

Review of Method Study Approach to Productivity Gain: A Multi-case Study of Portable Water Producing Factory

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Abstract— This study evaluated level of work-study approach (WSA) to productivity advancement in Southwest-Nigeria Portable Water Producing Factories (PWPF). Objectives were to, measure productivity trend (PT) and, evaluate managers' recognition and contribution(s) of WSA to productivity growth. PT was measured from 4 years records provided by 50 employers in 50 PWPF. Questionnaires were used on the employers and 120 employees to measure adopted WSA and impacts with responses reported on the scale of 1 to 5. Data was analyzed using t-test statistical analysis. The best performed PWPF was rated 43.75%. Disloyalty, low remuneration, lack of trainings and unsafe workplace were the major factors reported to have influenced the PT. Machinery Utilization (MeU) maximization was the commonly adopted approach. The employers' ratings of MeU statistically significantly lower (mean=3.6364, SEM= 0.06913) to that of employees (mean=3.7333 SEM=0.6645) $t(169) = 0.641$, $p=0.522$. Human resources management ($p=0.235$) and workers' performance evaluation ($p=0.906$) were also significant and rated above average. However, work-method, safe work-practices and work-demands reviews, which were key attributes of ergonomic techniques and workers-related factors (WRF), were not significant, rated below average. The author concluded that neglects of WRF in WSA, must have greatly contributed to the weak PT of the industry and should be properly addressed to enhance productivity growth.

Keywords— ergonomic, industry, productivity, water, work-study

1 INTRODUCTION

Work study is the systematic examination of the methods of carrying out activities so as to improve effective use of resources and to set-up standards of performance for activities being carried out. There are a number of work study approaches such as ergonomics, operations research, and time-and motion study (Mutombozana et al., 2013). Primarily, these work study procedures can be categorized into two; method study and work measurement. Method study critically consider the current and expected ways of performing work in other to improve in; the utilizations of all inputs of production (man, machine, material e.t.c), layout of plant and equipment, safety standard and procedures, working environment. The work measurement however establishes the time for a qualified worker to carry out a task at a defined rate of working.

The objectives of work measurement are to find the ineffective time in an activity, setting standard, evaluating workers performance, planning man power need, establishing wages incentive scheme among others (Shyam, 2010). Work-study is described as one of the most powerful tools that management can use to improve productivity. It is a straight-forward way of increasing productive efficiency of the organization by considering all the factors influencing productivity (Sujay, 2016). Work study is frequently used to increase the amount produced from a given quantity of resources with little or no further investment. According to Aakash et al. (2016), work study is to minimize costs either by designing the work for high productivity or by improving productivity in existing work through improvements in current methods by reducing ineffective and wasted time.

Work study analyses the existing method, finds weakness in the existing production process, effectively utilize the existing resources, setting and measuring performance standard, use performance standard to pay incentives, standardizes method, material and equipment used in the production process (Mishra, 2015; International Labour organization(1986).

Using work study approach, Duran et al. (2005) noted that measuring inevitable times in manufacturing industry and taking necessary precautions against them increased employees' efficiency and enhanced production capacity. Singh and Yadav (2016) used method study approach to identify inefficiency in the existing processes of some battery manufacturing plants and suggested improved layout and flow process chart to enhance its productivity. Sharma (2017) applied method study principles in Sugar industry to identified inefficient work procedures and workers' superfluous fatigue which reduced its productivity level. Bhiradi and Singh (2004) identified value-added and non-value added element in a heavy machine shop manufacturing industry using work study approach. Productivity improvement was recorded after elimination of non-value added elements. The methods of work study have direct relationship with improved productivity and can find applications in places where work is done (Vebamev, 2012).

Productivity is the ratio of an extent of output to the unit of all of the resources used to produce output. According to Sanjay and Nandkumar (2007), factor productivity indices are; labour, material, land, machine, capital, technology, product and management. Labour (human capital) however plays a vital role among others and it can be increased through: capital deepening- investing more or better equipment, structures, machinery, all of

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which make it possible for workers to produce more; increases in skill- employees with enhanced skills needed for production may produce more output in less time; and by implementation of new system. Enhancing productivity is one of the basic goals of economic policy. Productivity growth helps to obtain strong economic growth (Gross Domestic Product (GDP)) and hence increases GDP per capita (Organisation for Economic Co-operation and Development, 2012). Improving productivity has to do with how effectively people combine different resources to manufacture parts and services. With the correct choices, improved production, higher values and elevated incomes can be accomplished for every hour worked (Kulkarni et al., 2014).

Productivity losses are major problems encounter in many factories, most especially, in the developing countries. Some of which are caused by many factors relating to ineffective utilization of plant, equipment and labor. According to International Labour Office (2008), installation of modern plant and equipment and use of advanced technology can help to raise productivity in the long run. But these approaches require heavy capital investment. Advancing productivity using advanced technology may also affect the efforts aimed at expanding employment opportunities in the developing country like Nigeria. Hence, this present study aimed at carrying out assessment into type and level of work study approach engaged by managers of Portable Water Producing Factories (PWPF) in Southwestern Nigeria with the objectives of evaluating the productivity trend over a period of four years and the contribution(s) of such approach to productivity growth.

2 MATERIALS AND METHODS

2.1 RESEARCH DESIGN AND STUDY AREAS

A cross sectional design was adopted in this study. It included 50 PWPF, 50 managers and 120 employees. According to Chris and Diane (2004), cross sectional research studies are based on observations that take place in different groups at one time. The study was conducted in Abeokuta and Sango Ota towns, Ogun State, Western Nigeria. Abeokuta is the largest city and state capital of Ogun State. As of 2006, Abeokuta and the surrounding area had a population of 449,088. Sango Ota, the capital of the Ado-Odo/Ota local government area, is in Ogun state, Nigeria. It has an estimated 163,783 residents living in or around it (Hoiberg, 2010). The portable water producing factories considered in the study are those where drinking water is being processed and packed into plastic bottles.

Figure 1 highlighted the processes for a conventional water treatment factory. The first 3 steps remove colloids (including some microorganisms) and natural organic matter. Step 4 (rapid sand filtration) removes much of the colloidal material remaining after step 3 (sedimentation) (Hillis, 2000).

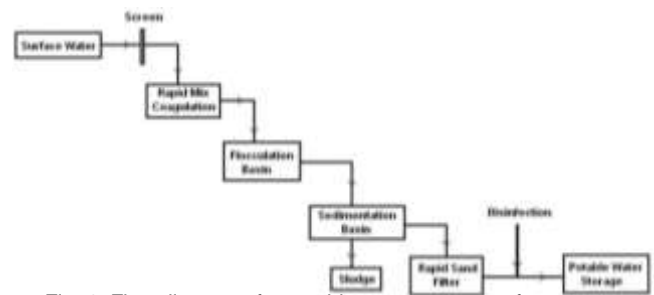


Fig. 1: Flow diagram of a potable water treatment factory

The activities involved in the industry are transformation of raw water into packaged portable water, product bottling, pumping, storage, treatments, securing with secondary packaging and storage until finished products are shipped outside of the factory.

2.2 SEMI STRUCTURAL INTERVIEW AND QUESTIONNAIRES

Information regarding various work study approaches adopted by the employers was recorded from 170 subjects (50 employers and 120 employees) through interviews and some structured questionnaires. The content included among others, general information about the subjects, employees' work condition, information about annual profits (monetary), factor(s) influencing productivity, the adopted work-study approach and its contributions to productivity. The subjects were asked to rate the work-study elements (method review, utilizations of man/machinery/materials, safety review, working environment, work time standardization, workers performance evaluations, wages incentive, among others (Shyam, 2010) engaged in the workplace on a five scale points (1 = 'poorly/not implemented' and 5= 'adequately implemented').

All potential volunteers agreed, and consents were taken in written form to have the interview conducted after they were informed that their participation was voluntary. Those subjects that were illiterate and were unable to read and understand English language were considered by reading and interpreting it loud to them in their native language (Yoruba). The purpose of the study and the information provided were emphasized. The interview was conducted during their break period and lasted approximately 15 minutes for each subject.

2.3 MEASUREMENT OF PRODUCTIVITY GROWTH

Productivity growth of all the factories studied were assessed for a period of four years (2013 till year 2016). With the required information provided by the managers, the productivity was measured by estimation of the appropriate output and input measures. Sales financial value (in Nigerian Naira) was used as output and the cost of labour and capital (in Nigerian Naira) were used as the output. Equation (1) was used to compute the productivity value for each of the four years period (Jodi and David, 2011).

$$Productivity = \frac{Output}{Input} \quad (1)$$

2.4 MEASUREMENT OF PRODUCTIVITY TRENDS

A numeric scale 1 to 4 was used (1, 2, 3 and 4, in this order, were assigned to the factory that advanced in productivity for each of the four years respectively). All values of productivity computed for each PWPF were initially assigned a score of 1.0 at the beginning of the assessment year (2013). In the followed year (2014), those that recorded higher productivity values above the previous year (2013) were allocated a mark of 2.0, while those without visible growth maintained same score of 1.0. In the year 2015, the factory with positive growth above that of the year 2014 were assigned 3.0 whereas those that maintained the neighborhood of productivity level as of the former year were allocated same value. These procedures were followed for the four years period for all the evaluated PWPF. Mean value for each of the years were derived for all the PWPF and compared. The outcome was used to judge the productivity trend (either increase or decrease) of all the PWPF.

2.5 DATA ANALYSIS

Using Statistical Package for Social Science (SPSS), descriptive statistics was used to describe the basic features of the data. The independent sample t-test was also used to analyse the means of the unrelated groups at $p < 0.05$. The independent t-test appraised whether the means for two independent groups were significantly different from each other or not.

3 RESULTS AND DISCUSSION

One hundred and sixty-two (95.3%) of the total one hundred and seventy subjects (50 managers and 120 employees) that participated in the study from 50 PWPF completed the questionnaires. All the subjects have spent not less than 2 years on their current job with average ages of 48 and 34 years for employers and the employees respectively. The ratio of female to male employees was 1 to 3. The demographics of the workers are presented in Table 1 showing the distribution of the subjects' participation in the study and the average hours spent daily on the job.

Table 1. Statistic of the Participated Workers in 50 Portable Water Producing Factories

Description	Age	Work Hours	Years of working experience
Means	48* (34)	11.5* (10.5)	5.5* (2.5)
Mode	50* (29)	11* (9.5)	6* (3)
Standard deviation	2.2* (3.5)	0.5* (0.5)	1.2* (0.65)

* = employers, () = employees

3.1 AVERAGE PRODUCTIVITY TRENDS

Table 2 shows the productivity trend of ten selected water factories. The selection was done such that at least one out of all samples with the same numerical values for the '4years average (ratings)' (column 6) was selected. Out of the expected 4.0 mark, no factory scored up to an average of 2.0. The highest however was rated 1.75 (43.75%).

Considering the scenario noted with sample 'B', the productivity increased from 1 to 2 in the year 2014. In the

followed year, the productivity dropped and was rated at par with the level attained in year 2013. It regained the strength in year 2016 and was rated as same with the productivity position in the year 2014.

Table 2. The Productivity Trend for the Selected Portable Water Producing Factories

Factories	2013	2014	2015	2016	Average (rating)	Productivity (%)
A.	1	1	1	2	1.25	31.25
B.	1	2	1	2	1.5	37.5
C.	1	1	2	3	1.75	43.75
D.	1	2	2	3	2	50
E.	1	1	2	2	1.5	37.5
F.	1	2	2	3	2	50
G.	1	1	2	3	1.75	43.75
H.	1	1	2	2	1.5	37.5
I.	1	1	1	2	1.25	31.25
J	1	1	2	3	1.75	43.75
Means	1.0	1.0	1.7	2.5	1.625	40.6
Expected	1	2	3	4	4	100

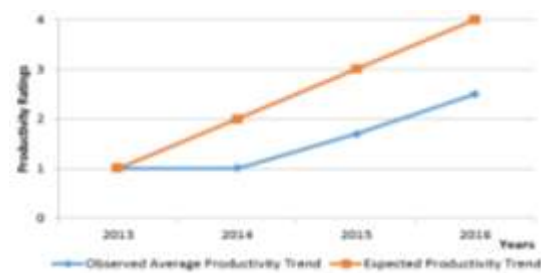


Fig. 2: Productivity trends compared with the expected

Figure 2 displayed the position of the assessed factories when compared with the expected. The data distribution shows that, throughout the four years period, generally the productivity ratings of all the industry measured were below the expected and therefore stood at an average of 40.6%.

3.2 FACTORS INFLUENCING PRODUCTIVITY: EMPLOYEES REPORTED

From Figure 3, use of wrong methods (23%), employees age (28%) and employees' disloyalty (51%) ranked high among the reported employees' personal related factors that influenced productivity trends of the industry. On managements' responsibilities related factors, low workers' pay (57.7%), lack of employees' exposures to trainings (54.5%) and poor workers' inspection (38.2%) were recited. Unsafe workplace (67.7%) was the highest recorded among the category of workplace organization and equipment's layout factors. Others in this group included; poor condition of machinery (14.3%), wrong location of raw materials (17.7%).

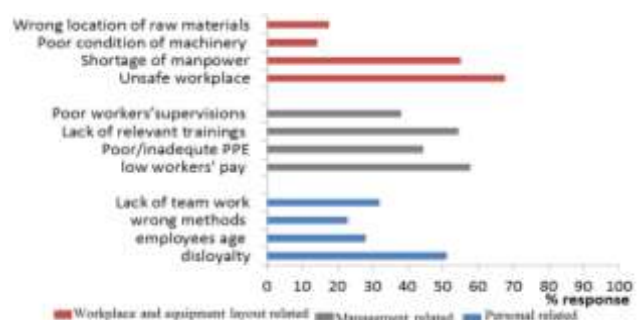


Fig. 3: Employees' response to factors affecting productivity

3.3 ADOPTED WORK STUDY APPROACHES TO PRODUCTIVITY ADVANCEMENT

3.3.1 EMPLOYEES' REPORTED

Figure 4 shows the response of the employees to the various work study elements visibly adopted to ensure higher productivity. 78% mentioned that the usage of machinery for production are maximized in terms of running with minimal down time, 68% reported that human resources wastages are minimize just as 58% said workers' performances were frequently evaluated. Work demand study, work method review, safety practices review, good working environment, work time standardization and wages incentive implementation were all reported below average (25%, 12%, 10%, 10% and 6% respectively).

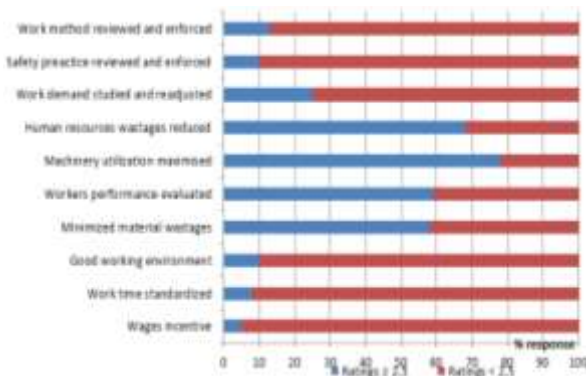


Fig. 4: Employees' responses to work study approach adopted by their employers

3.3.2 EMPLOYERS' REPORTED

Among the commonly reported approaches by the employers and as shown in Figure 5, 70% rated utilization of their machinery above average, this was followed by effective usage of their workforce (64%), maximizing material resources (62%), regulating work demands (56%) and promotion of safety practices among the workers.

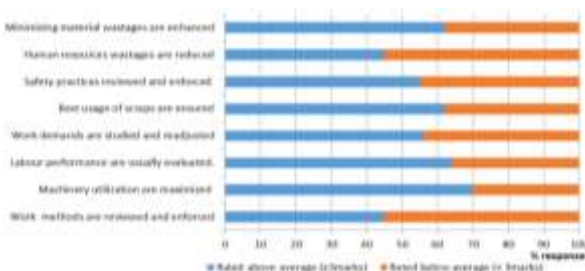


Fig. 5: Employers' responses to work study approach

3.4 EFFECTS OF WORK-STUDY APPROACH ON PRODUCTIVITY

As reported by the employers (Figure 6) higher production level and elimination of materials wastages highlighted by 67% and 66% respectively were among the commonly reported. Following these were the creation of more employment opportunities (46%) and increments in workers' wages (41%).

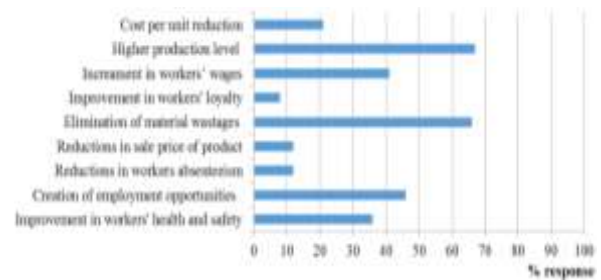


Fig. 6: Employers' reported effects of work-study approach on productivity

3.5 STATISTIC RESULTS

The result of independent-samples t-test in Table 3, which appraised whether the means of employees ratings' group and the employers ratings' group regarding the various work-study elements approaches adopted by the managers in the industry, found that in the case of machinery utilization maximization the employers' ratings statistically significantly lower (mean=3.6364, SEM= 0.06913) to that of employees (mean=3.7333 SEM=0.6645) $t(169) = 0.641, p=0.522$. The means of the two groups were therefore significant. Human resources management ($p=0.235$) and workers' performance evaluation ($p=0.906$) were also significant and rated above average. However, work-method review ($p=.0001$), safe work-practices ($p=.0001$) and work-demands reviews ($p=.0001$), were not significant.

Table 3. T-test Results on the Differences Between the Ratings of the Employers and the Employees to Various Work Study Approaches in the Industry

Tested variables	Means Values		t-value	Sig. Values	Decision
	Eyers	Eyees			
Work method review	3.7500	2.3636	.589	.0001	Not sig.
Safe work-practices	3.7167	2.2451	.4123	0.001	Not sig.
Plant utilization	3.6364	3.7333	.641	0.522	Sig.
Human resources management	3.8000	3.9818	1.183	0.235	Sig.
Workers' performance evaluation	3.8000	3.7818	.029	.906	sig.
Work-demands studied and readjustment	3.9333	2.4455	8.478	.0001	Not sig.
Material wastages minimization	3.4213	3.512	.542	.703	sig.

Eyer= Employers, Eyee=Employees

Work study was described by Mishra (2015) as one of the major means of enhancing production efficiency of an organization. The technique identifies non-value adding operations through investigation of all the factors affecting a job. The present study evaluated the productivity trends, and the various contributions of work study elements to advancing productivity, in some Portable Water Producing factories (PWPF) in the Southwestern Nigeria. The findings from this study suggested that the average productivity growth of the assessed factories was rated 'below average' going by the position of the estimated annual productivity (40.6% rating), for the 4 years assessment periods, compared with the expected (100%) growth. Improving productivity in the sector requires doing the right things better and making it a part of continuous process.

Among the key steps which the industry needs to undertake toward this goal, William (1999) mentioned: development of productivity measures for all operations; expansion of methods for achieving productivity improvement such as soliciting ideas from workers, re-examining the way work is done, team work practice among workers; safe work practices such as development of safety program, work review; elimination of waste in all forms; considerations of workers' comforts and incentives among others. These can be achieved by using work study approach and evaluation of performance.

As reported by the employees and equally confirmed by their managers, the approach commonly adopted by most administrators in the industry included maximizing usage of machinery and reduction of human and material wastages. However other equally important elements such as review of work demands, training for skill acquisition (most especially in proper work-method, safe work practices), which are human factors in the application of work study, seemed neglected. These were evidence by the employees' complaints and grievance for inadequate attentions to the human factor elements (HFE) of the work-study approach. Low workers' pay, lack of relevant trainings, unsafe workplace among others were highlighted. The oversights were also confirmed with t-test statistical analysis result where 'work method review', 'safe work-practices' and 'work-demands studying and readjustment' rated by the employees and the employers were not significant. The mean rating values of the employees (2.3, 2.24, 2.4 respectively) on the HFE signified they were poorly considered in the operations and the management of the industry. These may have developed the disloyalty reported among the workers and may have also influenced the productivity level of the industry.

According to Kwon (2009), though the productivity of an enterprise is affected by various factors such as labour (human capital), material, land, machine, capital, technology, product and management, human capital is the most important. Woodhall (2001) however mentioned that the investment on human capital (such as health, knowledge, motivation) is more effective than that of the physical capital (such as machinery). Exposure to workplace ergonomics training, for instance, allows workers to perform better- handles tasks more efficiently and more quickly. The employee can also apply more new ideas and be more innovative. This leads to more output per hour worked while productivity is higher.

One of the major challenges of many organizations is to continuously develop new solutions and strategies to manage workplace, as well as explore new and effective methods of doing things. Review and/or improvement in work method were however mentioned to have significant impacts at improving productivity level and have been successfully used by many industries. As reported by Yana (2012), this may include among others, professional development of the work force, automation and information technology, supply chain management, lean production methods and quality improvement

programs. The administrators of the industry however need to be adequately informed of the several advantages that come with work method review and improvement in their decision making processes. It can help to promote; high level of productivity, team work, workers' personal learning and growth, various on-the-job experiences among others.

Daly and Bound (1996) mentioned that provision of work adjustments by employers for his employees was an important decision at maintaining productivity growth. Such decision may include: the possibility of postponing work, working at a slower pace, taking longer breaks, shorting the workday, early closure from work and doing the work later, or working from home. Work adjustments, if properly executed, can fast track development of an organization. It can help to improve the health and well-being of workforce, reduce absenteeism, enhances employee sense of responsibility and loyalty and by extension increase productivity.

4 CONCLUSION

This study evaluated level of work-study approach to productivity advancement in Southwest-Nigeria Portable Water Producing Factories (PWPF). The study identified some key ergonomic and, human factors elements' oversights responsible for low productivity gain trend identified with the sector. Assessment result indicated that the highest among the factories productivity performance was rated 43.75%. On the average, the productivity level of all the industry evaluated was ranked below average. Employees' disloyalty, low workers' pay, lack of relevant trainings, poor remunerations and unsafe workplace were however mentioned, by the employees, as the major factors that influenced the productivity level of the industry. Comparing the means of the reported ratings of the employees with that of the employers, using t-test statistics analysis, proper plant utilization, maximizing human resources, workers' performance evaluation and reduction of material wastages were significant and were the mostly adopted work-study approaches among the study domain.

Work-method review, safe work-practices, work-demands studied/adjustment, which were key attributes of work-study approach and responsible for minimizing employees' injury and comfort, were not significant. The authors, however, concluded that the neglects of human factor elements - key attributes of ergonomics techniques of work-study approach, must have greatly contributed to the weak productivity trend of the industry and should be properly addressed to enhance productivity growth.

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