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Improving Productivity at the Currency Processing Centre (Bank of Ghana) Through Six Sigma.

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Abstract
A programme of working long hours was introduced by Bank of Ghana, in its Currency Processing Centers to increase output to meet growing demand for processed cash. Incidental problems with employee dissatisfaction and poor health of the programme raised questions about its sustainability. Analysis of productivity in the period before and during the extended hour programme indicated a 17% increase in productivity, suggesting some inefficiency in the bank's currency processing operations. Six Sigma is a systematic data driven approach to reducing defects, improving efficiency and hence productivity. The study sought to investigate the application of Six Sigma as a tool for reducing defects and increasing productivity. A simplified version of Six Sigma was adopted and applied to improve productivity in the Currency Processing Centre, Kumasi. The results indicated a 75% increase in productivity in spite of the limitation of not having the full commitment of top level management.
Keywords: Productivity, Currency Processing, Bank of Ghana, Six Sigma

1.0 Background of Study

The Central Bank of Ghana's clean note policy, in line with internationally accepted best practices, seeks to issue only good quality currency notes and coins to the public while soiled and mutilated notes are withdrawn from circulation. To implement this policy, Bank of Ghana (BOG) has installed high speed banknote processing systems (BPS-1000-30) which verifies the authenticity of the notes, counts and sorts the notes into good and bad quality (soiled) notes. Soiled notes are either shredded online (as part of banknote processing) or manually shredded by a Banknote destruction system, BDS 400 and briquetted. Coins are processed; authenticated, sorted and counted, by SC4000 sorters from Scancoin. Presently, there are two operational sites in Ghana, called Currency Processing Centres, in Kumasi and Accra while two additional sites are being set up, one in Accra and the other in Takoradi. Processing the banknotes enables the Bank to take out counterfeits and also sort out dirty and mutilated banknotes for destruction. All things being equal, banknotes issued to the public should always be either mint (new) or processed.

Currency in circulation has increased by 125.6% from GH¢1,436.09 million in December 2007 to GH¢3,239.50 million in December 2010 (Issue Department (BOG), 2011). Growth in the economy has increased demand for processed cash from the Deposit Money Banks (Commercial Banks), the main vehicle through which bank of Ghana issues banknotes and coins to the public. As of October 2010, the output of the currency processing Centres was not enough to meet the growing demand. To make up for the shortfall a programme of gradually increasing its processing capacity through acquisition and installation of new processing systems to process and recycle more cash was developed as a medium term measure. The long term goal of moving towards a cashless economy would ultimately solve this problem. In the meantime it stands to reason that we should not only increase our processing capacity by acquiring and installing new processing systems but also optimize our currency processing operations in order to increase productivity.

A short term measure adopted by management was to increase working hours at the centres from the normal 8 hour working period (8:00am to 5:00 pm; 1 hour break) to an 11 hour working period from 8:00am to 8:00pm; 1 hour break) in order to increase output. Surprisingly, in addition to an increased output, productivity defined as output/input (Tangen 2005) increased by 17% during the extended hour period raising questions about the level of productivity that can be achieved at the centre. The extended working hour programme had problems including the expensive overtime wages, an increased numbers of sick leaves and employee dissatisfaction. Employees of the centres, most of whom are pursuing some academic programmes through evening lectures, were unhappy and dissatisfied. Spending their evenings working meant that they were missing lectures and sometimes reaching home very late. In addition, employees became lethargic, a phenomenon which was a result of not having ample rest because of late closing times.

The situation presented an opportunity to adopt a management system that can address management's desire for higher output and improve employee satisfaction, through an improvement in productivity to achieve the same or even better output within the normal working hours.

1.1 Research Problem

Analysis of productivity in the period before and during the extended hour programme indicated a 17% increase in productivity during the extended hour period (a three hour extension of normal working hours). This brought to the fore the fact that the Bank's currency processing operations were inefficient and may have more room for improvement.

1.2 Research Questions

The study will address the following questions

- Can Six Sigma be applied to improve efficiency and hence productivity in the Central Bank's processing operations?
- If it can, which Six Sigma tools and techniques can be applied to the Bank's currency processing operations?

1.3 Research Goal and Objective

The research were set to achieve the following goal and objective

- To investigate the application of Six Sigma as a tool for reducing defects and increasing productivity.
- To adopt, if appropriate, and apply Six Sigma to improve the operations of the currency processing centre of the Central Bank.

1.4 Justification and Significance of the Study

The Central Bank's clean note policy demands that money issued to the public is always mint (new banknotes) or processed money. This among other things helps reduce the health risk associated with circulating dirty banknotes. The cost of frequent mint orders and the risks associated with circulating dirty banknotes can be avoided if the output of the Central Bank's currency processing operations is increased through efficient and effective operations.

2.0 Literature Review

2.1 What is Six Sigma?

The words "Six Sigma" are misleading as to the system they describe. The Greek letter sigma, σ, denotes standard deviation from the mean in statistics and it is a measure of the degree of variation in a data set, a group of items, or a process . In the context of quality management, Six Sigma quality means that there are fewer than 3.4 defects or deviations from the standard, per million units produced. Harry and Schroeder (2000) explain that the meaning of defect is much broader within the framework of Six Sigma and includes anything that blocks or inhibits the performance of a process or delivery of a service from meeting customers' expectations.

There is widespread misconception and misinterpretation of what Six Sigma is (Anthony *et al* 2008). A common perception is that Six Sigma is all about statistics. Przekop (2006) argues that even though Six Sigma derives its name from a statistical concept, the approach goes well beyond data and figures. Six Sigma utilizes statistics as one of its tools to analyze, interpret and present data but Antony *et al*.(2005) and Pande, Neuman and Cavanagh, (2000) submit that statistics alone is not enough for a successful implementation of Six Sigma, changes in organizational culture and full commitment from top management are even more important. Antony *et al* (2007) assert that it is more about changing the mindset of people and shifting from the traditional firefighting to a facts-based proactive approach to problem solving. An integral mix of both reliance on prudent judgment and numerical data is needed in solving problems using Six Sigma framework (Al-Mishari and Suliman 2008).

A statistical education or background is not needed to understand Six Sigma (Burton and Sams, 2004). Eckes (2001) simplifies the requirements for implementing Six Sigma by saying that all you need is addition and subtraction and that the biggest challenge will be changing to making decisions with facts and data. He believes the structured DMAIC (Define, Measure, Analyze, Improve and Control) methodology followed diligently, will give an answer to your problem. The availability of softwares (JMP, DOE Pro XL, Minitab, ARIS Six Sigma) which remove much of the statistical theory, leaving practitioners to focus on the interpretation of the information generated gives Eckes (2001) submissions some credence. As a management system Six Sigma encompasses a broad array of best business practices and skills.

2.2 Applicability of Six Sigma

Service organizations often believe that Six Sigma requires complicated statistical tools and techniques. Pfeifer, Reissiger and Caneles (2004) indicate that the pre-requisite for a successful implementation of Six Sigma is an analytical background and only part of methods, tools and techniques available. Six Sigma is about using common sense to make things easier not more difficult (Peterka, 2006), and producing better products and services faster and cheaper (Oakland 2008). In practice many processes and quality problems in service organizations can be solved using simple problem-solving tools of Six Sigma such as process mapping, cause and effect analysis, Pareto analysis and control charts (Anthony *et al*, 2007). The origins of Six Sigma also lend credit to the perception that it can only be deployed in manufacturing companies. The concept of Six Sigma began in Motorola in the mid 1980's and evolved and developed with its implementation by manufacturing giants like General Electric, Allied Signal and Johnson & Johnson. In their book, *The Six Sigma Way*, Pande, Neuman and Cavanagh, (2000), maintain that there are more opportunities for the application of Six Sigma in service industries than manufacturing. The applicability of Six Sigma has evolved beyond the confines of manufacturing where it first originated and sales, marketing, purchasing, banking, software, insurance and health care functions have also successfully implemented Six Sigma programs.

2.3 Six Sigma and other Quality Management Systems.

It can be argued that six sigma has historical roots in spite of Eckes (2000) claim that it is a unique and new approach. The opinion held by some Engineers and Managers (Antony 2004), that there is nothing new about six Sigma is not completely wrong. Six Sigma builds on many aspects of previous continuous improvement initiatives especially TQM (Antony, 2008: Kumar, Wolfe and Wolfe 2008). Although, all the key quality management systems and programs are each unique, they have some common underlying concepts. The concepts center on process focus, customer focus, collaboration, data driven management and strategic planning for quality. Przekop (2006), believes that the similarities in the various systems, is the reason for the belief that Six Sigma is merely a set of recycled management ideas, statistical and project management tools. Incorporating elements from the work of quality pioneers like Deming, Juran and Feigenbaum, Six Sigma is a rigorous, focused and highly effective implementation of proven quality principles and techniques which ensures quality control, total quality management and zero defects (Desai 2010). Pande, Neuman and Cavanagh, (2000), affirm that Six Sigma is in many ways a vigorous rebirth of quality ideals and methods, applied with greater passion and commitment. Distinguishing aspects of Six Sigma include its strong algorithmic approach (DMAIC) for getting things done and also its ability to logically integrate and coordinate the use of various tools, techniques and strategies that are commonly used in isolation as it progresses through DMAIC or DMADV applications (Edgeman 2008). Six Sigma has demonstrated success by clearly providing a roadmap and process not only for quality but also business management (Matthew 2008).

2.4 Why Six Sigma

Antony and Seow (2004) believe that Six Sigma is a powerful strategy that can be used to meet the need to achieve operational and service excellence in the twenty first century. According to Pande, Neuman and Cavanagh, (2000) the proven benefits of the Six Sigma management system are diverse and include cost reduction, productivity improvement, market-share growth, customer retention, cycle-time reduction, defect reduction, culture change and product or service development. Six Sigma is used to improve process capability which impacts every aspect of a business.

.**2.5 Methods of Six Sigma**

Six Sigma employs three main step by step methodologies; DMAIC (Define, Measure, Analyze, Improve and Control), DMADV (Define, Measure, Analyze, Design and Verify) and DFSS (Design for Six Sigma). Applying a step-by-step process based road map is a key success factor in implementing any six sigma project regardless of the size or type of the business (Nabhani and Shokri, 2009). The focus of the improvement effort determines the method selected. Albeanu, Hunter and Radford (2010) acknowledge that DMAIC methodology is a key approach to process improvement but add that it is not suitable for every project or process improvement. Tennant (2002) thinks that DMADV was born out of a desire to unite both Six Sigma DMAIC and DFSS. He observes that there is sometimes a negative reaction to DMADV especially where there is nothing to measure or analyze.

2.6 The DMAIC Methodology

The DMAIC methodology defines a process to improve, measure baseline and target performance of the process, analyze process data to determine the key process inputs that affect outputs, improve the process to optimize outputs and control the improved process. Six Sigma prescribes the use of specific quality management, project management and statistical tools for each stage of the DMAIC cycle. Chakrabarty and Tan (2007) write that Six Sigma tools and techniques are not new, statistical process control, failure mode effect analysis, gage repeatability and reproducibility studies, and other tools and methodologies, have been in use for some time.

2.7 A Review of Successful Implementation of Six Sigma at Dow Chemical Company and Bank of America.

Six Sigma has three main components; the strategic, tactical and cultural (Eckes 2001). Strategy is a prerogative of executive management. Process change usually begins with strategic initiatives from senior management (Kotter 1995). The tactical component involves project teams applying the principles and strategies of Six Sigma to improve the efficiency and effectiveness of processes. The cultural aspect, often ignored, deals with change management which is a major driver of quick and dramatic improvement in sigma performance. Larson (2003) argues that Six Sigma involves a transformational change in an organization’s culture, structure, and processes. Implementing Six Sigma will automatically lead to changes in the organization that need to be managed properly for the success of the program. Harry and Schroeder (2000) believe change management is a critical element that contributes to the success of introducing Six Sigma in an organization.

2.8 Theoretical Framework for Six Sigma Implementation

Kotter’s eight-stage change process provides a framework for managing the expected changes that will accompany the deployment of Six Sigma while the DMAIC methodology provides the step-by-step approach for improving processes. Harry and Schroeder’s DMAIC methodology integrated with Kotter’s eight-stage change management process gives what is felt to be a suitable framework for the application of Six Sigma to the currency processing operations of the Central Bank.

3.0 Research Methodology

3.1 Scope

The study was conducted at Kumasi Currency Processing Centre over the Six month period from July to December 2011. The Kumasi processing centre has a banknote processing unit, a coin processing unit and a banknote destruction unit. Given the 6 months’ timeline, the Six Sigma methodology was, for the purposes of this study, applied only to the banknote processing activities. The banknote processing unit has 20 contract staff organized in groups of 5. Each group is responsible for and works on one BPS-1080-30 banknote processing system.

3.2 Research process

The study followed the implementation plan below:

- A pilot implementation was done to verify the viability of the study
- Established targets, set timelines and defined the purpose and scope of the study
- Acquired approval from management for the introduction of a continuous improvement initiative.
- Formed the problem solving team.
- The components of the conceptual framework were implemented.
- The continuous improvement strategy developed was used in process improvement efforts.
- Results were analyzed, conclusions drawn and recommendations made.

3.3 Data collection

Data was collected through observation and from the databases of each of the four BPS-1000-30 systems and the Report Management Unit (RMU server) which receives and consolidates all reports generated by all the systems in the currency processing center.

3.4 Data analysis

Minitab, a statistical and quality management software and Excel were used in the analysis of data gathered. The

Six Sigma tools used include process maps, cause and effect diagrams, Pareto charts, SIPOC diagrams and descriptive statistics.

3.5 Limitations of the Study

A limitation of this study is that high-level support which is important for the successful implementation of Six Sigma (Oakland 2008a; Gupta 2003) was not obtained. This study is a line manager's application of Six Sigma concepts and techniques, without enlisting the full commitment of top level management within the organization.

4.0 Data Analysis, Presentation and Interpretation

4.1 Establishing a Sense of Urgency

At the end of June 2011, which marked the end of the extended hour programme the prevailing conditions were demand for cash was very high and rising. The amount of banknotes processed working normal hours was inadequate to meet the rising demand. Unfortunately, the extended hours programme implemented by management to increase output saw employee overtime wages going up, an increase in employee dissatisfaction in spite of the extra money and an increase in the number of sick leaves because of long hours of work and inadequate rest leading to poor health.

In response to staff complaints, an appeal was made to management to allow staff of the currency processing centre to take a one month rest from the long working hours during the month of July citing reasons such as increased number of sick leaves and general lethargy. During this period the team experimented with a pilot programme to see if a continuous improvement programme based on Six Sigma will yield higher productivity.

With the positive results obtained, approval was sought from and given by management to stop the extended hour exercise in favour of the suggested continuous improvement programme with the hope that productivity and hence output will increase above what is currently being achieved under the extended hour programme.

4.2 Forming the guiding coalition (the Problem Solving Team)

The Six Sigma team consisted of Mr. Yaw Opoku-Fofie, an Engineer who is the head of the Currency Processing Unit, Kumasi and Mr. John Akwasi Akowuah, also an engineer and an expert in troubleshooting who has a high analytical ability. It is believed that the two by way of their experience, expertise and position had enough influence and the requisite leadership skills to champion the change. Over time the team's size is expected to increase as more people are identified and trained. The required support of fellow managers was gained because of the demand for cash and the pressure from top management for higher output.

4.3 Developing a vision and strategy

In consultation with staff of the unit and after considering the concerns of all stakeholders as well as the Central Bank's overarching vision, the team carved the vision statement "To achieve a daily target throughput of 280,000 pieces of banknotes per hour through continuous improvement of our processes by a happy and satisfied staff."

The strategy adopted for continuous process improvement within the currency processing centre was adopted using Six Sigma DMAIC.

4.4 Communicating the change vision

(Chowdhury 2002) identifies ineffective and inaccurate communication as one of the factors that leads to failure of Six Sigma implementation. The team used printed reports, email, face to face meetings and other tools and techniques to communicate with various stakeholders. Slogans such as "work and happiness" "no waste, no delays" "no errors, no delays" were introduced to drive home the need to remove waste, errors and delays in order to increase process efficiency under working conditions conducive to productivity.

4.5 Define phase

Through observation and discussions, the team agreed that the banknote processing process offers more opportunities for improvements and is the most critical to productivity. Improvement efforts were therefore first directed at banknote processing activities. If successful, the methodology will be applied to all processes within the unit in order to optimize the total productivity of the currency processing operations. Productivity is measured by the number of pieces of banknotes processed per day by the centre.

4.6 Empowering employees for action

Committed and hardworking employees, who exhibited good leadership qualities, were identified and made group leaders. The Group leaders were made responsible for the productivity of their systems and were to report to the Engineer-in-Charge at the end of each day. Employees were allowed to contribute to process improvements discussions at weekly meetings and their input (suggestions for improvement) were documented and followed up with immediate action if feasible.

4.7 Measure phase

12 months of historical data was collected on banknote processing from the RMU database. The data covered total number of pieces of banknotes processed per day for the 5-month period June to October 2010, before the extended hour programme and the 7-month period December 2010 to June 2011 during which the extended hour programme was carried out. The average daily throughputs were determined from the total number of pieces of banknotes processed per day by dividing the total number by the number of hours worked.

THROUGHPUT FROM JUNE 2010 T0 OCTOBER 2010

Variable	Mean	StDev	Minimum	Maximum
THROUGHPUT	140,988	24,440	62,500	185,000

THROUGHPUT FROM DECEMBER 2010 TO JUNE 2011

Variable	Mean	StDev	Minimum	Maximum
THROUGHPUT	165549	39601	69091	241818

The increase of 17% and 31% in the average and maximum throughput during the extended hour programme indicated that low productivity was not due only to poor banknote quality which has for a long time been the reason given for the low level of productivity. It was therefore important for the problem solving team to find out what operational factors accounted for the low productivity.

4.8 Analyse phase

Cause and effect diagrams and Minitab the process was analyzed to identify underlying causes of performance inadequacies. Data collected was analyzed quality tools from Minitab.

4.9 Improve Phase, Consolidating Gains and Producing more Change

The information gathered from the process maps, observation and the fish bone diagrams provided enough ground to take some immediate action.

4.10 Control Phase and Institutionalizing New Approaches

Standard operating procedures and maintenance checklists for banknote processing will be documented to ensure a common understanding of the process and for training new staff. A deployment flowchart will also be mapped to show who is responsible and accountable for recommended changes. More importantly a monitoring plan will be established.

5.0 Introduction

Complying with the basic principle of statistical thinking and decision-making in the application of Six Sigma, potential causes of low productivity were first determined and confirmed by further analysis of data.

5.1 Determining potential root causes

Information gathered through brainstorming, observation, detailed process maps and fish bone diagrams indicated that the primary factors causing low productivity are;

Quality of banknotes

The quality of the banknotes affects the number of missed feeds i.e. the system makes more than one attempt in order to single or pick a note from a stack of banknotes.

System stoppages due to machine errors.

Anytime there is a machine error, the system stops for the error to be corrected. For a system that processes 30 banknotes per second, the number of errors and the length of time taken to correct an error have significant effect on productivity.

Late start.

A late start of banknote processing means less time for effective work and man hours are lost as employees idle around.

Employee morale, commitment and skill level.

Employee motivation and commitment determines how work is done. Quick responses to system messages and errors, proper feeding of banknotes and attitude towards work affects productivity.

5.2 Confirming root causes and improvements

5.2.1 Quality of banknotes

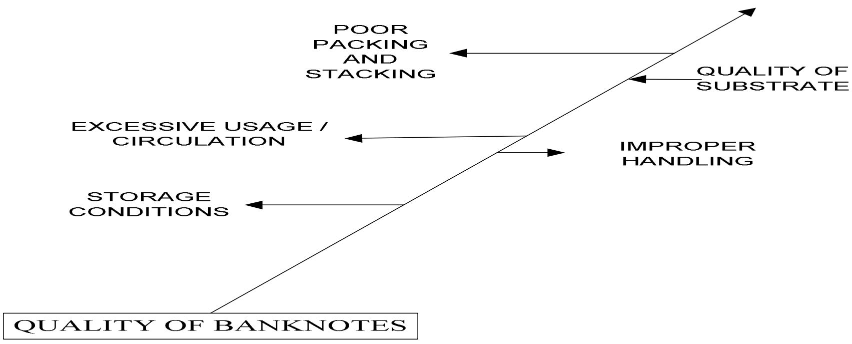

Figure 5.1 Fish bone diagram of factors affecting quality of banknotes.

After a careful examination of the factors affecting the quality of banknotes, the team concluded that control of these factors fell outside the scope of this work and powers of the team. For example, the quality of the substrate which is determined before printing is done, is not part of the center's work and storage conditions of banknotes can only be modified by the vault management team.

5.3.2 Machine errors

Data collated from the operational log of each system indicated the number of system errors and time taken to correct them. It was determined that an average of two hours per machine was spent correcting errors and changing consumables each day. This meant that on the average the centre was not working for 2 hours each day.

Table 5.1 A typical data on error events showing the types of errors on the BPS machine.

TYPE OF ERROR	COUNT	TOTAL TIME IN MINUTES
Jams	50	17
Sensors	30	14
Bundler	45	18
Photo detectors	2	1
Singler	11	0.5
Operating	32	34
Transport	2	1
Bander	100	81
Stepper motors	1	1
	273	**168**

Pareto charts were used to rank causes of errors from the most significant (in terms of number and time taken) to the least significant.

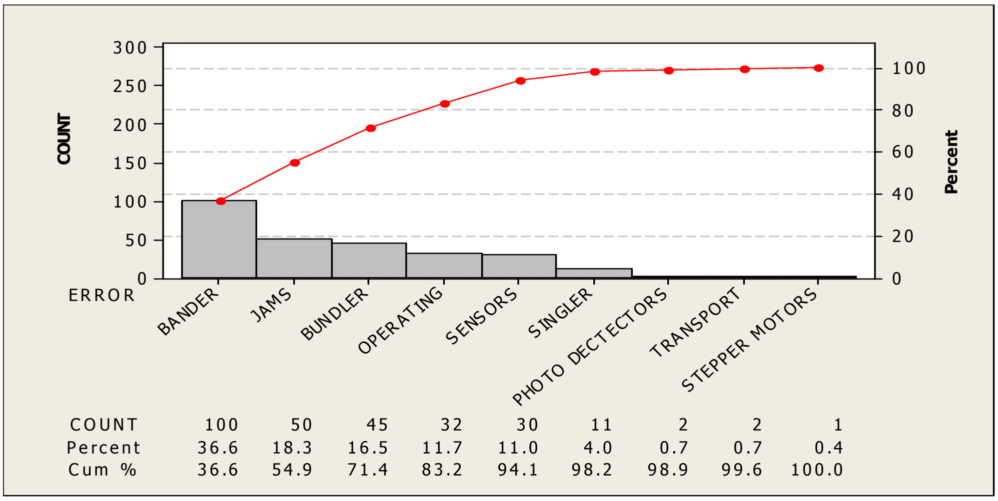

Fig 5.2 Pareto Chart of Errors and Number of Times they occur (Count).

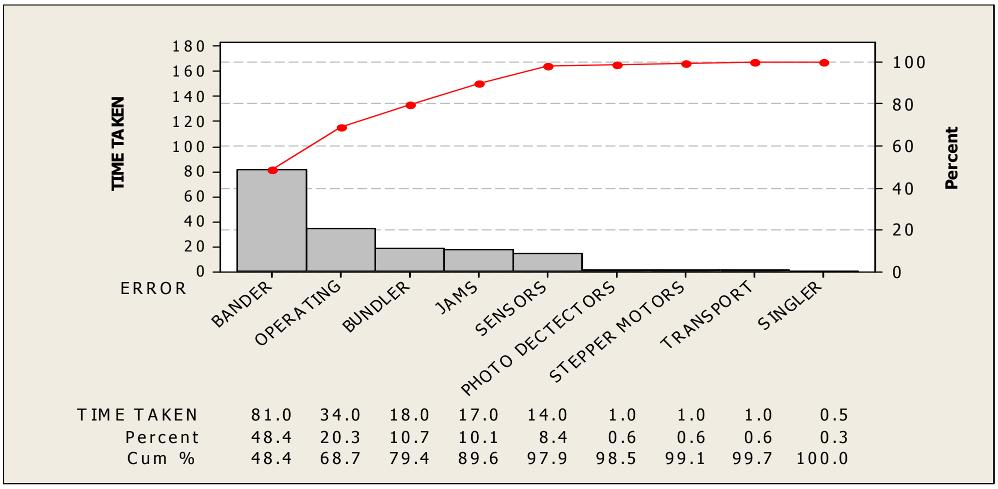

Fig 5.3 Pareto Chart of Errors and Time Taken to Correct Them.

Once the team identified the most significant errors for each system, brainstorming sessions were held to determine potential causes of each error. Fish bone diagrams were generated as depicted in fig. 5.4 for bander errors.

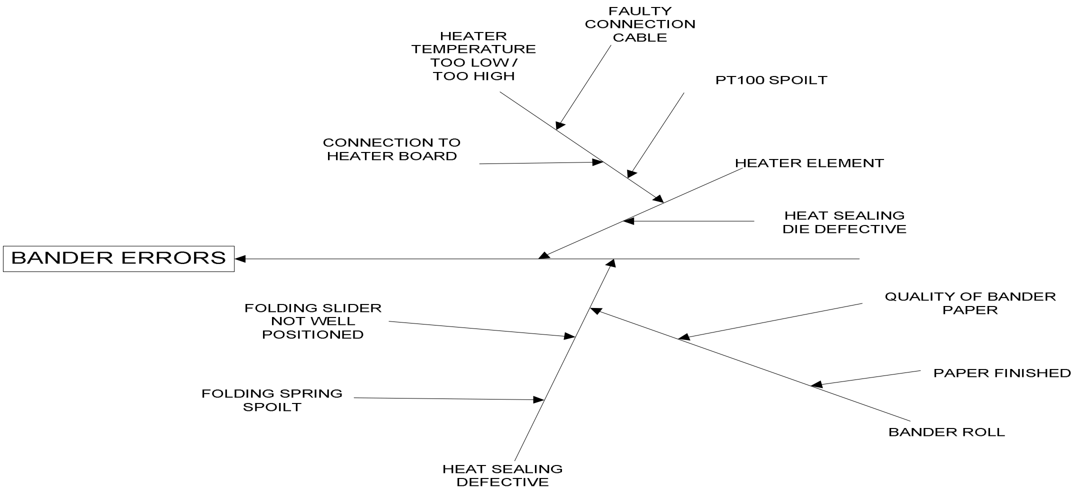

Fig. 5.4 Fishbone diagram of bander errors

After determining the causes of the errors, brainstorming sessions were held to generate alternative solutions. Each solution was then evaluated with respect to parts required, time to implement and how preventive maintenance can be used to pre-empt the occurrence of these problems.

Late start

Data collected for start of work for the month of July 2011 indicated that on the average work started by 8:27am each day. Given that the vault opens at 8:00am and looking at the processes involved in conveying the money to the centre, the team judged this time to be fine. However, the problem of occasionally starting after 9:00am could be addressed if other units within the branch would adopt Six Sigma.

Table 5.3 Work start times for the month of July, 2011.

WEEK 1					8:22
WEEK 2	8:18	8:30	8:14	8:15	9:35
WEEK 3	8:37	8:21	8:27	8:23	8:20
WEEK 4	8:34	8:19	8:28	8:39	8:20
WEEK 5	8:17	8:30	8:22	8:49	8:29

Average work start time 8:27am

Employee commitment and skill level

Since the motivation of workers is very important in the successful implementation of any change program, another area of concern was motivation of line workers. The agenda for weekly meetings included employee problems in addition to ideas generation and contributions to the improvement effort.

Improvements efforts

To show appreciation for hard work and commitment and also to motivate staff, management agreed on appeal to extend the contracts of four out of 8 members of staff whose contracts were about to end. Earlier one exceptional worker had been given a permanent job in the Banking and Supervision Department. Employees of the unit were reminded of such opportunities if they give off their best. In addition, the quarterly award scheme was also established to whip up motivation, as groups competed to win the awards. Training needs assessment was done to ascertain areas where employees needed training and short training programmes conducted where necessary. Production reports of each of the four groups were monitored daily. Compared with earlier reports the measures adopted appeared to have impacted positively on the performance of many of the staffs of the unit, as reflected in the production reports.

However, it was noticed that competition among the groups affected quality of work as errors in reports generated at the end of day increased. In some cases customers were called back for changes to be made to their report which affected the integrity of work done by the centre. It also affected the collaborative atmosphere needed. Members of one group were reluctant to help others when the need arose. The fun generated through competition increased productivity at the cost of quality and collaboration. Competition between the groups was stopped at the end of September, 2011. It is however important that the team finds a way to get people excited about their work. “The only way I see to get more productivity is by getting employees involved and excited about their jobs” Jack Welch (2000).

	

5.4 Results

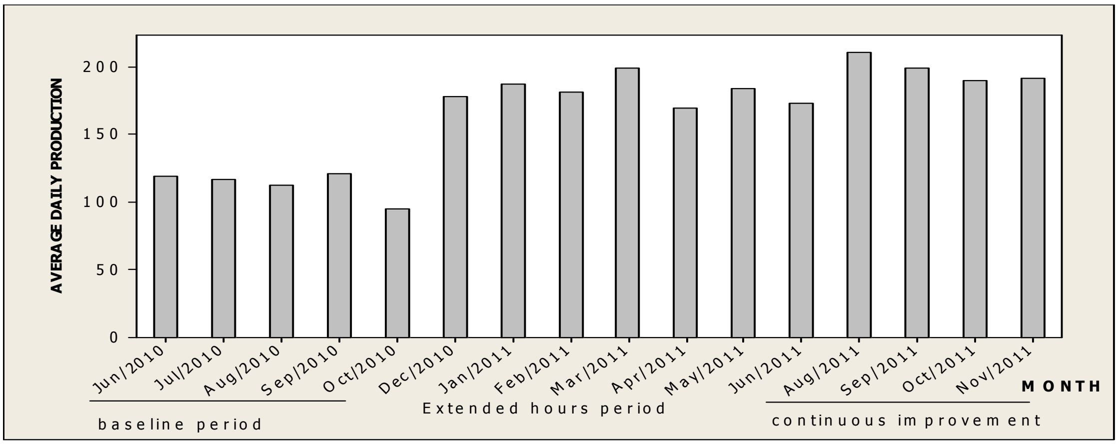

Fig 5.5 A Bar Chart of Average Daily Production for Each Month

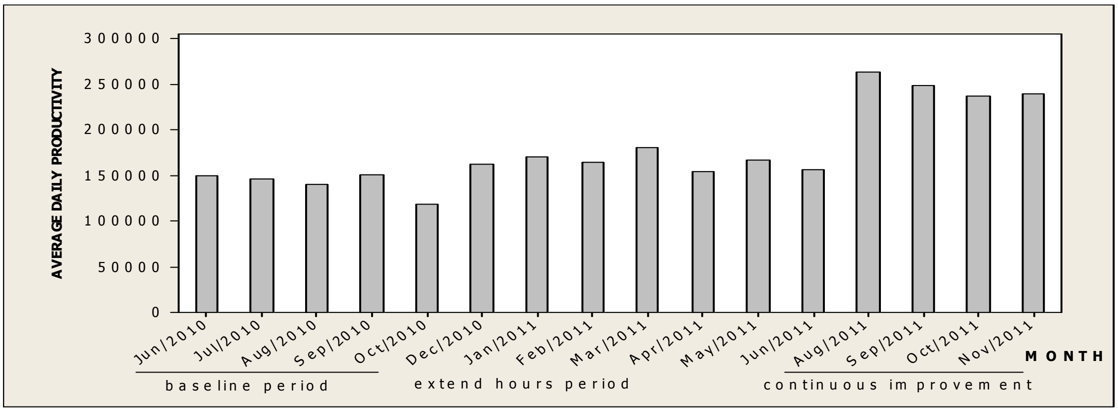

Fig 5.6 A Bar Chart of Average Daily Productivity for Each Month

The drop in productivity during the last two months of the continuous improvement period is attributed to the stoppage of competition between the groups and also no conscious effort was made to get good quality banknotes as was the case to ensure success in the beginning. Production (output) from the currency processing centre increased in the 11 month period of December 2010 to November 2011 (Dec. 2010 to Jun 2011 – "Extend hours programme" and Aug 2011 to Nov 2011- "Continuous improvement programme") as seen in figure 5.5. Average production or output and average productivity (throughput) within the two periods compared to the five month baseline period is presented in the tables below

Table 5.4 Average production and productivity values within the three periods

PRODUCTIVITY (NO. PIECES OF BANKNOTES PER HOUR)			
	Minimum	Mean	Maximum
Jun 2010 to Oct 2010	62,500	140,988	185,000
Dec 2010 to Jun 2011	69,091	165,549	241,818
Aug 2011 to Nov 2011	156,250	247,397	298,750

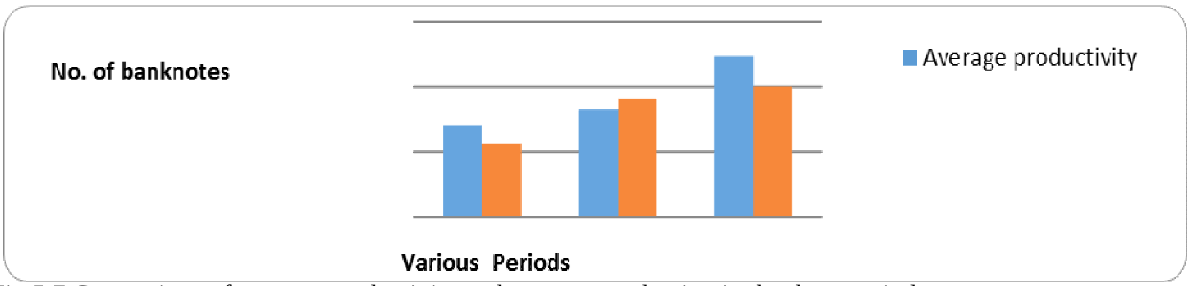

Fig 5.7 Comparison of average productivity and average production in the three periods.

Table 5.5 Percentage increments in average production and productivity over baseline period

	EXTENDED HOURS	CONTINUOUS IMPROVEMENT
OUTPUT	60	75
PRODUCTIVITY	17	76

The 60% increase in average production during the period between December 2010 and June 2011 was more because of working more hours rather than productivity which increased by only 17% compared to the continuous improvement months of August 2011 to November 2011 during which a 75% increase in average production was achieved through a 76% increase in average productivity.The short term target throughput of 250,000 pieces of banknotes per hour was not achieved since the average throughput within the period was 247,208 pieces of banknotes per hour. However it is encouraging to note that the target was met on 52 days out of 83 within the period and most often exceeded. In addition, the large increase of 75% in average productivity provides enough progress for the team and staff to continue in our continuous improvement effort.

6.0 Conclusion

6.1 Summary of research

The Six Sigma DMAIC method was applied to a critical process in the currency processing centre, banknote processing, in response to complaints from employees about long working hours introduced by management in the face of high demand for processed cash. Data from the process was analyzed using Minitab and Excel to identify areas of the process where improvement could be made. Process improvements implemented resulted in a significant increase in productivity.

6.2 Findings

Although the target throughput of 250,000 pieces of banknotes has not been achieved yet, the impressive increase of 75% in productivity and return to normal working hours has provided the necessary impetus for the Kumasi currency processing centre to continue in its efforts at continuous improvement through Six Sigma. Staff of the currency processing centre appeared happier and more satisfied. Some problems needed collaboration with other offices and departments to solve. Solutions requiring huge budgets such as public education on proper handling of banknotes, setting up agencies and getting commercial banks to exchange dirty and mutilated money required the full commitment of top level management. Bank of Ghana can adopt Six Sigma to improve many aspects of its cash management systems especially the currency processing operations. Functional departments such Human Resources, Finance and General Services can also adopt Six Sigma to improve the efficiency of their processes. The method, tools and techniques applied will depend on the processes involved, the strategy adopted and the type and how data is collected. A better maintenance scheme is needed to reduce machine downtimes.

6.3 Conclusions

Six Sigma, if implemented appropriately, produces benefits in terms of reduction in delays, errors and defects and therefore increased efficiency and effectiveness of processes. This usually translates to improved productivity and profitability. Implementation of the strategy has brought a sustained increase in performance to the Currency Processing Centre in Kumasi. Even though, solutions to some problems fell outside the powers of the centre and underscored the need for full management commitment for successful implementation of Six Sigma, the 75% increase in productivity achieved confirms the fact that a line manager or middle manager can apply Six Sigma method, tools and techniques to optimize processes in his “Personal” organization within the larger organization (Przekop 2006).

6.4 Recommendations

Six Sigma is a powerful business strategy that can be used to tackle operational costs and inefficient process problems. It is highly recommended that Six Sigma concepts are incorporated into the policies and strategies of the Central Bank in order to improve the effectiveness and efficiency of the operations of the Bank.

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