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MODELING THE IMPACTS OF E-GOVERNMENT SERVICES ON CORRUPTION REDUCTION IN RWANDA: A CASE EVIDENCE FROM NYAMASHEKE DISTRICT, RWANDA

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Abstract:
The study entitled modeling the impacts of e-government services on corruption reduction in Rwanda: Case evidence from Nyamasheke District, Rwanda was about assessing the contribution of e-government services use on reducing corruption in the area under study. The study was guided with the objective of exploring the utilization of multinomial logistic regression (MLR) in modeling the impact of e-government services on reduction status of corruption. In this regard, the MLR model was performed using a maximum likelihood estimation method on the data set collected to find the parameter estimates of the model describing the relationship between the explanatory and the outcome variables and determine the significance of the explanatory variables that contribute significantly to the reduction status of corruption in the area under study. The study adopted both qualitative and quantitative approaches to collect data from 381 respondents from the target population of 8041 using Solvin's formula for sample size calculation. Data were collected using questionnaire and interview schedule techniques and analyzed using SPSS-23. In this analysis, the results show that on the total of eleven independent variables, the explanatory variables such as age, income, ownership of the devices used in applying for the local government services and the advice types were dropped from the training set of explanatory variables that contribute significantly to the reduction of corruption in the area under study. In model selection that overall fits well the data, the obtained variables that contributed significantly to the outcome variable were education, e-government services' use status, cost of accessing e-government services and the e-government services types delivery. The parameters estimate of the

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selected model revealed that the variables that best predicted the probability of reducing corruption once the e-government services are delivered online were education, status of using e-government services, types of e-government services delivery online while the cost of accessing the e-government services decreased the logit (the probability) of reducing corruption. The main challenges faced by users of e-government services were the cost given while applying to these e-government services is high and lack of enough skills to cope with technological usage. Finally the study recommended that local leaders in the area under study should strengthen the online system in delivering local services to people, educate people to be aware about the use of e-government services since the more a person is educated the more is attempting to use e-government services and then reduce the cost of using e-government services while applying to the local services since this has been the only explanatory variable that decreased the logit of reducing corruption in the study area.

Keywords: modeling, multinomial regression model, e-government, corruption, Rwanda

1. Introduction

1.1 Background information

Corruption refers to efforts to secure wealth or power through illegal ways for private gain at public expense; or embezzlement of public funds, theft of the public assets, a misuse of public power for private benefit (Obayelu, 2007). It is the global problem, or a common phenomenon found not only in the developing countries and societies, but also in the developed world such as United States of America, Europe, South Korean, Japan, and Australia to name but a few regardless of their economic status.

Authors conducted various studies on the topics related to corruption. Many of them agree that corruption is a socio-economic phenomenon. A study conducted by KGPM international, a Swiss entity stipulates that corruption consists of both direct and indirect effects on the institutions of a country (KPMG International, 2016). About the direct effects of corruption there are bribes, funds wasted on inflated procurement contract prices, and also stolen public wealth. The indirect costs include but not limited to inefficiencies resulting from the deterioration of institutions and other activities related to the development of the institutions. It also points out that corruption has implications for social welfare by affecting the distribution of income and assets and unemployment, the environment and health.

Pulok reveals that corruption has undesirable, devastating and widespread consequences on investment, human development, poverty reduction, effectiveness of the institutions both public and private and thus on economic growth, development of countries in the world (Pulok, 2012). He concludes that when corruption dominates in a country, it causes economic problems, wastage of public resources, affects both national and international investments and destroys morality in public service. Corruption causes

political instability and propagates social and economic disparities despite well designed, developed and established economic and social policies.

It is therefore a duty of a good government leadership to put in place measures to fight against corruption by making sure that the initiated measures are well implemented through consistent monitoring and evaluation processes. One of the proposed measures was sensitizing citizens to adopt the use of e-government services at the maximum.

Why? Because these e-government approaches allow citizens to do a number of things and get served very quickly while they are sitting at homes, offices before their electronic devices (desktops, laptops, iPads, smart phones, etc.) applying for example for certificates for new businesses, receive information from government entities, paying taxes, paying bills, paying for official documents such as marriage certificates, land titles, passport to name but a few.

Rwanda was not left behind in the fight against corruption as one of its highest priorities. For instance, there is a revolution/slogan going on in Rwanda in the form of fighting corruption which is the zero tolerance to corruption in Rwanda. To achieve this, Rwanda implemented several anti-corruption measures including the National Tender Board (NTB), the anti-corruption Unit in the Rwanda Revenue Authority, the Auditor General's Office (OAG) and the Ombudsman's office. Apart from these measures, Rwanda also adopted a code of conduct and rules of disclosure for public officials where the public officials and civil servants in Rwanda have to declare their assets to the ombudsman's office.

It is in this framework that Rwanda is performing well in the process of fighting against corruption. This is revealed by the indicators of the United Nations from the survey made on the perceptions of people about the e-government services. Those indicators are e-government development index (EGDI) and e-participation index (EPI). For the case of Rwanda, they will be discussed in detail in the next section.

1.2 E-government: As an anti-corruption strategy

With the increase of cost-effective ICT infrastructures and services, e-government has become a major and hot topic of interest to many researchers and practitioners (Kim et al. 2009 and Kim, 2014).

The main purpose of introducing the e-governance initiatives was to deal with the problems related to the provision of public services when citizens need them. It is known that a visit to the government office requires patience as it is associated with a lot of paperwork, long queues, bureaucracy, full spaces, delaying of services delivery, and frustrations. Due to these problems, citizens tend to corrupt the officials in order to get the service as quick as possible. Thus, the introduction of e-governance has reduced corruption rates.

More governments around the world are shifting to electronic techniques to deliver services and communicate with citizens. These mechanisms shall contribute to the reduction of costs while improving services, saving time and increasing the productivity and efficiency of the public sector (Alshehri and Drew, 2010).

Prof. Shirish (2018) in his article entitled how-e-government curbs corruption? Reported that e-government prevents corruption in national institutional and service systems. He stated that advances in information and communication technologies are making e-government ubiquitous because citizens and Government interact by using e-government tools for example to pay taxes, register to vote, apply for licenses. Moreover, since the information is published and available online citizens can access it free of cost therefore, this increased transparency in accessing governmental services that led to a reduction of corruption. He concluded that there is less corruption in nations when e-government systems are active by showing a case of Singapore.

According to the United Nations report on the e-Government development Index (EGDI) 2018, it is reported that developed countries are advanced in accessing the e-government services than developing countries, whereby Denmark ranked first followed by Australia with 0.9150 and 0.9053 index values respectively, which scores are above the world EDGI standard value of 0.55. For instance, among the developing countries; India was rated as having high e-government index where it occupied the 100th position out of 193 UN member states. In the same report, it was revealed that four African countries such as Ghana, Mauritius, South Africa and Tunisia were rated as having the high e-government index indicating that their citizens accessed more government services through online.

The data from the report show that Rwanda has made significant strides to integrate e-government services in the development scenarios for her citizens. This made Rwanda to be classified among top ten ranked countries in Africa occupying the 9th place. As a result, Rwanda was shifted from the low EGDI level to the middle EGDI level of 0.4590 (UN, 2018). The value of EDGI in 2020 was 0.4789 which indicates a small increment.

Another indicator being used by the United Nations in the surveying process about e-government is the e-participation index (EPI) defined as the process of engaging citizens through ICTs in policy, decision making and service design and delivery in order to make it participatory, inclusive and deliberative. The indicator is measured based on e-information, availability of online information, e-consultation, online public consultations and e-decision making. It emphasizes the direct involvement of the citizens in decision making processes. According to the results from the UN e-government survey, Rwanda was ranked the 59th over 193 countries of United Nations with an EPI of 0.7584 (UN, 2018) and 0.6310 in 2020 implying as small reduction.

It is evident that e-government initiatives have contributed and are still contributing to the reduction of corruption in their respective countries. Baniamin (2015) examined two cases whereby corruption is highly observed. The first is the provision of railway tickets and the second case is the provision of land record from the district land administration office. He realized that the introduction of electronic and mobile ticketing in Bangladesh Railway system was very contributive to the reduction of corruption since corrupt officials tend to request for bribes or tips by creating obstacles in the provision of tickets.

He argued that since the introduction of e-ticketing, the rate of corruption declined. In the case of land records, he found that corruption levels appear to have increased even after the introduction of the e-governance. Then, he suggested that after conducting initial processes online, a printed copy must be submitted in hands by the applicant at an official counter and receives a copy for reception.

Shim and Eom (2008) confirmed that e-governance has the potential to lessen corruption risks by limiting the direct contacts between public officials and citizens. They reported that there is a need for the citizens to avoid interaction with public officials while looking for public services. This could support significantly in reducing malpractice linked to these services.

It is in this regard that this paper sought to model the impact of e-government services on corruption in Rwanda through answering the question of "what is the impact of e-government services on corruption?"

1.3 E- Government initiatives in Rwanda: Irembo Platform/Portal

In Rwanda different government services are received through Irembo platform. The services are under family, identification, police, health, education, notarization and gazettes services, criminal records, media and Rwanda museum categories.

Under Family category there are services related to certificate for widow/widower, certificate of residence, certificate of genocide survivors, birth certificate, marriage certificate, adoption record, death certificate, and certificate of cohabitation, among others. Identification related services are included but not limited to application for national ID, application for the national ID correction, change of name, national ID replacement, certificate of nationality, and certificate of divorce. Services offered by police are duplicate of driving license, traffic fines, replacement of definitive driving license, registration for driving license test, etc. For Health services there are COVID-19 test or travel restriction adjustment requests. Yellow fever vaccination and community-based health insurance. Educational services including application for equating foreign qualification and application for equating foreign qualification: general education. Services from Rwanda Museums are related to schedule and re-schedule a visit. Regarding criminal record service is the application of the criminal record certificate. Notary and accreditation for foreign media services are also applied from Irembo portal[ii].

2. Literature review

2.1 Definition of keys terms

a. E-government

E-government is also known as digital government, online government or transformational government. It refers to the use of internet technology as a platform for exchanging information, providing services and transacting with citizens, businesses, etc.

[ii] https://new.irembo.gov.rw/home/citizen/all_services

It may be applied for the legislature, judiciary, or the executive in order to boost internal controls of the delivery of public services (Kamal and Themistocleous, 2009).

E-government refers to the use of information technology to provide government services online, which aims at providing faster and better services for recipients. They added the categories of e-government viz. government to citizen (G2C), government to business (G2B), government to government (G2G) and government to employee (G2E) (Kevin, et al., 2016).

This study focuses on the government to citizen category because the aim of this research is to model the impact of e-government on corruption with target to the citizens of Nyamasheke district.

b. Corruption

According to Ekiyor corruption is the unlawful use of official power to enrich himself at the expense of the public in contravention of his oath of office (Ekiyor, 2005). The World Bank defines corruption as "*the abuse of public office for private gain*" (Begovic, 2005). He indicates that the definition considers the cause of corruption in public authority and relates corruption to the state. In other words, it excludes the possibility of corruption in the private sector. It is in consistency with the opinions of Nobel Prize laureate Gary Becker who notes that *"if we abolish the state, we abolish corruption".* This paper considers corruption as the abuse of public office for private gain.

c. Modeling

Modeling is the process of estimating the model on the basis of the observed data set and tested for their suitability. It is the part of inferential statistics.

Simply modeling is a forecasting technique that uses various software to process econometric models based on historical data and certain assumptions in order to predict economic conditions. It is processed in determining the economic aspects of changes in government policies, regulatory conditions, interest rates, demographic changes, etc. Such forecast helps the policy makers to assess the goodness of the estimated model and take necessary measures in order to re-adjust the relevant economic measures.

2.2 Theoretical review: An institutional theory of corruption

As stated earlier, corruption is a complex and common phenomenon meaning that choosing an appropriate theory of corruption under study is not an easy decision. However, an institutional theory of corruption or institutionalism theory was chosen for the purpose of this study as it uses government institutional characteristics such as pre-existing rules of law, defined anti-corruption measures, establishment of the institutions needed to fight, monitor, and enforce initiated measures to fight the corruption.

The institutional theory of corruption was developed by Dennis Thompson when he studied congressional ethics in the 1990. Thompson wanted capture differences between institutional and individuals' corruption. He tried to answer the question of why

do the institutionalists believe that it is important to give greater attention to the institutional conception to corruption?

First, the conception shows how corruption is related to the theory and practice of the institutions in which it is embedded. Second, the conception enables efforts to broaden the reach of legal and ethical regulation. Third, the conception helps more appropriate and more precise targeting of reforms as it shifts the focus from deterring and removing corrupted persons. Last, by the institutionalists' conception, it can be better to explain why identifying corrupted individuals is very hard to find and acknowledge. However, it is very simple to identify corrupted individuals through institutions in which they work. Institutional corruption does not involve individuals' corruptions who engage in illegal or unethical behavior instead it involves public official who attempts to deviate rules and regulations approved by the government in relation to fight corruption. Consequently, public officials demotivate individuals/citizens from using e-government services and thus stimulate corruption.

According to Scott (2004), institutional theory focuses on the processes by which structures, schemes, rules established by the government to help controlling the corruption. Authors have been argued that e-government usage is one among many strategies that is effective in the reduction of corruption.

2.3 Conceptual review

Important information to know before conceptualizing the theory is about the facets of a potential conceptual model of e-government anti-corruption impact.

2.3.1 Identification of the types of e-government services

As mentioned earlier, e-government can be broadly categorized as G2C, G2B and G2G. It is the responsibility of the authors to undertake one of category under study (Ojha et al., 2018).

2.3.2 Characteristics of e-government services

The e-government are low uncertainty (online availability of information, services available for 365 days in 24×7), low information asymmetry, low monitoring costs and audit trail of interactions and transactions between a government and citizens and government and businesses.

2.3.4 Benefits of e-government

Before constructing a model that intends to analyze the impact of e-government on corruption, researchers must thoroughly understand the likely benefits of e-government.

The following are the benefits of adopting e-government:

- Improve government efficiency,
- Maintain user satisfaction,
- Better surveillance,
- Early warning on frauds,

- Extensive audits,
- Reduce corruption.

Constructing a model that links corruption and e-government would be important for the policy makers, public officials, academicians among many to take serious measures and further strategies in tackling the corruption matters.

Consistent with other empirical studies, the model specification includes variables related to the socio-economic and institutional characteristics of the e-government service users (age, gender, marital status, education, income levels, time experienced in using e-government services, types of e-government services, types of device, ownership of device, cost to access e-government services and e-government services' use status)under the objective of understanding the perceptions of the users on corruption levels and the impact of e-government on corruption using the multinomial logistic regression model. We hypothesize that there is a direct relationship between corruption and e-government users and the conceptual framework guiding this study is shown in the following in Figure 1.1.

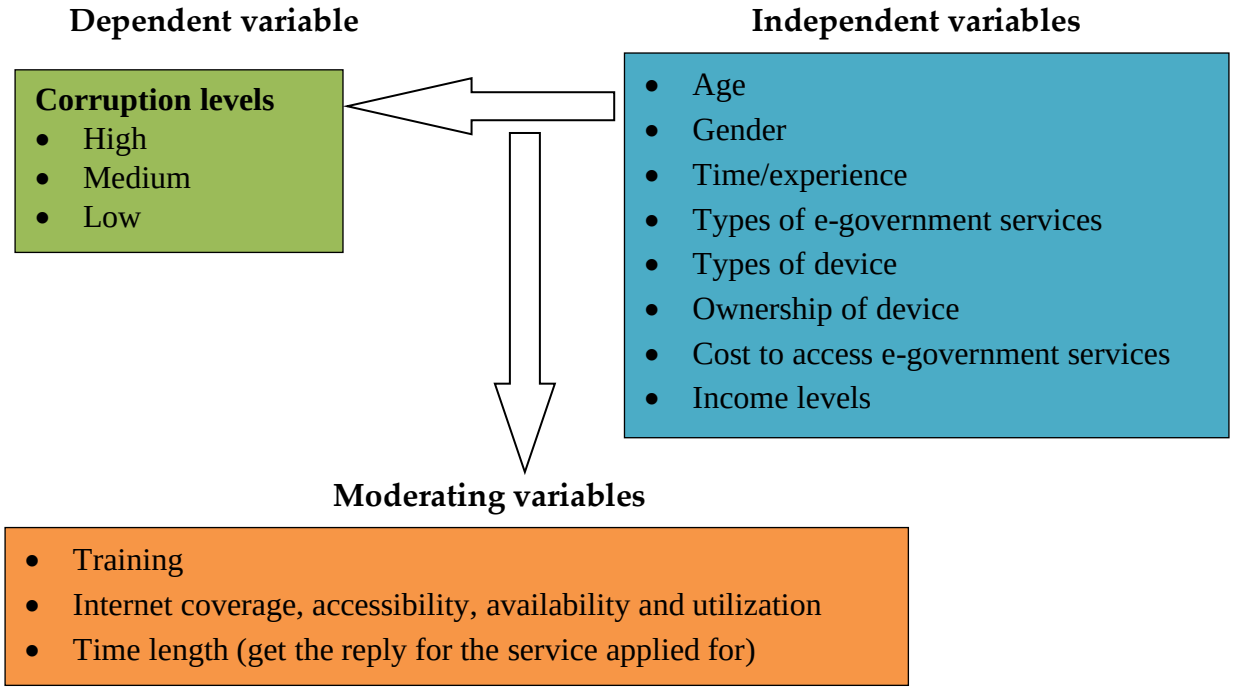

Figure 1.1: The conceptual framework of corruption
(**Source:** Own construct)

2.4 Empirical review

Many research studies in line with corruption were conducted by various scholars specifically focusing on measuring the impact of the e-government on the corruption. Hence, this part reviews some of the studies in relation to the topic under study.

Bakunzibake and Klein (2019) worked on the e-government implementation process in Rwanda by exploring changes in a socio-technical perspective. The study aims at exploring the extent of changes and effects in the implementation of e-government service-oriented initiatives in Rwanda. Data were collected from 8 agencies during the

period from January 2017 to May 2018. Furthermore, online materials were analyzed. Results show that there is a number of changes in technology, processes and people aspects. They concluded that addressing the issues as a socio-technical system would contribute to improved work systems of agencies and better services.

Lupu and Lazar (2013) investigated the influence of e-government on the level of corruption in some Europeans Unions and Europeans Unions States. They tested hypotheses whether the EU new members and those who are not EU members benefit more from using e-government in fighting corruption. Results from the developed model confirm that increasing the use of e-government will reduce corruption. For instance, an increase of 1 percent in the index of e-government can decrease corruption by 6.7 percent for countries entering the EU and 6.3 percent for non-EU member. They also found that countries that joined the EU have benefited most from the increased use of e-government in 2004 to 2012.

Machova, et al. (2018) studied the impact of e-government development on the level of corruption in the Republic of Czech. First, they emphasized on the importance of measuring the impacts by quoting that understanding the relationship between e-government development and the level of corruption would help for monitoring the related projects of anti-corruption. Second, results from the study showed that higher levels of e-government development were linked to lower levels of corruption.

Mistry and Jalal (2012) conducted an empirical analysis of the relationship between e-government and corruption in the United States of America. In the perspective of examining the impacts they developed and tested empirical model that studied the relationships. The results confirmed that as the adoption levels of ICT related e-government by users increases, corruption levels decline. They measured also the impact of e-government in developing and developed countries and found that impact of e-government is higher in developing countries than in developed countries from 2003 to 2010.

2.5 E-government and the COVID-19 pandemic

Not only was the e-government initiated in the purpose of dealing with corruption but also in the processes curbing the spread of the COVID-19. Their contribution in the identification/tracking, management and treatment processes of the COVID-19 was of great importance. During the pandemic the role of digital government in ensuring business continuity and service delivery has brought innovative ways on dealing with the crisis such as tracing people, e-health and remote working.

A study conducted by United Nations Department of Economic and Social Affairs, (UN/DESA) on embracing digital government during the pandemic and beyond revealed that a review of the national portals of the 193 United Nations member States on 25th March 2020 about 57 percent (110 countries) have displayed some kind of information about COVID-19, while 43 percent (83 countries) did not.

Picture 1: Information on measures about COVID-19
(Source: https://www.un.org/development/desa/dpad/publication/un-desa-policy-brief-61-covid-19-embracing-digital-government-during-the-pandemic-and-beyond/)

On 8th April 2020 the findings showed that 86 percent (167 countries) have provided information and measures about COVID-19 on the portal. Not only information regarding COVID-19 was provided on different portals of government but also during the crisis, government were encouraged institutions whether government or private to work from home in order to curb the spread of the COVID-19.

Specifically, in Rwanda information about COVID-19 was posted on all the government/ministries portals. The most information found was about informing people about the pandemic and how to keep one safe and curb the spread of the pandemic based on measures developed by the Ministry of Health (MoH) of Rwanda. Amazing and important information which also was disseminated by each ministry through its portal was the questions that might be asked by the citizens during the pandemic and answers were provided for each question.

2.6 Research objectives

The purpose of the paper is to:

- Attest the utilization of multinomial logistic regression in modeling the reduction status of corruption in based on the e-government services in the area under study.
- Evaluate the use maximum likelihood estimation method to estimate the parameters of the model governing the reduction status of corruption and the explanatory variables
- Assess the goodness-of-fit of the multinomial logistic regression model with the presence of the explanatory variables.
- Determine the significance of the explanatory variables that contribute significantly to the reduction status of corruption in the area under study.

Following fourth research purpose, the hypothesis of the research to be posed is:

H_0: There is no significant impact of e-government services on reduction status of corruption.

H_a: There is significant impact of e-government services on reduction status of corruption.

3. Methods and Materials

This study used a target population of 8041 from which a sample has been drawn using of Slovin's formula (Altares, et al. 2003) for sample size computation as follows:

$$n = \frac{8041}{1+8041(0.05)^2} \approx 381,$$

with n being the sample size to be selected in the target population of 8041 in Nyamasheke District having access to e-government services and the margin error employed here was 5% (level of significance). Then simple random sampling was employed to select the items to be included in the sample. After having this sample size, primary data were collected using questionnaire and interview guide and multinomial logistic regression model was used to model the response variable under study using the predictor variables

3.1 Brief introduction on Multinomial Logistic Regression Model

The multinomial logistic regression (MLR) model is a generalization of the binary model and both models depend mainly on logit regression (Abdallah, 2012). Logistic analysis in the logistic regression can be extending to models with multiple explanatory variables. Let consider the case of k predictors for a binary response Y by $x_{1,}x_{2,}, \ldots . x_{k,}$ the model for log odds is

$$Logit[p(Y=1)] = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \cdots + \alpha_k x_k.$$

And the alternative formula, directly specifying $\pi(x)$, is

$$\delta(x) = \frac{\exp\,(\alpha_0+\alpha_1 x_1+\alpha_2 x_2+\alpha_3 x_3+\cdots+\alpha_k x_k)}{1+\exp\,(\alpha_0+\alpha_1 x_1+\alpha_2 x_2+\alpha_3 x_3+\cdots+\alpha_k x_k)}$$

The parameter $\alpha_i$refers to the effect of $x_i$on the log odds that Y =1, controlling otherx_j, for instance, $exp(\alpha_i)$ is the multiplicative effect on the odds of a one unit increase in x_i, at fixed levels of x_j.

If there are m independent observations with q-explanatory variables, and the qualitative response variable has k categories, to construct the logits in the multinomial case, one of the categories must be considered the base level and all the logits are constructed relative many ways is the natural complement of ordinary linear regression whenever the response is categorical variable. When such discrete variables occur among the explanatory variables, they are dealt with by the introduction of one or several $(0, 1)$

dummy variables, but when the response variable belongs to this type, the regression model breaks down. Logit analysis provides a ready alternative. For a response variable Y with two measurement levels (dichotomous) and explanatory variable X, let: $\delta(x) = p(Y = 1|X = x) = 1 - p(Y = 0|X = x)$, the logistic regression model has linear form for logit of this probability

$$Logit[\delta(x)] = \log\left(\frac{\pi(x)}{1-\pi(x)}\right) = \alpha_0 + \alpha_1 x,$$

where the $odds = \frac{\delta(x)}{1-\delta(x)}$.

The $odds = e^{(\alpha_0+\alpha_1 x)}$, and the logarithm of the odds is called logit, so:

$$Logit[\delta(x)] = \log\left(\frac{\delta(x)}{1-\delta(x)}\right) = \log[\exp(\alpha_0 + \alpha_1 x)] = \alpha_0 + \alpha_1 x\,.$$

The logit has linear approximation relationship, and logit = logarithm of the odds. The parameter α is determined by the rate of increase or decrease of the S-shapedcurve of $\delta(x)$. The sign of α_1 indicates whether curve ascends ($\alpha_1 > 0$) ordescends ($\alpha_1 < 0$), and the rate of change increases as $|\alpha_1|$ increases.

3.2 Multinomial logistic regression

The logistic regression can be extending to models with multiple explanatory variables. Let consider the case of k predictors for a binary response Y by $x_1, x_2, \ldots\ldots x_k$, the model for log odds is

$$Logit[p(Y = 1)] = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \cdots + \alpha_k x_k.$$

And the alternative formula, directly specifying $\pi(x)$, is

$$\delta(x) = \frac{\exp(\alpha_0+\alpha_1 x_1+\alpha_2 x_2+\alpha_3 x_3+\cdots+\alpha_k x_k)}{1+\exp(\alpha_0+\alpha_1 x_1+\alpha_2 x_2+\alpha_3 x_3+\cdots+\alpha_k x_k)}$$

The parameter β_i refers to the effect of $x_i$on the log odds that Y =1, controlling otherx_j, for instance, $exp(\alpha_i)$ is the multiplicative effect on the odds of a one unit increase in x_i, at fixed levels of x_j.

If there are m independent observations with q-explanatory variables, and the qualitative response variable has k categories, to construct the logits in the multinomial case, one of the categories must be considered the base level and all the logits are constructed relative to it. Any category can be taken as the base level, so we will take category k as the base level. Since there is no ordering, it is apparent that any category may be labeled k. In this case we let δ_j denotes the multinomial probability of an observation falling in the j^{th} category, to find the relationship between this probability

and the m explanatory variables, $X_1, X_2, \ldots . X_q$, the multiple logistic regression model is then

$$\log\left(\frac{\delta(x_i)}{\delta_k(x_i)}\right) = \alpha_{0i} + \alpha_{1j}x_{1i} + \alpha_{2j}x_{2i} + \cdots + \alpha_{qj}x_{qi},$$

where $j = 1, 2, \ldots, (k-1), i = 1, 2, \ldots, m$.

Since the sum of all the $\delta's$ add to unity, this reduces to:

$$\log[\delta_j(x_i)] = \frac{\exp(\alpha_{0i}+\alpha_{1j}x_{1i}+\alpha_{2j}x_{2i}+\cdots+\alpha_{qj}x_{qi})}{1+\sum_{j=1}^{k-1}\exp(\alpha_{0i}+\alpha_{1j}x_{1i}+\alpha_{2j}x_{2i}+\cdots+\alpha_{qj}x_{qi})},$$

for $j = 1, 2, \ldots, (k-1)$, the model parameters are estimated by the method of Maximum Likelihood estimation.

3.3 E-government services data

We used the real data collected from the sample in Nyamasheke District, on e-government services use for the application of multinomial logistic regression model. The data set consisted of 381 observations recorded on 12 variables.

4. Modeling corruption: Rwandan context

4.1 Specification of the variables

4.1.1 Outcome variable

From the questionnaire of the survey, there was a question that brought attention to the respondents in determining whether the use of e-government services reduces corruption status a high level, medium level or low level, and with this regard, the outcome variable had three levels "0" for high level, "1" for medium level and "2" for low level respectively. With the aim of the analysis, the reference category of this response variable has been "2" of low level of reduction of corruption status.

4.1.2 The predicator variables

We attempted to select a set of predicator variables related to e-government services use, that, we believe to have an impact on the reduction of corruption. These predicator variables are viewed in detail using the following questions on the questionnaire of the survey:

- How often do you use e-government services to apply for service in local government? The answer to this question has three categories "Always", "Sometimes" and "Never" coded on the scale of "1", "2" and "3" respectively. In SPSS, this variable is named as "EGSuse".

- What is the cost of using e- government service on average do you use? This variable is named in the details of the analysis as "Costofacc" with the corresponding response of amount of money used by the respondent.
- How long have you used e-government services in applying for local services? This variable is named as "Time (in months)" in the fully data analysis having the time spent using the e-government services.
- Which type of e-government service have you applied for in the last month? This variable is named "EgsType" and it has 15 levels of the e-government services available in the local administration of Nyamasheke District.
- Which device do you use in applying to e-government services? Is it your own device? From this question, we recorded two categories either "0" for those who used phone and "1" for those who used computer-based devices. On the ownership status of the device used, we recorded two categories; "1" for those who use their own devices and "0" else.
- The remaining set of questions of the survey were demographic questions related like age, gender, education and the income status of the respondents.

4.2 Baseline category of the outcome variable

Any category of outcome variable can be chosen to be the baseline category, the model will fit equally well data, obtained the same probability and yielding the same estimated values, only the values and interpretation of the parameters will vary (Abdalla, 2012). In this situation under study, we considered the reference category with smallest frequency so we selected category of (1-negatively). With this choice of the reference category, we meant the comparison will be against the people who suggested that e-government services reduce the corruption negatively.

5. Results and Discussions

5.1 Estimation of the multinomial logistic regression model

We selected 10 predictor variables that we believed they had impact of corruption reduction using the e-government services. We attempted to seek the effect of these explanatory variables on the outcome variable by constructing the multinomial logistic regression model and then checked out the results. To accomplish this aim, we used SPSS software version 23, and NOMERG command to estimate the response variable and all the explanatory variables to find the primary model.

5.2 Control of outcome variable

From the Table 4.1 below of case processing summary we can exam some points:

Table 4.1: Case processing summary by using 11 independent variables

Outcome variable categories	N	Marginal Percentage
0 High	193	50.70%
1 Medium	188	49.30%
2 Low	0	0.00%
Valid	381	100.00%
Missing	15	
Total	396	
Subpopulation	381	

Source: Computed.

The dependent variable has only one value observed in 381 (100.0%) subpopulation. Table 4.1 above is a part of large table from SPSS that contains all the variables, outcome variable and independent variables. Since we were focusing on the outcome variable, from the above table we could see that the number of valid observations used in the response variable is 381, distributed into three categories. The column of marginal percentages in the table gives the proportion of valid observations obtained in each of the outcome variable' groups,

50.7% of the valid case (High level of corruption reduction) due to the use of e-government services, 40.7% of the valid case had been subjected by (medium level) of corruption reduction and 0.0% by (low level of corruption reduction) because of using e-government services. From the above table we can directly compute the chance accuracy of the model as:

$$(0.507)^2 + (0.493)^2 = 0.500098 = 50.0098\%.$$

At this level we could compute the proportional by chance accuracy that will be compared to the overall percentage of the final model and this yielded 62.5% (1.25 x 50.0098% =62.5 %).

5.3 Examination of explanatory variables

To determine which predictors to be included in the final model we extracted the information from the output from SPSS in the table of likelihood ratio tests. Table 4.2 below reveals the predicator variables that contribute meaningfully to the model.

Table 4.2: Checking of explanatory variables by Likelihood Ratio Tests

Effect	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	262.283	368.739	208.283[a]	0	0	.
Age	262.865	365.378	210.865[b]	2.582	1	0.108
Time	268.247	370.76	216.247[b]	7.964	1	0.005
Income	260.968	363.48	208.968[b]	0.684	1	0.408

Cost of acc	312.986	415.499	260.986	52.703	1	0.000
G. Status	267.683	366.253	217.683[b]	9.4	2	0.009
ED	288.096	390.608	236.096[b]	27.812	1	0.000
Own	260.311	362.824	208.311[b]	0.027	1	0.868
Device type	260.358	362.871	208.358[b]	0.075	1	0.784
Egs Type	467.237	518.493	441.237	232.953	14	0.000
EG Suse	302.262	400.832	252.262[b]	43.978	2	0.000
Gender	260.19	362.703	208.190[b]	.	1	0.000

Source: Computed.

We deduced from the above table that the age, income, ownership of the device used and device type are predictor variables to be removed from the final model since they do not contribute significantly to the full model and this test is done by comparing the corresponding p-value of the Chi-Square statistics with a cutoff (.05). That is, their Chi-square metrics and the corresponding p-values the above four predictor variables to be dropped from the final model and the overall fit of the model will not be significantly reduced are, χ^2 (1) = .75, *p value=.784* > .05, χ^2 (1) = .27, *p value=.868* > .05, χ^2 (1) =.684, *p value=.408* > .05 and χ^2 (1)) =2 .582, *p value=.108* > .05 respectively revealed the cause of why these predictor variables age, income, ownership of the device and the device used are excluded in the full model.

4.4 Model selection

In the next phase, we recomputed the model after excluding the predicator variables that did not contribute significantly to the final model given by the test of Likelihood Ratio Tests in table 4.2 above. This procedure has been replicated 5 times and stopped when we found parameters estimates are significant.

Table 4.3: Specification of the selected model

Description	**Model(1)**	**Model(2)**	**Model (3)**	**Model(4)**	**Model (5)**
Number of explanatory variables	7	6	5	4	6
Valid cases	381	381	381	381	381
Missing cases	15	15	15	15	15
Chi-square value (likelihood ratio test)	341.167	310.432	305.569	304.167	67.803
Subpopulation	368	320	*332*	196	127
Df	22	21	19	18	4
R-square Cox and Senell	*.564*	.557	*.552*	.550	*.161*
R-square Nagelkerke	.752	.743	*.735*	.733	*.215*
R-square Mc Fadden	.598	.588	.579	.576	.12.7
Classification Overall percentage	89.8%	*92.1%*	90.8%	94.5%	82.2%

Table 4.3 above revealed that the Model (4) is the best to be appropriate to the data compared to the remaining other models. It has the highest classification overall

percentage, includes 4 predictor variables. The details of this selected model can be summarized by its case processing from SPSS output in NOMERG command.

Table 4.4: Case processing of the selected model

Outcome variable categories	N	Marginal Percentage
0 High	193	50.70%
1 Medium	188	49.30%
2 Low	0	0.00%
Valid	381	100.00%
Missing	15	
Total	396	
Subpopulation	196	

Source: Computed.

In addition, by comparing the classification overall percentage of this selected model computed from SPSS, we could notice is greater than the proportional by chance accuracy criterion computed, that is 94.5% > 62.5%and this supported again the overall fit of the selected model.

4.5 Goodness of-fit and parameters estimation

To test whether the null hypothesis is rejected or retained, we needed to check if the model without explanatory variables is different from the model with explanatory variables. The table below showed that the final model is close to fit the data than the null model.

Table 4.5: Model Fitting Information

Model	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC	BIC	-2 Log Likelihood	Chi-Square	Df	Sig.
Intercept Only	509.422	513.365	507.422			
Final	241.256	316.169	203.256	304.167	18	.000

Source: Computed.

The presence of a relationship between the response variable and combination of explanatory variables is based on the statistical significance of the final model chi-square. In our model, the p-value of the model chi-square (304.167) was 0.000, less than the level of significance 0.05.

We rejected the null hypothesis which states that there was no difference between the model without explanatory variables and the model with explanatory variables. The existence of a relationship between the explanatory variables and the response variable was supported.

The AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) can be used to check how the fitted values and observed values of the model are close.

Using the likelihood ratio test of the selected model, the AIC, BIC and -2log likelihood are close.

Table 4.6: Likelihood ratio tests of the selected model

Effect	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	Df	Sig.
Intercept	241.256	316.169	203.256[a]	0	0	.
costofacc	293.14	364.11	257.14	53.884	1	.000
EGSuse	280.276	347.304	246.276[b]	43.021	2	.000
ED	266.132	337.103	230.132[b]	26.877	1	.000
EgsType	450.34	470.054	440.34	237.084	14	.000
Source: Computed						
The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.						
a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.						
b. Unexpected singularities in the Hessian matrix are encountered. This indicates that either some predictor variables should be excluded or some categories should be merged.						

The parameters estimate of each predicator variables gave the information of the expected amount of change in the logit for each one unit change in the predictor. The table below revealed the logistic coefficients of the selected model that contribute to the logit of the alternative category of the outcome variable.

Table 4.4: Parameter Estimates of the selected model

CR[a]		B	Std. Error	Wald	df	Sig.	Exp(α)	95% Confidence Interval for Exp(α)	
								Lower Bound	Upper Bound
0	Intercept	-1.110	2.529	.193	1	.661			
	costofacc	-.003	.001	11.567	1	.001	.997	.995	.999
	[ED=1]	6.414	2.583	6.168	1	.013	610.474	3.867	96383.648
	[ED=2]	0[b]	.	.	0	.	.	.	.
	[EgsType=1]	10.375	5.336	3.781	1	.052	32062.520	.921	1116408433.319
	[EgsType=2]	7.891	5.238	2.270	1	.132	2673.965	.093	76808371.866
	[EgsType=3]	4.016	7.810	.264	1	.607	55.455	1.247E-5	246666000.188
	[EgsType=4]	4.065	7.812	.271	1	.603	58.253	1.305E-5	259975016.233
	[EgsType=5]	4.081	4.922	.687	1	.407	59.194	.004	915505.472
	[EgsType=6]	7.828	5.023	2.429	1	.119	2508.982	.133	47309707.580
	[EgsType=7]	85.932	.000	.	1	.	2.088E+37	2.088E+37	2.088E+37
	[EgsType=8]	7.688	5.382	2.040	1	.153	2182.258	.057	83213482.252
	[EgsType=9]	8.010	6.078	1.737	1	.188	3011.410	.020	449249528.624
	[EgsType=10]	7.523	6.375	1.393	1	.238	1850.111	.007	493707882.268
	[EgsType=11]	2.847	4.897	.338	1	.561	17.230	.001	253696.176
	[EgsType=12]	-.287	6.796	.002	1	.966	.750	1.231E-6	457329.555
	[EgsType=13]	-.178	9.545	.000	1	.985	.837	6.281E-9	111413206.812
	[EgsType=14]	-.377	4.694	.006	1	.936	.686	6.929E-5	6791.727
	[EgsType=15]	0[b]	.	.	0	.	.	.	.
	[EGSuse=1]	-10.845	5.333	4.136	1	.042	1.950E-5	5.635E-10	.675
	[EGSuse=2]	.099	4.265	.001	1	.982	1.104	.000	4709.374

	[EGSuse=3]	0[b]	.	.	0	.	.	.	.

Source: Computed
a. The reference category is: 1.
b. This parameter is set to zero because it is redundant.

The Parameter estimates in Table 4.4 revealed the information related to the coefficient α for each predictor variable for each alternative category of the outcome variable. The logistic coefficient is the expected quantity of change in the logit for each one unit variation in the predictor and the logit being the predicted one; it is the odds of elements in the category of the outcome variable which has been specified (in our situation is the first value: 1 that was specified, rather than the alternative value 0). As we could notice in the table, the predictor variables in the final model that less influence in predicting the logit are the cost of accessing e-government services (coded in SPSS as "costofacc") and e government services use status (specified as "EGSuse" in SPSS recoded from people who never used the e-government services) and this is due to the fact that their logistic coefficient that are closer to zero (cf. Table 4.4). The Wald statistic and the associated p-value have been used to assess whether or not the estimated logistic coefficients of the predictor variables are different from zero. In our situation we expected predictor variables which increased the logit to show anexp (α) which is greater than 1.0, those predictor variables that which did not have impact on the logit showed an exp (α) of 1.0 and predictors which decreased the logit have displayed an exp (α) values less than 1.0. Applying these criteria, we found that the predictors that increased the logit of the outcome variable (that is, "using e-government services has a positive impact of reducing corruption") are Education (coded as "ED=1" for educated persons), e-government services use status (coded as "EGSuse") and e-government service types (coded as "EgsType") respectively and the predictor variable that could decrease the logit of the outcome variable was the cost of accessing e-government services(coded as "coastofacc") and no explanatory variable had been found to no have impact on the reduction of corruption by the use of e-government services.

5. Conclusion

We modeled the impact of e-government services on the reduction of corruption in Nyamasheke District, using multinomial logistic regression (MLR) model on eleven independent variables that we believed they had positive or negative impact on this outcome variable. Using some statistical associated to multinomial logistic regression model tests in model assessment and specification of explanatory variables, the predictor variables like age, income, ownership of the devices used and device types have been dropped at the initial stage from other predictor variables since they did not contribute significantly to the outcome variable at all. Next we attempted to select the model that fits well the data and that can predict the logit of the outcome variable and found the model that overall fitted the data had only four predictor variables that could have impact on the reduction of corruption in Nyamasheke District and could be used to predict the

logit of this outcome variable and these predictors were "Education, Cost of accessing the e-government services, E-government services and E-government services' types". In addition, among these predictor variables that contributed significantly in the final model that modeled the reduction of corruption using e-government services, three of them increased the logit of the outcome variable, that are, "Education, E-government services and E-government services' types" and the one that decreased the logit of the outcome variable has been found to be "Cost of accessing e-government services". The overall fit of the model concluded that the explanatory variables that had impact on reducing corruption in the selected area under study were Education, E-government services and E-government services' types and Cost of accessing e-government services.

6. Recommendations

With the conclusion revealed by the model that has been used to fit the data and the clarification percentages of the selected, the recommendations to the public and to local leaders in Nyamasheke District, in the following outlines:

1) Educate people in the area under study since the results from the study revealed that educated people are attempting to use the e-government services towards the reduction of corruption.
2) Reduce the cost of accessing the e-government services since displayed that with a high cost of accessing these e-government services has an impact of reducing the probability (logit) of corruption reduction.
3) Strengthen the use of e-government services to apply for local services that are available in the area under study and advertise to people to be familiar with this use of e-government services.

Conflict of Interest Statement

The authors declare no conflicts of interests.

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