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STATE OF PLAY ON THE USE OF BUILDING CONSTRUCTION STANDARDS IN CONGO-BRAZZAVILLE

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ABSTRACT
This work aims to assess the existence and use of local standards in the field of building construction in Congo-Brazzaville. Surveys were carried out among construction companies, design offices and construction control firms operating in the construction industry. The results show that, overall, design offices, control or engineering consulting firms have more knowledge about the existence of construction standards, unlike construction companies. Indeed, it appears from this study that the probability of knowing of the existence of Congolese standards in construction control firms and construction companies is very low compared to engineering firms. The evidence provided by our sample also shows that structures involved in technical studies and real estate expertise are less aware of the existence of Congolese standards. Also, we note that the rate of knowledge about the existence of Congolese standards is more recorded at the level of structures that use foreign standards (16.90% against 9.09%), than those that do not use them. These structures also have knowledge of the effects (negative or positive) on the use of these foreign standards on construction (22.22% versus 3.57%) in Congo. Construction professionals must take into account certain technical specificities related to natural and social phenomena in the implementation of their construction projects in order to avoid early depreciation of the works carried out.

Keywords: *Standards, building construction, survey, use, statistical analysis.*

1. INTRODUCTION

The construction of current buildings seems to be better and more comfortable than those of the 1970s, it is partly because of the evolution of the very restrictive standards that now govern construction. Among the essential points are compliance on structural works, user traffic, accessibility for the disabled, thermal comfort, ventilation, fire safety, sanitation, plumbing, electricity, home automation, computer networks, garages, parking, which are currently the major concerns of manufacturers. But this improvement or evolution does not only produce comforts, of course, there are also additional costs in the construction [1]. Indeed, in the construction of buildings, the requirements are such that it is necessary to comply with urban planning, architectural or engineering rules enacted in each country. These rules, which are often very restrictive, are mandatory in order to guarantee not only a minimum standard of living of "construction quality" but also to prevent all possible pathologies and disorders, and in short, to guarantee the durability of the works carried out [2, 3]. The International Organization for Standardization (ISO) emphasizes that standards address the challenges of sustainable development while controlling technical and functional performance requirements [4].

However, the construction sector occupies a key position in national economies. ISO standards provide this sector with solutions to address all aspects of the industry, traditional or innovative, and provide instruments to address new challenges such as pollution, energy performance, etc. [5]. Similarly, according to preconceived ideas, the rapid increase

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in the world population (currently about 7,668,700,909) and the accelerated urbanization of cities have created a growing need for a high quality built environment. Nevertheless, out of a total of nearly 21,700 international standards and related technical documents, including additives to standards already promulgated, ISO has developed more than 1,100 standards for buildings and construction, specifically in the following areas: structures, masonry, building materials and products, information management in construction, energy performance and sustainability, heating, air conditioning and lighting, fire safety etc. Thus, these ISO standards have always essentially contributed to codifying best practices and technical requirements at the international level, in order to ensure that buildings, other structures and structures are safe and suitable for their intended use. In addition, they also enable the construction sector to improve efficiency and profitability by establishing design and manufacturing specifications and processes [6]. The application of standards in the construction of structures is a good way for any company to receive their production model, to improve their production quality and productivity.

However, it should be noted that in some developing countries (DCs), this area of construction is characterized by a remarkable imbalance in relation to the pace of housing production, for example. This has led to the development of "self-construction" in the construction of all types of housing. In these countries, this sector contributes nearly 90% to housing production [7, 8]. Unfortunately, self-construction does not very often provide quality assurance for the works carried out due to a lack of technical knowledge. However, in addition to the formal construction sector using construction standards, many informal and semi-informal sectors are engaged in the activity of building or building with great enthusiasm [8] and without rigour from a quality point of view. The predictability of risks in the operation of the works carried out is hardly ever considered. However, in Congo, the development of construction standards is still in its infancy. Much work remains to be done both in the implementation of a comprehensive standardization strategy and in their applicability. Indeed, more than 2/3 of large constructions are insured by foreign companies; Chinese, European... Thus, in the absence of local standards, these companies are obliged to apply the standards of the countries where they are established. This raises the problem of the adaptability of the materials to be used, since the climatic environment is not the same.

To this end, some materials deteriorate very quickly and end up with a very high obsolescence rate. This present work, which is part of the use of construction standards, aims to make an efficient statistical evaluation of the theme for Congo-Brazzaville, based on the cities of Brazzaville and Pointe-Noire. It is based mainly on the data from this survey because it was conducted to study the problem of the use of foreign standards in the design or implementation of construction works and to analyse the determinants of knowledge on Congolese construction standards. Several studies are relevant to the development of construction standards, but few report their use, especially in developing countries.

2. MATERIALS AND METHODS

2.1. Geographical location

For this work, the surveys were conducted in the cities of Brazzaville and Pointe-Noire respectively.

The methodological approach adopted consists in determining the factors that explain the knowledge and use of Congolese standards. In this section, we will present the data and variables used to model our phenomenon. Next, we will present the mathematical model used.

2.2. Presentation of data

The data for this study come from a survey conducted in 2018 in the major cities of Congo, Brazzaville and Pointe-Noire. The sampling plan used is the quota draw, whose variables are locality and legal status. Since the statistical unit is the enterprise, this survey considered a sample of 82 structures, 40 in Brazzaville and 42 in Pointe-Noire, as the reference cities for this study. The data in our study are classified into two groups: endogenous and exogenous variables.

Geographical coordinates :

- Brazzaville :
  - Latitude : 4°15.9678'S
  - Longitude : 15°16.9908'E
- Pointe-Noire :
  - Latitude : 4°46.5654'S

Longitude : 11°51.8112'E)

2.2.1. Endogenous variable of the model

The dependent variable of our model is qualitative and dichotomous in nature, which takes the value "1" if the structure knows the existence of Congolese standards, and "0" if the structure does not know the existence of Congolese standards.

2.2.2. Exogenous variables

The independent variables in this study can be grouped into three categories: variables related to the identification and location of the structure (location, legal status and type of structure), variables related to the speciality of the structure and the use of foreign standards in the design or execution of construction work (sector of activity, use of foreign standards and knowledge of the impact of foreign standards in construction) and variables related to the consideration of certain technical specificities related to natural and social phenomena in the implementation of projects (consideration of certain technical specifications).

a) Identification and location of the structure

We considered three variables: location, legal status and type of structure.

✓ Locality

This variable refers to a geo-administrative entity. During the survey, we selected two cities: Brazzaville and Pointe-Noire.

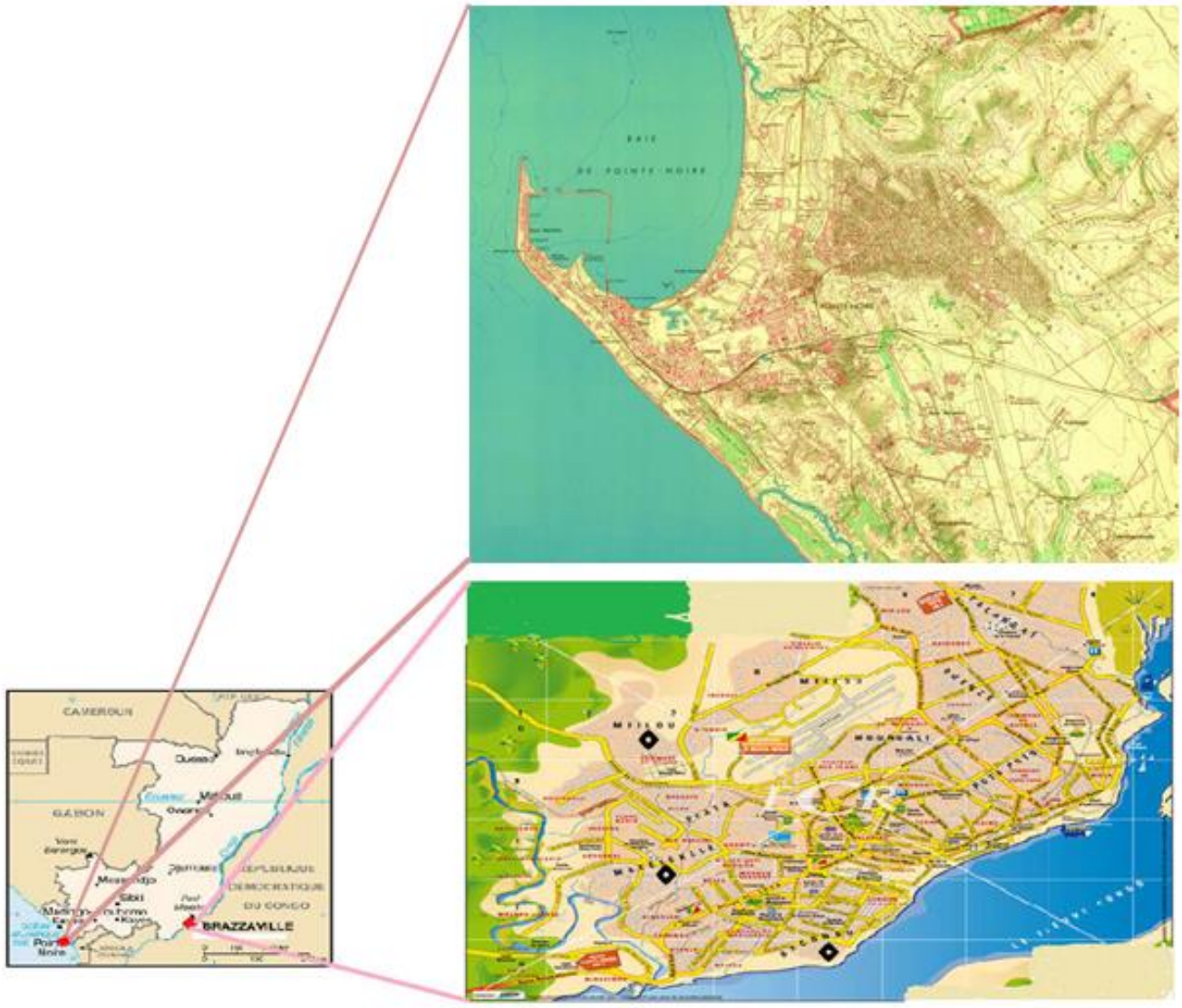

Fig. 1: Location map of the cities of Brazzaville and Pointe-Noire

✓ Legal status

The legal status identifies the structures from their creation and will determine their relationship throughout their life. Thus, by hypothesis, we assume that institutions, public limited companies and limited liability companies, informal companies and others do not have the same probability of being aware of the existence of Congolese standards.

✓ Type of the structure

It presents three modalities: design office, control office and construction company. This variable can also have an influence on the knowledge of the existence of Congolese norms, because of the fact that there is an unequal distribution of information between different types of structures.

b) Specialization of the structure and use of foreign standards

✓ Sector of activity

This variable is a multiple choice variable, the modalities of which are: technical studies, construction works, real estate expertise, maintenance and roadworthiness tests.

✓ Use of foreign standards

The use of foreign standards is a fundamental element in the analysis of the knowledge of the existence of Congolese standards. As part of this work, we have grouped together structures that use foreign standards and those that do not use them.

✓ Knowledge of the impact of foreign standards

It can also have an influence on the knowledge of the existence of Congolese standards insofar as, if one is aware of the impacts caused by foreign standards, one may be interested in knowing the existence of Congolese standards, and, otherwise, also know its impact (positive or negative) on the construction. This variable has two modalities: yes and no.

c) Taking into account certain technical specificities

This category contains only one variable in our study, namely: the consideration of certain technical specificities related to natural and social phenomena in the implementation of projects. This variable contains only two modalities: yes and No.

2.2.3. Presentation of the econometric model

Here, the goal is to determine relationships between a set of variables. We consider a dependent variable that we want to explain according to other variables called explanatory variables. In our case, we have a variable Y (knowledge of the existence of Congolese standards) to predict. It takes only two values: 1 (the structure knows the existence of Congolese norms) and 0 (the structure ignores it). For an individual i of the sample size n, Y takes the value Y(i). The database contains K explanatory variables or descriptors X_1, X_2, ..., X_k and for an individual i, X(i) takes the values $X_1(i)$, $X_2(i)$, ..., $X_k(i)$. Suppose that knowledge of the existence of Congolese standards is guided by an unobserved variable X. This latent variable, which by hypothesis adapts to a quantitative measure, then describes the knowledge of the existence of Congolese standards. Thus, individual i is aware of the existence of Congolese norms as soon as X(i) is above a certain threshold$_0$.

The hypothesis put forward on the latent variable allows us to write on the one hand

$$X(i) = \alpha_0 + \left(\sum_{k=1}^{j} \alpha_k X_k(i)\right) + \varepsilon_i \quad (1)$$

And on the other hand $Y = \begin{cases} 0 \; si \; X \leq y_0 \\ 1 \; si \; X > y_0 \end{cases}$ (2)

As a result, the probability of P_i that the individual is aware of the existence of Congolese standards (Y=1) will be :

$$P_i = P(Y = 1) = P(X > y_0) = P\left(\alpha_0 + \sum_{k=1}^{j} \alpha_k X_k(i) + \varepsilon_i > y_0\right) = P\left[\varepsilon_i > y_0 - \alpha_0 - \left(\sum_{k=1}^{j} \alpha_k X_k(i)\right)\right] \quad (3)$$

$$= P\left[\varepsilon_i \leq \alpha_0 + \left(\sum_{k=1}^{j} \alpha_k X_k(i)\right) - y_0\right] \quad (4)$$

$$= \emptyset\left[\alpha_0 + \left(\sum_{k=1}^{j} \alpha_k X_k(i)\right) - y_0\right] \quad (5)$$

with $\emptyset(.)$, the distribution function of the law of ε_i

Since we do not know the distribution of ε_i, we have to make assumptions about the distribution function $\emptyset(.)$. We will thus speak of a logit model, a probit model or a gombits model, whether the distribution function used is that of the logistic law, the normal law or the Gumbel law respectively. The logit model is the most widely used in the scientific field because it involves Odds Ratio. And when the dependent variable contains only two modalities, we are talking about the binary logistic model [9].

The objective of the model is to build a function that will allow to predict and explain the values of the variable Y from the set of descriptors. To do this, the binary logistic regression assumes the following hypothesis:

If ∅(.) is the distribution function of the logistics law, then by asking :

$$A = \alpha_0 + \left(\sum_{k=1}^{j} \alpha_k X_k(i)\right) - y_0, \quad (6)$$

$$P_i = P(\varepsilon_i \leq A) = \emptyset(A) = \frac{e^A}{1+e^A} = \frac{1}{1+e^{-A}} \quad (7)$$

We can observe that if ε_i follows a logistics law, then its Logit function is written:

$$ln\left(\frac{P_i}{1-P_i}\right) = A = \alpha_0 + \left(\sum_{k=1}^{j} \alpha_k X_k(i)\right) - y_0 \quad (8)$$

The ratio $\frac{P_i}{1-P_i}$ is called the Odds ratio.

The method used to estimate the model parameters is the maximum likelihood method and an individual's probability is modelled using the binomial law, i. e.

$$P(Y = y_k/X(i)) = P_i^{y(i)} * (1 - P_i)^{1-y(i)} \quad (9)$$

Thus the likelihood of the model is written $L(p, X) = \prod_{i=1}^{n}\left[P_i^{y(i)} * (1 - P_i)^{1-y(i)}\right]$ (10)

Wald's statistics make it possible to test the individual significance of the variables, i.e. to test whether each of the variables significantly influences the dependent variable [10, 11].

3. RESULTS AND ANALYSIS

Here, it is a question of presenting the results of the study through a description of the phenomenon through the uni and bi-varied analysis, after having implemented the chosen model.

3.1. Presentation of the results

3.1.1. Descriptive analysis

The sample size is 82 structures, 40 in Brazzaville and 42 in Pointe-Noire. Of these 82 structures, 13 acknowledged that they were aware of the existence of Congolese standards, i.e. a rate of 15.85%. This rate is much higher in Pointe-Noire (17.07%) compared to Brazzaville (14.63%), (figure 2).

In order to verify the significance of the gap between the knowledge rate in Brazzaville and Pointe-Noire, an independence test was implemented to verify the dependence of the variable knowledge of the existence of Congolese norms in the construction (Y) on the locality variable (X). The results showed that X and Y are dependent (Chi-square Pearson P-value = 0.031). In other words, the level of awareness of the existence of Congolese standards is not the same in Brazzaville as in Pointe-Noire. Although the rate of awareness of the existence of Congolese standards is low in both cities, there is a heterogeneity of this rate according to the characteristics of the structure. Indeed, the information collected in the field reveals that most of the structures that are aware of the existence of Congolese standards are *Sociétés Anonymes* (SA), with 25.00% of the knowledge rate, followed by institutions (20.00%) (figure 3).

Similarly, it can be seen that control firms (25.00%) and design offices (20.00%) have more knowledge about the existence of Congolese standards than construction companies (13.56%) (figure 4).

During the survey, data were collected with respect to certain structural characteristics of the two cities in Congo. To this end, we wanted to know the distribution of the structures of these localities by level of knowledge of the existence of Congolese standards according to their sectors of activity. This analysis shows that most of the structures that are aware of the existence of Congolese standards are in the technical inspection of the works (figure 5).

Similarly, in the case of structures that use or not foreign standards, those that are aware of the positive or negative impacts that these foreign standards can cause, and those that believe that construction companies take into account or not certain technical specificities, it can be seen that the rate of awareness of the existence of Congolese standards is higher at the level of structures that use foreign standards (16.90% compared to 9.09% for those that do not use them), and that have knowledge of the effects (negative or positive) of these foreign standards (22.22% compared to 3.57% for structures that do not know the effects). These companies, which may or may not use foreign standards, consider that construction professionals in Congo take into account certain technical specificities related to natural and social phenomena in the implementation of their projects (Figure 6).

3.1.2. Implementation of the model

In this section, we present the factors explaining the knowledge of the existence of Congolese standards in construction. To do this, we have two types of variables: the dependent variable and the explanatory variables. We apply the "binary logit" model while dichotomizing the variables "legal status" and "type of structure". The results in the table (Annex 1) show that the "work" variable does not explain the phenomenon studied. If we discard the "work" variable in the model, all variables are significant at 5%. Thus, from this information, we cannot say that the model we use is the best one until we determine the quality of the fit of the data in that model.

✓ *Validation of assumptions*

In our case, we will first verify the model's ability to properly classify structures that are aware of the existence of Congolese standards and those that are not, and then we will rely on the evaluation of the model's ability to discriminate between positives and negatives by inspecting the sensitivity, specificity and ROC curves.

And finally, we will do the Hosmer and Lemeshow test to verify the quality of fit of the model to the data.

✓ *Model Ranking Table*

It can be seen from the table (Annex 2) that for structures that are aware of the existence of Congolese standards (13 individuals), the model indicates that 4 individuals have an estimated probability of knowing of the existence of Congolese standards, less than 50%. In 30.77% of cases, knowledge of the existence of Congolese standards is correctly provided for at the 5% threshold.

For structures that are not aware of the existence of these standards (69) individuals, the model indicates that 66 have an estimated probability of more than 50 %. In other words, in 95.65% of cases, the risk of not knowing about the existence of Congolese standards is correctly predicted at the 5% threshold.

Overall, for a 5% threshold, the model seems to rank 70 structures out of 82 well. This gives a good ranking rate of 85.37%. The error rate is therefore low (14.63%).

✓ *Evaluation of the discriminating power of the model: sensitivity, specificity and ROC curve [12]*

With regard to the indicator of the model's ability to discriminate well, we have the ROC curve.

The area under this curve allows us to evaluate the accuracy of the model to discriminate between positives and negatives. Thus, it can be seen from figure 7 that the discrimination is excellent because we obtain the area of ROC (0.8506) between 0.7 and 0.9.

✓ *Hosmer and Lemeshow test [13]*

The results in the table (Annex 3) show us that the Hosmer and Lemeshow test is verified (the Hosmer-Lemeshow value is small: 3.05) and that, consequently, the overall fit of the model to the data is satisfactory (P-value = 98.03% >>>>> 5%).

Similarly, we have grouped individuals into ten (10) categories. And according to the results of this table, all categories are well adjusted because the maximum deviation of each group is small and their P-values are even higher than 10%. In view of all that has been observed in this analysis, the model we have chosen can be justified.

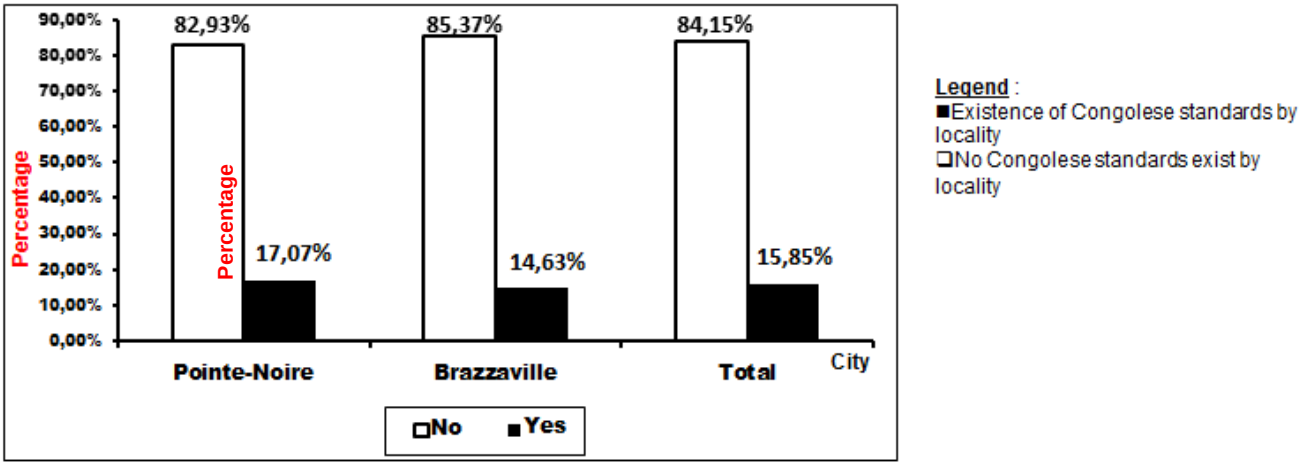

Fig. 2: Distribution of structures aware or not of the existence of Congolese standards by locality

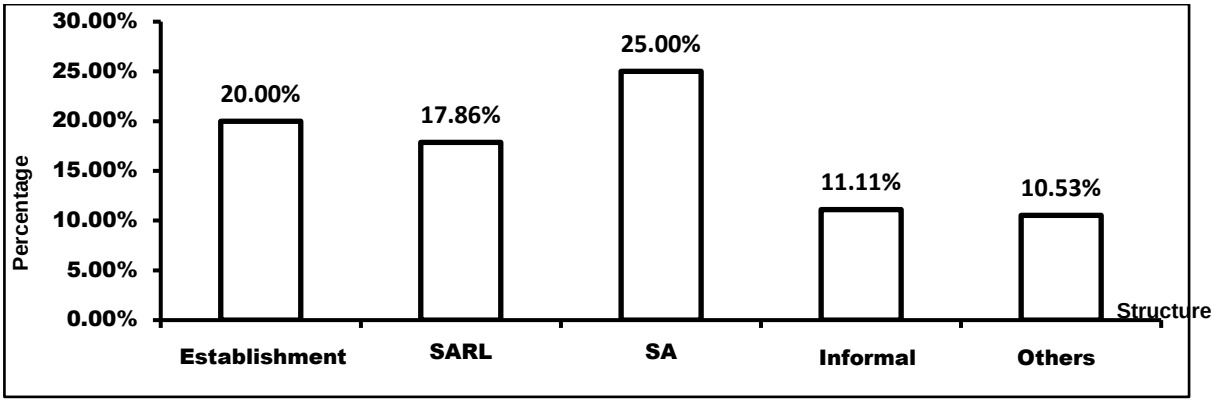

Fig. 3: Awareness rate of the existence of Congolese standards by legal status

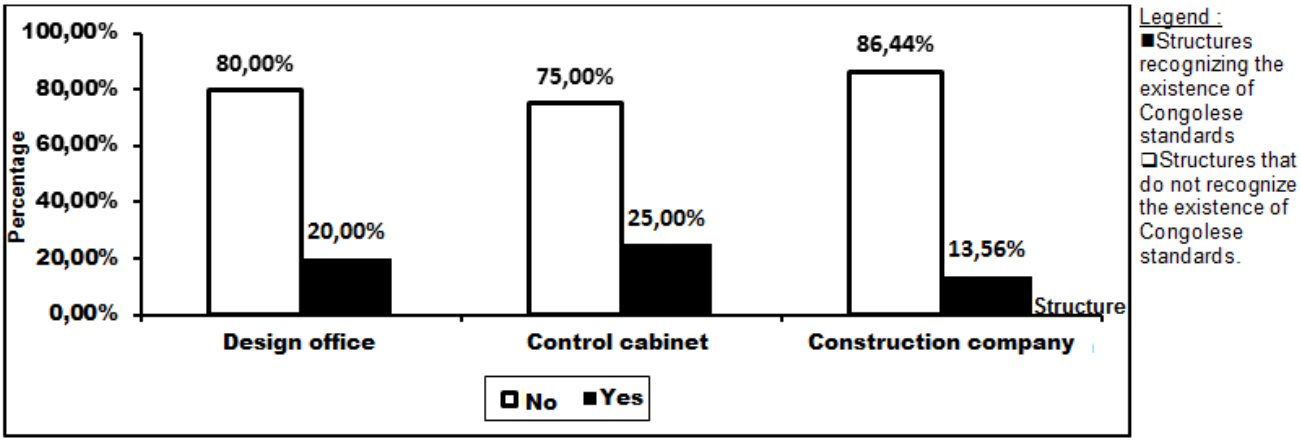

Fig. 4: Distribution of structures that are aware or not of the existence of Congolese standards by type of structure

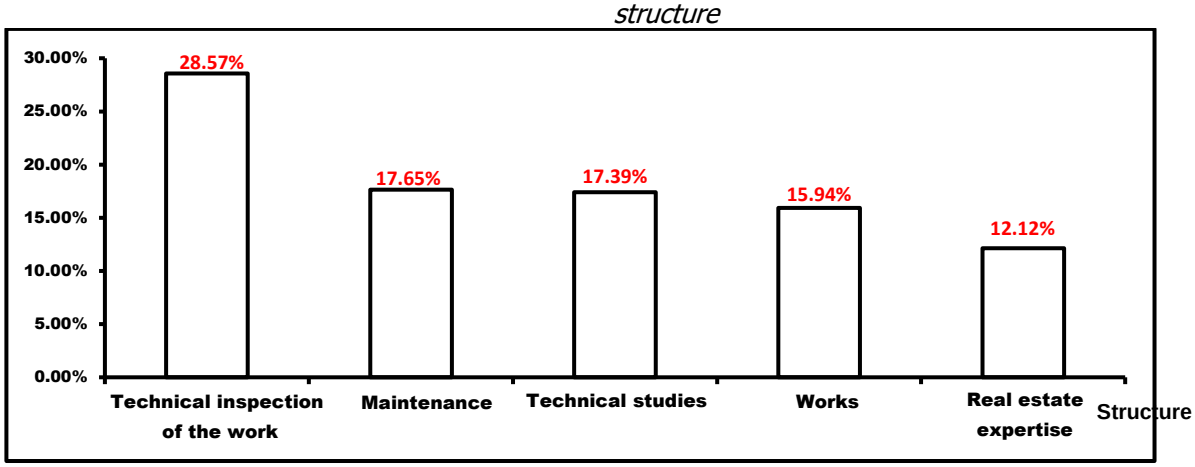

Fig. 5: Awareness rate of the existence of Congolese standards by sector of activity

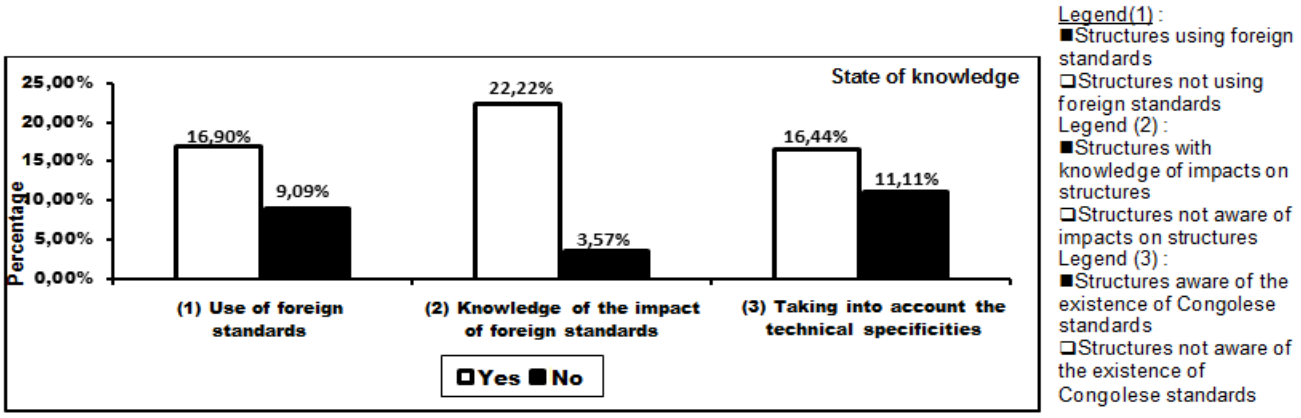

Fig. 6: Awareness rate of the existence of Congolese standards by taking into account of certain technical specifications and the use of foreign standards

3.2. Analysis of the results

Table 1 below summarizes the main results of the regression model that was explored with data estimation by the dichotomized method, which consists of considering explanatory and qualitative variables with at least 3 modalities. According to this table, it can be seen that the structures in Pointe-Noire have more possibilities or probability of knowing about the existence of Congolese standards than those in Brazzaville.

Indeed, it appears from the model used that construction companies based in Pointe-Noire have 5.41 times more chances of knowing about the existence of Congolese standards than those in Brazzaville. Thus, we note that legal status has a significant effect on awareness of the existence of Congolese standards. This effect is significant even at the 1% threshold. And, compared to structures working in the informal construction sector, public limited companies (SAs), single-person liability companies (SARLU), establishments, SARLs and other construction companies have respectively 101.46 times, 63.93 times, 39.61 times and 36.65 times more opportunities to be aware of the existence of Congolese standards. This result can be explained by the fact that informal sector enterprises are much more controlled by less educated managers in terms of mastery of construction standards and techniques. They do not necessarily make real professionals in the trade or field. Being less educated reduces the opportunities to acquire business market information. And so, since the information is asymmetrical, it is much more widely conveyed in the formal construction sector, where societies are much more structured and wealthy.

Similarly, when a structure wants to become formal, it seeks information on standards to be respected in order to be credible in the construction industry corporation. As a result, these results also show that design offices have more opportunities to be aware of the existence of Congolese standards than consulting firms or construction companies. Our analyses show that the probability of being aware of the existence of Congolese standards among design firms and construction companies is very low compared to design firms. This probability is respectively in the order of 18.55% and 22.70%. The evidence provided by our sample (82 individuals) also reveals that structures involved in technical studies and real estate expertise have fewer opportunities to be aware of the existence of Congolese standards.

As a result, according to our results, companies that do not work in the fields of technical studies or real estate expertise have respectively 18.97 times and 3.28 times more opportunities to be aware of the existence of Congolese standards. On the other hand, those involved in the maintenance or roadworthiness test of the works have more opportunities to be aware of the existence of Congolese standards. The model reveals that using foreign standards increases the possibility of knowing about the existence of Congolese standards by 96.81%. It is also noted that knowing the impact of foreign standards on construction increases the possibility of knowing about the existence of Congolese standards by 99.41%.

In short, structures that think that construction actors take into account certain technical specificities related to the natural and social phenomenon in the implementation of projects have 6.91 times more possibilities to know about the existence of Congolese standards than structures that do not think so [14, 15].

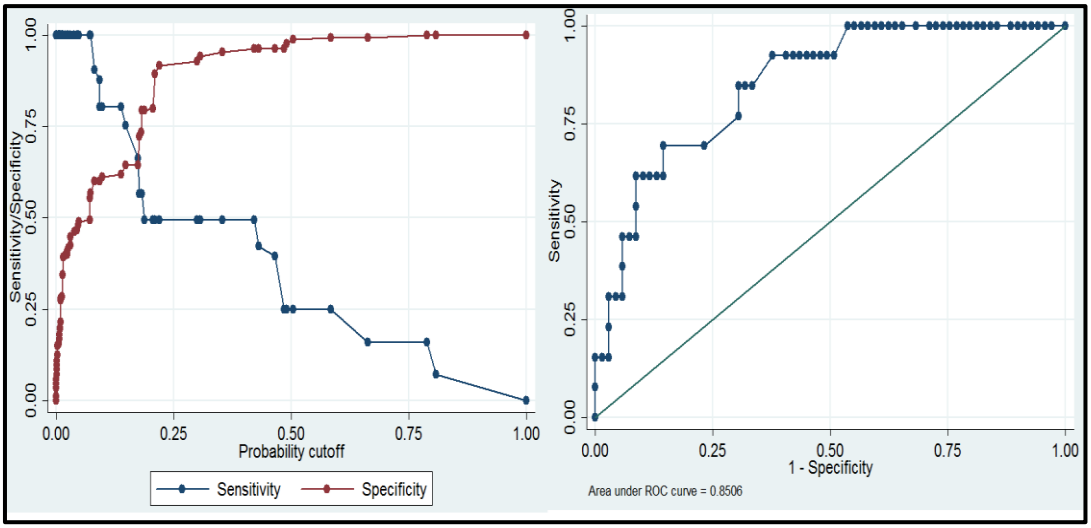

Fig. 7: Sensitivity, Specificity and ROC Curve

Table 1: Result of the dichotomized model of variables

Logistic regression			Number of obs	=	82	
			LR chi2(14)	=	223,59	
			Prob> chi2	=	0,000	
Log likelihood = -290.53875			Pseudo R2	=	0,2779	
P-Value Coefficients			Odds ration			Probability
			Value	lower boundary	upper boundary	
Locality : Brazzaville (Reference)						
Pointe-Noire	1,69	0,000	5,41	3,03	9,67	84,41%
Legal status of the structure: Informal (Reference)						
SARL	3,68	0,000	39,61	8,96	175,06	97,54%
SA	4,62	0,000	101,46	22,38	460,00	99,02%
Establishment	4,16	0,000	63,93	14,64	279,18	98,46%
Others	3,60	0,000	36,65	7,74	173,56	97,34%
Type of structure: Design office (Reference)						
Control cabinet	1,48	0,023	0,23	0,06	0,82	18,55%
Construction company	-1,23	0,008	0,29	0,12	0,72	22,70%
Sector of activity: Technical studies (Reference)						
No	2,94	0,000	18,97	7,26	49,55	94,99%
Business sector: Real estate expertise (Reference)						
No	1,19	0,000	3,28	1,93	5,58	76,62%
Business sector: Maintenance (Reference)						
No	-0,97	0,003	0,38	0,20	0,72	27,43%
Sector of activity: Technical inspection of the work (Reference)						
No	-2,50	0,000	0,08	0,03	0,20	7,56%
Use of foreign standards: Yes (Reference)						
No	-3,41	0,000	0,03	0,01	0,11	3,19%
Knowledge of the impact of foreign standards: Yes (Reference)						
No	-5,12	0,000	0,01	0,00	0,02	0,59%
Technical specificities taken into account: Yes (Reference)						
No	-1,93	0,020	0,14	0,03	0,74	12,64%
Constant	**14,40**	**0,000**				

4. CONCLUSION

This study shows that most companies in the building construction sector use foreign standards. Local building standards are very poorly developed or considered. This poses a problem of real optimization of the durability of the structures built, the materials used and the construction costs. In view of the above, we can therefore say that the rate of knowledge about the existence of Congolese standards is more recorded at the level of structures or societies that use foreign standards (16.90% against 9.09%), compared to those that do not use them. Similarly, these same structures have a real knowledge of the effects (negative or positive) on the use of these foreign standards on construction (22.22% against 3.57%) in Congo.

All statistical tests prove the veracity of these results. However, any building material imported for use in construction works should be certified before use, in order to take into account its adaptability not only to local climatic conditions, but also to all other technical specifications that compete with quality assurance of the works performed, i.e. good durability for better building comfort.

5. REFERENCES

[1]. Anonyme 1 (2016). Construction immobilière : les normes à respecter [En ligne]. Disponible sur https://reassurez-moi.fr/guide/construction-normes-respecter.

[2]. [Anonyme 2, 2019]. Les services de l'État dans le Haut-Rhin. Les règles de construction [En ligne]. Disponible sur http://www.haut-rhin.gouv.fr/politiques.-.les-regles-de-construction.

[3]. Loi Congo (2019). Loi n°6-2019 du 5 mars 2019 portant code de l'urbanisme et de la construction-Brazzaville, 2019, 44 p.

[4]. [OIN, 2017]. Organisation Internationale de Normalisation [En ligne]. Disponible sur https://www.iso.org/fr/publication/pub100317.html.

[5]. Normes ISO (2019). Normes ISO. L'état de l'art au service de la construction. [En ligne]. Disponible sur https://www.iso.org>2019/12.

[6]. (ISO, 2017). ISO et la construction [En ligne]. Disponible sur https://www.iso.org>pub100317.

[7]. Pettang Crispin, Vermande Paul, Zimmermann Monique (1999). L'impact du secteur informel dans la production de l'habitat au Cameroun [En ligne]. Disponible sur https://core.ac.uk/download/pdf/39855657.pdf

[8]. Malanda Narcisse (2007). Application du Sub-Structure Chaining Diagram (SSCD) comme outil de management dans les secteurs informel et semi-informel de la construction. Mémoire d'ingénieur. Ecole Nationale Supérieure Polytechnique (ENSP), université Marien Ngouabi, Brazzaville, Congo, 2007, 90 p.

[9]. Ricco Rakotomalala, Pratique de la régression logistique (2017), Université Lumière Lyon 2. https://eric.univ-lyon2.fr/~ricco/cours/pratique_regression_logistique.pdf

[10]. R. Giraud, Économétries, Collection "Que sais-je", no 1423, PUF, 1993

[11]. M. Tenenhaus, Statistique - Méthodes pour décrire, expliquer et prévoir, Chapitre 11, "La régression logistique binaire", Pages 387-460 ; Chapitre 12, "Régression logistique multinationale : réponses polytomique et ordinale", Pages 461-499, Dunod, 2007.

[12]. D.W. Hosmer, S. Lemeshow, Applied logistic regression, Second edition, Wiley, 2000.

[13]. G. Saporta, Probabilités, Analyse de données et statistique, Section 18.6, "Régression logistique binaire (deux groupes)", pages 475-480, Technip, 2006.

[14]. Kellie J. Archer and Stanley Lemeshow, Goodness-of-fit test for a logistic regression model fitted using survey sample data (2006), The Stata Journal, 6, Number 1, pp. 97-105.

[15]. Gilbert Saporta, Sensibilité, spécificité, courbe ROC (2012), École Pasteur, Cnam de Santé Publique, http://cedric.cnam.fr/~saprota/sensibilite_specificiteSTA201.pdf.

APPENDICES

Annex 1: Estimate of the risk of knowing about the existence of Congolese standards

Logistic regression			Number of obs	=	82	
			LR chi (15)	=	226.21	
			Prob> chi2	=	0.0000	
Log likelihood = 289.22538			Pseudo R2	=	0.2811	
NORMES_CONGOLAISES	Coef.	Std. Err.	Z	P> |z|	[95% Conf.	Interval]
LOCALITE	-1.750163	.3008264	-5.82	0.000	-2.339772	-1.160554
_ISTATUTS_2	-3.403548	.7975896	-4.27	0.000	-4.966794	-1.840301
_ISTATUTS_3	-4.55914	.7779817	-5.86	0.000	-6.083956	-3.034324
_ISTATUTS_4	-3.925209	.7838073	-5.01	0.000	-5.461443	-2.388975
_ISTATUTS_5	-3.34556	.8250209	-4.06	0.000	-4.962571	-1.728549
_ITYPE_ENTR_2	-1.199449	.6808455	-1.76	0.078	-2.533881	-1.349842
_ITYPE_ENTR_3	-1.24047	.4536911	-2.73	0.006	-2.129688	-.3512518
ÉTUDES	-2.675647	.5200101	-5.15	0.000	-1.656446	-3.694848
TRAVAUX	-.9984132	.6484617	-1.54	0.124	-2.269375	.2725484
EXPERTISE	-1.095863	.277828	-3.94	0.000	.5513302	1.640396
ENTRETIEN	-.9020344	.3310316	-2.72	0.006	-1.550844	-.2532244
CONTRÔLE	-2.634776	.4685061	-5.62	0.000	-3.553031	-1.716521
NORMES	-3.43053	.6053225	-5.67	0.000	-4.61694	-2.244119
INCIDENCE	-5.163046	.6412108	-8.05	0.000	-6.419797	-3.906296
TENIR_COMPTE	-2.035386	.8538458	-2.38	0.017	-3.708893	-.3618786
_cons	16.18356	2.644605	6.12	0.000	11.00023	21.3669

Annex 2: Predictive quality of the model

Logistic model for NORMES_CONGOLAISES			
	True		Total
Classified	D	~D	
+	4	3	7
-	9	66	75
Total	13	69	82
Classified + if predicted Pr (D) >= .5			
True D defined as NORMES_CONGOLAISES ! =0			
Sensitivity		Pr (+ / D)	30.77%
Specificity		Pr (- / -D)	95.65%
Positive predictive value		Pr (D / +)	57.14%
Negative predictive value		Pr (-D / -)	88.00%
False + rate for true ~D		Pr (+ / -D)	4.23%
False - rate for true D		Pr (- / D)	69.23%
False + rate for classified +		Pr (-D / +)	42.86%
False - rate for classified -		Pr (D / -)	12.00%
Correctly classified			85.37%