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# A STRATEGY FOR MANAGING THE VARIABILITY IN LABOUR PRODUCTIVITY OF MASONRY BLOCK-LAYING ACTIVITY ON BUILDING CONSTRUCTION SITES IN SOUTH-EAST ZONE, NIGERIA

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***Abstract***

*Proper management of labour productivity variability and application of corrective measures taken to achieve the required level of productivity will help keep the project on track, as well as influence the timely completion and cost control of building works. This studyproposes a strategy to model the variability of masonry crew productivity in block-laying activity,building on the theoretical basis of baseline productivity. The study relied on the analysis of labour productivity data from construction sitesof single storey residential buildings across the urban centers of Enugu, Anambra and Imo Sates of South-East of Nigeria. A field survey involving a stratified random sample of 30 projectswas conducted. Data were collected using standardized data collection procedures that focused on task-level labour productivity, specifically, the measurement of work accomplished by a single crew in a single shift. Analysis showed that when daily productivity values fall between the control limits, productivity loss is within normal variation, while daily productivity values that fall above the upper control limit implies that productivity loss is indicating an abnormality caused by certain influencing factors that need to be identified and remedied.The average of the labour productivity values for block-laying that may be considered as the lower control limits (baseline norm) of the States were found to be 0.801manhr/m² or 1.248m² / whr, while the performance gap value was found to be 0.257manhr/m² for block-laying , indicatingample room for improvement. The results conclude that site managers should close up performance gap by reducing the disparity between expected baseline productivity and current mean productivity for improved performance in execution of building projects.*

**Keywords:** Building Construction, Masonry Activities, Labour, Productivity Variability, Performance.

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**1: Introduction**

Construction industries are considered high-risk by contractors due to their relatively high labour components. It has been observed that the construction workforce, especially in developing countries, is not seen as an important input despite the fact that labour generallyconstitutes a large percentage of total construction cost, of up to 40% of direct cost in large projects, (Kazaz, Manisali and Serdar, 2008). Consequently, there is a continuous interest in productivity studies because of the importance of labour productivity in the management and control of project costs.Hendrickson and Au, (2003) maintained that good project management in construction must vigorously pursue the efficient utilization of labour, material and equipment, and that improvement of labour productivity should be a major concern of those responsible for the cost control of facilities being constructed.Thus, the efficient utilization of available but scarce resources is pertinent to theimprovement of the building construction sectorof developing countries (Idiake 2012).Unfortunately, labour (craf-tmen), which constitute about 60% of direct construction workforce in a project site, is the most vulnerable and grossly mismanaged resource in the local building construction sector (Chitikara, 2006). Over time, the trend has not shown any marked improvement in labour performance and this has resulted in the influx of craft-men from the neighboring African countries such as Ghana, Togo, and Bene Repulic. Rojas and Aranvareekul (2003), posited that improving productivity is a management issue, and that the use of modern techniques are helpful in providing new opportunities. Abdel-Razek, Hany, and Mohammed (2007), discovered that one of the problem associated with construction productivity is the possibility of its variation, not only over the duration of the activitybut across geographical locations, and thusconsidered one of the most important risks in a construction project when compared to other cost components,( Hanna, Chang, Sullivan and Lackney, 2008). Therefore, it is believed that a better understanding of the effects of variability of labour productivity on project performance would enhance its regulation and enable a construction manager to deliver his project within budgeted cost and schedule.

The scenario implies the need to examine the existing situation, in order to explore a successful strategy that can be implemented to evaluate productivity against an objective criterion. Taylor, (1928) has emphasized the application of the scientific method in business, bycomparison of work methods through work measurement, (a concept of lean production).Nigeria as a developing country, it is evident that the building construction sector has long suffered from poor level of productivity and budget overruns over the years, (Olugboyega, 1998, in Idiake, and Kabir,2012; Odesola, 2012).Given this situation, utilizing the lean construction tools (benchmarking and variability reduction), will bring improvement to the Nigerian building construction sector and would be pertinent to the delivery of building projects in South-East, especially given that no such studies on has been conducted in this region.This research, thereforeexamined the variability in labour productivity of masonry block-laying activity with the purpose sto improve the system performance of local building contractors on site.

## 2: REVIEW OF RELETED LITERATURE

### 2.1:Task or activity level Productivity Measures

Kingstom and Means, (2005), stated that task or activity level metrics are widely used within the construction industry, and deals with specific construction activities such as block-laying, concreting, to mention but a few. Most task level metrics are single factor measures such as average labour (ALP) productivity and focus mainly on labour productivity.Typical task level metrics estimate how much of a given output is produced by a designated crew in a normal 8-hour workday and is expressed as; **Productivity=Quantity output/Crew-day hour.** This means that for a chosen crew-day, higher output gives a better result of labour productivity.

However, in existing practice, hourly inputs are widely used to measure labour productivity in construction research, considering labour hour as input unit and physical quantity of the completed work as output, (Hanna, et. al., 2008, and Yi and Chan, 2014).Thus, based on the simple input and output concept, labour productivity for construction operations in this study is defined by: **Labour productivity = Work hour/ Installed quantity.**

Much attention has been paid to productivity measures at National and Industry levels of which are of more interest to economists, of recent construction researchers have been interested in productivity at micro level focusing mainly on labour productivity.As one of the consideration in this research is the development of a methodology that could be used to quantify the effects of labour productivity variability affecting performance, and influenced by several factors ( project and labour related), it is observed that there have been several approaches to the classification of these factors by researchers, but the most widely accepted classification is contained in the United Nations report of 1965, (Enshassi, Mohamed, Mayer and Abed, 2007).The report stated that in ordinary situations the two major factors influencing site labour productivity are, organizational continuity, (relating to the physical components of the works and design details), and execution continuity (relating to the work, and how well it is organized and managed).The model classifies factors into those related to work environment and those related to the work to be done.The conclusion of the UN report was validated by research conducted by (Thomas, Malony, Horner, Smith, Handa, and Saunders, 1990), which led to the development of the factor resource model and later extended in (Thomas, Horman, Sousa and Zarvsky, 2002). The factor resource model of (Thomas, et al., 2002), provides the theoretical base of this study.The steps in the development of the framework comprise;

(**1**)Inputs resources required for the production (labour and materials, tools ); (**2**)Conversion machinery (involves processing of all input resources, using appropriate work methods). (**3**) Products (inform of output quantities and work hours); (**4**) Data on labour productivity, (which is the ratio of input values and output values) will be collected resulting from the conversion process;(**5**) The productivity data generated in no3 above will be synthesized and observed for variability.(**6**) The result of no 4 will be regulated and benchmarked for improved labour performance.(**7**) The ultimate goal of the previous steps is summarized in step 6, in that the variability level is compared with the index of performance proposed, to enable benchmarks to be established for improved performanceThis study employed this framework to examine the effects of productivity variability on labour performance, with the view to its regulation and benchmarking project results, using productivity data obtained from building sites across the area of study.

**2.2: Factors Affecting Construction of Labour Productivity**

As the focus of this study is on improving productivity at the job site, the related literature review focused on factors affecting labour productivity at the micro-level. The discussions on the factors affecting construction productivity are both numerous and diverse. The necessity of identifying factors affecting labour productivity and the importance of conducting the research in every country is due to the effect of context on productivity, and is the reason behind the large number of studies on the topic (Ghoddousi, and Hosseini, 2012). As a result, study of factors affecting labour productivity has been treated as a context-reliant phenomenon, and researchers have limited their area of investigation to one country, and in some cases, to one section of the construction industry (Abdel-Razek, 2004; Mojahed and Aghazadeh, 2008). Literature has indicated a fairly similar array of factors as influencing productivity, especially in countries with comparable economies (Yi and Chan, 2014; Ghoddousi and Hosseini, 2012), but the order of importance scale of the effects of the factors on labour productivity is not the same for all countries, (Dai and Goodrun, 2011). However, the literature review has provided a pool of factors that may be considered relevant for labour productivity studies, and can be summarized as; lack of Labour skill and experience, Lack of materials, worker absenteeism, motivation system, lack of tools, labour skill, gang size, rework, power or water disruption, interference, management practices, accidents, climate condition, inspection delays, safety, job size and complexity, and labour age.

**2.3: PROJECT PRODUCTIVITY ATTRIBUTES**.

As the method of benchmarking is geared towards identifying the reasons behind the gap between the performance of the organization and its competitors, the typology presented by (Yi and Chan, 2014) confined benchmarking at project level. Mostly, studied have used the benchmarking method to enhance construction productivity building on the concept of productivity baseline, which means of setting standards or targets of performance. In relation to construction, the baseline productivity has been defined by researchers in different ways. There is no universally accepted methodology for computing construction baseline productivity. Proposed methodologies by different researchers are;

Sweis, et al., (2009) described baseline productivity as a numerical measure that shows the best productivity value a contractor is able to achieve from a particular project, when there are few or no disruption. They stated baseline productivity as the average of the daily productivity values that fall below the lower control limit (LCL), because productivity values that are below the LCL have the highest daily production or output. Thomas and Zavrsky, (1999); and Thomas and Sanvido,(2000) considered it as the median of individual productivity values in the baseline subset, based on best daily production or output and 10% requirement for the baseline sample size. Gulezian and Samelian, (2003), regarded it as the mean productivity of the points falling within the control limits of the individual control chart, which is within the normal operating performance of the contractor. Odesola, et. al., (2015), regarded it as average of the daily productivity values above the center line (CL), but below the upper control limit (UPL), based on the metric of productivity used in his study.However, (Ibb's, Ngujem, and Lee,2007), believed that the limitations of (Thomas and Zavrsky 1999 and Thomas and Sanvido, 2003) methodologies are that, baseline sample should be based on best daily productivity instead of best daily output, and 10% requirement for the baseline sample size is subjective, and not based on any scientific principle. Seweis, et. al., (2009), also opined that baseline productivity as the best or highest productivity devoid of any disruption; which (Ibb et. al., 2007) noted is also not attainable in real life. In this study, the statistical control limits proposed by (Gulezian and Samelian, 2003) provides a good basis for computation of baseline productivity. The underlying theory of this labour productivity variability modeling is that in general; the work of a crew is affected by a number of influencing factors that might lead to loss of productivity.

Baseline productivity as the best productivity a contractor can achieve on a particular project in a case where there are few or no disruptions. Difference in baseline productivity values from one data base to another is mainly due to work method and skill (Sweis, et. al., 2009).

The model representation is shown in figure 1.

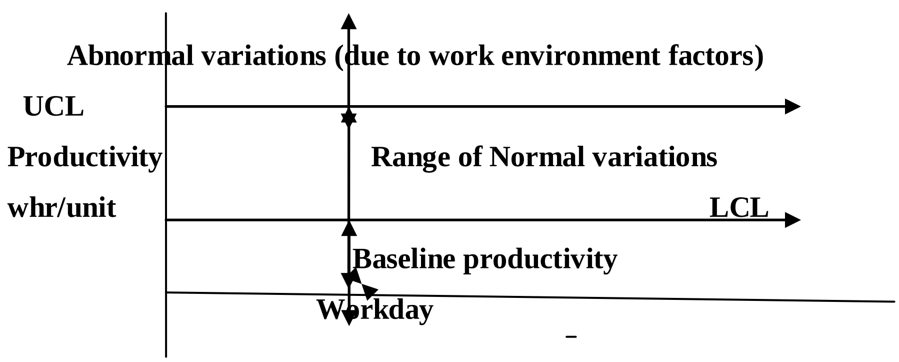


**Figure 1: Conceptual Representation of Labour Productivity Control Chart**

**Source, (Gulezian and Samelian, 2003, cited in Sweis, et. al., 2009)**

**2.4: Single Project Evaluation**

Thomas and Zarvsky (1999) introduced site-based standard for measuring labour productivity of construction activities- known as the theoretical model for international benchmarking of labour productivity- an analytical approach to compare labour productivity of one project to another.

The main application of the method is for comparing labour productivity of a construction activity internally or to that of another project, thereby establishing the baseline labour productivity. Afterwards, the model enables the researcher to compare the performance of project management as a determinant of baseline productivity in different projects for the same activity (Ghoddousi, et. al., 2014) .The framework illustrating the model is shown in figure2.

**A single project Evaluation model**

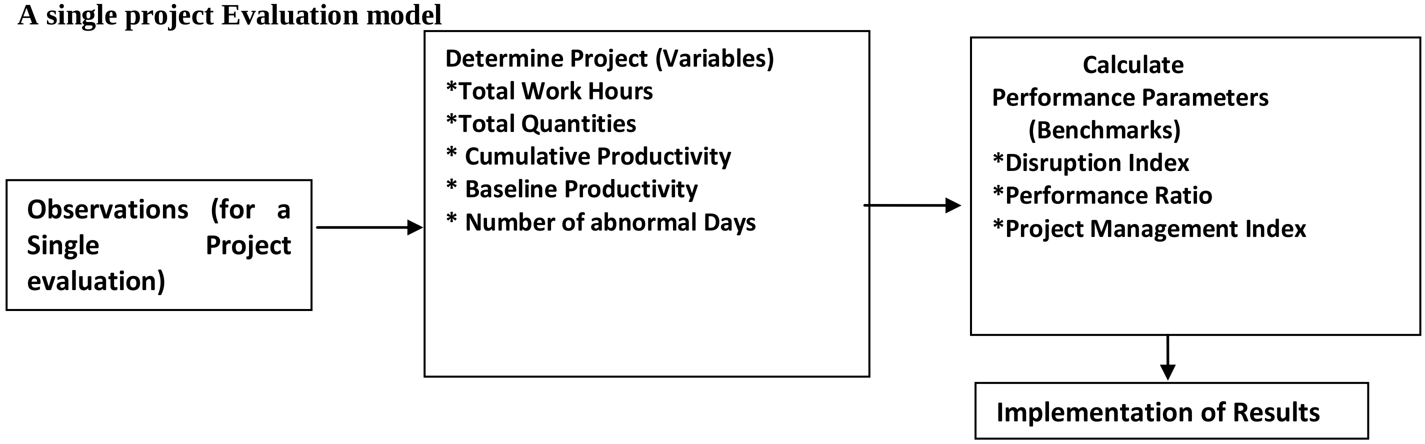


**Figure 2; Theoretical Model for Single Project Evaluation**
**Source: (Thomas and Zavrsky, 1999 in Abdel-Razek, et. al., 2007; Ghoddousi, et. al., 2014).**

**Productivity Variability and Labour Performance.**

. Variability in construction is universally believed by researchers as an inhibitor of project performance, (Thomas, et. al., 2002, in Idiake and Shittu 2014).. Thomas, et al., (2002) believed in flexible capacity management as a tool to manage variability because of its essential capacity, and is receptive under varying situations. Poorly performing projects exhibit higher variability in productivity when compared to projects that perform well, (Abdel–Razek, 2004; Thomas, Anu and Sudhakuma, 2013).

Thomas and Zarvaski, (1999), calculated variability in daily productivity using the following mathematical equations: **Variation (Vj) =** $\sum \frac{\sqrt{(\mathbf{urij} - \mathbf{baseline\ productivity})2}}{\mathbf{n}}$

Therefore, coefficient of variability is calculated for each project as follows (Thomas, et al, 2002);

**Coefficient of variation (Cvj) =** $\frac{\mathbf{Vj \times 100}}{\mathbf{Baseline\ productivity}}$

Normally, the variability concept is often used in a defined operation in a defined environment. Such a study would reveal a performance gap, which could be utilized for improvement within the process and is limited to the practices employed in the operation, the essence of benchmarking. Abdel-Razek, et al., (2007), suggested that better labour and cost performance can be achieved by reducing variability and measuring bench-marking. In this research, productivity variability is utilized to identify the performance gap in labour productivity.

**2.5:.Project Productivity Measures (Variables)**

The project characteristics (productivity measures and performance parameters) constitute the elements of the benchmarking model, explained by as follows (Thomas and Zavrsky, 1999 in Thomas et. al., 2002;Ghoddousi, Behzad, Hosseini and Chileshe 2014);

**(i)Total work hours:** ∑of daily work hours in each project.

**(ii)Total quantities:** ∑ of daily quantities of completed activities on each project.

**(iii)Cumulative productivity (CP):** The measure of the inclusive effort necessary to implement the work, calculated as;

**Total work-hours**

**Total quantities**

**(iv)Baseline Productivity (BP);** for each project is calculated by determining the range of random variability in daily productivity values when the project is satisfactorily managed.

The boundaries for the range are upper control limit (UCL) and lower control limit (LCL). The UC and the LCL can be calculated by applying the steps adopted by(Nelson, 1984, in Ghuodossi, et. *al.* 2014).The baseline productivity for each project is considered as the average of the daily productivity values that fall below the LCL, which the method used in this study.

**(v)Abnormal work-days**:Abnormal workdays are the work days when the project experienced disruptions. Ghoddousi, Yavari, and Hosseini (2010), also observed that the random variability rate of daily productivity values in cases when a project is working reasonably is about twice the average baseline values of all the projects in any data set. However, in this research, productivity values that fall outside the UCL is considered an abnormal or disrupted day.

**2.6: The Performance Gap Concept**

Thomas and Samvido (2000)), stated that the basic performance gap model assumes that;

(i)The construction process resulting in the same type of output, have some form of productivity distribution.

(ii)The distribution which defines the productivity variability provides an opportunity for its improvement.To achieve this, it is necessary to improve identified practices by eliminating or reducing operational and system inefficiencies through the application of lean constructionprinciples in order to achieve optimal productivity, ( Song and Rojas, 2010).

(iii)This can be quantified by determining the difference between the mean baseline productivity (Expected mean productivity (EMP) and Actual or Present mean productivity (PMP.The upper labour productivity value provides the gap which can be ascertained through analysis by individual construction firms. This is represented here by the equation, **performance Gap = EMP – CMP.** The gap between EMP and CMP is dynamic in nature and necessary within the benchmarking concept.

**3:1: THE STUDY AREA**

.The states chosen for this study out of the five states of the south-east are **Anambra, Enugu, and Imo states**. The choice of the three states stems from the fact that they have higher population figures, and hence population densities, (NPC, 2009), Table 3.1.The three states constitute a good representation of South East in terms of cultural, demographic and labour management practices.

**AnambraState** has 13 local government areas is located in the south central area of South-East Nigeria at coordinates 6* 20N and 7* 00E. It has a projected population of 4,538, 684 million people, (NPC, 2009; NBS 2009), which ranked it 10 out of 36 with an average population density of 860 persons per square kilometer. The total land area is 4,844.00 km2.

**Enugu State** was created in 1991 with Enugu as capital, Enugu urban has three local governments, namely Enugu North, Enugu South, and Enugu East. It is located at latitude 06* 30N and longitude 070 30*E in theSouthern part of Nigeria. The state has seventeen (17) local government areas with a population of 3, 570, 854 million people, projected to 3.8 million in 2012, (NPC/NBS, 2009).

**Imo State** was created in 1976 with Owerri as capital and largest city. The state is within latitude 4* 45N and longitude 6* 25E. The state has seventeen (17) local government areas with a population of 3, 570, 854 million people, projected to 3.8 million in 2012, (NPC/NBS, 2009).

**Table 1: Population and Percentage Distribution of Household by housing type and housing Tenure**

| State | Population ( Millions) | Whole Building (%) | Tenure (owner occupier) |
|---|---|---|---|
| Abia | 3, 082, 135 | 49.30 | 70.70 |
| Anambra | 4, 538, 684 | 44.70 | 77.20 |
| Ebonyi | 2, 417, 814 | 20.20 | 88.20 |
| Enugu | 3, 570, 854 | 54.20 | 65.90 |
| Imo | 4, 316, 803 | 74.50 | 80.70 |

**Source: (NBS, 2009)**

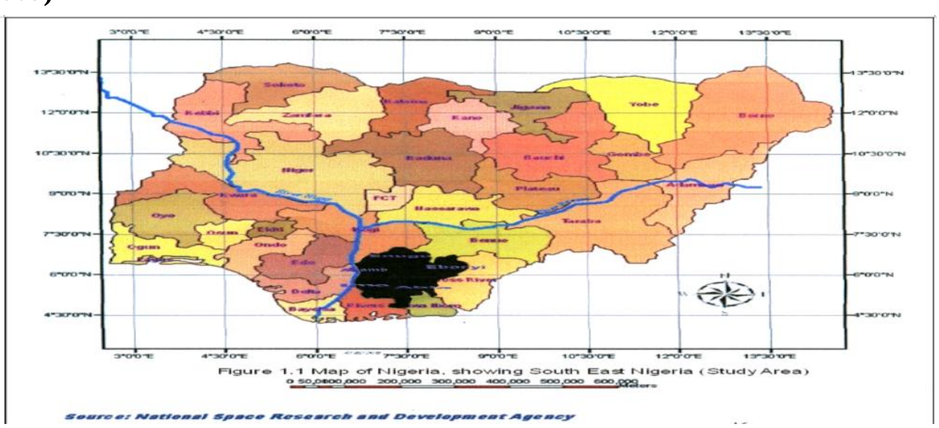


**Figure 3: Map of Nigeria Showing the South-East States**

**Source; https://www.mapsofworld.com/lat_long/nigeria-lat-log.html.**

**3.2:Building Construction and Labour Productivity Norm**

NIOB-NBCS, (2005), explained that craft-men are people who directly apply their human skill and ingenuity on construction work that all together produce a complete building structure of different designs and types. By training, craft-men have acquired hand-on-tool vocation, physical vigor and resilience to perform the practical construction work such as masonry, carpentry to mention a few.

A labour productivity rate is defined as number of units of work produced by a skilled and well-motivated worker, in a specified time and usually in man- hour or man-day. The time that a labour will consume on performing a unit of work varies between labor and between projects; and with climatic conditions, job supervision, work complexities of the operations, and others. Knowing the cost of employing a trade's man and his expected output will give the total cost contribution of the craft-men, which is an important aspect of estimating, cost control and worker perform. Data and information regarding house type's chosen for this research is limited to formal houses for human population, such as flats, semi-detached and detached houses which are prevalent in the area of study

**Activity and Material Description**

According to Paterson Board of Education, Facilities and Ground operations 4235 USA-masons are skilled tradesmen that perform all general masonry works involved in the construction and maintenance of block, brick, stone or concrete structures. In order to maintain consistency in performing the site productivity observations and interpreting the results, a standard for describing masonry activities was adopted, using the reference codes in the current edition of the Building and Engineering Standard Method of Measurement as issued by the **Nigerian Institute of Quantity Surveyors (NIQS), 2015**. Sandcrete blocks in production comprises of sand, water and binder (cement). Cement is an expensive input in the production of sandcrete blocks. Sand aggregate may be classified natural or manufactured. Since the 1920's, sandcrete block has been recognized as the material for construction of shelters in Nigeria. As a result block production firms developed since materials such as cement, sand, stone chippings are available as inputs used. In this study, mainly 450 x225 x225mm vibrated hollow Sand-crete blocks for both external and internal walls were supplied to the sites and used to erect 225mm thick cement-sand vertical wall with 12mm thick cement-sand motar joints.

**Availability and Characteristics of labour in the Area of Study**

The result of survey of some building construction sites conducted **a**cross the geographical states of Anambra, Enugu and Imo, revealed that employment of construction labour ( skilled and un-skilled) artisans, are predominantly casual and migratory in nature, occasioned by desire to search for places of better conditions of remunerations. Skilled workers generally are the artisans and comprise of the masons, carpenters, steel fixers, tilers, painters, electricians and plumbers, while the unskilled workers perform general labour works as attendants (helpers) to the skilled artisans. These categories of artisans use the traditional working implements of the building trades, and their services can be sourced from the labour market shops available in designated locations within the urban centers and suburbs of the states. The other classes of higher skilled workers available are the site project engineers and supervisors. Because labour productivity involved management of labour, project Engineers and supervisors are usually regarded as middle managers and responsible for coordinating the instructions passed down from the upper level managers for implementation by the craftsmen who are directly engaged on the site works.

**4.0: METHODOLOGY**

Reliable data from which the theoretical population size could be obtained was not available, a pilot study was conducted, using a team of research assistants in each state of the study area during themonths of May to September 2017. In other to achieve the purpose of this research, construction sites were identified through visits to ongoing project locations in the study area. The research samples were drawn from contractors currently constructing buildings works within the study area, and who have accepted the requestfor assistance were identified (purposive sampling). Pilot study was conducted to compare the labour productivity rates in the selected states with the purpose to ascertain if significant different exist across the states.

A total of 10 building projects for each state was actually enumerated (Quota/purposive sampling), giving a total of 30 building projects.The pilot study **r**equired daily site visits to record the **dates, number of workers, starting time, closing time, and measurement of length/ breadth of work done (quantities) of each work crew** on the instrument designed for the purpose. As a result, a total of 529 observations (data points) were obtained from the construction sites for Block-laying activity.

Data Collation **and Analysis of Masonry works collected** provided for the computation for each project, the values of **total work hours, total quantities, total work days, average daily productivity, cumulative productivity, Control limits, baseline productivity and abnormal days** as project characteristics (attributes). These attributes were used in the analysis and computation of project performance (benchmarks) for each project for the block-laying work trade, using the lean benchmarking approach of calculating performance, based on international mathematical model for benchmarking of labour productivity, (Thomas and Zarvsky, 1999, inSweis, et. al., 2009, Ghoddousi, et. al., 2014) The data collation summaryand analysis of the project characteristics (attributes) of the projects surveyed are numbered (1-10) for Anambra, Enugu and Imo states are illustrated in tables 2, 3 and 4 below.

**Table 2: DATA COLLATION AND ANALYSIS FOR BLOCK WORK ACTIVITY IN (ANAMBRA STATE)**

| SITE | TWH | TQTY | TWD | ADP | MEDIAN | CONTROL LIMITS | | BASELINE PROD. | CP | STD | COPV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | UPPER (UCL) | LOWER (LCL) | | | | |
| 1 | 1089.1 | 1088.67 | 20 | 1.005 | 1.009 | 1.14 | 0.87 | 0.803 | 0.999 | 0.131 | 0.147 |
| 2 | 727 | 658.73 | 18 | 1.122 | 1.157 | 1.257 | 0.987 | 0.884 | 1.104 | 0.173 | 0,154 |
| 3 | 796 | 765 | 17 | 1.094 | 1.091 | 1.238 | 0 950 | 0.841 | 1.041 | 0.203 | 0.227 |
| 4 | 355.2 | 306.13 | 16 | 1.178 | 1.195 | 1.338 | 1.018 | 0.99 | 1.16 | 0.176 | 0.149 |
| 5 | 1089 | 1282 | 19 | 0.854 | 0.853 | 0.961 | 0.748 | 0.702 | 0.849 | 0.123 | 0.144 |
| 6 | 1085 | 980.8 | 17 | 1.169 | 1.156 | 1.346 | 0.992 | 0.812 | 1.106 | 0.321 | 0.275 |
| 7 | 975 | 918.4 | 20 | 1.103 | 1.135 | 1.185 | 1.021 | 0.914 | 1.061 | 0.161 | 0.172 |
| 9 | 1200 | 1105.74 | 17 | 1.258 | 1.245 | 1.440. | 1.076 | 0.937 | 1.181 | 0.308 | 0.245 |

**Source: Researcher's field Survey, 2017**

**Table 3: DATA COLLATION AND ANALYSIS FOR BLOCK WORK ACTIVITY IN (ENUGU STATE)**

| | TWH | TQTY | TWD | ADP | MEDIAN | UPPER (UCL) | LOWER (LCL) | BASELIE PRO | CP | STD | COPV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1509.5 | 841 | 18 | 1.906 | 1.991 | 2.176 | 1.636 | 1.471 | 1.794 | 0.351 | 0.153 |
| 2 | 666.49 | 857 | 17 | 0,793 | 0.747 | 0.928 | 0.658 | 0.584 | 0.976 | 0.147 | 0.185 |
| 3 | 1665.5 | 1189.4 | 16 | 1.478 | 1.385 | 1.718 | 1.238 | 1.066 | 1.4 | 0.293 | 0.198 |
| 4 | 714.4 | 758.73 | 19 | 0.944 | 0.914 | 1.176 | 0.806 | 0.8 | 0.942 | 0.161 | 0.162 |
| 5 | 878.47 | 970.12 | 19 | 0.914 | 0.906 | 1.008 | 0.82 | 0.803 | 0.906 | 0.083 | 0.091 |
| 6 | 428.6 | 344.4 | 18 | 1.25 | 1.249 | 1.458 | 1.043 | 0.956 | 1.16 | 0.245 | 0.197 |
| 7 | 948 | 795.22 | 14 | 1.27 | 1.048 | 1.564 | 0.976 | 0.97 | 1.192 | 0.434 | 0.342 |
| 8 | 1376 | 1054 | 15 | 1.393 | 1.324 | 1.53 | 1.256 | 1.189 | 1.295 | 0.397 | 0.272 |
| 9 | 514.13 | 636.48 | 18 | 0.813 | 0.794 | 0.895 | 0.731 | 0.709 | 0.808 | 0.11 | 0.135 |
| 10 | 1744 | 1595.5 | 19 | 1.104 | 1.067 | 1.234 | 0.978 | 0.918 | 1.093 | 0.161 | 0.145 |

**Source: Researcher's field Survey, 2017.**

**Table 4;DATA COLLATION AND ANALYSIS FOR BLOCK WORK ACTIVITY IN (IMO STATE)**

| SITE | TWH | T QTY | TWD | ADP | MEDIAN | CONTROL LIMITS | | BASELINE PRODUCT | CP | SD | COPV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | UPPER (UCL) | LOWER (LCL) | | | | |
| 1 | 1060 | 1230.3 | 20 | 0.882 | 0.803 | 0.982 | 0.782 | 0.765 | 0.862 | 0.167 | 0.189 |
| 2 | 1163.5 | 1066.5 | 15 | 1.197 | 1.111 | 1.469 | 0.925 | 0.775 | 1.092 | 0.308 | 0.357 |
| 3 | 571 | 540 | 17 | 1.087 | 1.091 | 1.222 | 0.952 | 0.864 | 1.057 | 0.216 | 0.199 |
| 4 | 853.53 | 1336.63 | 19 | 0.624 | 0.627 | 0.659 | 0.589 | 0.578 | 0.622 | 0.037 | 0.059 |
| 5 | 806.34 | 1330 | 15 | 0.597 | 0.6 | 0.654 | 0.537 | 0.516 | 0.606 | 0.049 | 0.082 |
| 6 | 648 | 487.3 | 19 | 1.467 | 1.538 | 2.083 | 1.159 | 0.833 | 1.329 | 0.438 | 0.299 |
| 7 | 1481 | 1970.58 | 16 | 0.788 | 0.788 | 0.917 | 0.659 | 0.627 | 0.746 | 0.125 | 0 159 |
| 8 | 855 | 1056.84 | 18 | 0.856 | 0.853 | 0.953 | 0.759 | 0.729 | 0.838 | 0.069 | 0.085 |
| 9 | 1620 | 2212.4 | 18 | 0.744 | 0.707 | 0.8 | 0.688 | 0.679 | 0.732 | 0.092 | 0.124 |
| 10 | 832 | 757 | 15 | 1.14 | 1.116 | 1.305 | 0.975 | 0.808 | 1.099 | 0.219 | 0.24 |

**Source: Researcher's field survey, 2017.**

To achieve the objective of the pilot study, a hypothesis was postulated that productivity rates of masonry operations of block-laying do not vary significantly acrossthe South-East zone. The hypotheses were tested using ANOVA test for a p-value of 0.05. The rule for rejecting the hypothesis was that, when $\rho \geq 0.05$, the test would reject the hypothesis. The results of the ANOVA tests of the hypotheses are presented in tables 8(i), 8(ii) and 8(iii) for Anambra, Enugu and Imo States.

The results show that there is no significant difference in the labour productivity rates across the three states. This is indicated by ρ-values of 0.951, 0.163 and 0.171 all of which were greater than 0.05-reflecting at 5% significant limit. Having concluded that the productivity rates of masonry block-laying activities do not vary significantly across the states, the data collected were combined and the project statistics are summarized in table 9.

## 5.0:DISCUSSION AND RESULTS

The Objective is to demonstrate the application of labour productivity variability (benchmarks) in regulating the effects of variability in daily productivity on construction sites.The coefficients of variability for all the studied projects are shown table 9. The computed value of coefficient of variation, which is the ratio of standard deviation and the mean of the estimate ranges from 0.059 to 0.680.Figure 4 shows the variability in daily productivity of block-laying activity for project 26 typical among other projects, determined frominput (number of work-hours) to output (quantities installed) relationship. The block-laying task was monitored for project 26 for nineteen days. The total team size employed to construct 487.30square meters of block-work was 81 workmen utilizing a total of 648workhours. This indicates that the construction firm used one site worker to achieve approximately 6.016m² of block-work. The daily productivities ranged from 0.787whr/m² to 2.243whr/m², with a cumulative productivity of 1.329whr/m². This indicates that the labour output was low since the cumulative productivity was greater than unity.The days of 8, 9, 11, and 12 were identified as baseline days and productivities that have the highest score that were considered to the baseline subset below the lower control limitThe average of these scores represents the baseline productivity or benchmark for the project which is calculated as 0.811wkhr/ m².

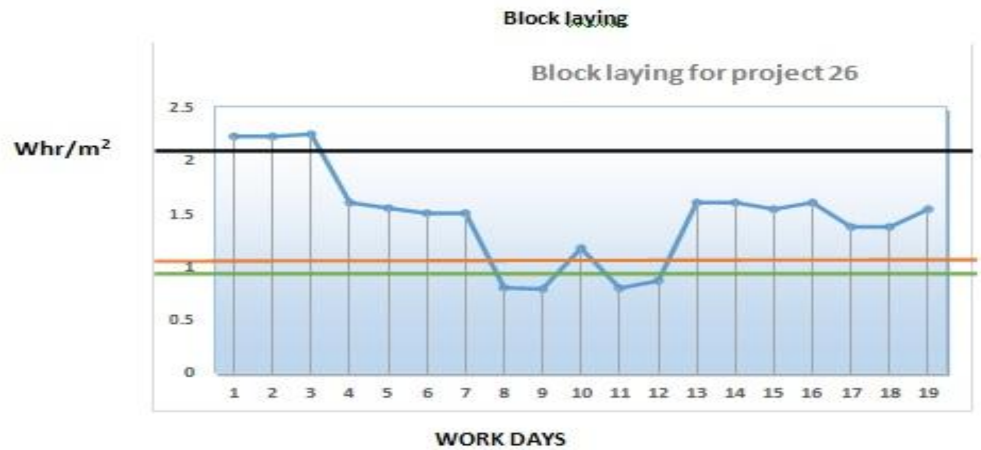


**Figure 4: Sample plot for Block-laying (Project 26), Showing poor Performance.**

The project witnessed two abnormal days for the block-laying task.The project performance ratio was found to be 1.719 which is poor performance compared to all projects investigated, as demonstrated in figure 4 indicating that a gap exists between the daily labour productivities and baseline productivity. The coefficient of variation is computed to be 29.85% which showed that there is room for improvement, because the closer the gag, the better the labour performance.

In contrast, the productivity for project 12was computed to be 0.655whr/m², and the gap between the daily productivities and the baseline provided a coefficient of variation of 6.60%, which produced a better labour utilization by reducing the variability in labour productivity as demonstrated in the sample plot as shown in figure 5

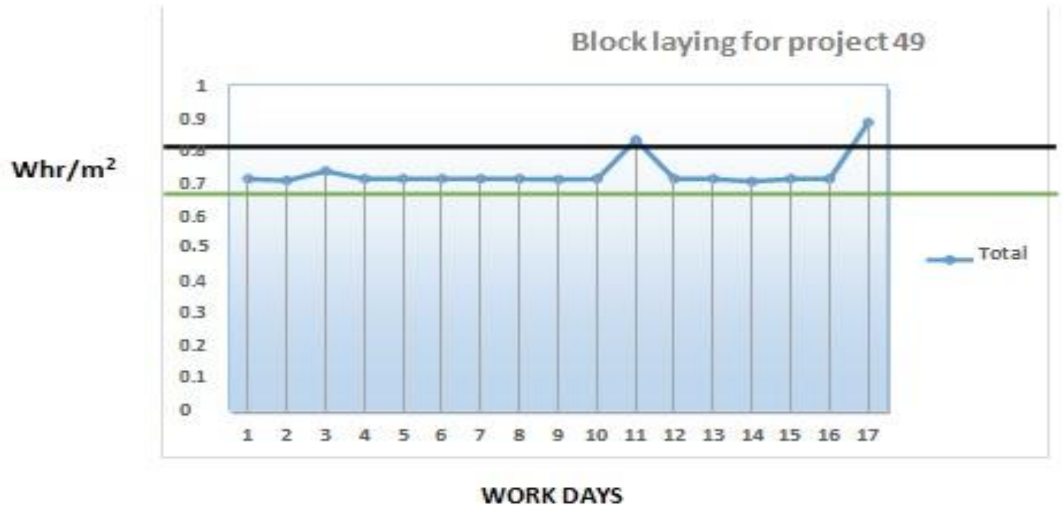


**Figure5: Sample plot of Block-laying for Project 12 Showing Improved Performance.**

**RESULTS**:Variability in daily productivity data was found to be important determinant of between good and poor performing projects in the data base of the 30 projects. Poorly performing projects exhibit higher variability.The baseline for the data base was found to be 0.912whr /m² which can be regarded as the labour productivity norm, is the average of the productivity values that of the lower control limits of all the 30 projects.Dailyproductivities that fall between the lower control limit (0. 912whr/m²) and upper control limit (1.22whr/m²) are within normal within normal variation due affecting factors. Construction manages need not worry since the random variation is part of the open conversion peculiarity of the construction process. When daily productivities fall outside the upper control limit, the loss of productivity is due to significant factor(s) that need to be identified by the construction manager and take action to reduce their effect.

**Conclusion**: It is proposed that site project managers should close up performance gap in project execution by reducing the disparity in values between expected baseline and mean productivity of their project, by applying flexible capacity management, which suggests that reducing variability will bring about improvement in labour performance.The application of a methodology that quantifies comparable measures of productivity levelsand impact of contributory factors among projects is a contribution of this research.

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**Table 5: Data presentation and Analysis of work measurement of Block-laying Activity from (Project 26)**

| S/N Day | Crew size | Daily Input (whrs) | Daily Output Quantities ($m^2$) | Daily productivity whr/m² | Daily Prod, Ranked Whr/m² | Control Limits whr/m² | Baseline Days/ Prod. Whr/m² | (X-x) | (X-x)² |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 | 32 | 14.4 | 2.222 | 0.787 | 0.007 | * | 0.680 | 0.4624 |
| 2 | 2 | 16 | 7.20 | 2.222 | 0.794 | 0.004 | * | 0.673 | 0.4529 |
| 3 | 3 | 24 | 10.70 | 2.243 | 0.798 | 0.067 | * | 0.669 | 0.4476 |
| 4 | 2 | 16 | 10.00 | 1.600 | 0.865 | 0.306 | * | 0.602 | 0.3624 |
| 5 | 6 | 48 | 31.00 | 1.548 | 1.171 | 0.200 | | 0.296 | 0.0876 |
| 6 | 6 | 48 | 32.00 | 1.500 | 1.371 | 0.000 | | 0.096 | 0.0009 |
| 7 | 6 | 48 | 32.00 | 1.500 | 1.371 | 0.129 | | 0.096 | 0.0009 |
| 8 | 4 | 32 | 40.10 | 0.798 | 1.500 | 0.000 | | 0.033 | 0.0011 |
| 9 | 3 | 24 | 30.50 | 0.787 | 1.500 | 0.038 | | 0.033 | 0.0011 |
| 10 | 3 | 24 | 20.50 | 1.171 | 1.538 | 0.000 | | 0.071 | 0.0050 |
| 11 | 4 | 32 | 40.30 | 0.794 | 1.538 | 0.010 | | 0.071 | 0.0050 |
| 12 | 4 | 32 | 37.00 | 0.865 | 1.548 | 0.052 | | 0.081 | 0.0066 |
| 13 | 6 | 48 | 30.00 | 1.600 | 1.600 | 0.000 | | 0.133 | 0.0177 |
| 14 | 6 | 48 | 30.00 | 1.600 | 1.600 | 0.000 | | 0.133 | 0.0177 |
| 15 | 2 | 16 | 10.40 | 1.538 | 1.600 | 0.000 | | 0.133 | 0.0177 |
| 16 | 2 | 16 | 10.00 | 1.600 | 1.600 | 0.622 | | 0.133 | 0.0177 |
| 17 | 6 | 48 | 35.00 | 1.371 | 2.222 | 0.000 | | 0.755 | 0.5700 |
| 18 | 6 | 48 | 35.00 | 1.371 | 2.222 | 0.021 | | 0.755 | 0.5700 |
| 19 | 6 | 48 | 31.20 | 1.538 | 2.243 | Ucl=2.083<br><br>Lcl=1.159 | | 0.776 | 0.6022 |
| | 81 | 648.00 | 487.20 | 1.467 | 1.538 | | 0.811 | | |

***Researcher's Data Analysis,2017***

**Key to Abreviations of project variables;**

**Average Daily Productivity (ADP); Cumulative Productivity (CP); Standard Deviation (STD; Coefficient of variation; Number of abnormal Day =2.**

**Table 6: Data presentation and Analysis of work measurement of Block-laying Activity from (Project 12)**

| S/N Day | Crew size | Daily Input (whrs) | Daily Output Quantities ($m^2$) | Daily productivity whr/m² | Ranked whr/m² | Control limits whr²/m² | Baseline Days/Prod whr/m² | (X-x) | (X-x)² |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 14 | 112 | 157.50 | 0.711 | 0.703 | | | 0.026 | 0.0007 |
| 2 | 12 | 96 | 136 | 0.706 | 0.706 | | | 0.023 | 0.0005 |
| 3 | 6 | 48 | 65.70 | 0.735 | 0.709 | | | 0.020 | 0.0004 |
| 4 | 8 | 64 | 90.00 | 0.711 | 0.711 | | | 0.018 | 0.0003 |
| 5 | 4 | 32 | 45 | 0.711 | 0.711 | | | 0.018 | 0.0003 |
| 6 | 4 | 32 | 45 | 0.711 | 0.711 | | | 0.018 | 0.0003 |
| 7 | 4 | 32 | 45 | 0.711 | 0,711 | | | 0.018 | 0.0003 |
| 8 | 12 | 96 | 135 | 0.711 | 0.711 | | | 0.018 | 0.0003 |
| 9 | 6 | 48 | 67.70 | 0.709 | 0.711 | | | 0.018 | 0.0003 |
| 10 | 5 | 40 | 56.25 | 0.711 | 0.711 | | | 0.018 | 0.0003 |
| 11 | 10 | 80 | 96.25 | 0.831 | 0.711 | | | 0.018 | 0.0003 |
| 12 | 4 | 32 | 45 | 0.711 | 0.711 | | | 0.018 | 0.0003 |
| 13 | 8 | 64 | 90 | 0.711 | 0.711 | | | 0.018 | 0.0003 |
| 14 | 8 | 64 | 91 | 0.703 | 0.711 | | | 0.018 | 0.0003 |
| 15 | 6 | 48 | 67.50 | 0.711 | 0.735 | Ucl=0.80 | | 0.006 | 0.00004 |
| 16 | 6 | 48 | 67.50 | 0.711 | 0.831 | | | 0.102 | 0.0104 |
| 17 | 8 | 64 | 72.35 | 0.885 | 0.885 | Lcl=0.654 | | 0.156 | 0.0243 |
| | 125 | 1000.00 | 1372.75 | 0.729 | 0.711 | | 0.654 | | |

*Researcher' Data Analysis, 2017*

**TABLE 7(i): MEASUREMENT OF VARIATION FOR BLOCK WORK (ANAMBRA)**

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 12.417 | 1 | 12.417 | 9.951 | .014[b] |
| | Residual | 9.983 | 8 | 1.248 | | |
| | Total | 22.400 | 9 | | | |

a. Dependent Variable: Total work days

b. Predictors: (Constant), Average daily productivity for block work (ANAMBRA)

**Residuals Statistics[a]**

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | 16.7580 | 20.1446 | 18.4000 | 1.17461 | 10 |
| Residual | -1.38956 | 2.01838 | .00000 | 1.05318 | 10 |
| Std. Predicted Value | -1.398 | 1.485 | .000 | 1.000 | 10 |
| Std. Residual | -1.244 | 1.807 | .000 | .943 | 10 |

a. Dependent Variable: Total work days

TABLE 7(II): MEASUREMENT OF VARIATION FOR BLOCK WORK (ENUGU)

ANOVA[a]

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | .176 | 1 | .176 | .163 | .808[b] |
| | Residual | 22.224 | 8 | 2.778 | | |
| | Total | 22.400 | 9 | | | |

a. Dependent Variable: Total work days

Residuals Statistics[a]

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | 18.0024 | 18.4444 | 18.4000 | .13970 | 10 |
| Residual | -2.44434 | 1.55620 | .00000 | 1.57142 | 10 |
| Std. Predicted Value | -2.846 | .318 | .000 | 1.000 | 10 |
| Std. Residual | -1.467 | .934 | .000 | .943 | 10 |

a. Dependent Variable: Total work days

TABLE 7(III): MEASUREMENT OF VARIATION FOR BLOCK WORK (IMO)

ANOVA[a]

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | .197 | 1 | .197 | .171 | .797[b] |
| | Residual | 22.203 | 8 | 2.775 | | |
| | Total | 22.400 | 9 | | | |

a. Dependent Variable: Total work days

Residuals Statistics[a]

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | 18.1186 | 18.5816 | 18.4000 | .14788 | 10 |
| Residual | -2.56723 | 1.70741 | .00000 | 1.57067 | 10 |
| Std. Residual | -1.541 | 1.025 | .000 | .943 | 10 |

a. Dependent Variable: Total work days

**TABLE 8: SUMMARY OF DATA AGGREGATION OF PROJECTS STATISTICS FOR BLOCK WORK ACTIVITY**

| SITE / CODE | TWH | T QTY | TWD | ADP | MEDIAN | CONTROL LIMITS | | BASELINE PRODUCT | CP | PR | SD | COPU | % DISTRICT (PR) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | UPPER (UCL) | LOWER (LCL) | | | | | | |
| 01 | 1089.1 | 1088.67 | 20 | 1.005 | 1.009 | 1.14 | 0.87 | 0.803 | 0.999 | 1.292 | 0.131 | 0.147 | 1.6 |
| 02 | 727 | 658.73 | 18 | 1.122 | 1.157 | 1.257 | 0.987 | 0.884 | 1.104 | 1.428 | 0.173 | 0,154 | 1.77 |
| 03 | 796 | 765 | 17 | 1.094 | 1.091 | 1.238 | 0 950 | 0.841 | 1.041 | 1.348 | 0.203 | 0.227 | 1.67 |
| 04 | 355.2 | 306.13 | 16 | 1.178 | 1.195 | 1.338 | 1.018 | 0.99 | 1.16 | 1.5 | 0.176 | 0.149 | 1.86 |
| 05 | 1089 | 1282 | 19 | 0.854 | 0.853 | 0.961 | 0.748 | 0.702 | 0.849 | 1.098 | 0.123 | 0.144 | 1.36 |
| 06 | 1085 | 980.8 | 17 | 1.169 | 1.156 | 1.346 | 0.992 | 0.812 | 1.106 | 1.431 | 0.321 | 0.275 | 1.78 |
| 07 | 975 | 918.4 | 20 | 1.103 | 1.135 | 1.185 | 1.021 | 0.914 | 1.061 | 1.373 | 0.161 | 0.172 | 1.7 |
| 08 | 1146.23 | 1349.47 | 20 | 0.888 | 0.881 | 1.07 | 0.797 | 0.796 | 0.849 | 1.089 | 0.059 | 0.066 | 1.36 |
| 09 | 1200 | 1105.74 | 17 | 1.258 | 1.245 | 1.440. | 1.076 | 0.937 | 1.181 | 1.528 | 0.308 | 0.245 | 1.9 |
| 010 | 1946.5 | 2406.5 | 20 | 0.829 | 0.784 | 0.928 | 0.73 | 0.714 | 0.809 | 1.046 | 0.14 | 0.169 | 1.3 |
| 011 | 1509.5 | 841 | 18 | 1.906 | 1.991 | 2.176 | 1.636 | 1.471 | 1.794 | 2.321 | 0.351 | 0.153 | 2.88 |
| 012 | 1000.00 | 1372.75 | 17 | 0.729 | 0.711 | 0.804 | 0.655 | 0.655 | 0.728 | 0.942 | 0.048 | 0.066 | 1.169 |
| 013 | 1665.5 | 1189.4 | 16 | 1.478 | 1.385 | 1.718 | 1.238 | 1.066 | 1.4 | 1.811 | 0.293 | 0.198 | 2.25 |
| 014 | 714.4 | 758.73 | 19 | 0.944 | 0.914 | 1.176 | 0.806 | 0.8 | 0.942 | 1.219 | 0.161 | 0.162 | 1.513 |
| 015 | 878.47 | 970.12 | 19 | 0.914 | 0.906 | 1.008 | 0.82 | 0.803 | 0.906 | 1.172 | 0.083 | 0.091 | 1.45 |
| 016 | 428.6 | 344.4 | 18 | 1.25 | 1.249 | 1.458 | 1.043 | 0.956 | 1.16 | 1.501 | 0.245 | 0.197 | 1.862 |
| 017 | 948 | 795.22 | 14 | 1.27 | 1.048 | 1.564 | 0.976 | 0.97 | 1.192 | 1.542 | 0.434 | 0.342 | 1.903 |
| 018 | 1376 | 1054 | 15 | 1.393 | 1.324 | 1.53 | 1.256 | 1.189 | 1.295 | 1.677 | 0.397 | 0.272 | .2.081 |
| 019 | 514.13 | 636.48 | 18 | 0.813 | 0.794 | 0.895 | 0.731 | 0.709 | 0.808 | 1.045 | 0.11 | 0.135 | 1.296 |
| 020 | 1744 | 1595.5 | 19 | 1.104 | 1.067 | 1.234 | 0.978 | 0.918 | 1.093 | 1.414 | 0.161 | 0.145 | 1.75 |
| 021 | 1060 | 1230.3 | 20 | 0.882 | 0.803 | 0.982 | 0.782 | 0.765 | 0.862 | 1.115 | 0.167 | 0.189 | 1.383 |
| 022 | 1163.5 | 1066.5 | 15 | 1.197 | 1.111 | 1.469 | 0.925 | 0.775 | 1.092 | 1.413 | 0.308 | 0.357 | 1.753 |
| 023 | 571 | 540 | 17 | 1.087 | 1.091 | 1.222 | 0.952 | 0.864 | 1.057 | 1.367 | 0.216 | 0.199 | 1.696 |
| 024 | 853.53 | 1336.63 | 19 | 0.624 | 0.627 | 0.659 | 0.589 | 0.578 | 0.622 | 0.805 | 0.037 | 0.059 | 999 |
| 025 | 806.34 | 1330 | 15 | 0.597 | 0.6 | 0.654 | 0.537 | 0.516 | 0.606 | 0.784 | 0.049 | 0.082 | 973 |
| *026* | 648 | 487.3 | 19 | 1.467 | 1.538 | 2.083 | 1.159 | 0.833 | 1.329 | 1.719 | 0.438 | 0.299 | 2.133 |
| 027 | 1481 | 1970.58 | 16 | 0.788 | 0.788 | 0.917 | 0.659 | 0.627 | 0.746 | 0.965 | 0.125 | 0 159 | 1.197 |
| 028 | 855 | 1056.84 | 18 | 0.856 | 0.853 | 0.953 | 0.759 | 0.729 | 0.838 | 1.084 | 0.069 | 0.085 | 1.345 |
| 029 | 1620 | 2212.4 | 18 | 0.744 | 0.707 | 0.8 | 0.688 | 0.679 | 0.732 | 0.744 | 0.092 | 0.124 | 1.173 |
| 030 | 832 | 757 | 15 | 1.14 | 1.116 | 1.305 | 0.975 | 0.808 | 1.099 | 1.422 | 0.219 | 0.24 | 1.765 |

**Mean 1.058 1.039 1.22 0.912 0.8011.0170.1960.182Source, researcher's field survey, 2017**

**Expected (mean) baseline productivity=0.801whr/m²**

**Actual or current mean productivity = 1.058whr / m²**

**Performance gap = 0.257 or 25.70%**