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# Construction Projects Productivity in West African country of Benin: Case of Ground Earthworks

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***Abstract：In this paper, a survey related to excavation construction activities among national and international construction companies was conducted to evaluate site productivity in construction industry. To analyze the respective productivity levels of each construction company, a benchmarking measures analysis that featured calculations of the performance ratio (PR) and performance management index (PMI) was performed. As a result of these analyses, it has been found that the work performed by local companies was marked by lower productivity and that of international companies was characterized by good productivity. Further analysis of construction workforce resources P% revealed that a construction company's productivity is largely dependent on production capacity and consumption resources, which means that the retention of skilled workers and utilization of high-quality resources yields the highest level of productivity. These results suggest that for a local construction company to be competitive in the construction work market, it must retrain skilled craftspeople, foremen, engineers, and project managers, and strengthen its building capability by leveraging new equipment and technologies.***

***Keywords: Construction productivity, labor productivity, construction companies, project management, construction project management***

## I. INTRODUCTION

Construction is a driving force of the Beninese economy's growth. Construction activity in Benin serves as a form of investment in that economy, and provides the principal basis for which the production of goods and delivery of services is implemented there. Construction activities affect nearly every aspect of Beninese life, making the construction industry vital for the continued growth of the economy. Given their importance for the Beninese economy, construction projects must be improved to allow for the sustainable use of limited resources.

Although the Beninese construction industry has developed extensively in recent years, construction productivity remains very low. The low degree of productivity suffered by the construction industry in Benin can cause delays in the delivery of goods and

services, thereby damaging relationships with customers. The benefits of high productivity, however, are manifold.

Productivity growth improves living standards, increases

the population's capacity to purchase goods and services, promotes leisure activities, enhances the housing market and educational system, and contributes to social and environmental programs.

There are a number of ways to measure productivity. For example, within factories, productivity is gauged in terms of the number of hours needed to produce goods. In the service sector, productivity is equal to the revenue generated by an employee divided by his/her salary. Economists and accountants define productivity as the ratio of the total input of resources to the total output of products. Finally, project managers and construction professionals use the ratio of earned work hours to expended work hours to conceptualize productivity [1].

As in the rest of the world, the construction sector in Africa is not as productive as other industrial sectors on the continent [2]. As such, the construction industry has long been criticized for its underperformance. Despite these criticisms, firms in the industry have done little to improve their productivity. As a result, the debate has continued, and researchers have investigated appropriate measures for measuring the performance of contractors, projects, and industries. Still, research related to the efficiency of multiple projects or contractors remains scarce despite its promise for facilitating a more comprehensive understanding of industry performance.

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A number of European countries have seen the rise of initiatives intended to improve the competitiveness of their respective construction industries (e.g., constructing Excellence in the UK, PSI Bouw in Holland, and BQR Best Practice in Sweden). These initiatives were developed largely on the basis of the fact that the construction sector's productivity lagged behind that of other industrial sectors. Similar to those methods for measuring productivity outlined above, other researchers have measured labor productivity in terms of cost and quality management maturity [3], concurrent engineering [4], organizational analysis [5], construction process improvement [6], and human resource management [7].

Given these challenges, some researchers have also sought to improve global productivity in the construction industry. For example, Zhai et al. [8] demonstrated that labor productivity is positively related to the integration and implementation of information technology (IT). Certain benchmarks of labor productivity—the disruption index (DI), the performance ratio (PR), and the project management index (PMI)—are reliable indicators of project labor performance [9]. Moreover, they also found variability in daily labor productivity to be a key predictor of a project's performance. Productivity was largely contingent on the skills and experience possessed by the workforce, management, job planning, workers' motivations, and availability of materials [10]. However, construction companies can improve work activities and increase task efficiency by applying training policies in addition to motivational practices [11]. According to Hwang and Liu [12], measuring productivity is essential for estimating the duration and cost of a construction operation.

A better understanding of the factors influencing construction productivity can yield improvements in that domain. However, these improvements are not feasible without first identifying those factors that influence productivity [13]. Thomas and his colleagues [14] concluded that the most significant hindrances of civil engineering projects in Hong Kong included a lack of materials, overcrowded work areas, and the need to re-perform work. Nasirzadeh and Nojedehi [15] used a system dynamics approach to simulate and assess labor productivity in terms of time and cost. Furthermore, other work by Khoramshahi et al. [16], Enshassi et al. [17], Alinaitwe et al. [18], Weng-Tat [19], Hanna et al. [20], and Kazaz et al. [21] has sought to identify factors that influence labor productivity. Much of this research has shown that reductions in construction project productivity occur because contractors may be forced to overcome shortages in skilled laborers by utilizing unproductive labor. Shortages in materials, tools, or equipment to support labor resources may also limit the extent to which a project is productive. Finally, the contractor him/herself may not be able to effectively manage the labor force owing to a lack of personnel that can engage in supervision. All of these issues contribute to low productivity in African construction development projects. This problem is particularly pronounced in Benin, therefore precipitating an urgent need to improve construction productivity as a means to enhance organizational capability.

This paper compares the productivities of national and international construction companies by evaluating the effect of labor productivity and equipment resources on excavation construction activity. To perform this analysis, we opted to evaluate top-ranked firms in the West African country of Benin. Specifically, we developed and administered a survey related to construction projects in Cotonou City to construction engineers, construction managers, and project managers in the Beninese Public Interest Works Execution Agency. To determine the degree to which firms are productive, we gathered data related to inputs and outputs of each construction company. Further, we employed a benchmarking measure to calculate the performance ratio (PR) and project management index (PMI). The PMI provides a measure of the impact of poor materials, equipment, and information flows and inadequate planning. To ensure the validity of this study's analysis, we analyzed the workforce resources of each construction company in addition to the benchmarking measures provided by the performance ratio and project management index. Results of our analyses are intended to illuminate each construction company's respective productivity level. On the basis of these findings, we also offer conclusions that include future directions of research development.

## II. Background

Construction affects the ability of the nation to attract foreign investment and this is important in this era of globalization as all nations are competing nations to position to attract foreign investment. Construction industry in developing countries has been a source of concern for industry practitioners. Studies show that the construction industries of developing countries, including that of West African country of Benin, face many problems.

Among the construction problems developing countries are facing, productivity is one of the most critical. Productivity is core to the success of any project and has a direct impact on the program of any project. Par example a change in a project of any kind usually means there will be associated productivity impacts that can be attributed to inefficiencies as well. Such changes may cause manpower increases and work areas to be overcrowded with workers who now need to share and occupy the same work space, scaffolding, or equipment with other crafts, causing a further drop in productivity so

construction practitioners must understand and effectively manage productivity on the project. So construction companies must measure their performance on a regular basis and draw comparison with their previous performance in order to identify performance gap and identify best practice [22]. There are many factors that affect the productivity in construction but the severity of the factors on construction productivity is different from project to project and from country to country so construction practitioners in order to successfully handle construction project in terms of productivity need a research survey databases across the world. However no real research has been conducted in this regard for African countries, many of previous investigations were based on sketchy evidence as there are no much empirical studies to drive home most of these perceptions. As past research works, Ameh and Odusami [23] identified low wages, lack of materials and unfriendly working atmosphere as having key impact on productivity of craftsmen involved in in-situ concrete operation in single storey building projects in Nigeria. Kaliba et al. [24] mentioned that contractors, consultants, and clients should ensure that they have the right personnel with appropriate qualifications to manage their projects efficiently. A research project by Mutijwaa and Rwelamila [25] showed that the South Africa Infrastructural Department (SAID) is under pressure to improve performance, that is, to deliver projects on time, on budget and to higher standard of quality.

West African country of Benin construction industry is less productive than that of many developing countries and seems also less productive than the most of West African countries construction industry in terms of construction efficiency. This lower production could be demonstrated by the unique culture of the workforce or construction technologies using in Benin. Based on extensive analysis of available data and interviews with stakeholders it is found that there is potential for investment in core infrastructure in West African county of Benin and this is confirmed by many development construction projects that are taking place. So to be able to well performing those projects, the management style that are unique to the construction industry must be identified in order to deliver a more accurate and useful tool to improve productivity. This study is designed out with that sense of idea to analyze site productivity among major construction companies so the expected result could help construction practitioners to successfully handle construction projects in West African country of Benin. In West African country of Benin there is different size of construction companies: small, medium and big companies. However, the selection of main contractor for government public construction project is 80% done by competition so from interview carried out with government construction agency managers, engineers and some construction company leaders it has been listed out that local companies such as: Company A and Company B and international companies such as: Company C and Company D are all the time the executing construction companies of government public construction projects in West African country of Benin. As criteria of selection it has been reported from the interview that beside the basic requirements of the tendering competition those companies have many years of experience in construction field and have the equipments, the workforce resources needed to even challenge the most complex construction projects.

## III. METHODOLOGY

The current research focuses on residential building performed by national and international civil engineering construction companies that have been classified as top performers in Benin. Data were related to construction projects performed between January 6, 2010 and February 28, 2011 in Cotonou City.

We collected salient data through the use of structured surveys comprised of questions that could be responded to with a “yes” or “no.” These surveys were sent to Public Interest Works Execution Agency engineers, construction managers, and project managers in Benin to evaluate the equipment and human resources possessed by four major civil engineering construction companies. Specifically, the surveys were designed to obtain respondents’ assessments of the availability of equipment resources. We calculated the percentage of workforce resources P% by dividing the sum of numerical values of responses on the use of equipment resources by each contractor to the total numerical values of required equipment resources (for example : 2.5/3 = 84%) .

Moreover, we calculated the productivity as total work hours per the total quantities produced by all persons or equipment employed. Therefore, our evaluation of productivity requires the measurement of work time and construction output produced by each construction company. Using these metrics, we can calculate productivity in terms of construction output produced per hour. To effectively gauge each contractor’s productivity, we must also calculate their respective productivity performance ratios (PR) and project management index (PMI) scores. The performance ratio is actual cumulative productivity (CP) divided by expected baseline productivity (EBP; i.e., the average value of baselines for all projects). The PMI measures the difference between the actual and baseline productivity (BP), thereby providing a measure of the effect of poor material, equipment, and information flows and inadequate planning. Calculations for the performance ratio (PR) and project management index (PMI) are determined by the following equations:

(PR) = CP/EBP (1)

(PMI) = (CP x BP)/EBP (2)

Where CP refers to cumulative productivity, BP signifies baseline productivity, and EBP represents baseline productivity. We performed the following steps to calculate BP:

1) Determine the number of workdays that comprise 10% of the total number of workdays observed (n).
2) Allow n (which should be greater than or equal to five) to represent the number of workdays in the baseline subset.
3) Recognize that n workdays have the highest daily production or output.
4) Determine the sum of the quantities produced and work hours for n workdays.
5) Allow baseline productivity to be the ratio of the number of the baseline subset work hours divided by the quantities produced.

Fig. 1 illustrates our methods for analyzing productivity performance and Table 1 summarizes some information about past projects in this domain.

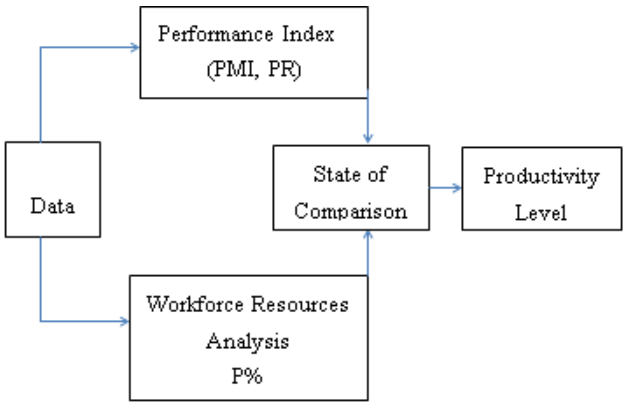


FIGURE I
Methodology of productivity analysis.

TABLE I
CHARACTERISTICS OF SELECTED PROJECTS

| Companies | Project name | Work days | Start day | End date |
|---|---|---|---|---|
| Company A | Project 1 | 15 | 15/3/2010 | 30/3/2010 |
| | Project 2 | 16 | 7/2/2010 | 23/2/2010 |
| Company B | Project 3 | 15 | 25/3/2010 | 09/4/2010 |
| | Project 4 | 15 | 11/5/2010 | 26/5/2010 |
| Company C | Project 5 | 15 | 6/1/2010 | 21/1/2010 |
| | Project 6 | 15 | 13/7/2010 | 28/7/2010 |
| Company D | Project 7 | 15 | 24/6/2010 | 08/6/2010 |
| | Project 8 | 15 | 14/4/2010 | 29/4/2010 |

To evaluate the percentage of equipment resources assigned to each contractor, each "yes" and "no" response on the survey was respectively associated with the use of required equipment resources and the use of zero equipment resources. Responses of yes/no (indicating that a resource was "sometimes" available) suggested that an unsatisfactory equipment resource was used. Given this scheme, we assigned the following numerical values to the respondents' ratings: 0 = zero use of equipment resources, 1 = the use of required equipment resources and 0.5 = for the use of unsatisfactory equipment resources. Through these questions, we were able to determine the percentage of each contractor's resource pool that was comprised of equipment.

Following this, we collected data related to daily work hours and output (operationalized as daily quantities excavated) for each construction company to determine their respective work level productivities. Total work hours are the summation of daily work hours for each project, and output is the summation of daily quantities excavated for each project. On the basis of the calculations outlined above, baseline productivity represents the best performance a contractor can achieve for a given design. These data provide the basis for Tables 2 and 3. Table 2 illustrates the availability of each contractor's resources; Table 3 illustrates the productivity for all companies.

TABLE II
WORKFORCE RESOURCES OF EACH CONSTRUCTION COMPANY

| Companies | Skill and Equipment | Recourses % |
|---|---|---|
| Company A | Equipment | 67 |
| | Skilled workers | 60 |
| | Unskilled workers | 40 |
| Company B | Equipment | 75 |
| | Skilled workers | 60 |
| | Unskilled workers | 40 |
| Company C | Equipment | 84 |
| | Skilled workers | 83 |
| | Unskilled workers | 17 |
| Company D | Equipment | 92 |
| | Skilled workers | 100 |
| | Unskilled workers | 0 |

TABLE III

CASE STUDY OF DAILY PRODUCTIVITY FOR ALL COMPANIES

| Companies | Day | Crew size | Work Hours (h) | Daily quantities (m3) | Labor daily Productivity (h/m3) | Baseline Days |
|---|---|---|---|---|---|---|
| Company A | 1 | 2 | 16 | 30.7 | 0.521 | |
| | 2 | 3 | 29 | 53.1 | 0.546 | |
| | 3 | 3 | 28 | 46.13 | 0.607 | |
| | 4 | 4 | 31 | 63.13 | 0.491 | |
| | 5 | 4 | 32 | 67.23 | 0.476 | * |
| | 6 | 4 | 32 | 68.37 | 0.468 | * |
| | 7 | 5 | 39 | 86.28 | 0.452 | * |
| | 8 | 3 | 25 | 46.81 | 0.534 | |
| | 9 | 3 | 24 | 44.69 | 0.537 | |
| | 10 | 5 | 40 | 85.47 | 0.468 | * |
| | 11 | 5 | 39 | 84.96 | 0.459 | * |
| | 12 | 2 | 16 | 30.02 | 0.533 | |
| | 13 | 2 | 17 | 32.01 | 0.531 | |
| | 14 | 2 | 16 | 30.53 | 0.524 | |
| | 15 | 2 | 15 | 28.51 | 0.526 | |
| Sum | | | 399 | 797.94 | 0.511 | |
| Company B | 1 | 2 | 16 | 31.81 | 0.503 | |
| | 2 | 2 | 16 | 29.79 | 0.537 | |
| | 3 | 2 | 17 | 31.36 | 0.542 | |
| | 4 | 3 | 25 | 49.21 | 0.508 | |
| | 5 | 3 | 24 | 48.38 | 0.496 | |
| | 6 | 3 | 24 | 46.42 | 0.517 | |
| | 7 | 4 | 32 | 67.65 | 0.473 | * |
| | 8 | 4 | 33 | 68.61 | 0.481 | * |
| | 9 | 4 | 31 | 63.01 | 0.492 | * |
| | 10 | 5 | 39 | 84.41 | 0.462 | * |
| | 11 | 5 | 40 | 79.68 | 0.502 | |
| | 12 | 2 | 16 | 27.30 | 0.586 | |
| | 13 | 3 | 24 | 39.66 | 0.605 | |
| | 14 | 2 | 16 | 27.68 | 0.578 | |
| | 15 | 5 | 41 | 83.84 | 0.489 | * |
| Sum | | | 394 | 778.81 | 0.518 | |
| Company C | 1 | 3 | 24 | 56.47 | 0.425 | |
| | 2 | 3 | 24 | 55.9 | 0.429 | |
| | 3 | 3 | 25 | 57.8 | 0.432 | |
| | 4 | 4 | 32 | 77.29 | 0.414 | * |
| | 5 | 4 | 33 | 78.75 | 0.419 | |
| | 6 | 5 | 40 | 103.63 | 0.386 | * |
| | 7 | 5 | 40 | 104.44 | 0.383 | * |
| | 8 | 3 | 24 | 58.1 | 0.413 | * |
| | 9 | 4 | 32 | 83.55 | 0.383 | * |
| | 10 | 3 | 24 | 57.83 | 0.415 | |
| | 11 | 3 | 24 | 58.68 | 0.409 | |
| | 12 | 2 | 16 | 33.61 | 0.476 | |
| | 13 | 2 | 16 | 33.26 | 0.481 | |
| | 14 | 2 | 17 | 35.56 | 0.478 | |
| | 15 | 2 | 16 | 34.18 | 0.468 | |
| Sum | | | 387 | 929.05 | 0.427 | |
| Company D | 1 | 3 | 24 | 58.25 | 0.412 | |
| | 2 | 3 | 25 | 61.27 | 0.408 | |
| | 3 | 4 | 33 | 85.49 | 0.386 | * |
| | 4 | 4 | 32 | 81.63 | 0.392 | |
| | 5 | 4 | 32 | 83.98 | 0.381 | * |
| | 6 | 5 | 40 | 113.63 | 0.352 | * |
| | 7 | 5 | 41 | 112.95 | 0.363 | * |
| | 8 | 5 | 40 | 108.9 | 0.367 | * |
| | 9 | 3 | 24 | 57.27 | 0.419 | |
| | 10 | 3 | 24 | 57.69 | 0.416 | |
| | 11 | 3 | 25 | 59.38 | 0.421 | |
| | 12 | 2 | 16 | 32.78 | 0.488 | |
| | 13 | 2 | 16 | 33.12 | 0.483 | |
| | 14 | 2 | 17 | 35.94 | 0.473 | |
| | 15 | 2 | 16 | 33.26 | 0.481 | |
| Sum | | | 405 | 1015.5 | 0.416 | |

## IV. RESULTS

We used a benchmarking measure to analyze the productivity among national and international

construction firms in Benin. In particular, we calculated the PR and PMI for these firms to determine the degree to which they are productive. Parameters for gauging performance should typically include a disruption index, but there were few disruptions or abnormal workdays in our sample, so these factors did not affect construction output.

Table 4 illustrates the performance ratios for all sampled projects. As can be shown in the table, the maximum value for the performance ratio was 1.22 and the minimum was 0.95. Local companies (PR range = 1.18-1.22) were shown to be somewhat more productive than international companies (PR range = 0.95-1.02). The average performance ratio of all investigated projects was 1.09; all local projects had PR scores above this score and all international companies had PR scores below it.

We also tabulated PMI scores (see Table 4). Lower PMI scores indicate better project performance. The average PMI index for all projects was 0.09; the maximum PMI score for all projects was 0.11; and the minimum was 0.07. PMI scores were similar for local companies (PMI range = 0.07-0.11) and international companies (0.07-0.11). All three projects performed by international companies have a PMI score lower than 0.09, but all projects performed by local companies have a PMI score that exceeds 0.09. This result indicates that nearly all projects performed by international companies were implemented as planned and possessed an effective control system. The local companies, however, were marked by a lack of effective project or human resource management. Figs. 2 and 3 illustrate the performance ratios and project management index scores for local and international companies. These diagrams confirm the results described above.

TABLE VI

VALUES OF PERFORMANCE RATIO AND PROJECT MANAGEMENT INDEX

| Companies | Projects | CP | BP | EBP | (PR) | (PMI) |
|---|---|---|---|---|---|---|
| Local company | | | | | | |
| Company A | Project 1 | 0.511 | 0.464 | | 1.19 | 0.11 |
| | Project 2 | 0.509 | 0.465 | | 1.19 | 0.10 |
| Company B | Project 3 | 0.518 | 0.479 | | 1.22 | 0.09 |
| | Project 4 | 0.504 | 0.473 | **0.426** | 1.18 | 0.07 |
| International company | | | | | ***1.19*** | ***0.09*** |
| Company C | Project 5 | 0.438 | 0.402 | | 1.02 | 0.08 |
| | Project 6 | 0.427 | 0.395 | | 1.00 | 0.07 |
| Company D | Project 7 | 0.407 | 0.366 | | 0.95 | 0.09 |
| | Project 8 | 0.416 | 0.369 | | 0.97 | 0.11 |
| | | | | | ***0.98*** | ***0.09*** |

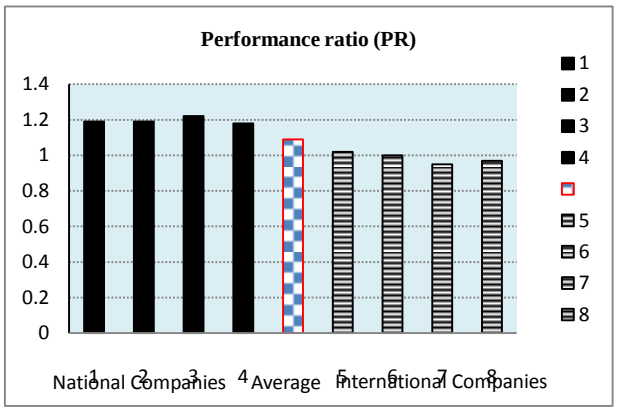


FIGURE II

PERFORMANCE RATIOS (PR) OF INVESTIGATED PROJECTS

Our equipment analysis showed that Companies A and B (the local companies) respectively used 67% and 75% of their equipment resources. Companies C and D (the international companies) were shown to have 84% and 92% of the equipment resources necessary for carrying out their respective projects.

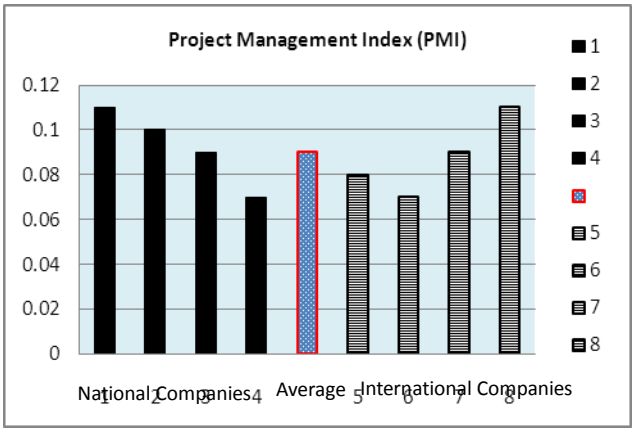


FIGURE III

PROJECT MANAGEMENT INDICES (PMI) OF INVESTIGATED PROJECTS

In addition, local construction companies utilized a larger number of unskilled workers (about 40% of all workers on the ground site) than international construction companies (17% for Company C, 0% for Company D). Fig. 4 demonstrates that local companies utilize their resources at a 25% higher rate than international companies. These figures suggest that international construction companies have mobilized their workforce resources to the degree to which they optimize their construction productivity. This is not the case for local construction companies.

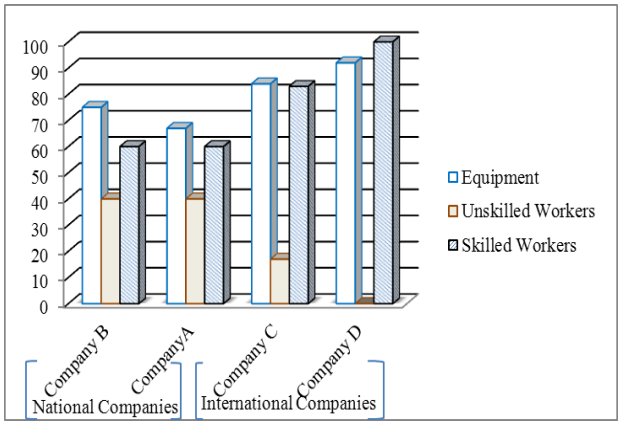


FIGURE IV
Workforce resources

Problems associated with workforce productivity are a concern not only to Beninese construction companies, but also to other countries across Africa as well. African construction companies have tended to recruit workers only when they were needed for production, leaving few opportunities to train those workers. As such, many workers simply learn their trade on site, affecting the company's quality of workmanship and productivity. Construction productivity depends on increased use of IT, automation, and workers' skills and experience. International construction companies have managed to achieve strong productivity through the effective use of skilled workers and automated construction equipment (e.g., bulldozers). Through the use of this equipment, large construction contractors around the world can reduce costs and improve productivity [26]. In most of African countries, local construction companies lease equipment and are engaged in many different projects simultaneously. As a result, equipment may not be available on the ground sites for all projects. This shortage of equipment, in turn, affects productivity rates.

Another problem associated with limited equipment capacity and work speed relates to the insubordination of some workers. Sometimes, when an estimator chooses a piece of equipment to perform a task, he/she neglects to account for job conditions and operational characteristics of large civil works projects. As a result, many equipment decisions are ignored.

Causes of unsatisfactory work productivity vary by geographical region. The structural quality of residential construction in Taiwan declines measurably as production reaches its later stages and skilled labor shortages arise. However, the quality of project deliverables is significantly improved with the effective use of automated technology [27].Some developed countries, including the United States and Japan, have invested significant resources in automating and integrating construction-related tasks. However, these countries have found that the costs of purchasing and using these technologies exceeded the costs of existing practices. As a result, research in the field of earthwork is largely centered on the introduction of new control techniques to existing machinery (e.g., excavators, bulldozers, draglines). One of the major representative events of this research area is the Commonwealth Scientific and Industrial Research Organization's (CSIRO) control of the 100-m tall walking crane used in surface coal mining [28]. Despite their failure to incorporate automated systems into the construction practices, the United States and Japan have managed to maintain high levels of productivity through effective project management, equipment management, and the use of skilled workers. Contractors in mainland China and Hong Kong have also improved their efficiency between 2004 and 2010. Firms in Hong Kong have improved their productivity largely on the basis of their managerial competence. Moreover, construction firms in China, the Republic of Korea, Malaysia, and Brazil have significantly increased their construction productivity since 2005 through the use of properly skilled, experienced workers. Taken together, these findings demonstrate that there are substantial differences in how construction productivity is achieved in developed countries relative to developing countries.

Most African countries are populated by low-income households in which families earn low wages or are unemployed. Therefore, local companies are in a position to not only enhance their productivity, provide a social benefit by training and retaining skilled workers and recent graduates. In this way, local Beninese construction companies can remain competitive in the construction market by training skilled craftsmen and foremen, engineers, and project managers, thereby strengthening their construction capabilities. This conclusion illustrates that workforce resources have a strong effect on a construction company's overall performance, as optimal performance is based exclusively differences in the skills and experiences offered by employees of international construction companies.

## V. Conclusion

This study identified some of the most important factors that affect construction project productivity. We utilized a benchmarking measure to calculate the performance ratio (PR) and project management index (PMI) scores of several local and international construction companies in Benin. Our analysis showed that international companies are more capable of maintaining productivity than local companies. International companies were also shown to be more productive than local companies in terms of workforce and equipment resources. These findings suggest that to effectively compete in the market in Benin, local construction companies must improve their labor

productivity through the use of properly skilled and experienced workers and improve their construction capabilities through the use of modern technology. The results further demonstrate that the management of workforce and equipment resources is critical for improving construction productivity. The results and conclusions of this study can be expanded upon by evaluating the effect of workforce resources on construction productivity in other fields of civil engineering. This will allow for the development of a specific database that documents the successes of new development projects.

## VI. Acknowledgments

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