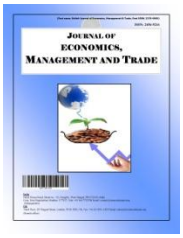

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Potential Prospects and Challenges of Smart Contract Diffusion: Case Study of the Computerized School Selection Placement System (CSSPS) in Ghana

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

The popularity of smart contracts is synonymous with blockchain. However, the blockchain application supersedes smart contracts. Nonetheless, sub-Saharan African countries can benefit from the cost-reduction, risk elimination, and timely execution properties of smart contracts. Therefore, the study assesses the prospects and challenges of diffusing smart contracts in the sub-region. Using the Computer School Selection and Placement System (CSSPS) of Ghana Education Services as a case study, the investigation applies 1154 online survey data in a hierarchical logistic regression model to estimate the effects of end-user demographics (students, teachers, parents), the prospects and challenges of the CSSPS on diffusion. The results disclose that although the CSSPS reduces cost and improves efficiency, lack of flexibility, information asymmetry, and inequity in the selection and placement of students is problematic. Further, end-user characteristics had marginal significant effects on the diffusion, the perceived prospects of the CSSPS had strong positive effects on diffusion, and the perceived challenges of the CSSPS had a negative relationship on the diffusion of CSSPS in Ghana. This provides guidelines for the design and the deployment of smart contracts in public and private service delivery in sub-Sahara Africa.

Keywords: Smart contract; blockchain; CSSPS; diffusion; Ghana.

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1. INTRODUCTION

Before the introduction of smart contracts, humans mediated the formation and execution of all forms of contracts. Similar to the gradual metamorphosis of fiat money into digital currencies, contracts have evolved to eliminate human arbitrations. The conception of Nick Szabo in 1990 to run contracts with computer programs without human mediation has until the emergence blockchain technology received minimal attention. Although smart contracts have divergent definitions, the underlying force is the execution of contracts digitally [1-4]. According to Szabo (1996), smart contract embodies set of promises particularly in the form of codes, with the addition to the protocols within which the parties perform these promises. Thus, computer programs execute on the satisfaction of specified conditions with no consideration for emotions or renegotiations. Nonetheless, these contracts can take the form of a fully digitized or partially digitize promises to eliminate the perceived human deficiencies [2].

Introduced as the main technology behind peer-to-peer transfer of bitcoin (Nakamoto, 2008), the blockchain technology has transformed several industries in the past decade and continues to attract interest worldwide [5-7]. However, the most disrupted industry of all is the financial industry because the blockchain technology has successfully replaced mediation in the transfer of cryptocurrencies, initial coin offering (ICOs) and crowdfunding contracts [4,8,9]. Presently, the smart contract is intertwined with the blockchain technology to the extent that the two are basically inseparable [2,10]. For instance, Fairfield [2] defines smart contracts as an automated program transferring digital assets within the blockchain upon certain triggers. Again, Ream et al. (2016) regard smart contracts as a great advancement in the blockchain technology application. Ultimately, smart contracts are recorded on blockchain because of the offerings of the technology which promotes transparency, accuracy, and temper proof records [11].

Per the continual improvements in the regulatory framework of blockchain, the global diffusion of the technology continues to surge across industries [12,13]. However, in the sub-Saharan Africa the diffusion of blockchain is teething [1]. This is so because of the infrastructural requirements for the diffusion of blockchain technology. However, other technologies supporting the delivery of financial services (mobile money) continue to receive growing diffusion rates because of the relatively cheaper technology and infrastructural requirements [14,15]. Consequently, the sub-region is recognized to have the greatest potential for the diffusion of blockchain [14,16]. Therefore, experts predict that high diffusion of blockchain applications can be attained in Africa when it is provided at a relatively cheaper cost [14,15]. This is because majority of individuals in the sub-region reside in rural areas with averagely low incomes. Nonetheless, because the smart contract is a step ahead of the application of blockchain in the delivery of financial services, it raises unanswered questions on the preparedness of the sub-region to deploy smart contracts in the delivery of public and private services.

The study examines the prospects and challenges of smart contract diffusion in the sub-region using a case study of the Computer School Selection and Placement System (CSSPS) of the Ghana Education Service. Specifically, the study seeks answers to the interactions between CSSPS user satisfaction, user demographics, the prospects, and the challenges of the CSSPS diffusion in Ghana. Unlike other studies based on the conceptualization of blockchain mediated smart contract [11,17,18], this study employs the live practical example of the CSSPS case in Ghana to provide first-hand evidence of smart contracts practicality in the sub-region. Although smart contracts in actual sense differ in specific ways from the CSSPS of Ghana, the CSSPS shares rudimentary similarities with smart contracts. Aside the benefits of saving time, money, and resources, both the CSSPS and smart contracts eliminates human mediation, executes on the trigger of an underlying condition, and to an extent are immutable. Thus, we argue that the CSSPS provides the perfect parallel for the estimation of future application of smart contracts in public services. While the application of smart contract is popular in private services involving the exchange of goods/service for money, the popularity of smart contracts in public services like voting and registration devoid of the exchange of money is gaining momentum [3,11]. Therefore, using online survey data from 1154 respondents (Students, Parents, and Teachers) across Ghana, the hierarchical logistic regression model estimates that the demographic characteristics, the prospects of the CSSPS, and the challenges of the CSSPS affects the diffusion

of CSSPS in Ghana. Therefore, this outcome is significant to industry practitioners, policymakers, and scholars. Industry practitioners need to consider the optimal design of smart contracts to eliminate basic flaws to improve the diffusion of blockchain-based applications in the sub-region. Policymakers can follow the example of the CSSPS to introduced policies which transforms the various sectors of the sub-region with the introduction of blockchain-based services. Further, research scholars can also inquire further into the application of blockchain technology in various other industries to improve the existing literature on blockchain technology in the sub-region.

The remainder of the paper is organized as follows; after the introduction, next is the literature review, then, the research methodology, the presentation of the results and discussion, and conclusion.

2. LITERATURE REVIEW AND HYPO-THESES DEVELOPMENT

2.1 Traditional Contract Meets Technology

The marriage between traditional contracts and blockchain births smart contracts. Traditional contracts have basic components; offer, acceptance, consideration, mutuality of obligation, a written instrument as well as competency and capacity making them legally binding [3]. Consequently, the creation of a smart contract begins with negotiations and arrangements between contracting parties and stakeholders which highlights these components with the assistance of lawyers. After an agreement is reached between parties, the contract is then converted into computer programs through the help of software engineers. According to Catalini and Gans [19], technology is a general-purpose technology because it enforces contracts across a wide combination of digital assets. This resolves the global on-going discussion on the legality of using blockchain in contracts [12]. After the contract terms are mutually agreed and converted into computer programs, the next step is to upload the entire contract onto a blockchain. Once the contract is stored on the blockchain, data is stored permanently, decentralized, and temper-proofed to provide maximum security for the contracting parties [4]. Parties to the contract cannot change the terms of the contract in their favor unless all parties agree to do so which would require the creation of a new contract.

The blockchain is described as digital, decentralized, distributed ledger recording transactions such that all network nodes have the same copy of the ledge and no one has the sole authority to update it [20]. However, first, blockchain can be deployed as either a public ledger, a private ledger, or a hybrid ledger depending on the context of the application of the technology. Public ledger provides free access to all users on the internet and depends on a consensus mechanism of proof-of-work for validation [21]. Using a private ledger relies on write-permission for decision making and read-permission is either made private or public. Private ledgers provide less decentralization and high anonymity. A hybrid ledger is introduced to harness the positives of these two ledgers and minimize their negatives. It balances the low-trust in the Public ledger with the high-trust in the private ledger [21]. Next, the execution of smart contracts depends on the trigger of a contractual condition. Upon a condition being is triggered, the corresponding action will be automatically executed, validated, stored, and updated on the blockchain by miners providing instant access for all parties. After a smart contract is duly executed, new states of all parties involved are updated. Therefore, the transactions during the execution of the smart contracts and the updated states are stored on the blockchain. See Table 1.

Economically, smart contracts offer better gains than traditional contracts. Smart contracts are not the same as e-commerce and thus understanding this difference is key to uncovering the legality of smart contracts [3]. This has pushed many countries to ban the operations of initial coin offerings and other public fundraising activities running on the blockchain [22]. In spite, contracts are established on key principles

Table 1. Creation of smart contracts

Smart contract	Formation	Organization	Execution	Completion
Traditional Contract	Yes	Yes	Yes	Yes
Blockchain	No	Yes	Yes	Yes

Source: Authors construct

and therefore the legal enforceability is derived from these pillars, therefore, smart contracts can absorb all the principles of traditional contracts, and therefore it fulfills the requirement for its enforceability by law. Coding is another way of writing digitally and this does not disqualify a smart contract from being acknowledged by the law court. While paper documentation of contracts could be lost through theft, fire, or deliberate alterations, digitized smart contracts are immutable, and changing data requires the consent of all parties involved [10]. The cost of storing digital information over the years has proven to be much cheaper and safer than using paper (Wiles, 2015). Again verbally established contracts could be problematic and create a dispute shortly but digitized contracts establish the intention of the parties and this is difficult to disprove [2]. Again, smart contracts promote decentralization (Zhao & Coffie, 2018). Centralization is discouraged for the negative effect of slowing down processes and not being able to provide real-time information. While some smart contracts are centralized, the flexibility in the deployment of blockchain as the baseline technology provides an opportunity to support decentralization (Tapscott and Tapscott 2016).

Humans have weaknesses and this can affect the execution of a contract. There is a high tendency of amending the conditions of a contract to favor a party but with smart contracts, there is no avenue for human intervention, and for that matter, the computer executes the commands once the condition is satisfied [23]. Computers are programmed to work according to strict instructions and nothing can change their response to a trigger (Nicolescu, 2019). According to Möslein (2019), smart contracts are self-enforcing and require no human assistance to make it happen. Finally, Cost should be discussed as the overall amount spent on the establishment, execution, and enforcement of contracts. Traditional contracts look cheap from the onset but with the need for enforceability because of the breach of contract, the cost of traditional contracts can be exorbitant. Smart contracts might be expensive concerning the computing power but the average cost associated with enforceability and execution of the contract on a smart contract is cheaper compared to traditional contracts [24]. See Table 2 for details.

2.2 Prospects and Challenges of Smart Contract for Sub-Sahara Africa

The application of blockchain has advanced into numerous expanses and it is no more restricted to the operation of bitcoin which was introduced in 2008 but drives past exchanges, payments, information sharing, to extend to other aspects such as smart contracts, corporate governance, voting, and social institutions and can support varied operations in the industry [25]. Further, blockchain has attracted huge interest from across the globe because; it reduces risk, cost, and improves efficiency [20]. According to Kuczwara (2017), blockchain mediated applications provide a better solution compared to other technologies because records are immutable, verifiable, support privacy, and are decentralized. In sub-Sahara Africa, infrastructure is limited and with many residing in rural communities, technology is a useful agent in reaching many without heavy investment in physical infrastructure. Smart contracts provide the following prospects for the sub-region.

Prospects: In sub-Sahara Africa, government contracts for the construction and building of public amenities such as roads, hospitals, bridges, and malls. constantly face challenges such as abandonment, delay in completion, and worse of litigation leading to the countries losing huge sums of money through compensations for untimely payment of contractors. The major cause of this is a change in government and subsequently policies. This is an area that smart contracts can assist governments in the sub-region to ensure that projects are completed on time irrespective of changes in government. Using smart contracts, the government can agree with contractors with the assurance

Table 2. Economic force of smart contracts

Types of Contract	Legality	Mode of establishment	Administration	Execution	Cost
Traditional	Compliance	Verbal/Paper	Centralized	Uncertain	Expensive
Smart	Disputed	Digital	Decentralized	Certain	Less expensive

Source: Authors construct

that payment would be made on time, and projects would be completed so far as the project is completed. The payment for Public utilities in the sub-region can be made using smart contracts. Paying for water, electricity, property rates, and other revenue-generating services have constantly created challenges in the sub-region. In many instances, public workers are asked to commute long distances to disconnect the services of individuals in default of payment, and this sometimes results in altercations leading to violence. Smart contracts that can automatically disconnect services once the user owes would significantly reinforce the revenue collection efforts of governments in the sub-region and save the cost of commuting. Smart contracts can be applied in the registration of vehicles, lands, and other properties as well as for the receipts of periodic payments. The government of Ghana is reported to be piloting a project with Bitland, a local not-for-profit organization engaged in blockchain development, to record land title deeds in Kumasi, the regional capital of the Ashanti Region, using blockchain to reduce fraud and allow for a more efficient mortgage lending (Oxford Business Group, 2019). The potential for blockchain usage in the supply chain environment and logistics for a Tilapia, a popular fish product used in meals in Ghana, has also been identified (Rejeb, 2018).

Challenges: Smart contracts have potential challenges irrespective of the location of formation, deployment, and execution. The first challenge with smart contracts happens during the formation stage. Usually, all parties must agree on the terms and conditions before converted into computer codes. Since blockchain-based smart contracts are immutable, errors at the coding stage cannot be edited after deployment [3]. Therefore, parties to a smart contract must carefully review the contents of the contracts and the converted codes to ensure error-free deployment. Further, the codes should be human-readable and not only machine-readable to enable parties with no coding knowledge to understand. Classically, blockchain is seen as temper proof. However, Although, the blockchain offers secure, accurate and, an immutable time-stamped record keeping making it resistant to collusion, and fault attacks, there have been reported acts of manipulations related to flaws in the system or other closely linked applications such as the stolen bitcoin on Japanese Mt. Cox platform and the millions stolen from the first initial coin offering by DAO [26]. Zheng et al. [11] assert that out of 16,082,269 blockchain-based transactions from July 2015 to May 2017, an estimated of 17,777 were Ponzi scheme related. Therefore, several models are proposed to help detect, identify, and quantify Ponzi schemes irrespective of the multiple internet service providers' addresses (Bartoletti et al., 2020).

2.3 Theories of Technology Diffusion

Based on existing theories of technology diffusion at the individual level; Technology Acceptance Model (TAM), Theory of Reasoned Action (TRA), and the Theory of Planned Behavior (TPB)(Yousafzai et al., 2010) and the diffusion of innovation theory (DOI) (Rogers & Murcott, 1995), the study proposes the following hypotheses;

2.4 Hypothesis Development

Based on existing theories of technology diffusion at the individual level; Technology Acceptance Model (TAM), Theory of Reasoned Action (TRA), and the Theory of Planned Behavior (TPB) [27] and the diffusion of innovation theory (DOI) (Rogers & Murcott, 1995), the study proposes the following hypotheses;

H1: The demographic factors of users affect the diffusion of the Computerized School Selection and Placement System in Ghana

Individual diffusion of technology per the TAM, TRA, and the TPB [27] is significantly affected by the demographic characteristics of the individual in question. Empirically, gender, age, level of education, and location positively affects the diffusion of technology [28,29]. Consequently, the study postulates that the diffusion of CSSPS in Ghana is affected by the demographic factors (*role, gender, and location*) of end-users.

H2: The prospects of the Computerised School Selection and Placement System positively affects diffusion in Ghana.

The offering of the technology in question has proven by the diffusion of innovation theories to positively affect diffusion [30,31]. Consequently, based on the prospects identified in the case of CSSPS in Ghana, the study proposes that the prospects (*trust, cost-effective, and equity*) of the CSSPS in Ghana contributes positively to the rate of diffusion.

H3: The Challenges of the Computerized Selection and Placement System positively affects diffusion in Ghana.

Similarly, the limitation of technology contributes to non-mass diffusion. Therefore, the study estimates that the perceived challenges (*information asymmetry and lack of flexibility*) of the CSSPS contribute to the unwillingness of many to diffuse. Consequently, individual and technology characteristics contribute to the diffusion of technology.

3. RESEARCH METHODOLOGY

3.1 Research Approach and Description of Data

The study employs the quantitative case study approach to provide answers to research questions (Garson, 2013). Besides the difficulties of replication, and the possibility of biasedness, this approach creates new knowledge unobtainable from secondary data. Ghana is well-adapted to the research objectives because of the previous and on-going initiations of the country concerning technology diffusion. Ghana is the first sub-Saharan African country to launch a cellular mobile network (1992), one of the first countries in Africa to be connected to the internet and to introduce ADSL broadband services. Further, Ghana launched the first world biometric payment card known as the e-zwich in 2008. Currently, the country has made positive strides in the computerization of most public service services leading to efficiency in delivery, improved revenue, and transparency. Consequently, we chose the case of the Computer School Selection and Placement System (CSSPS) introduced by the Ghana Education Service to eliminate human intermediation in the selection and placement of students in junior high schools in the country. The justification for using this case is based on the fact that the system eliminates human intermediation and also functions on the immediate trigger of a predefined condition making it synonymous with any smart contract. Therefore, we explore the CSSPS case by gathering primary data from students, parents, and teachers using an online administered questionnaire. The data was gathered between November 2019 and February 2020. Administered via social media platforms, a total of 1154 responses were gathered. Although this method generated opinions across the country, it is clear that individuals not using social media could not take part in the survey. This limitation is mitigated with the secondary data gathered from the Ministry of Education Website and published new articles. See Table 3. For details of respondents.

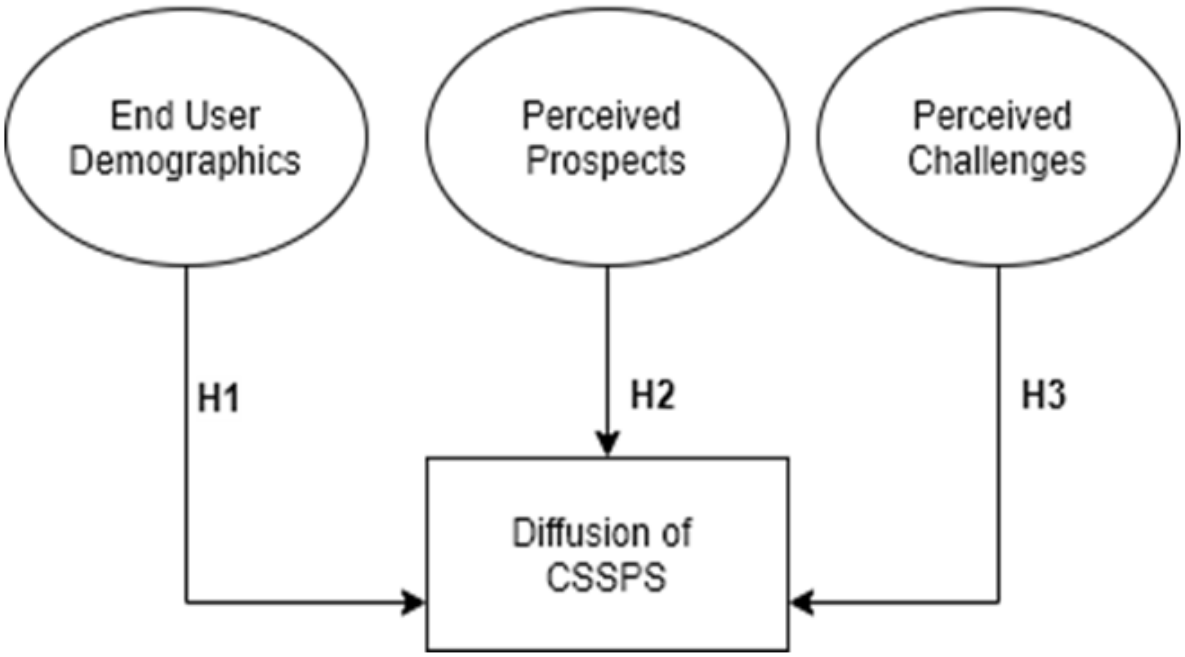

Fig. 1. Conceptual framework

Table 3. Summary of data

Regions	Parents	Students	Teachers	Total
Ashanti	27	71	50	148
Brong Ahafo	11	14	19	44
Bono East	16	23	11	50
Ahaho	7	40	5	52
Central	15	28	8	51
Eastern	26	46	49	121
Greater Accra	45	101	77	223
Northern	12	36	22	70
Savannah	6	20	4	30
North East	13	11	8	32
Upper East	5	16	7	28
Upper West	8	21	9	38
Volta	18	39	16	73
Oti	11	42	8	61
Western	17	37	18	72
Western North	8	41	12	61
	245	586	323	1154

Source: Authors Construct

3.1 Case Background

The Ghana Education Service established in 1974 is an arm under the Ministry of Education with the sole responsibility for the implementation of government policies that ensure that Ghanaians of school-going age regardless of their tribe, gender, disability, religious and political affiliations receive quality formal education. In September 2005, the Secondary Education Division of Ghana Education Service through its secretariat introduced the Computerised School Selection and Placement System (CSSPS) to place qualified Basic Education Certificate Examination (BECE) candidates into Senior High School (SHS)/ Technical Institute (TI)/ Vocational Institute without human intermediation. Before the introduction of the CSSPS, the Ghana Education Service together with stakeholders recognized severe challenges with the existent manual system of selecting and placing students. Similar to the problems with manual intermediation, some of the challenges identified were but not limited to the following; lack of transparency, higher administrative cost, bribery of heads of schools to influence the selection process, human errors (intentional and unintentional), and nepotism among others. Consequently, in the year 2003, The Ministry of Education Ghana took a policy stand to mitigate these challenges with the introduction of a computerized system that needed no human intermediation in the selection and placement process. The computerized system promised; cost-effectiveness, prompt selection and placements, elimination of human errors, transparency in selection, and, an equal chance of selection and placement devoid of nepotism.

3.1.1 How does the CSSPS work?

The CSSPS selects and places students into schools similar to the concept of smart contracts as the selection and placement process is triggered by the scores of students. Candidates pre-select five schools and programs per the order of preference, then the actual scores of students are fed into the computerized system which selects and places students considering first the pre-selected choice of the candidates. In an event that the candidates fail to get a pre-selected school based on the results, the best matching school is selected. While the previous manual system deployed grades (A, B, and C) in the selection and placement process, the CSSPS uses actual numerical scores for the selection and placement. Although students are required to sit for all subjects, the CSSPS uses the scores of English language, Mathematics, Integrated Science, and in some cases Social Studies for the selection process. The final selection and placements are shared with all Senior High Schools, Technical and Vocational Institutes; and copies made available to all Junior High Schools, Regional and Districts Offices of GES on time.

3.1.2 The success of the CSSPS

The main aim of the CSSPS is the selection and placement of candidates and concerning this, the

system has been successful in achieving this objective consistent with the findings of studies (Ajayi, 2016; Ahiatrogah & Bervell, 2013). Records manifest that between the years 2005 and 2015 the aggregate selection and placement of candidates stood at 151,000 and 439,000 respectively. In 2019, an estimated 90% of candidates were successfully selected and placed in schools. Records of all students successfully placed and waiting to be placed as well as students who failed and for that matter could not be placed are stored permanently for easy retrieval and decision making. The records from the system are shared distributed amongst all schools across the country to help easy verification and thus this prevents tampering with the records. Further, the system has reduced the cost of placing students compared to the manual placement years. This is consistent with the offerings of smart contract and other e-services in public service delivery in Africa (Osei-Kojo, 2017; Tchao et al., 2017; Welsch et al., 2013)

3.1.3 Challenges of the CSSPS

Despite the success of the CSSPS in Ghana, several challenges have plagued the system year in year out. Information asymmetry has become a big challenge to the system over the years (Ajayi, 2016): first, because candidates do not have adequate information on all the schools across the country to help them make their pre-selections, they are often posted to schools they do not like. Second, the CSSPS sometimes places girls in purely boys' schools, places day students in schools which are several kilometres from their homes. Again, the unequal infrastructural endowments of the schools across the country forced many students to choose "A" ranked schools which they are probably not qualified for selection. Further, the underlying software of the CSSPS was hacked and compromised causing delays and erroneous selection and placement of candidates. Worse of all, the CSSPS is centralized and not easily accessible by all heads of schools causing delays in information dissemination.

4. SUMMARY OF DESCRIPTIVE STATISTICS AND TEST OF MULTICOLLINEARITY

Per the data gathered from the 1154 surveyed respondents, the data exhibits that majority of the respondents are satisfied with the diffusion of the CSSPS in Ghana. This is buttressed by the fact that the dichotomous response yielded a mean value of 1.2 with a corresponding skewness value of 1.4 and a standard deviation of 0.4. The outcome is because currently, the only way to get selected and placed in a senior high school in Ghana is through the CSSPS. Next, the role of end-users was categorized as Students, Parents, and Teachers and coded 1, 2, and 3 respectively. The data show an average value of 1.7 to mean the majority of the respondents were students, followed by parents and then teachers. Rightly so, the system was mainly designed for students and parents with the assistance of teachers if applicable. On the gender of the respondents, the mean value of 1.5 outlines that the number of male respondents outnumbers the number of females. However, the standard deviation of 0.5 conveys that the difference is not big. Thus, the diffusion of the CSSPS is not affected by gender disparity like other forms of technologies. Further, on the level of education, the mean value of 1.8 indicates that the majority of the respondents had a basic level of education compared to secondary and tertiary education. Moreover, the standard deviation of 0.9 shows the higher gap between the educational qualifications. This result is because most students and parents have basic and secondary level education and they account for a higher percentage in the respondents. Data on the location of the respondents show that majority reside in urban areas. However, the standard deviation of 0.4 reveals that the difference between the urban and rural respondents is marginal. This surmises that although people in urban areas have an advantage with the diffusion of technology, those in rural communities can equally diffuse technology given the right motivation. Further, data on the prospects of diffusing the CSSPS show that many consider the CSSPS trustworthy concerning the selection and placement of students into senior high schools. This is corroborated by an average of 2.4 on a scale of 1-5. Besides, the standard deviation of 1.1 and the variance value of 1.2 respectively express that a strong percentage of respondents consider the system trustworthy. This is because the CSSPS was introduced to eliminate human mediation plagued by corruption. Again, the mean value of 2.8 divulges that most of the respondents find the CSSPS to be cost-effective. This is corroborated by a higher standard deviation of 1.0 and a variance of 1.1 respectively. This result is because parents and students do not have to travel to schools and pay bribes to get selected and placed in senior high schools in the country. Further, on the ability of the CSSPS to ensure

equity, the data indicate that some respondents consider the system efficient in the equitable selection and placement of students, however, the mean value of 3.0 conveys that a significant cross-section of the respondents also considers the system ineffective. This is partly because of the numerous challenges and complaints surrounding the diffusion of the CSSPS in Ghana. Finally, on the perceived challenges of diffusing the CSSPS in Ghana, the mean value of 3.1 manifests that most of the respondents consider information asymmetry to be a challenge. Further, the lack of flexibility is perceived by the respondents to affect the diffusion of the CSSPS in Ghana. This is supported by the mean value of 3.5 and a standard deviation of 1.2. See Table 4 for details.

The test of multicollinearity is necessary to justify the inclusion of the explanatory variables in the model. Again, it helps to determine if the explanatory variables are independent of each other. The result in Table 5 shows the correlation matrix and the variance inflator (VIF) and the tolerance values for the explanatory variables. The variable "level of education" is eliminated from the final set of explanatory variables employed in the model because it did not meet the requirement and thus unfit as an explanatory variable in the model. Specifically, the figures for the explanatory variables in the correlation matrix must be less than 0.7 percentage. Again, concerning the VIF and the tolerance value for checking multicollinearity, statistically, the VIF values should not exceed 10. Therefore, with all the values in Table 5 substantially below 10, this is an indication of the absence of multicollinearity. Further, using the tolerance all the values are above 0.4 to confirm the absence of multicollinearity in the variables. Consequently, this suggests that the variables employed in estimating the relationship between end-user demographics, prospects, and challenges in the diffusion of the CSSPS in Ghana have no multicollinearity issues.

4.1 Model Specification

To estimate the relationship between users' demographics (DM), prospects (PT), and challenges (CH) on the diffusion (Diff) of the CSSPS in Ghana. The study proposes a hierarchical logistic regression model based on the preliminary insights gathered from the case study, the theories of technology acceptance, and the innovation diffusion theories. End-users' characteristics, the potential benefit of technology, and the challenges associated with the diffusion of technology have varying effects on technology diffusion (Garrett *et al.*, 2014). Consequently, the study proposes the following model;

$$Model\ 1\ : Diff(y_i) = \beta_0 + \beta_1 DM + \beta_2 PT + \beta_3 CH + \varepsilon_i \quad (1)$$

Table 4. Descriptive statistics

	N	Mean	Std. Deviation	Variance	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Satisfaction	1154	1.204	.40288	.162	1.474	.072
Role	1154	1.705	.7958	.633	.579	.072
Gender	1154	1.508	.5002	.250	-.031	.072
Education	1154	1.864	.9376	.879	.274	.072
Location	1154	1.441	.4967	.247	.238	.072
Trust	1154	2.446	1.1016	1.214	.213	.072
Cost-effective	1154	2.828	1.0831	1.173	.359	.072
Equity	1154	3.010	1.3170	1.734	-.512	.072
Information asymmetry	1154	3.095	1.3468	1.814	-.210	.072
Lack of flexibility	1154	3.532	1.1289	1.274	-.618	.072
Valid N (listwise)	1154					

Source: Survey data February 2020

Table 5. Test of multicollinearity

Variables	Demographics			Prospects			Challenges		VIF	Tolerance
Demographics	**Role**	**Gender**	**Location**	**Trust**	**Cost**	**Equity**	**Inf. asymmetry**	**Flexibility**		
Role	1								2.218	0.451
Gender	.310**	1							1.156	0.865
Location	.301**	.567**	1						1.077	0.929
Prospects										
Trust	.172**	.124**	-.032	1					1.291	0.775
Cost	.564**	.280**	.325**	.191**	1				1.638	0.610
Equity	.419**	-.216**	-.195**	.514**	.410**	1			1.431	0.699
Challenges										
Inf. asymmetry	.153**	.285**	.331**	-.265**	-.039	-.180**	1		1.052	0.950
Flexibility	.186**	.304**	.387**	-.061*	.584**	-.037	.558**	1	1.001	0.999

*Note[1]: ** and * indicate that the correlation is significant at 5% and 10% respectively. The statistical significance at a 5% level provides evidence that allows the rejection or non-rejection of the null hypothesis with a probability of type 1 error. The values in Table 5 are Pearson product-moment correlations computed using the formula:* $\sum_{i=1}^{n}(x_{1i}-\bar{x}_1)(x_{2i}-\bar{x}_2)/\sqrt{\sum_{i=1}^{n}(x_{1i}-\bar{x}_1)^2}\sqrt{\sum_{i=1}^{n}(x_{2i}-\bar{x}_2)^2}$*, where* $\bar{x}$ *refers to the sample mean value. The Tolerance values are not less than 0.2 and VIF values are all less than 5, which implies there is no multicollinearity.*

Source: SPSS Output

Where $\pi(Diff_i)$ represents the proxy for the diffusion of the CSSPS in Ghana, DM represent the demographic factors (role, gender, education, and location), PT represents the prospect of the CSSPS (trust, cost-effective, and equity), and CH represents the challenges of diffusing the CSSPS (information asymmetry and lack of flexibility). Further, β_0 is the intercept whereas β_1 β_2 , and β_3 capture the multiplicative effects DM PT of, and CH on $Diff$ with ε_i as the error term. Also, because the response variable $Diff$ is dichotomous where 1 indicates the diffusion of CSSPS and 0 indicates the non-diffusion of CSSPS, the model in Equation (1) follows a binomial distribution based on exponential canonical form. Therefore, the model can be written as;

$$Model\ 1a: \pi(Diff_i) = \frac{\exp(\beta_0 + \beta_1 DM + \beta_2 PT + \beta_3 CH + \varepsilon_I)}{1 + \exp(\beta_0 + \beta_1 DM + \beta_2 PT + \beta_3 CH + \varepsilon)} \quad (1a)$$

5. RESULTS AND DISCUSSIONS

5.1 Hierarchical Logistic Regression Estimation

Estimating the multiplicative effects of DM, PT, and CH on the Diff of the CSSPS in Ghana, Table 6 depicts the results. The proxies or indicators of DM, PT, and CH are categorical. Thus, by default, each of the first categories of the measurements illustrated in Table 6 serves as a reference point to interpret the multiplicative effects. Further, Table 6 contains parameter estimates (coefficients), standard error values, odds ratios, and the significance levels denoted with stars of the categorical variables engaged in the models. The parameter estimates are interpreted in terms of the significance levels and the odds ratio (*exp*(*β*)). Specifically, the significance levels identify the variables contributing to the response variables whereas the odd ratio (*exp*(*β*)) reflects the multiplicative effects of the various variables in the model. The intercept of -2.246*** with an odds ratio of 0.106 is statistically significant for the model.

Further, concerning the first hypothesis, demographic factors indeed affect the diffusion of the CSSPS in Ghana. Specifically, the role of the end-user reveals that students are 1.2 times probable to interact or diffuse the CSSPS in Ghana compared to parents and teachers. This extrapolates that student with a basic education in Ghana can use ICT-enabled services and this is good for the future diffusion of other ICT-enabled services. However, the least involvement of parents could clarify why the data capture on the CSSPS is sometimes erroneous. On the role of gender, the odds ratio of 0.944 and a coefficient of -0.058** contend that females are 0.944 times less likely to diffuse the CSSPS compared to males. While this is consistent with the studies on gender and the diffusion of technology, the marginal gap suggests that gradually female participation in technology is gathering pace in Africa. Again, on the location of the end-users, the odds ratio of 1.245 and the coefficient of 0.219*** means those in urban areas are 1.2 times more likely to diffuse the CSSPS compared to those in rural areas [28]. This could be explained by the level of infrastructural development in urban areas. However, because the system is for the entire nation, this suggests that there is a need for the government to prioritize ICT investment across the country to support the diffusion of technology.

Further, the results suggest that the diffusion of the CSSPS is affected significantly by the prospects. This is significantly consistent with the proposal of the diffusion of innovation theory [31]. On trust, the odds ratio of 1.113 and the coefficient of 0.107*** delineates that majority of the end-users of the CSSPS consider it trustworthy. This is typical of an average smart contract as human mediation is eliminated to ensure safety, trust, and compliance. Accordingly, the rot surrounding the selection and placement of students at the Ghana education system necessitated the introduction of the CSSPS. This is consistent with the effects of e-government and smart contract in the elimination of fraud and irregularities (Tchao et al., 2017); [23,32]. Therefore, a smart contract provides an opportunity for governments across the continent to save costs, distribute resources meaningfully, and resolve inequalities in society. Next, on whether the CSSPS is cost-effective, the odds ratio of 0.931 and the coefficient of -0.071** purport that end-users are 0.9 times least likely to consider the cost of diffusing the CSSPS as affordable. While the margin depicts that a significant number of end-users consider the system cost-effective, this imparts the differences

Table 6. Estimation results for the Hierarchical logistic regression models

Variables	Coefficient	Std. error	Odds ratio
	-0.2.246***	0.428	0.106
Demographic factors			
Role			
Student	0.257***	0.164	1.293
Gender			
Female	-0.058**	0.214	0.944
Location			
Urban	0.219***	0.192	1.245
Prospects			
Trust	0.107***	0.095	1.113
*SA**			
Cost-effective			
*SA**	-0.071**	0.178	0.931
Equity			
*SA**	0.043**	0.095	1.044
Challenges			
Information asymmetry			
*SA**	-0.122***	0.101	0.885
Lack of flexibility	0.131***	0.159	1.140
*SA**			

*Note: *** represented statistical significance at 1% level. P-values can be provided upon request*
Source: SPSS Output

Table 7. Model fitness result

Significance Test	Test	Probability Value
Hosmer and Lemeshow test	2.098	0.95
Omnibus test	1152.219	0.02

in the cost of accessing internet facilities across the country. Therefore, to ensure the mass diffusion of this system and other systems in the future, stakeholders should explore policies to reduce the cost of internet usage in the country [33]. Finally, the end-users consider the CSSPS efficient in the selection and placement of students equitably with an odds ratio of 1.044 and a coefficient of 0.043** to suggest that end-users are 1.0 times likely to consider the CSSPS efficient. However, the marginal change in probability provides that a significant number of end-users consider the CSSPS inefficient. This is consistent with the findings of (Ahiatrogah & Bervell, 2013), that public school students have a higher probability of getting selected and placed than private school students. Nonetheless, this disparity could be explained by the least number of private schools in the country compared to public schools. However, although it was not influenced by gender, there is the need to ensure equity in the delivery of e-public services irrespective of the ownership structure of school, geographical location, religion, and or political affiliation (Osei-Kojo, 2017). Further, the disproportions in school infrastructure should be reduced to promote acceptance of the results of the selection and placement irrespective of the location of the schools (Chanimbe & Prah, 2020).

Finally, on the challenges of diffusing the CSSPS, the model proffers a relationship between the CSSPS diffusion and the challenges. In detail, end-users consider information asymmetry as a challenge that hinders the diffusion of the CSSPS. This contradicts the offerings of smart contracts as information dissemination is pivotal (Catchlove, 2017). However, with a coefficient of -0.122*** and an odds ratio of 0.885, this is an indication that a significant number of the end-users are 0.8 times least likely to accept that information asymmetry is a challenge. This suggests that end-users consider the benefit of having accurate, timely, and cost-effective information useful in the use of the CSSPS in Ghana (Ajayi, 2016). Therefore, to drive the mass diffusion of smart contracts and other e-government services in sub-Sahara Africa, the perceived lack of information should be resolved through the provision of education at all levels. Typically, smart contracts are meant to resolve the challenge of information asymmetry by providing data and information simultaneously to support end-user decision making [11]. Further, the odds ratio of 1.140 and the coefficient of 0.131*** reveals that end-users are 1.1 times more likely to consider the CSSPS as lacking flexibility. Smart contracts are criticized for inflexibility once a condition is triggered [17]. Similarly, it is uncommon to identify a lack of flexibility as a major challenge in the diffusion of the CSSPS in Ghana. However, this could be explained by limited education and training provided to support the diffusion of the system. Further, the inability of the system to allow for review or revision after submission could also be a reason. Therefore, the design of smart contracts and other e-services in Africa should consider the thorough engagement of stakeholders to minimize the risk of errors during contract formation and deployment [1].

5.2 Model Fitness Assessment

Table 7 depicts the measurement of fitness for the model. using the Omnibus test and the Hosmer and Lemeshow test. The Omnibus and the Hosmer and Lemeshow tests together prove how well the model fits over and above an empty model (model with no predictors) and its significance. The Hosmer and Lemeshow test are substantiated by the significance level value greater than 5% whilst Omnibus measures the good fit of the model base on significance level value less than 5%. Accordingly, per the findings from Table 5, all the models are statistically significant and fit better than an empty model because all the significance level values are greater and less than 0.05 respectively. Therefore, this implies that the estimated models are efficient and capable of giving better predictions for the likelihood of diffusing the CSSPS in Ghana.

6. CONCLUSION

In approximating the multiplicative effects of DM, PT, and CH on the Diff of the CSSPS in Ghana, the demographic characteristics of end-users significantly affect the diffusion of the CSSPS in Ghana marginally. Although the relationship is relatively weak, it is synonymous with existing literature on the diffusion of technologies at the individual level. Therefore, this outcome is useful for the potential design and implementation of smart contracts in Africa. Simple and easy to diffuse systems are likely to attract high diffusion, unlike complex systems. Thus, smart contracts should be designed considering the average educational within a country to minimize the risk of non-diffusion. While females are proven to be less likely to diffuse technology, current literature suggests that technologies running on mobile-

based devices drive women participation. Thus, similar to mobile money, smart contracts executed via mobile devices in sub-Sahara Africa is likely to drive mass diffusion irrespective of gender. Empirically, individuals in urban areas have access to developed infrastructure compared to those in rural areas, therefore, in sub-Sahara Africa, most parts are considered rural with deficient ICT infrastructure, thus, an improvement in these infrastructures or the use of mobile phones are the only avenues to reach such areas.

The prospects of the CSSPS drive the diffusion of the system in Ghana. This is evident with the strong positive relationship depicted by the result. This confirms the proposal of innovation diffusion theory (Rogers & Murcott, 1995) to suggest that the offering of superior innovation capable of solving real societal problems drives mass diffusion. While the total elimination of human mediation is far-fetched in the sub-region, the introduction of systems like the CSSPS to reduce corruption is welcomed because it provides equal opportunities for the poor and the rich. Again, it eliminates nepotism, favoritism, and political influences in the distribution of natural resources. However, the unequal regional development in ICT infrastructure could hinder the mass diffusion of such systems. Consequently, as countries prepare for the uptake of smart contracts and other blockchain mediated services, ICT infrastructure improvement should be a priority. Further, the cost of diffusing these services should be kept at a reasonable level to drive diffusion by all. Therefore, governments in the region should explore policies that promote indigenous ICT companies to design systems suitable to the continent. This can create a platform for governments to deliver other public services via smart contracts to reduce costs and save time.

The challenges of the system discourage end-users from diffusing the system. This is proven by the strong negative effects established from the analysis. The lack of adequate and accurate information in a typical contract deprives parties of the right to information. Practically, the sub-region struggles with information dissemination because of the relatively scattered settlement. Consequently, the lack of enough education on the implementation of CSSPS in Ghana created the information asymmetry challenge identified by the end-users. To eliminate this from smart contracts in the sub-region, lawyers and all other stakeholders must be engaged to outline the details of the contract before the formation and execution. In the case of digitally written contracts, it should not only be machine-readable but also human-readable to prevent information asymmetry. Again, the use of indigenous languages to explain the offerings of technology and the terms of engagement could also eliminate this challenge. Further, smart contracts once formed and deployed cannot be changed. In Africa, this is a major setback because empathy forms the basis for contract renegotiations. Consequently, in the design of smart contracts, it is necessary for parties to pre-agree on conditions that may necessitate renegotiations and such conditions should be part of the original contract.

We anticipate that the sub-region can benefit from the offerings of the smart contract only with the creation of the necessary awareness to generate the interest of stakeholders. In summary, the findings of this study are strong, robust, and reliable since the various proposed models employed in the study are significantly fit and valid.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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