Can ICT Create Public Value in Africa?
Efficiency Assessment Using Data Envelopment Analysis
(DEA) Approach

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Recently, researchers and international bodies have recognized the potential of ICT in public service value creation. Many countries have implemented ICT to transform public services and create public value. Citizens are increasingly demanding public value from their governments, the notion being similar to return on investment from private sectors. However, little research has been conducted on ICT and public value creation. This article adopts public value framework to interrogate ICT public value creation. Using data envelopment analysis (DEA) and cluster analysis, data for 53 African countries were analyzed. The findings indicate that for a period from 2010 to 2019, ICT has efficiently transformed public values in Africa by 14%, 35%, and 63% in countries of clusters 1, 2, and 3, respectively. More compelling, the findings indicate that the highest performer of ICT efficiency among the clusters' best performers have low human development. This is consistent with the public value theory, which predicts doing more with less. The current study has theoretical and methodological implications.

Keywords: ICT, public value, accountability, data envelopment analysis (DEA), cluster analysis, Africa

For the past three decades, government reforms across the world have been at the top of every performance agenda. Governments are continuously experiencing pressure to provide public services with a public value notion in mind. Under the banner of new public management (NPM), reinventing governments has been touted as a solution to many of the challenges related to government inefficiencies. Public value is fundamental in public administration to ensure citizen satisfaction and trust (Moore, 1995; Ott, 2010). The increased pressure for citizens' demands for public value has contributed to the adoption of an entrepreneurial approach to governance (Blaug, Horner, & Lekhi, 2006). Citizens are now putting an emphasis on public value similar to that put on return on investment in the private sector.

Public sector reform is important in socioeconomic development and serves as a means of innovation in performance management. The objective of public sector reform, since its inception, has been geared toward innovative ways of bringing about socioeconomic development. Performance management is the concept of the NPM that has its roots in the agenda of continuously doing better in public administration (Van Dooren,

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Bouckaert, & Halligan, 2015). Since the inception of the doctrine of NPM, many governments have implemented strategies to improve their public services delivery (Alonso, Clifton, & Díaz-Fuentes, 2015).

ICT, as an enabler of public sector reforms, has been implemented to reinvent governments to improve performance (Bannister & Connolly, 2014; Gauld, Goldfinch, & Horsburgh, 2010). In line with this, ICT is touted as having the potential to create public value (Bannister & Connolly, 2014). However, many pieces of research related to value creation using ICT have focused mainly on business (private) values. Value creation in private organization is different from that of public organizations. In private organizations, value creation is normally premised on economic value, such as return on investment, while in public-sector organizations, such as governments, consisting mostly of non-profit-seeking entities, the focus is on public value creation (Moore, 1995; Pang, Lee, & DeLone, 2014).

The relationship between ICT and public sector reforms is an important area of study in which to interrogate the impact of ICT enabled initiatives on public sector reforms (Cordella & Bonina, 2012). International bodies and researchers have recognized the importance of ICT in public administration in creating public value. For example, the *World Public Sector Report* (United Nations Department of Economic and Social Affairs, 2015) points out that ICT should be harnessed in public services to achieve socioeconomic development. Importantly, it emphasizes that ICT should be a tool for creating public value. However, little research that focuses on ICT public value creation, particularly in Africa, exists (Bannister & Connolly, 2014; Cordella & Bonina, 2012; Pang et al*.,* 2014; Sami, Jusoh, Nor, Irfan, & Qureshi, 2018; Samoilenko & Osei-Bryson, 2019; Twizeyimana & Andersson, 2019). In fact, only a minuscule number of studies on ICT in the public sector have been published in major information systems academic journals (Pang et al*.,* 2014). This study intends to fill this gap by investigating the efficiency of ICT in public value creation in Africa. Therefore, the objective of this study is to determine the efficiency of ICT in public value creation in Africa. This study proposes to analyze the data of ICT and public value in 53 African countries using data envelopment analysis (DEA) and cluster analysis. The study focuses on public value rather than on value created in the private sectors. In other words, the study focuses on the efficiency of ICT in creating public value. I intend to answer the main research question:

RQ1:   *How efficiently has ICT performed to enable or create public value in Africa?*

Conceptual Background

Africa and Information Communication Technologies (ICT)

Africa is the second largest continent and comprises 54 countries. An African Development Bank (AfDB) Group report indicates that Africa's economic outlook continues to brighten, and it registered a real GDP growth of 3.4% in 2019. AfDB Group projects that the GDP growth of 4.1% would be registered in 2021 (African Development Bank Group, 2020). Over the years, ICT in Africa has demonstrated its potential to foster socioeconomic development (Kayisire & Wei, 2015; Mimbi, Bankole, & Kyobe, 2011), and subsequently, ICT has expanded across the whole continent. ICT indicators in Africa show a considerable development for the past year. For instance, in 2019, there were 34 mobile broadband subscribers per 100 inhabitants (International Telecommunication Union [ITU], 2019) from a mere 17 mobile broadband

subscribers per 100 inhabitants registered in 2015. This is a 100% increase in mobile broadband subscription in Africa. Internet use also continued to grow over the past five-year period. The year 2019 concluded with 28 in 100 people being Internet users in Africa, and 17% of Africa's population had Internet access at home (see Table 1). However, ITU (2019) reports that besides this growth, women lag behind their male counterparts in ICT uptake in Africa. General ITU report indicates that ICT development in Africa is still behind that of Europe and America, and more efforts are required to make improvements.

Table 1. Selected ICT Indicators (2019).

Indicator	Europe	America	Africa
Percentage of households with Internet access	86.5	71.8	17.4
Percentage of individuals using the Internet	82.5	77.2	28.2
Mobile broadband subscriptions per 100 inhabitants	97.4	104.4	34.0

The Concept of Public Value

The concept of public value can be traced from the new public service theory and is linked to the seminal work of Moore (1995). Public value is defined as the value that citizens and their representatives seek in relation to strategic outcomes and experience of public services (Moore, 1995). Public value focuses on performance evaluation of public organizations in their delivery of services, and emphasizes the significant role public managers can play in maintaining the legitimacy of government organizations in the eyes of the public. Public value therefore focuses on the wider notions of valued public services and efficiency that call for the increased accountability of public managers (Blaug et al., 2006). Public value has been influential in public services reform initiatives since the mid-1990s because of its potential to address the shortcomings of its predecessors—NPM and traditional public management approaches. Scholars argue that NPM lacked a focus on combating corruption, while traditional public management lacked a focus on economic efficiency (Turkel & Turkel, 2016). Public value has emerged as an alternative management approach to address those shortcomings and respond to contemporary technologies and societal norms that have flattened organizational hierarchies (Turkel & Turkel, 2016). Public value recognizes these shortcomings within a broader context of democratic politics and public life and integrates solutions to those (Turkel & Turkel, 2016). The contemporary world has seen the use of ICT as an enabler of public value (Bannister & Connolly, 2014). Brewer, Neubauer, and Geiselhart (2006) argue that using ICT to create public value is a priority, and they emphasize on embracing the information revolution as a means of improving governance and enhancing the democratic process. This study therefore adopts the public value framework to examine the relationships between ICT and the creation of public value.

The Public Value Framework

The public value framework (Moore, 1995) was developed to assist public managers in their responsibility of creating public value.

The public value framework consists of three elements which form the strategic triangle (see Figure 1).

(i) *Public value*—This is a value circle that relates to the substantive program of the public organizations, such as governments, by which the impacts and performance should be evaluated (Moore, 1995).

(ii) *The authoring environment*—This element relates to the environment in which the individuals and organizations operate to support public value creation (Moore, 1995). These individuals and organizations, in good governance, are collectively known as actors and they include both government and non-government actors (Mimbi & Kyobe, 2017) who play an important role in implementing the program aimed at creating public value.

(iii) *The operational capability*—This element relates to the resources required to achieve the objectives of the public organization. These resources require the organization to position itself strategically to achieve the agreed objectives (Moore, 1995). These resources include finance, skills, and technology which are always limited and must be used to maximize outputs in the pursuit of substantive public value aims (Williams & Shearer, 2011). Importantly, public managers in public organizations must use ICT as one of their resources to create public value (Pang et al., 2014).
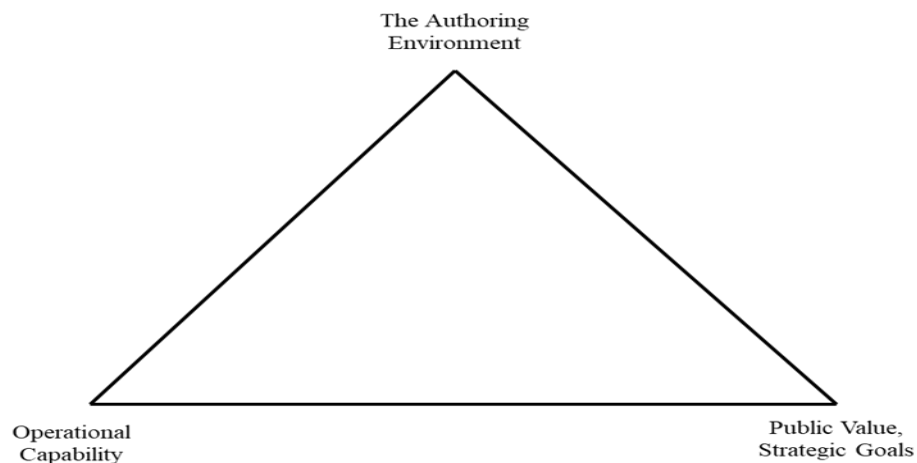

Figure 1. The strategic triangle (Moore, 1995).

Public managers use these three elements to create public value, which is the underpinning proposition of the public value framework. In other words, they use public resources to create value (Moore, 1995). The public value framework is an important tool for examining the performance management of public administration. It empowers public managers to focus on resource allocation and their performance accountability; while integrating democratic values (Bryson, Crosby, & Bloomberg, 2014; Moore, 1995; Williams & Shearer, 2011). Therefore, this framework is appropriate to interrogate the phenomena relating to ICT and public value creation, because ICT, in this context, is a resource to be used to maximize output (public value). Pang and colleagues (2014) also used this framework to examine IT resources and value creation in public-sector organizations. Further, scholars argue that the objective of using ICT in public

administration is to produce public value (Castelnovo & Simonetta, 2008; Yu, 2008). Based on the above claims, this study adopted the public value framework.

Public Value Creation

The essence of public value creation is to evaluate the extent to which public organizations have achieved their set goals and objectives. Based on the new public service and governance theories, the government has a constitutional obligation to implement public policies that ensure that collective or shared public values are created. Public value moves beyond the value for the individual by serving the wider public interests. For example, public interests could be served better by the government with a set of public values that focus on efficiency and the provision of public services, with impartiality (Ahrens, 2007; Teorell, 2009). The question now is how are these values created? Public values are created when the least resources are used to produce the greatest output—doing more with less (Moore, 1995; Osborne, 1993). Based on this principle, public organizations that use fewer resources than those used by other organizations from the same settings to produce more outputs than those produced by those other organizations, are considered efficient.

The literature suggests that values must be convertible into some behavioral form to have meaning (Bannister & Connolly, 2014). In this context, ICT is a tool that can enable this conversion. Therefore, this study focuses on the behavioral forms that ICT has the potential to modify or transform. ICT use in public administration is both an "enabler and embedder" (Bannister & Connolly, 2014, p. 120). It is an enabler because it makes possible those actions or activities related to public value that would be impractical in its absence. It is an embedder because it is possible to place this created value into the system (Bannister & Connolly, 2014). In addition, ICT enables the three dimensions of public value–namely, duty-oriented, service-oriented, and socially oriented public values, as discussed in the next section.

Duty-Oriented Public Values

Duty-oriented public values relate to the duties of the public servant to the government or to the state that focus on accountability of the public servant (Bannister & Connolly, 2014). Accountability arises from the fact that public servants must be controllable and answerable for their actions in public administration (Gregory & Hicks, 1999). Accountability has been used to enforce values of an ethical nature such as integrity and honesty, by forcing individuals to comply with the law guiding the provision of public services and instils the will to do things right by choosing the right thing (Bannister & Connolly, 2014; Gregory & Hicks, 1999; Twizeyimana & Andersson, 2019). ICT in the duty-oriented public value affects the accountability value.

The literature indicates various mechanisms in which ICT can ensure accountability of public servants. Under the principal—agent environment, public servants are agents and citizens are principals. As agents, public servants are accountable for their actions to the citizens (their principals). For the public servants to be accountable, there must be one prerequisite condition—transparency. Without transparency, it is almost impossible for a public servant to be held accountable (Heeks, 2009; Islam, 2006). For citizens to hold the public servant accountable, they must know what the public servant is doing (Heeks, 2009). This means that performance information about the public servant must be available to the citizens. In this case,

ICT, and in particular the Internet, makes the performance information transparent and available to a wider population (i.e., citizens) and enables citizens to evaluate the performance of the public servant. While ICT helps in providing information that can assist in the performance evaluation of the public servant, it can also force the public servants to comply with the laws and behave in an honest manner (Bannister & Connolly, 2014). Knowing that performance information about the public servants is available to the public helps in ensuring responsiveness, integrity, and honesty of public servants (Gregory & Hicks, 1999; Islam, 2006). However, Bannister and Connolly (2014) argue that ICT cannot make people more honest, but it can make people behave in a more honest way. Studies show that ICT increases honesty, improves compliance with law, and fairness by removing the human element from the process and decision-making chain (Bannister & Connolly, 2014).

Service-Oriented Public Values

Service-oriented public values refer to values related to the provision of high-level public administration services to their citizens. This is analogous to the provision of good services by private companies to their clients or customers (Bannister & Connolly, 2014). The values in this category are considered to be of NPM nature (Van Der Wal, Pevkur, & Vrangbaek, 2008), and they include effectiveness, efficiency, and transparency. Government effectiveness is a pivotal public value for the provision of public services in the new governance. According to the World Bank, government effectiveness refers to the perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies (Kaufmann, Kraay, & Mastruzzi, 2008). Efficiency is related to the extent to which government uses particular inputs to produce outputs. Since the objective of this study is to examine the extent to which ICT can enable the provision of quality public services, government effectiveness seems to be a more appropriate indicator for this study and was adopted. Government effectiveness has also been used in other studies (e.g., Mimbi & Bankole, 2016b).

Since the 1990s, measuring government performance has been a top agenda item, and governments have established performance measures in public services. For instance, the government performance project in the United States has been one of the most elaborate projects for assessing government effectiveness across all levels of government (Lee & Whitford, 2009). Government effectiveness initiatives focus on making the citizenry happy by providing high-value public services. Research shows that quality of government is positively related to happiness of citizenry (Ott, 2010). The literature also suggests that when the citizens are happy, they tend to feel respected by the government, and consequently trust their government (Ott, 2010).

On the other hand, transparency is important in ensuring accountability. Transparency refers to the full flow of useful information within a polity (Hollyer, Rosendorff, & Vreeland, 2014) that can assist the citizenry in the performance evaluation of governments (Grigorescu, 2003). Transparency is the lateral value of accountability that assumes the prerequisite condition for government accountability and responsiveness (Grigorescu, 2003; Hollyer et al., 2014). Previous studies indicate that transparent governments are more accountable and govern better than opaque ones (Islam, 2006).

ICT as a tool for enabling government functions has the potential to create or transform effectiveness and transparency values (Bannister & Connolly, 2014). The transformative impact of ICT on effectiveness is a well-established phenomenon in the information systems literature. Effectiveness was one of the motivations for implementing ICT systems in both the public and private sectors. However, in recent times, the Internet, in particular, has transformed transparency, and citizenry are now expecting more from government disclosure. ICT has transformed transparency by opening more avenues for information availability to the wider public (Hollyer et al*.,* 2014; Pang et al*.,* 2014). The essence of ICT in service-oriented public values is to enable or create effectiveness and transparency in public administration to improve service provision for citizenry satisfaction (Mimbi & Kyobe, 2017). For instance, ICT can facilitate transparency strategies by exposing wrongdoing, thereby deterring public servants from committing corrupt practices (Jaeger & Bertot, 2010). In this case, citizenry may be assured of improved public services.

Socially Oriented Public Values

Socially oriented public values refer to those that incorporate quasipolitical views encompassing broader social goals. They include aspects of providing public services to all citizens (inclusiveness), by treating them equally in a just way, and granting them access to public services. Socially oriented public values can be bundled together to refer to impartiality in public services provision (Bannister & Connolly, 2014).

Impartiality refers to the "norm of the output side that is most compatible with the normative principle of treating everyone with equal concern and respect" (Teorell, 2009, p. 4). Rothstein and Teorell (2008) add that "when implementing laws and policies, government officials shall not take into consideration anything about the citizen/case that is not beforehand stipulated in the policy or the law" (p. 170). These values are implemented under the banner of rule of law, defined as the extent to which agents have confidence in and abide by the rules of society and, in particular, the quality of contract enforcement, the police, and the courts, as well as the likelihood of crime and violence (Kaufmann et al*.,* 2008). This means that rule of law ensures impartiality by ensuring that laws are applied equally to all people (Ahrens, 2007). ICT in public services offers a relatively less expensive mode of access than the traditional face-to-face mode, thereby significantly impacting equity and access. Recognizing this impact, several governments have implemented ICT for public value creation in this regard. For example, the UK and Denmark governments have established ICT policy of "digital by default" in providing public services (Bannister & Connolly, 2014, p. 124). The literature points out how ICT can have an impact on or create public values. According to the International Telecommunication Union (2006), ICT impacts can be assessed in two ways—by their efficiencies or their impacts on social dimensions. I chose the former to assess ICT performance (efficiency) in creating public values.

Using Data Envelopment Analysis to Measure Efficiency in Public Sectors

Performance management is one of the growing research areas in information systems and public administration. This growth, particularly in governments, is driven by increased citizen demands for government accountability in service delivery. There is an increased interest, on the part of legislators, in performance information to assist in program evaluation and resource allocation decisions. Similarly, the efforts of various organizations and professional associations are geared toward making governments more results

oriented (Municipal Research and Services Center, 2015). It has become important to determine the efficiency of governments in converting inputs into outputs. The International Telecommunication Union (2006) contends that the best way to examine ICT impacts is to assess their efficiency in producing outputs. This means that ICT is an input that can be used to produce output (public values). This is also consistent with Moore's (1995) public value framework, which explains how ICT, as a resource, can be used to create public value. Efficiency is a measure of how well the government resources are used to achieve specific goals (Neely, Gregory, & Platts, 1995). Efficiency in this study refers to how well ICT has transformed/enabled public values in Africa.

ICT value creation is a performance phenomenon that can be analyzed using the DEA methodology. DEA is appropriate where the objective of the investigation is to evaluate efficiency (productivity and performance) of a decision-making unit (DMU), such as a group of countries, companies, and schools, in which inputs are converted into final outputs (Saranga & Moser, 2010). DMU refers to any group of production entities that receives the same set of inputs and produces the same set of outputs. Since ICT and public value represent input and output respectively, then DEA is an appropriate analytic technique to analyze the present phenomenon. DEA has several advantages which include, firstly, the ability to evaluate each DMU relative to its peers—for example, one country can be compared with other countries in the same group (Saranga & Moser, 2010)—and secondly, the ability to allow for the use of multiple inputs and multiple outputs that eliminates the use of unidimensional measures that may promote dysfunctional behavior (Easton, Murphy, & Pearson, 2002). As such, DEA provides performance managers with a comprehensive measurement that enables them to take strategic actions on all DMUs performances that lag behind those of their peers (Easton et al., 2002). Therefore, DEA is an analytic technique of choice for many efficiency studies (Nataraja & Johnson, 2011). Many researchers have examined efficiency of DMUs using DEA (Kayisire & Wei, 2015; Mimbi & Bankole, 2015, 2016b). For example, Mimbi and Bankole (2015) adopted DEA to investigate the efficiency of ICT and health systems in Africa. This study therefore adopts DEA to investigate the relative efficiency of ICT in public value creation in 53 African countries. DEA is discussed further in the Methodology section.

Methodology

Phase 1: Data Envelopment Analysis (DEA)

Data envelopment analysis (DEA) is a nonparametric method for measuring efficiency of a DMU. A DMU could be a group of people, companies, or countries (Samoilenko & Osei-Bryson, 2013). DEA focuses on a principle of extracting information about a population of observations to evaluate efficiency with reference to an imposed efficient frontier. The DMUs which are considered to be efficient are identified by their ability to use the same level of inputs and produce the same or higher outputs (Coelli, 1996; Cooper, Seiford, & Zhu, 2011). All DMUs efficiencies are checked against the condition that all observations lie on or below the extreme frontier (Cooper et al., 2011). The efficiency score is a reflection of the performance, and the highest ranking DMUs are considered relatively efficient and are assigned a perfect score of 1.

DEA was initially introduced by Farrell (1957), and years later Charnes, Cooper, and Rhodes (1978) improved on the earlier version by proposing a DEA model that assumed constant returns to scale (CRS). Later on, Banker, Charnes, and Cooper (1984) proposed alternative theoretical assumptions known as the

variable returns to scale (VRS). The two models of DEA—the CCR, which was developed by Charnes and associates (1978), and the BCC, which was developed by Banker and colleagues (1984)—are basic models for investigating efficiency. DEA models can be performed in two common orientations: (i) input orientation, which involves the minimization of inputs to achieve a given level of output. The relative efficient DMU in this case cannot reduce its inputs further to achieve the given output. However, the relative inefficient DMUs, with scores greater than 0 but less than 1, can. (ii) Output orientation, which is the maximization of outputs for a given level of inputs (Cooper et al., 2011). A relatively efficient DMU cannot increase its level of output given the level of its input. However, the relatively inefficient DMU, with efficiency score of greater than 1, can. In summary, in both cases, the relatively efficient DMU will receive a score of 1 and the relatively inefficient DMU will receive a score of greater than 1 under output orientation, while a score in the (0, 1) interval will be assigned under input orientation.

DEA can be applied under different economic assumptions concerning returns to scale. The CRS model signifies that the changes in output are in the same proportion as the changes in inputs. While the VRS model signifies an increase in outputs given a change in inputs. In addition, the no-increasing return to scale (NIRS) model signifies a decreasing return to scale scenario. For example, a change of 50% in inputs results in a change of 25% in outputs.

Given the emphasis on value creation in public administration, and consistent with public value theory of using the available limited resources to maximize outputs in the pursuit of substantive public value aims (Moore, 1995), an output-oriented approach based on the CCR model, under a VRS economic assumption (Charnes et al., 1978) was adopted. DEA is an appropriate technique to analyze the efficiency phenomenon in Africa because countries represent DMUs that use ICT—in this case, as an input (resource) to produce output (public value).

Phase 2: Cluster Analysis

Cluster analysis is a data reduction technique used to group cases based on multivariate attributes. The principle behind cluster analysis is to minimize the differences between group members (homogeneity) and thereby increase the differences between the groups—heterogeneity (Ketchen & Shook, 1996). Cluster analysis can be performed using either a hierarchical algorithm or a nonhierarchical algorithm (K-means). The nonhierarchical algorithm was adopted in this study because it is not affected by outlier elements, unlike the hierarchical algorithm (Hair, Anderson, Tatham, & Black, 1992). An *F*-statistic test (analysis of variance [ANOVA]) was used to assess the cluster validity as recommended by Jain, Murty, and Flynn (1999) and Ketchen and Shook (1996).

I used cluster analysis to determine whether the African countries are similar in terms of human development, using the human development index (HDI). I wanted to test the null hypothesis, that there are no discernible clusters (groups) of African countries in terms of their level of human development. Thus, I state the null hypothesis as follows:

H0:　　　The sample of 53 African countries is homogenous in terms of the level of human development.

Consequently, the null hypothesis (H0) is rejected if the results of the cluster analysis produce more than one cluster. Then, the relative efficiency scores, over a 10-year period (2010–19), identified in the DEA analysis within the emerged clusters, will be averaged. I can expect that if heterogeneous groups are identified in the sample of 53 African countries, then these groups will have different average relative efficiencies.

Data Sources and Variable Explanation

The data for this study were obtained from several archival sources: ICT infrastructure data were obtained from the ITU (http://www.itu.int). Accountability, government effectiveness, and rule of law data were obtained from Legatum Institute (www.prosperity.com). Accountability, government effectiveness, and rule of law scores are expressed out of 100, with 100 being the best. Government transparency data were obtained from Freedom House (https://freedomhouse.org). To measure government transparency, this study adopted the press freedom index as a proxy for transparency. The press freedom index has been used in previous studies investigating transparency (Hollyer et al*.,* 2014). The press freedom index ranges from 0 to 100, with the smaller score corresponding to greater freedom. Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. In addition, HDI data were obtained from the United Nations Development Program (http://hdr.undp.org/en/data) and were used to cluster the 53 countries into three clusters. HDI is a measure of average achievement in key dimensions of human development encompassing a long and healthy life, being knowledgeable, and having a decent standard of living.

The data were readily available for 53 African countries covering a 10-year period from 2010 to 2019. Somalia was not included in the analysis because it did not have HDI data for the time period considered in this study. Other countries with few missing data were imputed using group means as recommended by Scheffer (2002). The data from the mentioned sources are reliable and have often been used in ICT research. For example, Freedom House has been collecting data related to freedom and democracy since 1941 and its data have been used in many studies (Hollyer et al*.,* 2014).

Development of Data Envelopment Analysis (DEA)

Factors to consider when selecting DMUs include homogeneity and number of DMUs (Tyagi, Yadav, & Singh*,* 2009). DMUs must be homogeneous units performing the same tasks and must have similar objectives. Based on this requirement for homogeneity, the 53 countries selected were all African, and all the data relating to these countries, obtained from the sources stated above, were for the 10 years from 2010 to 2019. For running DEA, Avkiran (2001) recommends that the number of DMUs be larger than the product of the number of inputs and outputs, for effective discrimination between efficient and inefficient DMUs. Banker and colleagues (1984) contend that the number of DMUs should be at least three times larger than the combined number of inputs and outputs. To comply with these requirements, 530 DMUs representing 53 countries for the 10-year period were developed.

In the selection of DEA variables, the literature recommends using the researcher's expert judgment and knowledge about the variables (Nataraja & Johnson, 2011). I therefore carefully selected the

variables based on the experience of previous studies and variable relevance, as recommended by Nataraja and Johnson (2011). Input variables for the DEA model for ICT were represented by mobile cellular subscribers per 100 inhabitants, percentage of Internet users, and main telephone lines per 100 inhabitants. These input variables have been used in previous studies (e.g., Mimbi & Bankole, 2015, 2016a). At the same time, output variables (public values) were represented by accountability, government effectiveness, transparency (press freedom), and rule of law (see Table 2). These output variables were derived from the literature relating to ICT and public value creation (Bannister & Connolly, 2014).

Table 2. Input and Output Variables for DEA Model of ICT Public Value Creation.

Value/dimension	Input and output variables
Duty oriented public value	Accountability (O)
Service oriented public value	Government effectiveness (O)
	Press freedom (O)
Socially oriented public value	rule of law (O)
ICT infrastructure	Mobile cellular subscribers (I)
	Internet users (I)
	Main telephone line (I)

Note. "I" stands for input and "O" for output.

Results

DEA Results

I used MaxDea Basic (Version 6.4) software to calculate the relative efficiency scores for the 53 African countries. Results indicate that no single country scored 100%, indicating that the ICT infrastructure did not efficiently create public values in Africa for the 10-year period from 2010 to 2019. However, one major shortcoming of DEA is that it tends to evaluate DMUs as efficient when they use fewer inputs or when they produce high output values (Ali, 1994). Consequently, the nature of the relative efficiency of African countries based on these results cannot be determined. To determine the nature of relative efficiency and make a valid comparison of ICT efficiency, countries should be compared with those with a similar level of human development. Schultz (1961) argues that productivity differences among countries is largely explained by human capital, which is the key indicator of the HDI. Therefore, cluster analysis was performed to group (cluster) countries based on their HDI scores. Such groupings will enable the researcher to have similar countries in each subgroup, while each subgroup exhibits substantial differences. This approach has been used in other studies (e.g., Mimbi & Bankole, 2015).

Cluster Analysis Results

Thus, after running the DEA on the 53 countries, I then clustered the countries into clusters based on their HDI scores over the period 2010–19. Human capital theory posits that human capital, in the form of education, knowledge, skills and health, which are collectively included in HDI, explains much of the differences in productivity between countries (Schultz, 1961). I chose HDI as a clustering variable because it has an influence on how ICT can be used, and hence on ICT's efficiency. Further, HDI is more

encompassing than economic measure alone as it provides a comprehensive picture about the development outcomes of a nation. Economic measures, such as gross national income (GNI) per capita, may indicate different economic outcomes of two countries, while they have the same GNI per capita. The HDI clustering scheme has been used in other studies (e.g., Mimbi & Bankole, 2016b). SPSS software was used to perform cluster analysis (K-means). I started experimenting with six clusters (K = 6), five clusters, and four clusters. Finally, the three-cluster solution seemed to be optimal, and the ANOVA confirmed that these groups (clusters) were significantly different from one another (F = 191.383, Sig = .000). Earlier, it was hypothesized that

H0:   The sample of 53 African countries is homogenous in terms of level of human development.

However, the cluster analysis results indicate that there is more than one cluster (i.e., three, and hence not homogenous) in the sample of 53 African countries. Therefore, the null hypothesis (H0) is rejected.

Earlier, I promised to compute average relative efficiency scores if the cluster analysis results indicate the presence of more than one cluster from the sample of 53 countries. The cluster analysis results have confirmed that there are three clusters, and consequently, I have computed the average relative efficiency score for the period 2010–19 for each cluster, as indicated in Table 3.

Table 3. DEA Results for ICT Public Value Creation (2010–19).

Cluster 1 Countries	Efficiency Scores	Cluster 2 Countries	Efficiency Scores	Cluster 3 Countries	Efficiency Scores
Algeria	0.1117	Angola	0.4032	Burkina Faso	0.3603
Botswana	0.1768	Benin	0.3349	Central African Rep	0.8790
Cabo Verde	0.1810	Cameroon*	0.1471	Chad	0.6091
Egypt	0.1148	Comoros	0.3792	Burundi	0.6820
Gabon**	0.1996	Congo, Rep.	0.2523	Eritrea	0.6363
Libya*	0.0686	Cote d'Ivoire	0.2525	Congo, Dem. Rep.	0.8165
Mauritius	0.1332	Equatorial Guinea	0.4009	Ethiopia	0.6249
Morocco	0.1405	Djibouti	0.4069	Gambia*	0.2334
Namibia	0.1963	Ghana	0.3296	Guinea	0.6479
South Africa	0.1621	Kenya	0.3940	Guinea-Bissau	0.7832
Seychelles	0.0921	Lesotho	0.2708	Liberia	0.5565
Tunisia	0.1334	Madagascar	0.5711	Mali	0.2828
Mean score	**0.1425**	Mauritania	0.1877	Malawi	0.8514
No of countries	**12**	Nigeria	0.3566	Niger	0.7263
		Rwanda**	0.6348	Mozambique	0.6138
		Senegal	0.2811	Sierra Leone	0.5234
		Sao Tome and Principe	0.3011	South Sudan**	0.9390
Cluster 1		Tanzania	0.5781	**Mean score**	**0.6333**
Minimum	0.0686	Eswatini	0.1711	**No of countries**	**17**
Maximum	0.1996	Sudan	0.3027		
Cluster 2		Togo	0.3823		
Minimum	0.1471	Uganda	0.5477		
Maximum	0.6348	Zambia	0.4256		
Cluster 3		Zimbabwe	0.1974		
Minimum	0.2334	**Mean score**	**0.3545**		
Maximum	0.9390	**No of countries**	**24**		

Note. * represents countries with the lowest efficiency scores
** represents countries with the highest efficiency scores.

Cluster 1 (*n* = 12) has an average relative ICT efficiency score of 0.1425, which is the lowest among the three clusters (see Table 3). This means that Cluster 1 performs the worst in terms of ICT efficiency in creating public value. In this cluster, Libya and Gabon scored the lowest (0.0686) and highest (0.1996) ICT efficiencies, respectively.

Cluster 2 (*n* = 24) has an average relative ICT efficiency score of 0.3545 and has the largest number of countries of the three clusters. Rwanda in this cluster performed the best by scoring 0.6348 (63%) ICT efficiency in creating public value, and the lowest score (0.1471) in this cluster was taken by Cameroon (see Table 3).

Cluster 3 (*n* = 17) has an average relative ICT efficiency score of 0.6333, which is the highest among the three clusters. In this cluster, the South Sudan is the highest overall performer, and also of the three clusters (see Table 4). It has a score of 0.9390. It can be seen that Gambia scored the lowest (0.2334) ICT efficiency in creating public value in Cluster 3. The computed average relative ICT efficiency in each of the three clusters affirms that the clusters are different (see Table 4). Consequently, the findings confirm that the sample of 53 African countries contains heterogeneous groups.

Table 4. Cluster Results Summary of ICT Efficiency and Human Development Index.

Cluster ICT efficiency score (mean)	Best performer	Score	Ranking
Cluster 1 = 0.1425	Gabon	HDI = 0.6799	1
		ICT efficiency = 0.1996	3
Cluster 2 = 0.3545	Rwanda	HDI = 0.5207	2
		ICT efficiency = 0.6348	2
Cluster 3 = 0.6333	South Sudan	HDI = 0.4227	3
		ICT efficiency = 0.9390	1

Based on the theoretical underpinnings of the DEA methodology, efficiency comparison of DMUs (i.e., countries) can only be performed among peers—members of the same cluster (Saranga & Moser, 2010). This means that in Cluster 1 member countries, having the same level of human development can be compared with their peers within the cluster (Saranga & Moser, 2010). Therefore, Gabon is efficient in Cluster 1 by its ability to use the same level of inputs and produce higher outputs than other countries in this cluster. Similarly, Rwanda and South Sudan use the same level of inputs to produce higher outputs than other countries in their respective clusters (see Table 4). However, the findings indicate that the highest performer of ICT efficiency among the clusters' best performers have a low HDI (see Table 4). These findings suggest that the industrious characteristics of some African countries make them achieve high performance (efficiency) while using fewer resources. These findings are consistent with the public value theory of doing more with less (Moore, 1995; Osborne, 1993; Williams & Shearer, 2011).

From the findings, I can infer the following. First, based on the level of human development, Cluster 3 is the highest performer among the clusters, followed by Cluster 2 (see Table 4). The findings also indicate that Cluster 1, which is characterized by the highest level of development among the three clusters, performs worse than others. The findings further indicate that the countries that are most efficient at using ICT to create public value in their respective clusters are Gabon, Rwanda, and South Sudan.

Second, the findings also indicate that ICT has not been leveraged to any great degree in public value creation, particularly in the countries of Cluster 1. For example, in Cluster 1, the 14.25% cluster average of ICT efficiency in transforming public values is very low. However, regardless of its low efficiency, ICT shows a potential in public value creation, as suggested by many scholars (Bannister & Connolly, 2014; Hollyer et al*.,* 2014; Jaeger & Bertot, 2010; Samoilenko & Osei-Bryson, 2019). Given the results, I feel that African countries still need to improve their efficient use of ICT to create public values. This is due to the finding that after more than a decade of using ICT in Africa, the most efficient cluster (17 countries) has used ICT to transform public values by 63%.

Contribution of the Study

This study has theoretical, methodological, and practical contributions. The public value framework is relatively new, and scholars have called for future studies to empirically test it and develop appropriate concepts. Williams and Shearer (2011) have called for future researchers to "define the central concepts and arguments that make up public value and subject these to empirical investigation and testing" (p. 15). In addition, Bryson and associates (2014) have called for "the development of suitable typologies and measures, and rigorous empirical testing" (p. 453) as well as bringing scholarship from other research fields to help enrich public administration. This study responded to some of these calls by defining and empirically testing three typologies of public value—namely, (i) duty-oriented public value, (ii) service-oriented public value, and (iii) socially oriented public value. In addition, consistent with the theory of public value, which puts an emphasis on the use of resources to create public value (Moore, 1995; Williams & Shearer, 2011), ICT was used in this study as an input (resource) for creating public value. Findings of this study indicate that countries in clusters with a low HDI are characterized by high ICT efficiency (see Table 4). These findings confirm the central proposition of public value, that of using fewer resources to produce more public values, or doing more with less, as it is known in public value terms (Moore, 1995; Osborne, 1993). Thus, this study advances the public value theory and adds to the number of articles, in this nascent area of research, that have been published in information systems journals (Bannister & Connolly, 2014; Pang et al., 2014; Samoilenko & Osei-Bryson, 2019) and adds to the number of public value research about Africa and least developed countries (Twizeyimana & Andersson, 2019). The findings of this research have implications for practitioners. Individual countries should see what context favors their peers' best performance within their respective clusters and determine whether they can adopt the same to maximize public services offerings (outputs). Further, the researcher calls for other researchers to consider other variables within those three topologies and operationalize them in future research.

Conclusion

This study set out to investigate the efficiency of ICT in public value creation in Africa. Since the 1990s, public sector reforms have been linked to the NPM paradigm, which emphasizes public value creation in the public sectors. International bodies and researchers alike have recognized the potential of ICT in public sector reforms. It has become clear that ICT can be used in performance management to create public values. International bodies have emphasized that ICT should be harnessed in public services for socioeconomic development (United Nations Department of Economic and Social Affairs, 2015). However, little research has investigated this nascent field of research (Bannister & Connolly, 2014; Sami et al., 2018; Samoilenko & Osei-Bryson, 2019; Twizeyimana & Andersson, 2019). Using DEA and cluster analysis, this study investigates the efficiency of ICT in public value creation in 53 African countries for the period from 2010 to 2019. The findings from cluster analysis indicate that there are three distinct groups of countries from the sample of these 53 countries. These findings indicate that, by using ICT, Cluster 1 countries efficiently transformed the public values by an average of only 14%. Clusters 2 and 3 performed higher than Cluster 1 by scoring average ICT efficiencies of 35% and 63%, respectively. Cluster 3 countries seem to have performed the best compared with those in other clusters. However, the highest performer of ICT efficiency among the clusters' best performers has a low HDI. This is consistent with the theory of public value, which emphasizes doing more with less (Moore, 1995; Osborne, 1993). This study has empirically

demonstrated the role of ICT in public value creation in Africa. Therefore, policy makers are urged to leverage the use of ICT in creating public values to bring about socioeconomic development in Africa.

Besides its contribution, this study has limitations. This study has assumed that all African countries have the same focus on public values. However, it may be that different countries focus on public values in different ways. For example, Vandenabeele, Scheepers, and Hondeghem (2006) found that in the UK there was a stronger focus on values such as impartiality and neutrality, while in France the focus was more on the values related to public provision of services. It is also recommended that investigations carried out in the factors that influence ICT efficiency would provide answers as to why in some countries ICT has efficiently transformed public value, while in others it has not. Such studies would have practical implications for finding better ways of maximizing public values, from the limited resources available in the public sectors, for socioeconomic development.

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