

Smuggling Of Oil Products In The DRC: Capturing Determinants By The Maximum Likelihood Method Of The Variables

LUBENDO LELO Pierrot-Gomez

Master of Science in International Trade Management
Corresponding Author : LUBENDO LELO Pierrot-Gomez



Abstract: Understanding the determinants of smuggling in the Democratic Republic of Congo is a crucial task, but one of paramount importance for better understanding the informality of cross-border trade in petroleum products. As such, while the omnipresence of trade transactions between the DRC and Angola has existed since then, the establishment of border lines in Africa has given a different impression, as populations that were once united are arbitrarily separated, giving rise to the existence of cross-border populations. This is one of the explanatory factors for the informality of trade transactions between the two countries.

Data manipulation using the Maximum Likelihood Method of variables made it possible to capture the determinants of petroleum product smuggling, grouped into three categories, including sociodemographic, sociocultural, and economic determinants. Certainly, in addition to sociodemographic factors, certain sociohistorical and geographical factors are often put forward by various researchers to explain the recurrence of informal cross-border trade transactions in Africa.

Keywords:Smuggling, cross-border trade, petroleum products, informality, Democratic Republic of Congo.

Résumé : Saisir les déterminants de la contrebande en République Démocratique du Congo est une tâche cruciale, mais d'une importance capitale pour mieux comprendre le fonctionnement de l'informalité du commerce transfrontalier des produits pétroliers. A ce titre, si l'omniprésence des transactions commerciales entre la RDC et l'Angola est un phénomène qui existe depuis lors, l'instauration des lignes frontières en Afrique en a donné une autre sensation, car les populations autrefois unies sont arbitrairement séparées, donnant lieu à l'existence des populations transfrontalières. C'est l'un des facteurs explicatifs de cette l'informalité des transactions commerciales entre les deux pays.

La manipulation des données, par la Méthode de Maximum de Vraisemblance des variables, a permis de capter les Déterminants de la contrebande des produits pétroliers, groupés en trois catégories, parmi lesquelles : les déterminants sociodémographiques, socio-culturels et économiques. Certes, outre les facteurs sociodémographiques, certains facteurs d'ordre socio-historique et géographique sont souvent avancés par les différents chercheurs pour expliquer la récurrence des transactions commerciales informelles transfrontalières en Afrique.

Mots-clés : Contrebande, commerce transfrontalier, produits pétroliers, formalité, République Démocratique du Congo.

1. Introduction

Informal trade, or at best smuggling, consists of the illegal importation (illegal trade) of genuine or counterfeit products (illicit trade) with the aim of reselling them without paying the taxes charged. It is in fact an activity prohibited by law or conducted by agents who do not have authorization. In all cases, the individual seeks to evade paying taxes. However, in practice, these distinctions are

rather unclear. The literature makes no clear distinction between these two terminologies in the sense that they refer to the unauthorized nature of the activity. Benjamin et al. (2012) define the illegal economy as an economy that contains all illicit activities, such as drug trafficking and counterfeiting.[1] This paper focuses on illegal imports of petroleum products without regard to their authenticity. For the sake of harmonization, the term illegal trade is used throughout the document.

In principle, trade involves at least two parties: a seller and a buyer. The parties can be legal entities or individuals. Cross-border trade is always an economic relationship between a resident and a non-resident involving the exchange of goods and services. This trade can be carried out remotely (including in the form of e-commerce) or through the movement of one of the two parties. For the category of trade between companies (B to B), the reference framework is constituted by the principles and sources of foreign trade statistics. This analysis is therefore limited to trade in petroleum products, the collection system for which is the one that records fuel trade between authorized companies.

Regarding the cross-border trade between businesses and individuals (B to C), we consider cases where the resident actor (here, the reseller) travels to the border, or even to the neighboring country (Angola in this case) to buy fuel and returns to his country the same day. More concretely, this involves the sale of Angolan (or non-resident) companies to Congolese (resident) resellers.

This paper aims to present the elements determining the choice of informal cross-border trade. These determinants are on the one hand of a theoretical nature, the identification of which is based on the analysis of the contents of previous documents, and those of an empirical nature, the identification of which is made through specific tools, relating to the collection of qualitative data, like the Influence-Interest matrix.

2. Literature review

Several socio-historical, geographical and economic factors are often put forward by various specialists to explain the omnipresence and recurrence of informal cross-border commercial transactions in Africa. The weight of each of the factors actually depends on the socio-cultural context and the States involved in the transactions, as well as the economic situation at the time. Clearly, Bessan, E. (2016) informs that the disparities in economic, monetary, commercial and fiscal policies between States occupy an important place in the functioning of this trade[2].

In the literature, it is accepted that illegal transactions in cross-border trade can only take place when there are certain forms of restrictions or distorting factors that generally lead to divergences between domestic and foreign prices. Distorting factors are generally cited as customs taxes, differences in trade policy, obstacles to trade facilitation and the premium of the parallel foreign exchange market.

Customs tariffs: The primary cause of the growth of informal trade is customs taxes. The incentive to avoid paying taxes has been recognized since the work of Bhagwati (1964, 1967).[3]. Thus, the increase in the customs duty rate not only reflects the price differences between cross-border countries, but also induces a significant level of smuggling into the economy.

Differences in trade policies: The difference between trade policies is reflected in the prohibition or even the outright ban of certain consumer products. Thus, many authors, such as Golub (2012b), widely recognize differences in national trade policies as a determining factor in encouraging informal trade.[4]. Golub and Mbaye (2009), for their part, go into more depth by indicating that the significant and varied differences in retail prices of goods between bordering countries confirm the existence of incentives for smuggling.[5].

Monetary factors, the argument of monetary parity and the parallel exchange rate: the existence of two prices at the same time for the same currency (official exchange rate and parallel exchange rate) also constitutes a distorting factor that can lead to and/or intensify smuggling. The factor that conditions this development is also monetary.[6].

Business network theory: Generally, research on the impact of networks on trade concerns co-ethnic networks and business groups with publicly registered members, such as the Japanese keiretsu.

3. Methodological approach

The problem of petroleum product smuggling between the DRC and Angola is not a new phenomenon. Trade between the two countries is so intense and sensitive that we were forced to first conduct field observations to understand how this trade is practiced in the various sites chosen, with a particular focus on its informal nature.

The interviews adopted an approach that combines both socio-anthropological and participatory research approaches. The aim is to consider cross-border trade actors as economic units, whose functioning is primarily sought to be analyzed. Specifically, the investigations should seek to characterize the actors, outline their temporal itinerary, and highlight the specific conditions in which they operate.

The socio-anthropological approach has made it possible to decipher the complexity of the social ties that give networks and market organizations their effectiveness. We are witnessing cross-border populations that belong to the same tribe on both sides of the border, and sometimes to the same family line.

3.1. Determining sample size

The goal of qualitative research is not to have a representative sample (as is the case with quantitative research), but rather a significant sample that reflects the characteristics and richness of the context and/or population studied. In short, the sample size is defined when there is information saturation in the individual interviews with stakeholders, that is, there is no longer any added value in the responses, thanks to the Snowball effect.

Marshall et al (2013) distinguished between different qualitative approaches to approach the size of qualitative samples. The sizes of these samples vary between 23 for simple case studies and 40 for complex case studies.[7]Miles and Huberman (2003) advise that qualitative researchers usually work with small samples of people nested in their context and studied in depth.[8]Qualitative samples tend to be purposeful, rather than random, and are usually not entirely pre-specified but may evolve once the research work has begun.

Taking into account the significance criterion, the sample size is set at 270 individuals across all 10 survey sites. This sample size is based on the literature, such as Morse (2000) who proposes different variables that are likely to have an influence on the size of the qualitative sample, including: (i) the type of problem (specific or general); (ii) the type of subject (abstract or concrete); (iii) the quality of data; and especially (iv) the probability of collecting all the information from a single respondent.

3.2. Sampling procedure

Like NOY (2008), sampling was done in multiple stages (in waves): the analysis of the data collected during the first wave revealed new phenomena that required investigation and therefore new sampling. These new phenomena appeared during the application of sampling using the Snowball effect. The "Snowball effect" is this technique which therefore makes it easier to recruit respondents in difficult contexts, so that, with each contact, the list of potential respondents grows like a snowball that continually grows when pushed.

In terms of functionality, the study used, in a participatory manner, three data sources, namely:

- (i) **Data collection from border, administrative and political authorities.;**
- (ii) **Data collection by standard questionnaire**intended for traders in border sites, chosen according to their availability to collect their responses, following the Snowball effect;
- (iii) **Collection of additional information**through organizations and associations and organizations defending the rights of traders

This triangulation made it possible to minimize certain biases in the survey results through interviews with the various stakeholders in cross-border trade and to assess the proportion of the population making this cross-border trade one of the mainsourcesincome for their households.

3.3. Sample Description

The sample used to study the governance of cross-border trade in petroleum products between the DRC and Angola is constituted by combining the status of the trade carried out, the nature of the border through which the petroleum products are transported and the gender of the actors involved. The structure of this sample is as follows:

Table 2: Sample of respondents according to the Trade Status by Border Type and Gender

Respondent's Gender			TRADE		TOTAL
			Formal	Informal	
Male	Nature of the Border	Terrestrial	50(=18.5)	90(=33.3)	140(=51.9)
		River	30(=11.1)	70(=25.9)	100(=37.0)
		Total	80(=29.6)	160(=59.3)	240(=88.9)
Female	Nature of the Border	Terrestrial	0(=0.0)	10(=3.7)	10(=3.7)
		River	10(=3.7)	10(=3.3)	20(=7.4)
		Total	10(=3.7)	20(=7.4)	30(=11.1)
Total	Nature of the Border	Terrestrial	50(=18.5)	100(=37.0)	150(=55.6)
		River	40(=14.8)	80(=29.6)	220(=44.4)
		Total	90(=33.3)	180(=66.7)	270(=100.0)

Source :Author's calculation based on field data

Legend :values in parentheses are percentages.

The significance criterion, thanks to the snowball effect, was the basis for the constitution of the sample of this research. The size of this sample is composed of 270 interview subjects in all 10 sites, among which, 33% are in formal commerce and the other large part in the informal sector on the one hand, and 89% of men against 11% of women, on the other hand.

4. Highlighting the Determinants of Cross-Border Smuggling

This section is mainly devoted to the econometric analysis of the variables, in order to highlight the determinants of informal cross-border trade in petroleum products, mainly composed of socio-demographic, economic and socio-cultural factors.

4.1. Analytical framework

In order to enrich this study and provide answers to the problem of the study, an econometric modeling is essential. The dichotomous nature of the explained variable "Informality of cross-border trade in petroleum products" leads to the use of binary choice modeling. To do this, the estimation of the model thus adopted consists of considering individuals (the Actors of cross-border trade in petroleum products) observed facing the observation of a situation "Exercising one's activity in the informal sector" noted and which takes two values, namely 1 or 0. We thus attempt to conceptualize a model for analyzing the unobserved variable (latent variable) of cross-border trade in petroleum products through the variable "Exercising one's activity in the informal sector" considered as the visible manifestation of the latent variable. Based on the empirical strategy developed by Bensassi et al (2016), the problem is formulated as a function of the choice of informality and denoted $(C)nY_iy_i^*[2]$.

Thus, we consider for a given actor (i) having characteristics (X_i) , the probability of opting for informal cross-border trade is subject to a level of acceptability given by the pair $C(1, X_i)$, while the choice of formality is subject to a level of acceptability given by the pair $C(0, X_i)$. The mathematical formalization of this approach can be summarized as presented in equation (1) below:

$$Y_i = \begin{cases} 1 & \text{si } C(1, X_i) > C(0, X_i) \\ 0 & \text{si } C(0, X_i) > C(1, X_i) \end{cases} \quad (1)$$

Given that the situation chosen is that of informality and will allow the actor entering this trade to maximize his profile, this therefore amounts to considering the latent variable by assuming:

$$y_i^* = C(1, X_i) - C(0, X_i) \quad (2)$$

Equation (2) can then be written:

$$Y_i = \begin{cases} 1 & \text{if } y_i^* > 0 \\ 0 & \text{if } y_i^* < 0 \end{cases} \text{ avec } y_i^* = X_i\beta + \varepsilon_i \quad (3)$$

In equation (3), X_i is a vector of explanatory variables; β is the vector of parameters of the model to be estimated and ε_i is the error term. Since informality is a binary qualitative variable, we estimate for an actor the probability of opting for informal cross-border trade given by equation (4) such that: $X_i\beta\varepsilon_iY_i = 1$

$$P_i = P_r(Y_i = 1) = P_r(\varepsilon_i < X_i\beta) = F(X_i\beta) \quad (4)$$

In equation (4), F is the distribution function. It is thus a question of determining the functional form so that the following conditions are met: $F P_r(Y_i = 1)$

$$0 < P_r(Y_i = 1) < 1 \text{ and such that } \sum_{i=1}^N P_r(Y_i = 1) = 1 \quad \lim_{X_i\beta \rightarrow +\infty} P_r(Y_i = 1) = 1 \quad \lim_{X_i\beta \rightarrow -\infty} P_r(Y_i = 1) = 0$$

Considering that the distribution function follows a normal law, it therefore follows that the probability that an actor adopts informality depends on a set of factors (explanatory variables including economic factors, sociocultural factors and sociodemographic factors) represented by the vector X_i such that: $F(X_i\beta)X_i$

$$P_i = P_r(Y_i = 1) = F(X_i\beta) = \frac{\exp(X_i\beta)}{1 + \exp(X_i\beta)} = \frac{1}{1 + \exp(-X_i\beta)} \quad (5)$$

4.2. Choice of variables and model specification

The analysis of the informality of cross-border trade in petroleum products and its determinants uses several variables, of which we retain twelve, taking into account the constraint of the existence of reliable official data. Among these variables of interest, five are sociodemographic variables, four are economic variables, and three are socio-cultural variables.

The "Maximum Likelihood" method is therefore used to estimate the CIT of petroleum products. Indeed, The analyses in this work empirically highlight the determinants of the choice of informality in cross-border trade in petroleum products. The model is thus specified as given in equation (6) below:

$$CIT_i = \beta_0 + \delta X_i + \gamma V_i + \rho Z_i + \varepsilon_i \quad (6)$$

With: the dependent variable capturing informal cross-border trade in petroleum products. It takes the value 1 if the trade is informal and 0 if it is formal, with X_i is the vector of economic variables. V_i is the vector of socio-demographic variables. Z_i is the vector of socio-cultural variables. These three vectors provide information on the potential determinants of informal cross-border trade in petroleum products. In addition, $\beta_0, \delta, \gamma, \rho$ are parameters to be estimated. While ε_i is the error term. It is a normally distributed random variable controlling for other variables that influence the informality of cross-border trade in petroleum products and which are either unobservable or not considered in the regression.

4.3. Measurement and definition of study variables

In this study, the variables were selected based on their theoretical and empirical importance, with reference to the literature, particularly regarding the determinants of informal cross-border trade. Among the factors that are likely to influence the choice of informality to the detriment of formality, there are both: (i) socio-demographic factors (marital status, position of the individual within the household, gender, level of education and age); (ii) economic factors (customs tax, predisposition to informal tax, volume of products traded, and volume of the product squared out of 100); and (iii) socio-cultural factors (membership in an associative group, place of residence as well as the existence of other fragmentation relationships), as presented in Table 8 below.

Table 3: Definition of variables and expected signs

Variables	Definition	expected signs
Dependent variable		
Informal Cross-Border Trade (ICT)	Cross-border trade status which takes the value 1 if the trade is informal and 0 if it is formal	
Economic factors		
Payment of Customs Duty (TD)	Binary variable coded 1 if the actor regularly pays the tax and 0 otherwise	(+) Javorcik and Narciso (2008) Golub (2012); Bensassi et al, (2016); Mitaritonna et al, (2017)
Predisposition to informal tax (PTI)	Binary variable coded 1 if the actor pays the informal tax in his activities and 0 otherwise	(-)
Volume of product traded (VOLP)	Continuous variable indicating the number (expressed in terms of quantity of cans of the product exchanged)	(+)
Volume of product traded squared over 100 (VOLP ² /100)	Captures the quadratic effect of the VOLP variable	(-)
Sociodemographic factors		
Sex	Binary variable capturing gender, it is coded 1 if the actor is a woman and 0 if it is a man	(+) Ackello-Ogutu and Echessah (1997), Titeca and Kimunaka (2012)
Education level (EDUC)	Highest level of education attained, 0=none, 1=Primary, 2=Secondary, 3=Higher and university	(-)
Age	Takes the value 1 if the actor belongs to the age group [21-30[; 2 if [31-40[; 3 if [41-50[and 4 if [51 and over[.	(+/-), Atta et al, (2016).
Marital status	Marital status coded 1 if the actor is in a relationship and 0 if he lives alone	(+)
Position within the household	Binary variable which takes the value 1 if the actor is Head of Household and 0 otherwise	(+)
Socio-cultural factors		
Membership of an Associative Group (RSOC)	Binary variable which takes the value 1 if the actor is a member of a commercial network helping him in his activity, and 0 otherwise	(+)Egg and Herrera (1998), Golub and HansenLewis (2012)
Residential Environment (RESID)	Binary variable which takes the value 1 if the actor resides at the border site and 0 otherwise	(+)
Existence of other fragmentation relationships (REF)	Binary variable which takes the value 1 if the actor maintains non-commercial relations with the other partners and 0 otherwise	(+)

Source: Author

Informal cross-border trade (ICT): is the basic variable of the model. It provides information on commercial transactions (imports) of petroleum products that escape the control of the public authorities, due to their smuggling. The crossing of smuggled products is both the result of the absence of tax officials at illegal crossing points, and the complicity of these officials at legal

crossing points along the border. The CIT is a function of several controllable and non-controllable factors that we have named determinants, exploited as business opportunities by economic operators.

The Customs Tariff (CT): Faced with restrictions or trade taxes that are deemed high, traders often resort to illegal means of trading, such as smuggling and fraud on import invoices. The higher the customs tariff, the more legal trade tends to be reduced in favor of illegal trade. This is when Yitzhaki (1974) shows that the tax rate in the Allingham model has a substitution effect favoring smuggling and a discouraging effect on state revenue, and that the net effect is uncertain.[9].

Predisposition to informal tax (PTI): PTI is a variable that attempts to show how cross-border trade actors are predisposed and attracted by informal tax payment facilities. The expected negative sign of this variable is explained by the fact that, as the costs of informal payments increase, informal trade tends to decrease in favor of formal trade.

The volume of the product traded (VOLP): in order to avoid and reduce scale effects, we square and divide by 100 the volume of the goods (i.e. $VOLP^2/100$), we are able to capture the quadratic effect of the VOLP variable. This effect provides information on the maximum quantity (150 25-liter cans) of the product traded informally, beyond which the trader tends to leave the informal sector in favor of the formal sector. This is the reason for the expected negative sign of the new variable.

Education level (EDUC): It is assumed that from a certain level of education, the actor is more attracted to formal trade and is aware of the interests linked to the formalization of his activity and the risks of informality, this is the reason for the expected negative sign of this variable.

Age: While younger individuals are predisposed to informal trade because they are more able and mobile to overcome obstacles, older individuals are more aware of the risks associated with smuggling and tend to move from the informal to the formal sector. In addition to the positive sign of age on trade informality, we also expect a negative sign of this same variable when there is awareness of risk. This situation has also been demonstrated and proven in labor market research. Kalemasi, M. (2024) ended up concluding that the behavior of individuals in the labor market takes the form of reversed, to explain the predisposition of individuals to leave the informal sector to the formal labor sector, due to wanting to protect themselves from end-of-service compensation.

Marital status and position in the household: are two variables that go in the same direction in explaining the behavior of traders on the informality of cross-border trade. Their positive sign explains the freedom that individuals living alone have to make commercial decisions, because they are heads of their own household.

Membership of an associative group (RSOC): belonging to a commercial network with ethnic and/or religious connotations (personal commercial network, tontine group) significantly influences this trade. Through the Graudfunding mechanism, a member in difficulty can obtain the resources necessary to resume his activity. While individuals without a network are exposed to police harassment, network members benefit from lobbying by their leaders to resolve certain disputes. This is the direction taken by the expected positive sign of the variable.

The place of residence (RESID): Residents have the advantage of knowing the routes, the timing of operations, and the dangers of each stake. Generally speaking, living in the border area implies the creation of relationships other than commercial ones with local populations. The expected positive sign indicates an increased chance of success in the contraband trade induced by living in the border area.

The existence of other fragmentation relations (REF): While commercial relationships are clearly defined between trade actors, non-commercial relationships, however, still retain their ambiguous character. Quite often, these relationships, generally and deliberately undisclosed, create a strong proximity between actors, thus causing a form of operational discrimination on the ground. Indeed, market access during periods of petroleum product scarcity is sometimes conditioned by the degree to which these fragmented relationships are maintained. Actors in so-called friendly relationships have the advantage of benefiting from procedural relief, and even certain exemptions to the detriment of others. The ease of passing goods without paying taxes at the border, both formal and informal, significantly increases the smuggling of petroleum products. Male-female relationships in the business environment remain, generally speaking, not clearly acknowledged, but have a significant impact on the behavior under study. The

expected positive sign of this variable indicates that the more non-commercial relationships are maintained between different actors in cross-border trade, the more its informality is developed.

4.4. Econometric results

Overall, the theoretical predictions concerning the explanatory factors of the CIT are largely verified. Moreover, the different estimations, considering each factor (sociodemographic, economic and cultural), show that the models are well specified. Indeed, the ROC curves of prediction (in appendix) attest that the empirical models are specified at the prediction rates of 79.32%; 94.18% and 97.17%, respectively for the estimation taking into account sociodemographic factors first, then economic, then cultural.

Similarly, for all factors considered, the estimation results show that the CIT variable appears to be well explained by the model. It appears that the regression model is significant at 1% for the three groups of factors. Also, these results support the results of the descriptive analyses based on the different statistical tests. In addition, the theoretical work and the results of the empirical studies mentioned in the literature on the CIT are largely confirmed by this study.

Table No. 4: Determinants of the CIT of petroleum products

Variables	Coefficients			Marginal effects		
	-1	-2	-3	(4)	(5)	(6)
Sociodemographic factors						
Women	1,053*** -0.333	2,375*** -0.627	3,740*** -1,108	0.270*** -0.056	0.412*** -0.076	0.447*** -0.016
Between 21-30 years old	0.449** -0.237	0.462** -0.22	0.451** -0.228	0.138** -0.062	0.137** -0.064	0.163** -0.078
Between 31-40 years old	0.888*** -0.281	0.603** -0.233	0.769** -0.296	0.374*** -0.091	0.345** -0.155	0.362** -0.125
Between 41-50 years old	0.413* -0.217	0.292* -0.177	0.251 -0.264	0.148* -0.0801	0.104* -0.057	0.081 -0.079
Over 50 years old	-0.525** -0.209	-1,852*** -0.59	-1,934*** -0.617	-0.193** -0.107	-0.448*** -0.101	-0.473*** -0.109
Secondary education	1,161*** -0.212	2,306*** -0.559	2,211*** -0.321	0.399*** -0.0689	0.423*** -0.122	0.426*** -0.855
As a couple	0.12 -0.193	0.053 -0.201	0.207 -0.152	0.042 -0.069	0.012 -0.681	0.069 -0.051
Economic factors						
Payment of customs duties		-2,528** -0.891	-1,743*** -0.459		-0.563** -0.198	-0.274*** -0.047
Predisposition to informal tax		0.618* -0.351	0.576* -0.321		0.234* -0.136	0.211* -0.117
Volume of product traded		0.087*** -0.0226	0.069*** -0.02		0.031*** -0.009	0.016*** -0.004
Volume of product traded squared/100		-0.080*** -0.018	-0.045** -0.018		-0.028*** -0.007	-0.024** -0.011
Socio-cultural factors						
			0.368*			0.114*

Associative network			-0.201			-0.063
Residence site			0.086			0.029
			-0.199			-0.069
Constant	0.844*** -0.23	1,125** -0.439	0.879*** -0.153			
Number of observations	270	270	270	270	270	270
LR chi2(7)	85.36			84.81		
LR chi2(10)		206.24			206.24	
LR chi2(12)			246.3			246.3
Prob > chi2	0	0	0			
Pseudo R2	0.25	0.6	0.72			

Source: Results obtained from the survey, *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Standard deviations in parentheses.

While this trade is open to anyone with the necessary skills, there is little information on cross-border traders and the conditions under which they operate, although there is a significant gender dimension to this issue. Gender refers to the socially constructed roles and behaviors of men and women and the socially established relationships between the sexes, as opposed to biological differences.

Indeed, our investigations show that gender is a sociodemographic factor that explains the CIT of petroleum products, at the 1% significance level. Age is an explanatory factor for the informality of cross-border trade in petroleum products at the 5% significance level. Indeed, like Kalemasi, C. (2024), if younger individuals are predisposed to informality, our analyses show that older individuals are aware of the risks associated with the activity, and are therefore predisposed to leaving the informal sector in favor of the formal sector. However, this same factor is significant at the 1% significance level when individuals approach retirement age, thus considering the CIT as a small local activity for survival.

The level of education is revealed among the explanatory factors of the informality of cross-border trade in petroleum products, at the threshold of 1%. Indeed, it emerges from our analyses that individuals with lower levels of education predominate in the informality of cross-border trade. This is explained by their low participation in the formal labor market which requires a level of education above secondary education. Marital status, however, did not prove to be decisive in explaining the informality of cross-border trade in petroleum products.

Regarding economic factors, our analyses show that Customs Law explains the informality of cross-border trade in petroleum products at the 1% threshold; whereas it is at the 10% threshold that cross-border traders of petroleum products have been found to be predisposed to paying the informal tax. Three major reasons are put forward to justify this predisposition of traders to informal payments: the high costs of the formal tax; the negotiable nature of the informal tax; and the hassles of paying the formal tax. Furthermore, the volume of the product traded determines the informality of cross-border trade in petroleum products at the 1% significance threshold. However, when squared and divided by 100, the quadratic effect indicates the quantity beyond which individuals are predisposed to leave informality for the formal sector, thus taking the shape of an inverted U, like marginal utility in the analysis of consumer behavior. This question determines, at the 5% significance level, the CIT of cross-border products for reasons of security and requirements related to the inherent risks of product handling.

As for socio-cultural factors, the results of our analyses indicate that belonging to an associative network of traders is a determining factor in the informality of cross-border trade in petroleum products, at the significance threshold of 5%, alongside the place of residence. Indeed, the fact that a trader resides at the border site gives him an advantage in better seizing the business opportunities offered by smuggling, and even in better capturing situations of moments of turbulence and harassment. These individuals are often members of cross-border populations, whose families are located on both sides of the border line between the DRC and Angola (mainly the Kongo, Woyo and Asolongo).

5. Conclusion

Analyzing the determinants of petroleum product smuggling between the Democratic Republic of Congo and Angola has provided a better understanding of the logic underlying informal cross-border trade in this border region. Far from being marginal, this phenomenon constitutes a veritable parallel economy, structured around social, cultural, and economic networks deeply rooted in local dynamics.

The results of this study, derived from econometric modeling using the maximum likelihood estimation method (MPLE) and field observations supported by the snowball effect technique, highlight three main categories of determinants: sociodemographic, economic and sociodemographic.

From a sociodemographic perspective, gender, age, and education level appear to be the main variables explaining the use of informal trade. Young people and women, often excluded from the formal market, perceive smuggling as a viable economic alternative. Conversely, older and more educated individuals tend to formalize, aware of the legal and economic risks associated with informal activities.

From an economic perspective, high customs duties, administrative burdens, and the propensity to pay informal taxes constitute strong incentives to circumvent legal channels. Econometric results show that increasing customs duties significantly increases the risk of smuggling, while rising costs of informal trade discourage it. Excessive trade volumes also encourage entrepreneurs to formalize for reasons of security and supply stability.

Sociocultural factors play a decisive role. Membership in associative networks, residence in the border area, and cross-border family ties constitute powerful levers for the maintenance and reproduction of informal trade. These networks guarantee solidarity, facilitate financing, and offer protection against administrative and police harassment. Far from being a barrier, the border thus becomes a space of opportunity, collusion, and informal exchange.

Overall, the study shows that petroleum product smuggling in the Democratic Republic of Congo is not just a legal problem, but a deeply rooted economic, social, and cultural phenomenon. This reflects weak economic governance, a cumbersome tax and customs system, and the population's resilience to poverty and unemployment.

In summary, the fight against smuggling cannot be limited to repressive measures. It must be part of a comprehensive and integrated approach, combining:

- tax and customs reform aimed at reducing incentives for informal trade;
- strengthening cross-border cooperation between the Democratic Republic of Congo and Angola to harmonize trade policies;
- and socio-economic support for informal traders to promote their gradual transition to formal trade.

Therefore, a detailed understanding of the determinants of smuggling, as presented in this study, is an essential prerequisite for the development of public policies that are more realistic, inclusive and adapted to the realities of Congolese cross-border trade.

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