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Effect of Transaction Costs on Inorganic Fertilizer Use Intensity in Rwanda

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Abstract: ***Increasing crop productivity is one of the key options of improving food availability in Rwanda. Although, emphasis was put in by the government to promote the use of this modern technology for the last 20 years, farmers are still using low levels of fertilizers and among the reasons .Therefore, the major concern of this paper is to empirically analyse effect of transaction costs on inorganic fertilizer use intensity in Rutsiro district, Rwanda. A multistage population-proportionate random sampling procedure was employed to select 192 respondents using structured questionnaires.Descriptive analysis and multiple regression were employed to estimate the data in stata 13 soft wire. The results of the study found that key transaction cost characteristics identified were asset ownership such as bicycle, radio ownership, transport, communication and negotiation costs.The study also used the ratio of fertilizer applied per unit area to assess the fertilizer use intensity .The results revealed that on average area of 0.889ha, the average NPK applied in 2017 was 178.5±15.5Kg per ha, in this case the fertilizer use intensity was 399.4±115.1kg/ha. Policies that aim to reduce transaction costs through improved transportation and rural infrastructure and better access to information media for smallholder farmers can be the most effective methods of increasing levels of fertilizer use.***

Key words: Transaction costs, Fertilizer, Intensity, Multiple regression Rutsiro District, Rwanda

I. BACKGROUND OF THE STUDY

Fertilizer is one of the most important technologies in increasing food production in the world. Several policy approaches have been used to promote increased use of fertilizer in smallholder farming systems, these have included the promotion of a state monopoly for fertilizer import and distribution, institution of price controls and subsidies at the fertilizer retail markets, provision of credit to farmers for the purchase of fertilizer, institution of import tariffs, decentralization of procurement and distribution, and deregulation of markets.

There is widespread agreement that increased use of fertilizer and other productivity enhancing inputs is a precondition for rural productivity growth and poverty reduction, for many agricultural scientists, economists and institutions too, increased fertilizer use is the key to increasing productivity in African agriculture (Crawford, Jayne, & Kelly, 2006; Yamano & Arai, 2011). Despite the growing evidence that fertilizers can substantially increase yields in sub-Saharan Africa (SSA) as well as slow down environmental degradation, farmers in this region still lag far behind other developing countries in fertilizer use (Liverpool-Tasie, Olaniyan, Salau, & Sackey, 2010).

The fertilizer supply is limited and the cost is prohibitive for SSA farmers because fertilizer may cost as much as five times the global market price (Erisman, van Grinsven, Leip, Mosier, & Bleeker, 2010). High transaction costs facing smallholder farmers in developing countries are mostly contributed by high transportation costs due to long distances from rural markets and poor road infrastructures, (Olagunju, Ayinde, Adewumi, & Adesiji, 2012). These costs which are also related to searching and gathering information and services involve costs of bargaining and negotiating contracts as well as costs of monitoring and enforcement have for long weaken the decisions of smallholder farmers to participate in the market. Practically, these costs can physically be seen in transportation, paying taxes in government and in markets as well as in obtaining service from the middlemen. Transaction costs can categorized as observable and unobservable costs paid by smallholder farmers in order to access information and other market procedures. Smallholder farmers are affected by transportation costs because in most of the developing countries, roads are underdeveloped especially rural feeder roads and communication; this makes transportation costs high. The impact of transaction costs on the participation of smallholder farmers and intermediaries in the banana market indicated that, long distances to markets and poor ownership of transport facilities as among the causes of high proportional transaction costs, meaning that, those farmers living far away from the markets incur more transportation cost than those living nearby the markets and those who own improved

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means of transport facilities can save some incomes which could be paid to transporters (Nabintu & Gaspart, 2017).Some scholars suggests that use of fertilizer supply is limited by the transaction costs because in Sub Saran Africa the cost is five times higher than the global market price (Morris, Ronchi, & Rohrbach, 2011), who says fertilizer use is unprofitable in many parts of Africa due to high prices and transportation costs.

On the supply side, having fertilizer available in appropriately sized packaged at the necessary time of year often prohibits access at the farm level and fertilizer costs are higher in Africa than other regions due mostly to high transport costs making it more difficult for poor farmers to obtain but still current chemical fertilizer application rate is still well below 50 kg of NPK per hectare (14.7 kg), fertilizer usage has increased by 30% over the past ten years (Salin-Maradeix, 2015).

In Rwanda, PSTA III targets that fertilizer use of 45Kg/Ha which translates to 55,000MT of fertilizers but this is still below the target as contained in the Abuja Declaration on Fertilizer for an Agricultural Green Revolution of 50Kg/Ha. Though Rwanda has made remarkable efforts in increasing productivity of agricultural sector through various policies including use of fertilizers however, the use of fertilizers is still below the target levels for example use of fertilizers in 2006 increased from 4kg/ha to 30Kg/Ha in 2013, yet PASTA III targets 45Kg/Ha which translates to 55,000MT of fertilizers (CIP 2013).Many factors contribute to the low levels of fertilizers use intensity based on available evidences some indicate that socioeconomic and institutional factors determine adoption of fertilizer use intensity (Diiro, Ker, & Sam, 2015). Others add technical knowledge and household characteristics as determinants (Ketema & Kebede, 2017). Despite the evidence in different countries there is barely any study conducted in Rwanda to investigate transactional cost factors influencing fertilizer use intensity. This study was conducted to close the knowledge gap and contribute to better understanding of the transactional cost factors influencing fertilizer use intensity in Rwanda.

II. THE CONCEPT OF TRANSACTION COSTS

Governance structures have been defined as mechanisms mainly for settling ex post (i.e., after contract agreement) disputes. The theory predicts that forward looking agents adopt governance structures that are best suited to handle the transaction(s) they carry between them Williamson (1996). Governance structures can be seen as a continuum ranging from spot market to hierarchy (or vertical integration) in which contracts are a typical hybrid governance structure (Ménard, 2004).TCE explains how economic actors choose from a set of feasible institutional alternatives and governance structures that safeguard their transactions at the lowest costs that is governance costs which refer to all costs incurred during a transaction in a specific contractual arrangement, and they vary across different arrangements (Bijman, 2008).

The majority of smallholder farmers in developing countries are located in remote areas with poor infrastructure and they often fail to participate in markets due to the high transaction costs involved (Makhura, 2002). Sometimes the transaction costs are so high that markets can be said to be "missing" while in other instances, farmers may choose to remain self-sufficient in order to minimize the transaction costs (Makhura, 2002). New Institutional Economics defines transaction costs as costs relating to searching and gathering information on agents and goods or services. They involve costs of bargaining and negotiating contracts while including costs of monitoring and enforcement (Bromley, 1991). However, (Eggertsson, 1990) defines transaction costs as costs which arise when activities such as information searches, bargaining, contracting, monitoring, enforcement and protection of property rights are done. Transaction costs are mostly considered as *hidden costs* due to lack of a clear cut definition and the difficulty in measuring them. Indeed, many forms of transactions may not take place when costs of transacting are very high (Key et al., 2000). More often, transaction costs are captured as opportunity costs faced by individuals in the process of exchanging property rights (Kirsten, 2009).Transaction costs, whether observable and unobservable, are associated with the exchange of goods or services and are often the embodiment of access barriers to market participation of smallholder farmers (Makhura, 2002). Likewise, (Jagwe & Ouma, 2010) define transaction costs to include costs associated with searching for a trading partner with whom to exchange, costs of screening and bargaining with the partner and then costs of enforcing the contract made with the trading partner. This theory is applied in the current study because small holder farmers like to choose the governance structure that minimizes transaction costs.

III. METHODOLOGY

A. Research Design

The study was cross sectional survey design. It also employed multiple regression analysis to estimate transaction cost factors influencing fertilizer use intensity. Both quantitative and qualitative data was employed in the study. Econometric design was used to estimate quantitative data

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B. Study Area

The study was carried out Rutsiro districts in three sectors. The area was selected based on the fact that it is one of the districts which have been selected among others to implement fertilizer program policy in Rwanda, sectors was selected based on the fact of high degree of adoption.

C. Target Population

The target population was small scale Irish potato farmers, engaged in Irish potato production. Out of 3200 farmers organized in their cooperatives only 192 was selected.

D. Sample Size

Using this formula the sample size was determined

$$n = \frac{Z^2 \times P \times Q \times N}{D^2(N-1) + Z^2 \times P \times Q}$$

Where n= sample size, N= size of population (number of household), Z= coefficient normal distribution, Q= probability of failure, D = margin error and P= probability of success.

For Kothari, the margin error or level of significance varies between 5 % and 10 %. The researcher used a margin error of 5 % (0.5), confidence level (confidence Interval) of 95 %. The probability of success is p=0.5, failure probability of q=0.5, and Z^2is1.65 according to probability tables. The total population under study is 3200 people.

$n = \frac{1.65^2 \times 0.5 \times 0.5 \times 3200}{0.1^2(3200-1)+1.65^2 \times 0.5 \times 0.5} = 192$

E. Sampling Techniques

Multistage sampling technique was employed. The steps involved purposive selection of the sectors in this district which are known for the high use of fertilizers and potato production, finally simple random selection of the respondents was employed. The list of total household heads in the selected sectors was obtained from sector and cooperative agronomists.

F. Research Instruments

Survey questionnaire was used to collect data from respondents. The questionnaire was composed of three sections that is transactional cost factors and level of input use as an indicator for the intensity of fertilizer use. Primary data on household, socioeconomic, characteristics, use of fertilizers, and other variables was collected using structured questionnaire during 2017 production year. Both quantitative and qualitative data was collected. Additional information on recommended fertilizer rates was collected from secondary sources such as reports and journals.

G. Operationalisation of Variables

The dependent variable was continuous variable indicating quantity of fertilizer used by a farmer in kgs divided by area cultivated in ha.

The independent variables included household, transactional and Insistutional characteristics.

Depending on the nature of variables their measurement was continuous, binary and categorical with the expectation to affect the fertilizer use intensity either positively or negatively.

Quantity of fertilizer applied (X1): Fertilizer was expected to have a positive relationship with fertilizer use and it is measured in kilogram per hectare (Blanc, Lepine, & Strobl, 2016).

Access to market to market information (X2): When there is access to market, smallholders are motivated to produce more and market price could affect the production of smallholder Irish potato growers. Access to market information was considered as a dummy variable estimated to affect positively fertilizer use (Begum, Alam, Rahman, & Van Huylenbroeck, 2013).

Cost of transport and negotiation cost (X3): Cost of transport and negotiation are the amount paid for purchasing fertilizer. The price would affect production as farmers produce more and more if market prices are increasing (Blanc, Lepine, & Strobl, 2016).

Distance (X4): Distance to the market and financial Institution in walking minutes. It was continuous variable hypothesized to negatively affect fertilizer use intensity (Blanc et al., 2016).

Total asset ownership (X5): This refers to the total number of assets possessed by the household measured in numbers (TAO).As the total number of asset holding of households increase, the household will less likely to use fertilizer (Cahyadi & Waibel, 2016).Asset ownership, therefore, has been hypothesized to influence fertilizer use positively.

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H. Analytical Model

Multiple linear regression models was used to estimate the effect of explanatory variables on the intensity of fertilizer use. The choice of the model as against the probit or logit models will be based on the fact that there are differentials in the level of use. The data was entered in SPSS version 16 and exported in STATA version 13, for analysis. The level of significance was based on the variables that have p -values of less than 0.05 in their relationship with the dependent variable in bivariate analysis.

This study adopted Fertilizer use intensity (FUI), defined by (Akpan, Udoh, & Nkanta, 2012).

$$FUI = \frac{\text{Quantinty of fertilizer applied in kgs}}{\text{Area cultivated in ha}} \text{ ---------- (1)}$$

A multivariate linear regression model based on the ordinary least squares estimation was specify and used to determine factors influencing fertilizer use intensity among food crop farmers in the study area. This was described as follows:

$FUI = \beta 0 +_{\beta 1} X_1 +_{\beta 2} X_{2+u}$ ---------- (2)

With the above equation, the model to be estimated in this study is in the following linear equation

Where:

$\beta_{0 =}$ Constant

β_1-β_3=Parameters to be estimated

FUI= fertilizer use intensity

U= error term

I. Application of Multiple linear function

The following multiple linear regressions were used to analyze how transactional cost factors affect fertilizer use intensity.

$Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_1 X_3 + \beta_2 X_4 \beta_1 X_{5+} u$

Where;

Y= Fertilizer use

Bo=Constant

B1=Coefficients to be estimated

II. RESULTS AND DISCUSSION

A. Transaction Cost Characteristics Influencing Fertilizer Use Intensity

Table 1, below shows the results from multiple linear regression models related to the sampled potato farmers. Expectedly, there is positive relationship between asset ownership and fertilizer use intensity and results showed that assets specifity like motorcycle, bicycle ownership and radio ownership statistically influenced fertilizer use in the study area. This is an implication that asset ownership reduce the transaction costs related to transport to purchase inputs from traders and they can act as financial capital of the farmer and can be used as collateral when the farmer access the bank credits and these findings are coherent to the results of (Aron, Duca, Muellbauer, Murata, & Murphy, 2012).Agricultural households that owned a radio were more likely to use fertilizers through useful information from radio programs, which motivates them to alter farming methods and apply new technologies than those who did not and our results are consistent with the findings of (Khanal, 2013).However, the results of the regression show a negative relationship between explanatory variable and expected outcome variable implying that those who did not own radios were not able to access information which consequently affected adoption (Sulumbe, Iheanacho, & Mohammed, 2010).

Access to information media increased likelihood of use of fertilizer. Farmers who have had access to information through television, radio or any other social media were considered to have access to information media. Better access to information could likely empower farmers to seek for agricultural technologies which may improve their farm productivity. This is mainly because access to information could enable one to have more knowledge and awareness about different technologies (Berhe, 2014; Terefe *et al.*, 2013).

The results from the study also found that cost information and communication affected the fertilizer use. This is an implication that availability of mobile phones, the cost of obtaining information and negotiation was so high that agents were not able to engage in optimal arbitrage. This means that access to a mobile phone is useful when accessing market information and in facilitating transactions in cases where there is no viable market information service available, which is the case within the study area.

Distance to input market is one of the major limiting factors for inputs purchase as it imposes a high transaction cost to producers. The adoption and fertilizer use intensity decreases with an increase in the distance to the nearest input market (Amanze & Eze, 2010). Long distance, road inaccessibility to smallholder farmer can could reduce the probability access the market of inputs like fertilizer either by selling their to a buyer at the farm gate or physically transporting the produce to the market place using available

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means because of transportation cost; when there an increase in operational cost, the farmer is expecting to gain small gross profit margin. A number of scholars have researched about what drives farmers' market access and much has been revealed, for example, Jari and Fraser (2009); (Sebatta, Mugisha, Katungi, Kashaaru, & Kyomugisha, 2014) found that good road condition and access to information positively influenced farmer participation and access to markets due to their effect on reduction in transaction costs. As expected, distance to the nearest markets had a positive and significant influence on inorganic fertilizer use intensity for Irish potato production, given that proximity to good roads can reduce the cost and difficulty of transporting produce to market their produce. These results are in line with the authors' expectations and theory, as long distances act as a disincentive to farming households who cannot easily travel to buy farm inputs and these results are in line with the findings of (Tunde & Adeniyi, 2012).

Table 1: Transaction cost characteristics influencing fertilizer use intensity

Total Quantity of fertilizer used	Coef.	Std. Err.	t	P>|t|
Car ownership	-0.006	0.006	-0.96	0.336
Bicycle ownership	-1198.694	263.102	-4.560	0.000***
Radio ownership	-28.243	8.231	-3.430	0.001***
Distance to nearest road	0.007	0.006	1.12	0.264
Distance to nearest market	0.037	0.007	5.53	0.000***
Distance to financial institutions	0.002	0.002	1.32	0.190
Cost of communication	-0.037	0.011	3.34	0.001***
Cost of negotiation	-0.040	0.012	3.3	0.001****
Motorcycle ownership	-0.165	0.299	0.55	0.582
Cost of transport	0.019	0.009	6.60	0.000***
Quantity sold	0.002	0.001	1.38	0.171
Access to markets information	-12.331	72.781	-0.17	0.866
_cons	-177.914	44.054	-4.04	0.000

Number of Obs=168; F(45,122) = 1423.36; Prob>F= 0.0000; R-squared= 0.9981; Adj R-squared = 0.9974; Root MSE = 16.868

B. Fertilizer use intensity

Tables 2.The results revealed that on average area of 0.889ha, the average NPK applied in 2017 was 178.5±15.5Kg per ha, in this case the fertilizer use intensity was 399.4±115.1kg/ha. There is a fertilizer gap in the study area which should be redressed with the time. These findings contradicts with the results of (Cai, Xia, Chen, Wang, and Zhang (2018).The fertilizer use intensity in Rutsiro Irish potato producers is significantly lesser than the international upper limit of safe fertilization (225 kg/ha) which should be redressed as far as farmers adopt the culture to use recommended quantity.

Table 2: Inorganic fertilizer use intensity

Estimates	NPK 2017A	NPK 2017B	Total NPK 2017	Avg NPK2017	Area 2017A	Area 2017B	Total Area 2017	Avg Area2017	FUI
Mean	182.9	174.1	357.01	178.5	0.890	0.889	1.778	0.889	399.4
Std Error	16.1	15.2	31.07	15.5	0.063	0.063	0.125	0.063	115.1
SD	222.6	210.41	430.4	215.2	0.867	0.868	1.734	0.867	1595.3
Variance	49553.8	44273.1	185283.9	46320.9	0.751	0.753	3.007	0.752	2544935.7
Count	192	192	192	192	192	192	192	192	192

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IV. CONCLUSION

The results of the study concluded that transaction costs characteristics influence fertilizer use intensity in Rutsiro District, Rwanda. The results of the study confirmed that the fertilizer use intensity in Rwanda is low. The results revealed that on average area of 0.889ha, the average NPK applied in 2017 was 178.5±15.5Kg per ha, in this case the fertilizer use intensity was 399.4±115.1kg/ha. Therefore the study concludes that there is a low level of NPK fertilizer rate application for small holder Irish potato producers in Rwanda compared to predicted quantity to be applied.

A. Recommendation

Based on the findings of the study the following policy recommendations are made.

Policies that reduce transaction costs through improved transportation and the promotion of marketing organizations would increase output; by both increasing market participation and production levels among market participants. Further study should be conducted economics of fertilizers in the study area.

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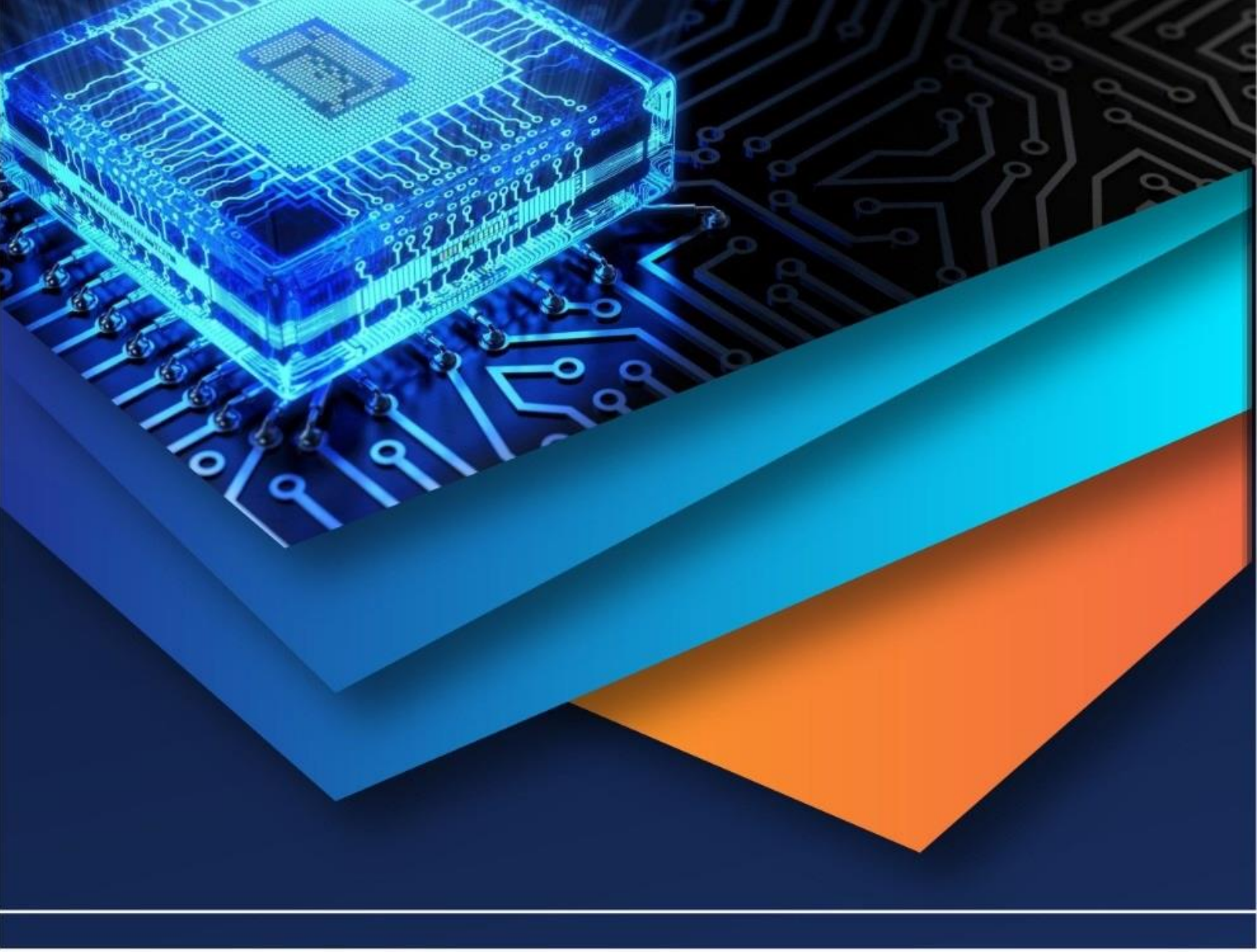

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