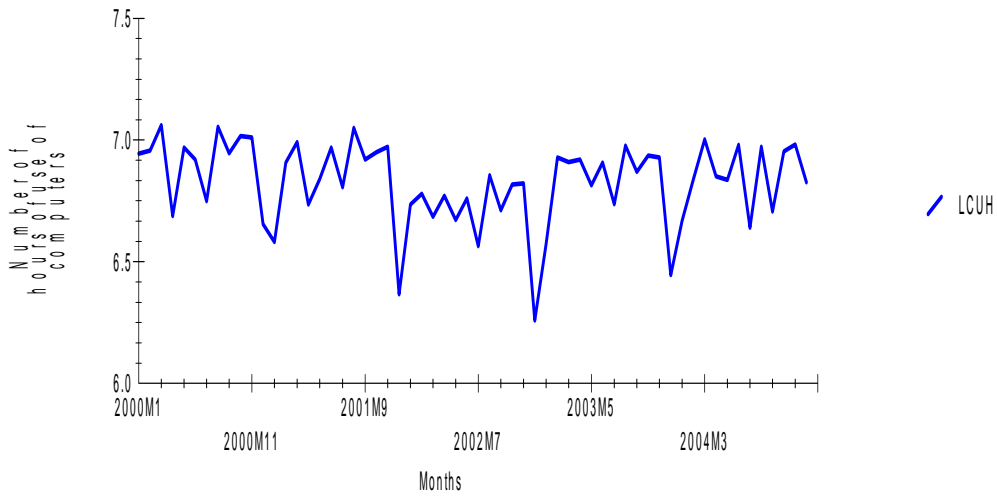
Plot of monthly hours of meter reading (MRH) in natural log (WUC)



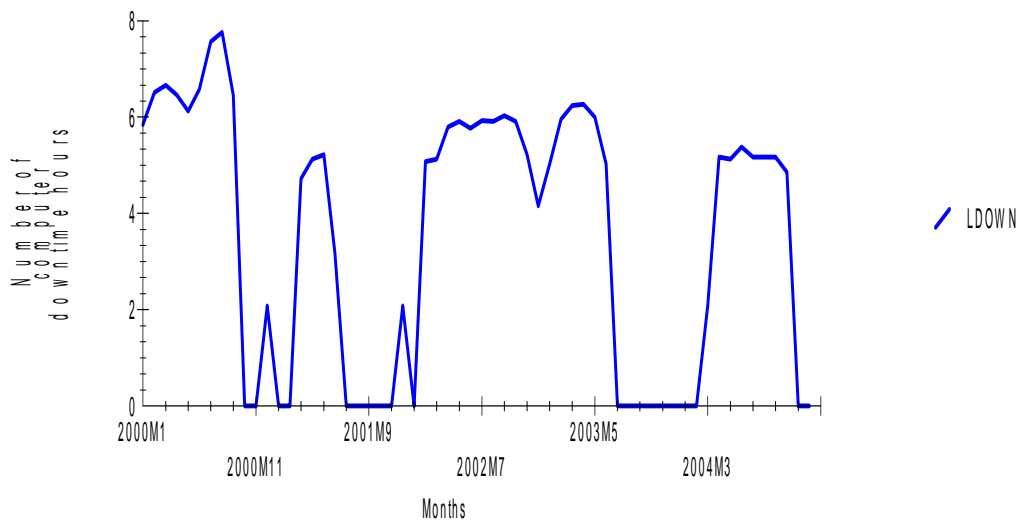
Plot of monthly hours of supervision (DEG) in natural log (WUC)



Plot of monthly hours of labour lost (LHL) in natural log (WUC)



Plot of monthly hours of use of computers (CUH) in natural log (WUC)



Plot of monthly computer downtime hours (DOWN) in natural log (WUC)