

DOI: <https://doi.org/10.53116/pgafmr.8795>

The Dark Side of Digital Finance?

Cryptocurrency Adoption and Money Laundering under Weak Institutional Enforcement in Colombia

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Submitted: 29 January 2026 | Accepted: 21 September 2026 | Published online: 6 October 2026

Abstract: Cryptocurrency adoption in Latin America has accelerated in recent years. Given that Colombia ranks second in the region in terms of transaction value received between 2023 and 2025, this study explores the drivers of total cryptocurrency transaction volume and how effective anti-money laundering (AML) policies in Colombia are under institutional weakness conditions. Using a heteroskedasticity- and autocorrelation consistent generalised method of moments (HAC-GMM) framework on quarterly time series data (2019–2024), the study models the short- and long-run elasticities of cryptocurrency transaction volume (*VTCT*). Instead of measuring isolated illicit flows, *VTCT* serves as a proxy for total market exposure, which reflects the financial institutions' capacity to absorb and obfuscate illicit capital. The empirical results show that institutional quality, measured by control of corruption (*CC*) and the rule of law (*ROL*), is the main deterrent for the use of digital assets for capital diversion. Nevertheless, while state enforcement (*lnAML*) exerts a significant deterrent effect, its capacity is partially limited by macroeconomic growth (*GDPG*) and global cryptocurrency adoption (*CADOP*). Hansen's J-test ($p = 0.5018$) and relevant diagnostics confirm the validity of the instruments. Considering the Colombian sociopolitical and economic conditions marked by a long history of civil war and drug trafficking, we conclude that Colombia requires structural institutional reinforcement for effective AML governance rather than reactive judicial tracking.

Keywords: anti-money laundering, digital assets, econometrics, institutional quality

1. Introduction

It is not a coincidence that in 2008, the evolution of FinTech into its third era started, shifting from *what* products and services were delivered to *who* was delivering them at retail and wholesale levels (Arner et al., 2015), and Satoshi Nakamoto's white paper was first published, presenting a peer-to-peer solution to allow online payments *without* intermediaries. Despite Bitcoin, as a digital currency, having evolved into a financial solution different from its origins, the argument about who is providing financial innovation tools versus what is provided has become a cat-and-mouse game for regulators. Besides, the 2008 global financial crisis played a major role in creating the social, political and economic conditions that created market factors such as public perception and regulatory scrutiny (Arner et al., 2015) that welcomed the evolution of disruptive financial technology such as cryptofinance. In this regard, Harvey (2016) states that the exchange and verification of ownership with minimal trust in centralised institutions is a gateway to what is coming with digital currencies in terms of the evolution of financial technology and its implications, including money laundering and regulatory risk. According to Arner et al. (2017), the challenge for policymakers and regulators to fight the criminal use of digitised financial services lies in the inadequate application of RegTech, or the use of information technology for monitoring, controlling and compliance. To expand this claim, the lack of understanding of the mechanics behind digital currencies, in particular, cryptocurrencies (Harvey, 2016), is part of the issue regulators face in enacting anti-money laundering (AML) policies.

In developing countries, the emergence of digital financial services arises in response to an infrastructure gap where mobile penetration is higher than the physical banking infrastructure and, in consequence, benefits financial inclusion (Arner et al., 2017). In Colombia, the need for cooperation between the banking system and the FinTech industry has sped up the acceptance of digital financial services, coupled with socioeconomic factors such as the aftermath of Covid-19 (Pertuz Yustes, 2021). More recent sociopolitical reasons, such as the transition from a right-wing to a left-wing government in 2022, have brought socioeconomic consequences that have pressured the local market to find solutions to inequality, high inflation, slow growth, and unprecedented depreciation of the Colombian peso (Freeman, 2023). Some of these solutions comprise the use of cryptocurrencies. Olugbenga (2025) exposes in his recent study that cryptocurrencies are used as a complementary as well as context-dependent hedge tool for storing value in economies where macroeconomic conditions are unstable, especially in countries with currency devaluation, limited access to the traditional financial system, and weak institutional capacity.

De la Puente Pacheco et al. (2024) argue that in 2014, the Colombian central bank (Banco de la República) recognised cryptocurrencies as a legal form of payment, but cautioned about the possibility of their use for money laundering and financing illicit activities. Factors such as the limitations in the traditional banking systems and an increase in the inflation rate exacerbate the potential use of cryptocurrencies for criminal activities due to their anonymity and the elimination of trusted intermediaries. Moreover, the number of cryptocurrency transactions in 2020 hit 1.5 trillion Colombian pesos, approximately 446 million USD, corresponding to a 16% rise since 2017. According to the 2025 Geography of Crypto report released by Chainalysis, Latin America (LATAM) recorded close to

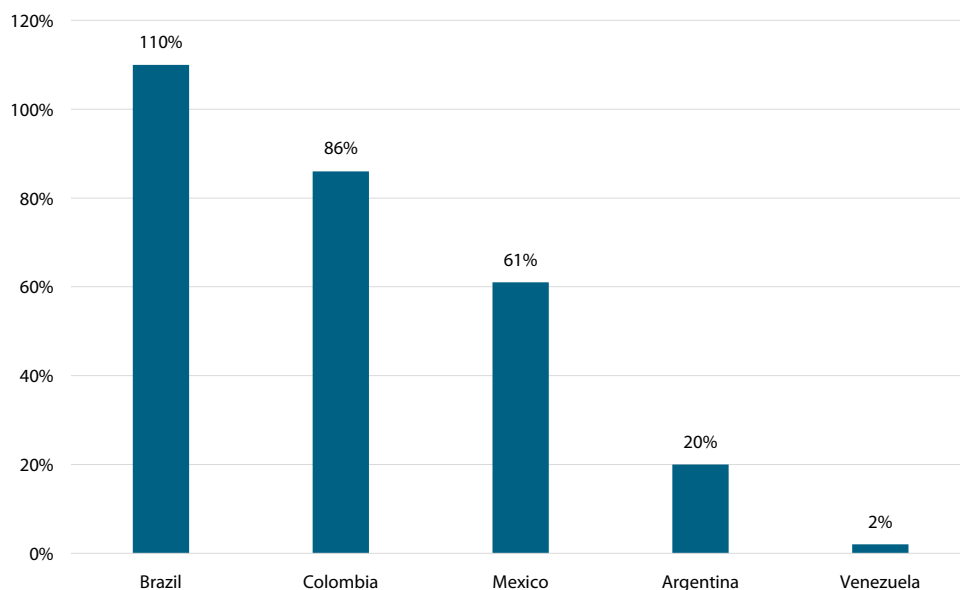


Figure 1

Period-over-period growth rates in cryptocurrency value received in LATAM (July 2023 – June 2025)

Source: Chainalysis, 2025a

1.5 trillion USD in cryptocurrency transaction volume between July 2022 and June 2025, earning it the name of one of the most crypto-dynamic regions globally. Colombia, for its part, ranked second after Brazil in the period-over-period growth rate for total transaction volume from July 2023 to June 2025 (Figure 1), with stablecoins being the primary purchase. Reasons such as persistent inflation, currency volatility, and capital controls encourage households and businesses in Latin American countries to use USD-pegged cryptocurrencies for savings, payments and trade (Chainalysis, 2025a).

With crypto regulation and policies falling behind adoption in LATAM countries (Chainalysis, 2025a), Colombia's regulators have strived to contain the risks associated with the use of cryptocurrencies. According to De la Puente Pacheco et al. (2024), since 2018, the financial superintendency (Superintendencia Financiera de Colombia) and the tax authority DIAN (Dirección de Impuestos y Aduanas Nacionales) have implemented strict know-your-customer (KYC) rules and taxation concerning the investment and trading of cryptocurrencies in Colombia. Colombian commercial banks have been restricted in the processing of cryptocurrency transactions, as dictated by the central bank, where only regulated fintech companies are allowed to trade fiat currencies for crypto under precise reporting rules. Regarding consumer protection, only warning advertising about the volatility of the crypto market has been officially established, but there are no compensation mechanisms for fraud and scams. Nevertheless, the lack of clear regulation for peer-to-peer crypto transactions using decentralised protocols has proven to be a struggle without technical reform. Therefore, the oversight is mainly focused on centralised crypto exchanges (De la Puente Pacheco et al., 2024).

Having said that, García Otero and Méndez Diaz (2025) assert that the inherent attributes of cryptocurrencies facilitate a system for money laundering and illicit activities. For instance, the “tulipán blanco” operation dismantled a crime ring based in Spain, from where Colombian drug dealers laundered their money coming from illicit activities through a well-known criminal method called *smurfing*, using a Bitcoin exchange based in Finland. This demonstrates not only that criminal actors are strengthening their links outside their local markets but also shifting from traditional criminal methods to more sophisticated ones through the use of cryptocurrencies. As a consequence, the need for a global, comprehensive cryptocurrency regulatory framework is imperative, yet still absent. This is the case since different jurisdictions are working towards combating the use of cryptocurrencies for money laundering and illicit financial activities based on their particular socioeconomic needs and characteristics (De la Puente Pacheco et al. 2024).

The aims of the study are to empirically measure the relationship between money laundering, illicit cryptocurrency transactions and regulatory measures in Colombia by employing a quarter-by-quarter econometric analysis between 2019 and 2024. The methodology used is the Generalised Method of Moments (GMM) framework (Arellano & Bond, 1991; Roodman, 2009) with a heteroskedasticity- and autocorrelation consistent (HAC) covariance matrix (Newey & West, 1987) to offer a quantitative analysis. To achieve these aims, the study is guided by the following research questions:

RQ1: What is the long-run and short-run elasticity of institutional quality indicators concerning the overall volume of cryptocurrency-related illicit activities in Colombia?

RQ2: Does the increase in the illicit cryptocurrency volume in Colombia indicate a shift from traditional money laundering methods to digital illicit channels?

RQ3: To what extent does AML enforcement decrease the illicit cryptocurrency volume in Colombia?

The novelty of the study resides in providing evidence of the effectiveness of Colombian AML enforcement, contributing to the literature by quantifying the relation between institutional quality and the use of cryptocurrencies for money laundering and illicit financial activities, testing the substitution effect from traditional money laundering methods to digital illicit channels, and measuring whether the deterrence effect is partial or complete.

2. Theoretical background

The literature is grouped into three distinct themes that provide the theoretical foundation to answer the proposed research questions. This theoretical framework is based on three pillars that comprise the following theoretical economic concepts: institutional quality, the substitution effect and the deterrence effect. The pillars include the possible drivers that motivate, enhance, or discourage the use of cryptocurrencies for money laundering and illicit financial activities in Colombia from 2019 to 2024, which correspond to the variables examined in our econometric model. To illustrate the interconnection of these drivers, a conceptual framework is presented in Figure 2.

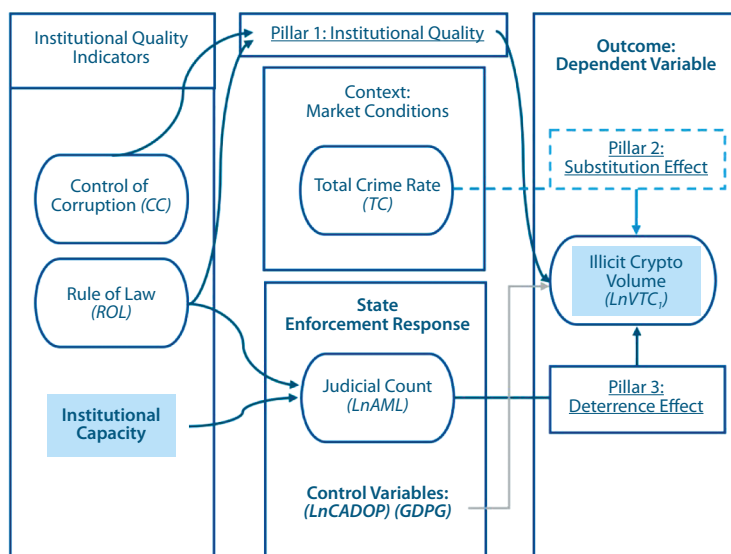


Figure 2

Conceptual framework: Drivers of illicit cryptocurrency volume in Colombia (2019–2024)

Source: Compiled by the authors.

2.1. Cryptocurrencies, corruption and institutional quality

Cryptocurrencies are a type of digital asset built on a distributed ledger, or blockchain, to secure transactions (Härdle et al., 2019). They are a digital representation of value, accepted as a means of currency, not issued by a central bank, and have payment, investment and utility functions (Wawrosz & Lánský, 2021). According to Alnasaa et al. (2022), the use of cryptocurrencies is empirically associated with countries with higher corruption perception and capital control. These findings are supported by Wawrosz & Lánský (2021), who state that cryptocurrency users are more prominent in countries with a high prevalence of abuse of power.

Considering the Institutional Theory (North, 1990), Boateng et al. (2024) argue that the quality of national governance (formal institutions) and national culture (informal institutions) have an articulated effect on countries with a high incidence of corruption. Ozegbe & Kelikume (2022), on their part, assert that the relation between institutional quality and corruption has a high impact on a country's economic activity. With that said, Yanguas-Botero et al. (2025) confirm that corruption in Colombia weakens economic interactions in addition to deforming financial systems and intensifying inequality. On the other hand, Monsalvo et al. (2025) conclude in their recent study that institutional reinforcement and fiscal governance improvement through digital transformation reduce corruption levels in Colombia.

In this regard, the Colombian tax authority DIAN has published Resolution 000240 on 24 December 2025, mandating local and foreign centralised cryptocurrency exchanges (CEXs) to provide user data, with the main purpose of matching the information crypto users declared on their returns and the information provided by the exchanges (DIAN, 2025).

The attempt to strengthen transparency in the Colombian public sector through technological innovation (Monsalvo et al., 2025) demonstrates the efforts Colombian regulators are making not only to catch up with the speed of the rapid evolution of cryptocurrencies and their use but also to align with international regulatory trends (FATF, 2021).

It is important, though, to differentiate the usage of cryptocurrencies through centralised exchanges (CEXs), hybrid exchanges (HEXs) and decentralised exchanges (DEXs) (Zhou & Shen, 2022) to understand the extent of institutional quality. CEXs are regulated exchanges that mainly comply with federal and state regulations, whereas DEXs avoid KYC and AML regulations because of the inherent characteristics of a public blockchain. While the former could be perceived by users as more secure, the latter raises concerns about money laundering and illicit financial activities (Hägele, 2024). Therefore, Colombian Resolution 000240, while indicating an improvement in institutional quality, is limited to centralised exchanges, which displays a gap in institutional capacity.

Moreover, Colombian institutional capacity weakness is also noted by Sanabria-Pulido & Velasquez-Ospina (2021), though they examine the sociopolitical causes. The authors claim that a heterogeneous state facilitates the escalation of violence and illegal actors, reducing Colombian institutional capacity and public administration. On the other hand, Mpabe Bodjongo et al. (2024) assert that institutional drivers such as controlling corruption, tax burden reduction, price stability, and trade liberalisation decrease trade-related illicit financial flows significantly. We have also reached similar results in an earlier study (Durguti et al., 2025a), confirming that institutional capacity and institutional rule of law have a significant influence on decreasing informality and enhancing the formal economy.

Regarding the influence of the rule of law on illicit financial flows, Zeiler et al. (2019) establish that the rule of law is undermined by illicit financial flows, increasing corruption and violence by debilitating state institutions. Consequently, our econometric model aims to assess whether an increase in the institutional quality indicators, represented by the control of corruption (*CC*) and rule of law (*ROL*) variables, discourages cryptocurrency users from engaging in money laundering and illicit financial activities in Colombia from 2019 to 2024 by testing their short- and long-run elasticities.

2.2. Violence, socioeconomic conditions and the substitution effect

In the hope that the new government administration of the current president of Colombia, Gustavo Petro, from 2022 to 2026, will break free from the influence of the right-wing control and bring a new era of security and economic development, the results after three years of Petro's administration are less than encouraging. According to Ríos Sierra (2025), violence in Colombia remains unchanged, founded on the guerrillas and paramilitarism. This failure is due to a peace policy based on no security policy, which is exacerbated by a lack of state presence in the territory and a weak fight against drug trafficking. Thornton (1998) asserts that the resurgence of Colombian violence started in the mid-1980s, with the main cause being the link between illicit drug trade and guerrilla insurgency. It is estimated that the guerrilla's annual income of USD 570 million in the 1990s was from the cropping,

processing, and trafficking of illicit drugs (Rubio-Ramos, 2024), among other illicit activities, at the expense of violent deaths.

Due to a decrease in human capital, between the 1980s and 1990s the GDP decreased, and the defence budget increased, reducing economic growth since public spending in education and health was diverted. Díaz and Orozco (2025) also state that the prolonged history of violence in Colombia, since 1976, has negatively impacted the country's economic growth. By economic growth, we mean Vallejo Zamudio's (2025) idea, who differentiates economic development from economic growth, arguing that growth is a means to achieve economic development. He declares that growth in Colombia has decreased since Covid-19, falling in 2020 to -7.2%. While in 2021 and 2022 there was an increase of 10.7 and 7.5%, respectively, the growth was just 0.6% and 0.4% in 2023 and 2024. Since Petro's "total peace" proposal has not been successful (Ríos Sierra, 2025), the argument that violence affects Colombia's economic development negatively is valid.

On the other hand, it has been argued by Durguti et al. (2025a) that the shadow economy or informality in emerging markets is a phenomenon that has developed in parallel to an economic system in countries where unequal economic transitions and poor institutional quality coexist, playing a significant role in shaping individuals' subsistence and state capacity. There is a misconception or belief that the use of cryptocurrencies generates fast or casual income for households and firms in emerging markets. This is criticised by Dunn (2026), who asserts that the crypto supporters' idea of using cryptocurrencies to improve socioeconomic conditions and empower individuals in developing countries is just a dangerous illusion.

In contrast, Kyriazis (2019) states that despite the efforts towards efficiency in cryptocurrencies in regard to volatility, the trading strategies for speculators have been less profitable in recent years. Since trading with cryptocurrencies has provided speculative trading opportunities due to a fragile legal framework and low transaction costs (Manahov, 2024), the possibility of using cryptocurrencies for criminal purposes has captured the attention of regulators and scholars. According to Europol (2021), the main criminal activities associated with the use of cryptocurrencies are fraud, trade of illicit goods and services, and money laundering. However, estimating the exact scale and share of the criminal use of cryptocurrencies, as criminal networks involved in organised crime still rely on traditional fiat money, is complex.

Conversely, Arnone et al. (2025) argue that the combination of the very nature of decentralisation and anonymity of cryptocurrencies is the appeal for criminals to circumvent tracking and oversight. In this regard, the substitution effect has its place as an option to replace traditional criminal methods with digital means. With the total crime (*TC*) variable, this study attempts to confirm if there is a shift from traditional money laundering methods in Colombia to digital illicit channels using cryptocurrencies, as a substitution effect.

2.3. Drug trade, money laundering and the deterrence effect

Drug trafficking has been the funding method for the illegal activities of the guerrillas' leftist groups, FARC and ELN, and the right-wing paramilitary groups in Colombia (Sturzaker, 2021).

These groups have been identified by the USA as terrorist organisations and have constituted the longest civil war, which started in 1946 (Shiraz, 2014). This political violence has left the country with deep socioeconomic constraints. Sturzaker (2021) claims that the failure of Colombia to provide a trustworthy and honest government is due to the involvement of political and military figures in the drug trade for personal benefits. This creates dissatisfaction and polarisation among the population, worsening Colombia's capacity to control corruption and provide economic opportunities for its development. This is a popular debate in the analysis of Colombia's case and corresponds to whether the civil conflict is the reason for the drug trafficking or if the lack of economic opportunities resulted in the drug trade (Sturzaker, 2021).

On the other hand, money laundering and drug trafficking are inherently related. Reuter and Riccardi (2024) affirm that drug trafficking is the most popular type of money laundering, among others, such as cyber fraud and high-level politicians' corruption flows. Since the income from illicit activities needs to be cleaned to be used in a licit economy, Loayza et al. (2019) argue that there is no consensus on whether money laundering has a negative or positive impact on countries' economic growth. Some authors (e.g. Ofoeda et al., 2024; Ajide & Ojeyinka, 2024) say that due to the resources injected into the financial system by dirty money, the economy, especially in emerging markets, has a positive impact. On the contrary, other authors (e.g. Ajide et al., 2025; Khelil et al., 2024) suggest that the resources coming from illicit activities and money laundering affect the economy negatively, because the licit factors within the financial system are eroded, undermining the state's capacity.

Masciandaro (2007) asserts that there are two perspectives to analyse the economics of money laundering. From a microeconomic perspective, criminal actors only engage in the risk of laundering money if the probability of detection and receiving severe sanctions decreases, while the expected average return of the laundered money increases. Moreover, for criminal actors, the value of laundered money is higher than the value of dirty money, since the former represents actual purchasing power ready to be used within the licit financial system and an investment with a lower risk of incrimination. From a macroeconomic perspective, criminal actors increase their economic power by funnelling laundered money not only into the licit financial system but also into the illegal sector, propagating their money laundering empire. Masciandaro (2007) refers to this cycle as the multiplying effect of money laundering.

Colombia remains a major actor in the global cocaine trade, with estimates suggesting that the country accounts for approximately 70% of global cocaine production (Sturzaker, 2021). The substantial profitability of the illicit cocaine market is reflected in reported wholesale values of approximately USD 60,000 per kilogram, while prices may reach as high as USD 235,000 per kilogram in Australia, according to Colombia Reports (2025). In 2023, 1,917.7 tons of cocaine were exported, representing a total revenue of approximately USD 115 million. To launder this dirty money, the most popular traditional methods have been trade-based money laundering, using transactions to move money to legitimise illicit funds; misinvoicing, or manipulating the value or contents of a shipment to avoid scrutiny; and environmental crime such as natural resource corruption (Saderup, 2024).

However, recent articles and studies have reported on the sophistication of more up-to-date money laundering methods.

García Otero and Méndez Díaz (2025), for example, state that criminal networks in Colombia are restructuring their modus operandi to facilitate money laundering through a scheme named “cyber burreros”, the refurbished version of the “mules” in drug trafficking. It involves recruiting people to buy large volumes of crypto through several wallets. And according to Mendoza (2026), more than USD 40 billion in crypto transactions were moved in Colombia between 2023 and 2024, though it is unclear whether it is solely from money laundering.

AML enforcement in Colombia, on the other hand, has played an insufficient role against money laundering, due to the country’s particular socioeconomic context. Zips (2024) argues that, despite Colombia having comprehensive AML policies and a robust financial intelligence unit listed by Arctic Intelligence, the laws are ineffective due to a lack of adaptability to the local realities. Slutzky et al. (2020) claim that Colombia’s AML policies have negative unintended consequences in the financial system and, thus, the economy. Hence, they demonstrate that AML enforcement undermines the ability of financial institutions to lend money in cities with high drug trafficking. The situation also affects the liquidity for credit in other cities, primarily for small firms with credit demand, decreasing sales, investment and profitability. Consequently, the deterrence effect within the Colombian context is moderately fruitless.

Concerning crypto AML measures, Leuprecht et al. (2023) assert that the main difficulty in establishing adequate AML enforcement when cryptocurrencies are used in money laundering and illicit financial activities is the absence of well-equipped regulators to handle the challenges posed by cryptocurrencies. In Colombia, with Resolution 314, the Unidad de Información y Análisis Financiero (UIAF) (2021) requires centralised cryptocurrency exchanges (CEXs) to report on suspicious activities, on the absence of suspicious activities, on transactions with cryptocurrencies, on the absence of transactions with cryptocurrencies, and on clients of the CEXs in an attempt to enhance crypto AML enforcement. Through the log of anti-money laundering judicial count ($\ln AML$) variable, this study wants to measure the effectiveness of the AML enforcement in Colombia in regard to the sensitivity of the log of the illicit crypto transaction volume index ($\ln VTC_i$) and whether the results are partial or complete.

3. Research methodology

3.1. Data and sample

To discover the above research objectives, the proposed research will use quarterly data of Colombia between 2019 and 2024 to explore the dynamics of cryptocurrency transactions in an institutional and macroeconomic background that has significantly transformed. The frequency will be applied quarterly, allowing the separation of short-run cycles and rapid responses of the market to economic, regulatory and criminal developments, which are particularly sharp in digital financial markets. The selected time frame not only coincides

with the dramatic rise in the number of individuals who have been using cryptocurrency in Colombia, but also with the mechanism of narrowing the regulatory description and the ongoing improvement of the money laundering and financial crime rules, which makes this time particularly appropriate to be empirically considered. The data used are based on five self-determining official and international sources, such as national and statistical institutions, as well as monetary authorities, specialised databases of digital markets, institutional variables and macroeconomic variables.

The usage of several data sources is aimed at increasing the accuracy and reliability of the empirical evidence, as it will limit the dependence on a single data source and minimise the possibility of systematic bias. According to the principles of transparency and the simplicity of methods, the origin of each variable is well documented (see Table 1) in the section on the variables, as the origin of the data and the formulation of the corresponding indicators are clearly identified. Following the collection of data, time series were processed, cleaned, and harmonised in such a way that it has frequency consistency and alignment across the sources. This process included the structure of units of measurement, filling gaps, and normalisation of series to create a sound and comparable empirical base on which econometric analysis can be conducted. This methodological approach enhances the empirical validity of the results and helps minimise unintended biases due to methodological or institutional differences within data sources.

As Table 1 indicates, the research uses a curated set of macro-institutional and digital market variables to econometrically investigate the factors affecting the activity of cryptocurrency transactions. The primary dependent variable is the total cryptocurrency transaction volume index (*VTCTI*), constructed using Chainalysis LATAM datasets (normalised to base 100). Methodologically, on-chain public ledger data cannot completely isolate illicit transactions from legitimate flows without extensive entity extraction throughout unhosted wallets (Lee et al., 2025). Therefore, *VTCTI* is not defined as pure illicit volume, but as an integrated proxy for market transaction capacity and obfuscation potential. According to Masciandaro (2007), Reuter and Riccardi (2024) and Zeiler et al. (2019), institutional environments that have gaps in enforcement tend to expand the operational space for illicit capital within the overall market volume to blend unnoticed alongside legitimate commercial transactions in order to lower the detection probability.

Another reason why this indicator was chosen is that it is widely employed in empirical works as an indicator of the level of cryptocurrency use in an economy (Magazzino et al., 2025; Nguyen & Nguyen, 2024). To measure governance quality, control of corruption (*CC*) and rule of law (*ROL*) data were integrated from the World Bank's Worldwide Governance Indicators (*WGI*). These statistics, used in econometric models, are considered to be respectable pointers of the quality of governance (Durguti et al., 2025b). They also quantify essential elements of the credibility of institutions, effectiveness of regulations and enforcement of laws, which are found to be critical in economic and financial behaviour such as the acceptance of alternative financial technologies, through empirical evidence. State enforcement capacity is captured through the anti-money laundering judicial proceedings (*lnAML*), sourced from official accountability reports of the Fiscalía General de la Nación and converted into natural logarithms to reduce distributional skew and make interpretation of estimated coefficients easier (Chellai, 2025). Likewise, cryptocurrency

Table 1
Variables description

Description	Acronyms	Role in econometric model	Measurement / unit	Sources
Total Cryptocurrency Transaction Volume Index (Colombia)	VTCTI	Primary Dependent Variable (Raw Data)	Index (Normalised, Base 100)	Chainalysis LATAM Crypto Reports (2020–2025c)
Log of Total Cryptocurrency Transaction Volume Index	lnVTCTI	Estimated Dependent Variable (Y)	Log (Index)	Chainalysis LATAM Crypto Reports (2020–2025c)
Corruption Control (WGI Score)	CC	Core Independent Variable (RQ1)	Estimated Value (WGI Index Score)	World Bank Worldwide Governance Indicators (WGI)
Rule of Law (WGI Score)	ROL	Core Independent Variable (RQ1)	Estimated Value (WGI Index Score)	World Bank Worldwide Governance Indicators (WGI)
Judicial AML Prosecution Count	AML_JC	Enforcement Variable (Raw Data)	Count (Time Series Value)	Fiscalía General de la Nación (2019–2025)
Log of Judicial AML Prosecution Count	lnAML	Core Independent Variable (RQ3)	Log (Count)	Fiscalía General de la Nación (2019–2025)
Quarterly Total Crime Rate	TC	Core Independent Variable / Control (RQ2)	Rate (per 100,000 inhabitants)	Policía Nacional de Colombia – Departamento Administrativo Nacional de Estadística (DANE)
Global Cryptocurrency Adoption	CADOP	Control Variable (Raw Data)	USD (Time Series Value, Billions)	Chainalysis Global Adoption Index Reports (2021–2025b)
Log of Global Cryptocurrency Adoption	lnCADOP	Control Variable (RQ1, RQ2, RQ3)	Log (USD)	Chainalysis Global Adoption Index Reports (2021–2025b)
Real GDP Growth Rate	GDPG	Control Variable (RQ1, RQ2, RQ3)	Quarterly % Change	Banco de la República – Departamento Nacional de Estadística (DANE)

Source: Compiled by the authors.

adoption, as reported by Chainalysis, is expressed in natural logarithms to reflect nonlinear associations and to reduce the influence of extreme values, as is customary in standard econometric practice. The total crime rate (*TC*), as a percentage of 100,000 inhabitants, is added to show the level of security of the population and the social risk, documented from Policía Nacional and DANE. Similarly, global cryptocurrency adoption (*lnCADOP*), as measured by Chainalysis, is transformed into natural logarithms to control for broader market expansion.

Additionally, with GDPD being a macroeconomic control variable, its use will be tracked with Guo et al. (2025) to enlighten the local business cycles and the degree of economic development. As a rule, the logarithmic transformation of the selected variables

increases the stability of statistics, model characteristics and the economic ability of the empirical data, which is in line with modern econometric evidence. As a result, the variables outlined, according to the arguments of this section, serve as the methodological context of the econometric analysis and make the further development of the selected econometric approach grounded.

3.2. Empirical models

Classical time series specifications, such as autoregressive distributed lag (ARDL) and vector error correction models (VECM), were initially evaluated for this dataset. However, diagnostic pretesting revealed bidirectional endogeneity between real economic growth ($GDPG_t$), global cryptocurrency adoption ($lnCADOP_t$) and local transaction volume ($lnVTCTI_t$), alongside cointegration breakdown under structural policy shifts. Estimating these relationships via Ordinary Least Squares (OLS), ARDL, or VECM yields biased and inconsistent parameter estimates due to simultaneous equation feedback and unobserved temporal shocks.

When lagged dependent variables ($lnVTCTI_{t-1}$) are included in the specification to capture chronological market dynamics, classical OLS assumptions are violated, generating dynamic persistence where $lnVTCTI_{t-1}$ is correlated with the error term. In this context, the model takes the form of a dynamic panel:

$$y_{it} = \alpha + \rho\gamma_{i,t-1} + \beta X_{it} + \varepsilon_{it}$$

Where $\gamma_{i,t-1}$ is the lagged value of the $lnVTCTI$, and ρ measures the degree of dynamic persistence of the process. The inclusion of the lagged variable generates a correlation between $\gamma_{i,t-1}$ and the error term, since unobserved individual components simultaneously affect both past and current values of the $lnVTCTI$. This produces endogeneity and intertemporal autocorrelation, rendering standard estimators biased, inconsistent and therefore unreliable. To resolve endogeneity while preserving dynamic time series properties, we employ the generalised method of moments (GMM) framework, specifically the system GMM estimator (Arellano & Bond, 1991; Blundell & Bond, 1998) equipped with a heteroskedasticity- and autocorrelation consistent (HAC) covariance matrix (Arellano & Bover, 1995; Newey & West, 1987). The dynamic panel specification takes the following form:

$$y_{it} = \alpha\gamma_{it-1} + \beta X_{it} + \eta_i + \varepsilon_{it}$$

In this context, η_i denotes the unobserved effects corresponding to individual effects, and α being different from zero ($\alpha \neq 0$) indicates that there is dynamic dependence. The system GMM application addresses three fundamental econometric challenges, characteristic of our data, as used in macroeconomic and digital market data. In the first place, endogeneity

that comes from bidirectional relationships between variables, such as simultaneous interaction between economic growth and market adoption (Barros et al., 2020); second, the arrival of autocorrelation when error terms are correlated across time periods; and third, unobserved temporal heterogeneity. While system GMM is conventionally applied to micro-panels with large cross-sectional dimensions (N), its application to dynamic time series with endogenous regressors is methodologically robust when instrument matrices are strictly controlled (Roodman, 2009). To address potential overfitting concerns associated with small sample horizons ($T = 24$) and prevent the weakening of the instruments, the instrument matrix was strictly restricted using the *collapse* option in Stata. This restriction limits instrument proliferation, keeping the total instrument count ($j \leq 12$) well below the sample size T and preserving the statistical power and the asymptotic consistency of the estimator. The system GMM estimator utilises lagged differences and variable levels as instruments and formulates moment conditions that guarantee the instruments are uncorrelated with the error term (Hauk & Wacziarg, 2009). Furthermore, HAC corrections applied to the covariance matrix yield robust standard errors that remain valid under non-homoscedastic error distributions and serial dependence (Arellano, 2003). As a result, the final empirical model that incorporates the dynamic properties of our specific variables is specified as follows:

$$\Delta \ln VTCI_t = \alpha + \rho \ln VTCI_{t-1} + \beta_1 \ln AML_t + \beta_2 CC_t + \beta_3 ROL_t + \beta_4 TC_t + \beta_5 \ln CADOP_t + \beta_6 GDPG_t + \epsilon_t$$

Where $VTCI_t$ represents the total cryptocurrency transaction volume index at time t , $VTCI_{t-1}$ is the lagged transaction volume index that captures dynamic market persistence as our dependent variable, AML_t is the log of judicial anti-money laundering prosecution counts as state enforcement, CC_t and ROL_t represent world governance indicators for control of corruption and rule of law as institutional quality, TC_t is the quarterly total crime rate per 100,000 inhabitants, which controls for conventional crime levels, $CADOP_t$ measures global cryptocurrency adoption, $GDPG_t$ exemplifies quarterly real GDP growth, and ϵ_t is the random error term. The validity of the model and reliability of the instruments are evaluated via standard specification diagnostics and confirmed with the Hansen's J-test statistic ($p = 0.5018$). The Hansen test of overidentifying restrictions indicates that instruments are strictly exogenous and uncorrelated with the error term ϵ_t by testing the null hypothesis (Hansen, 1982), which ensures consistent and efficient parameter estimates.

4. Results and discussion

The next section contains the preliminary information on the data analysis, which presents the overall features of the variables integrated in the research. It goes on to determine the level of association between the variables to evaluate the possible existence of multicollinearity. The variance inflation factor (VIF) analysis is used in this framework to evaluate potential multicollinearity among the regressors. The research then proceeds to test heteroskedasticity

and employs the Durbin–Watson test to determine whether there is a serial correlation or not. In order to ascertain the validity of the statistical analysis, the stationarity of the data is assessed with the use of the Augmented Dickey–Fuller test and the Phillips–Perron test. After estimating the diagnostic tests, the developed econometric models are estimated, and the section ends by discussing the empirical findings.

4.1. Descriptive statistics

Table 2 discloses the descriptive statistics of $\ln VTCI_t$, which shows that the mean value of the cryptocurrency transaction volume index is 5.26 with a relatively slight standard deviation (*SD*), which suggests a moderate fluctuation in the total amount of cryptocurrency transactions during the period studied. Similarly, the mean of $\ln AML_t$ is 3.21, with a higher *SD* than $\ln VTCI_t$, indicating more significant changes in the intensity of anti-money laundering judicial proceedings.

Table 2
Descriptive statistics

Var.	Obs	Mean	SD	Min	Max
$\ln VTCI_t$	24	5.2579	0.4680	4.3800	6.0200
$\ln AML_t$	24	3.2066	0.6579	2.200	4.0700
CC_t	24	-0.3133	0.0428	-0.3700	-0.2500
ROL_t	24	-0.4500	0.0328	-0.4900	-0.3900
TC_t	24	245.4792	35.1747	138.8700	294.6900
$\ln CADOP_t$	24	1.1450	0.9755	-0.3600	2.4000
$GDPG_t$	24	2.8258	7.1097	-16.7000	18.3900

Source: Compiled by the authors.

Characteristics of the institutional variables CC_t and ROL_t have negative means and extremely low *SD*, which means that these variables have low variability during the period under observation. The TC_t in our specific instance produces a mean of 245.48 with a pronounced *SD* compared to other indicators, which screens for fluctuations in crime rates. Besides, $\ln CADOP_t$ has a modest mean and a prominent *SD*, which means that there is heterogeneity in global market adoption. Lastly, $GDPG_t$ exhibits the largest *SD* compared to its mean value of 2.83, which indicates macroeconomic volatility in the period under analysis.

4.2. Multicollinearity

Table 3 presents the results obtained from the correlation matrix and VIF analysis. The correlation analysis in our specific instance was performed to identify initial associations between $\ln VTCI_t$ and explanatory variables included in the research, as well as to screen

Table 3
Correlation matrix and vector inflation factor (VIF)

	$\ln VTCI_t$	$\ln AML_t$	CC_t	ROL_t	TC_t	$\ln CADOP_t$	$GDPG_t$	VIF
$\ln VTCI_t$	1.0000							“-
$\ln AML_t$	-0.0941	1.0000						4.34
CC_t	-0.4903	-0.6958	1.0000					4.72
ROL_t	-0.5913	0.1803	-0.0495	1.0000				1.86
TC_t	0.0403	-0.0095	-0.3085	0.3801	1.0000			2.02
$\ln CADOP_t$	0.6705	-0.1001	-0.5242	-0.3531	0.3526	1.0000		4.01
$GDPG_t$	0.2051	0.5969	-0.5553	0.2872	0.4487	0.2174	1.0000	3.29
VIF Mean	“-	“-	“-	“-	“-	“-	“-	3.37

Source: Compiled by the authors.

potential multicollinearity on the other hand. From the direction of the correlations and their sign, it is seen that $\ln AML_t$, CC_t , and ROL_t have negative associations with transaction volume, whereas TC_t , $GDPG_t$, and $\ln CADOP_t$ have positive associations ranging from slight to high impact. The increase in the global adoption of cryptocurrencies, coupled with economic growth, is reflected as market expansion. Meanwhile, on the other hand, the negative institutional relationships support the argument that alternative digital financial channels have higher use in those environments where formal institutions are weaker, being used as alternatives to traditional financial systems.

Furthermore, in light of the initial signs of multicollinearity, Wang et al. (2022) provide empirical evidence that if the correlation coefficients of the examination are $r \geq 0.80$, symptomatically, they can be considered a warning sign of potential multicollinearity problems. Taking into consideration the highlighted condition, it is observed that the results reflected in Table 3 clearly show that no coefficient exceeds this value (where the highest absolute value achieved is between CC_t and $\ln AML_t$ at -0.6958). Furthermore, variance inflation factors (VIF) were calculated to evaluate the time series structure. Wooldridge (2013) notes that if any individual coefficient exceeds the condition $\beta \geq 5$, it can be considered a multicollinearity concern for econometric model performance. Consequently, based on this premise, the results presented in the last column of Table 3 show that none of the variables exceed this value, and the highest value achieved is $\ln AML_t$ at 4.34, with a mean VIF of 3.37. This confirms that our research has no concerns about multicollinearity.

4.3. Preliminary tests

Continuing with the econometric assumptions, the research paper continues to discuss the Durbin–Watson test, which is used to determine the existence of serial autocorrelation, especially first-order autocorrelation. Deficiency of fulfilment of this assumption can result in inefficient models and misconceived statistical inference because it means that the various model errors do not exist, but they are correlated over time periods. The Durbin–Watson

Table 4
Preliminary diagnostic tests

Some preliminary tests	Description	Constant or p -value
Durbin–Watson	(7, 24)	1.8861
Breusch–Pagan	$\chi^2(1) = 0.0400$	0.8406

Source: Compiled by the authors.

statistic is between 0 and 4, where a value close to 2 indicates that there is no autocorrelation (Durbin & Watson, 1950). The statistic which was obtained in the present instance is 1.8861, which is consistent with the given assumption and confirms that first-order serial correlation is not present.

We also used the Breusch–Pagan test in order to establish whether the error term variance is systematically associated with the explanatory variables. The null hypothesis is confirmed by the p -value of this test ($p = 0.8406$), in which the assumption is that the variance of the errors is constant and hence heteroskedasticity does not occur (Wooldridge, 2013).

4.4. Unit roots

The current study exhaustively explores the econometric implications of non-stationarity in time series data through empirical estimation, exclusively considering the usage of OLS and HAC-GMM methods. In line with both classical and contemporary empirical evidence in time series econometrics, the research employs the Augmented Dickey–Fuller and Phillips–Perron tests to verify the presence of unit roots and to determine the order of integration of the variables (Dickey & Fuller, 1979; Phillips & Perron, 1988). The empirical results reported in Table 5 indicate that all variables included in the analysis are non-stationary in levels, whereas stationarity is achieved after first differencing, thereby confirming that the variables are integrated of order, $I(1)$.

From an econometric standpoint, these findings are essential for avoiding spurious regressions, a problem extensively documented in the literature when non-stationary variables are estimated using OLS without appropriate treatment (Granger & Newbold, 1974; Hamilton, 1994). Although the use of HAC covariance matrices enhances the robustness of standard errors to heteroskedasticity and serial correlation, this approach does not correct the distortions arising from non-stationarity in the underlying variables (Newey & West, 1987; Wooldridge, 2010). For this reason, testing for stationarity and transforming the data constitute a methodological prerequisite even within the HAC-GMM estimation framework. The research further argues that employing variables in first differences improves the specification of moment conditions and ensures the asymptotic consistency of GMM estimators, in accordance with the theoretical principles of dynamic econometrics (Arellano & Bond, 1991; Stock & Watson, 2019). As a result, integrating the ADF and PP tests into the empirical strategy enhances the statistical reliability and economic interpretability of the results, providing a strong scientific foundation for empirical analyses based on time series data with complex dynamic error structures.

Table 5
Augmented Dickey–Fuller and Phillips–Perron unit root tests

Variable	ADF – at level		ADF – at 1 st difference		PP – at level		PP – at 1 st difference	
	Statistic	ρ -value	Statistic	ρ -value	Statistic	ρ -value	Statistic	ρ -value
$\ln VTCL_t$	-1.1620	0.6898	-5.5460	0.0000	-1.3360	0.6124	-6.0660	0.0000
$\ln AML_t$	-0.9290	0.7784	-7.5500	0.0000	-1.0340	0.7405	-9.0630	0.0000
CC_t	-1.6930	0.4348	-7.5500	0.0000	-1.7840	0.3882	-8.6810	0.0000
ROL_t	-2.3840	0.1463	-7.5500	0.0000	-2.3890	0.1450	-8.7370	0.0000
TC_t	-2.4890	0.1182	-9.1760	0.0000	-2.5140	0.1122	-11.7070	0.0000
$\ln CADOP_t$	-1.0000	0.7531	-7.5530	0.0000	-0.9290	0.7783	-9.5620	0.0000
$GDPG_t$	-2.1120	0.2399	-7.3650	0.0000	-2.2560	0.1865	-8.3530	0.0000

Source: Compiled by the authors.

4.5. Findings and interpretation

Table 6 displays the econometric results that validate the hypothesised relationships among the variables, using the HAC-GMM estimator. With statistically significant coefficients ($p < 0.01$), the model isolates the structural drivers of the total cryptocurrency transaction volume index ($\ln VTCL_t$) while accounting for the inherent endogeneity, serial correlation and dynamic persistence identified in the methodology (Arellano, 2003; Wooldridge, 2010). The empirical results thus allow us to answer the research questions proposed.

In regard to RQ1, the control of corruption (CC) and the rule of law (ROL) coefficients yield high negative short-run elasticities ($\beta = -10.0828$) and ($\beta = -12.6557$), ($p < 0.01$), respectively. For interpreting these magnitudes accurately and addressing scale concerns, it is necessary to consider the operational design of the WGI, which is strictly bounded between -2.5 and $+2.5$ (Kaufmann et al., 2010; World Bank, 2024), in which, within this index, a complete 1.0-unit increase represents a massive structural transition. This transition means a nation's institutional framework shifts from an emerging market baseline to an advanced OECD standard (Kaufmann et al., 2010). For the purpose of our research, and to provide a precise economic context, these elasticities are evaluated in terms of sample variation (Wooldridge, 2013) as shown in the descriptive statistics in Table 2. The standard deviation for CC and ROL in Colombia are 0.0428 and 0.0328, respectively, which indicates that one standard deviation improvement in rule of law ($\Delta ROL = +0.0328$) is associated with a 41.5% reduction in the log of transaction volume index ($\ln VTCL_t$), considering all else constant ($\beta \times \sigma = -12.6557 \times 0.0328 = -0.4151$). Similarly, a one standard deviation increase in control of corruption ($\Delta CC = +0.0428$) represents a 43.1% reduction in $\ln VTCL_t$ ($\beta \times \sigma = -10.0828 \times 0.0428 = -0.4315$).

These results confirm the institutional theory (North, 1990; Durguti et al., 2025a), which states that the informal economy decreases by enhancing institutional capacity and the institutional rule of law. Within the context of our paper, an increment in governance quality enhancements has a strong deterrent effect on the informal capacity and obfuscation of the digital asset markets. González-Gallego and Pérez-Cárceles (2021) assert that while

Table 6
Econometric estimation

	OLS estimator	System GMM (HAC)	System GMM (robust)
$\ln VTCI_{t-1}$	–	–1.9770*** (0.0000)	–1.9770*** (0.0000)
$\ln AML_t$	–0.5279*** (0.0010)	–0.4350*** (0.0000)	–0.4351*** (0.0000)
CC_t	–10.4904*** (0.0020)	–10.0828*** (0.0000)	–10.0828*** (0.0000)
ROL_t	–6.4067*** (0.0010)	–12.6556*** (0.0000)	–12.6557*** (0.0000)
TC_t	–0.0022 (0.1880)	–0.0027*** (0.0000)	–0.0028*** (0.0000)
$\ln CADOP_t$	0.0331 (0.7180)	0.2271*** (0.0000)	0.2271*** (0.0000)
$GDPG_t$	0.0074 (0.4800)	0.0092*** (0.0020)	0.0092*** (0.0020)
Constant	1.2660 (0.3120)	–	–
Observation (T)	24	24	24
F-test / Model Fit	19.91 (0.0000)	–	66.46 (0.0000)
R ² / Adjusted R ²	0.8754 / 0.8314	–	–
Hansen J-test (<i>p</i> -value)	–	0.5018	0.5018
Arellano–Bond AR(1) (<i>p</i> -value)	–	0.0242	0.0242
Arellano–Bond AR(2) (<i>p</i> -value)	–	0.6158	0.6158

Source: Compiled by the authors.

governance efficiency and regulation quality inhibit cryptocurrency usage, control of corruption and rule of law foster the adoption of cryptocurrencies. Their results support the idea that the effects of governance are heterogeneous in cryptocurrency adoption. To evaluate the dynamic persistence of the quality of institutional governance in Colombia, long-run effects are analysed using the implied autoregressive parameter γ of the dependent variable in levels (Wooldridge, 2010; Wooldridge, 2013). The estimated short-run elasticities demonstrate that improvements in control of corruption and rule of law ($\beta_{CC} = -10.0828$, $p < 0.01$) ($\beta_{ROL} = -12.6557$, $p < 0.01$), respectively, lessen the effects on transaction volume capacity. Because market adjustments decay at a high speed throughout quarterly horizons, the deterrent capacity is not sustainable over time. Consequently, the institutional quality in Colombia is inconsistent in the long run unless continuous reinforcement in the short run is assured to maintain its structural impact.

In reference to RQ2, the negative elasticity ($\beta = -0.0028$) ($p < 0.01$) of the quarterly total crime rate (TC) variable indicates a measurable diversion of illicit flows towards cryptocurrency usage amidst fluctuations in traditional criminal activities, proxied by the official registries of the Policía Nacional de Colombia and the victimisation surveys from the Departamento Administrativo Nacional de Estadística (DANE). These findings suggest a technological substitution effect from traditional money laundering methods to digital channels. Concurrently, the positive elasticity ($\beta = 0.2271$) ($p < 0.01$) of the log of total cryptocurrency adoption ($\ln CADOP$) demonstrates that global cryptocurrency adoption hinders the identification of illicit patterns from legitimate transactions for institutions such as the Unidad de Información y Análisis Financiero in Colombia due to the cryptocurrency market growth.

Regarding RQ3, the strong negative coefficient ($\beta = -0.4351$) ($p < 0.01$) of the log of judicial AML prosecution counts ($\ln AML$) indicates that the strengthening of state enforcement, proxied by the judicial proceedings from the Fiscalía General de la Nación, suppresses cryptocurrency market volume in Colombia. These results confirm the deterrence effect since the benefits coming from illicit flows are outweighed by the probability of being detected and an increase in the expected cost of illegal actions (Masciandaro, 2007). Notwithstanding, the positive correlation ($\beta = 0.0092$) ($p < 0.01$) of the real GDP growth rate ($GDPG$) reveals that macroeconomic expansion increases the overall transaction velocity, which offsets and nullifies the judicial deterrence effect of state enforcement. This is the case since Loayza et al. (2019) demonstrated the direct feedback loop among legal economic expansion, financial liquidity, and money laundering absorption capacity specifically within the Colombian context.

5. Theoretical contributions

5.1. Theoretical integration: The crime diversion hypothesis

The empirical findings support the crime diversion hypothesis proposed, which falls directly under the rational choice theory of crime (Becker, 1968) as well as new institutional economics (North, 1990). Becker (1968) argues that illicit actors behave as rational agents who allocate financial resources among different channels according to expected returns, probability of detection, and the severity of the penalties in case of detection. If state enforcement, in the form of AML policies, is enhanced in traditional financial systems, or state oversight capacity is hindered by institutional decay (CC_t , ROL_t), such as poor control of corruption and weak rule of law impacting the institutional quality, illicit actors switch to digital asset structures to divert financial resources.

Within Colombia's historical context of drug trafficking and informal economy, the total traditional crime negative elasticity ($TC_t = -0.0028$, $p < 0.01$) together with a rise in cryptocurrency adoption reflects a technological substitution effect, which does not represent a diminution in total crime activity due to enforcement pressure on physical cash channels, but instead a restructuring of money laundering channels by which illicit actors develop new and sophisticated digital networks.

5.2. The trade-off between economic growth and state enforcement

A central insight of this study is the structural counterweight that domestic macroeconomic expansion ($GDPG_t = 0.0092$, $p < 0.01$) exerts against judicial AML deterrence ($\ln AML_t = -0.4351$, $p < 0.01$). While judicial proceedings by the Fiscalía General de la Nación control illicit volume by enhancing formal enforcement risks, the transaction velocity at which trade and online payments happen is hiddenly increased by domestic economic growth. This facilitates illicit flows to blend with legitimate commercial transaction volume due to low identification by the financial intelligence unit UIAF of suspicious transactions when

these are not reported or when transaction monitoring infrastructure is not improved and automated. As a result, judicial deterrence alone is not enough to combat illicit flows, offsetting its usefulness in a partial way.

5.3. Policy application and practical governance

To transform the empirical findings into practical public governance, Colombian regulatory entities must improve their practices beyond mere reactive judicial prosecutions and static centralised exchanges (CEXs) reporting legislation such as the DIAN Resolution 000240 and UIAF Resolution 314 (DIAN, 2025; UIAF, 2021). In our opinion, these practices may include the following.

Compliance frameworks for DeFi and DEXs

Since existing regulation focuses almost completely on centralised exchanges (CEXs), DeFi compliance frameworks should be put in place to target decentralised exchanges (DEXs). Some of the strategies within the proposed framework that target DeFi and DEX compliance can include enhanced control over liquidity pools and decentralised protocols' access points by embedding regulatory compliance code directly into smart contracts (NCFA Canada, 2025), adopting next-generation RegTech tools by adopting AI-powered compliance systems (FinTech Global, 2025) to enforce anti-money laundering (AML) and know your customer (KYC) controls, and mandating wallet screening protocols or crypto address screening (Chainalysis, 2026) for non-custodial wallet interactions.

Automated blockchain intelligence

The Colombian Financial Intelligence Unit, Unidad de Información y Análisis Financiero (UIAF), should integrate automated blockchain intelligence to establish real-time heuristic analysis to detect off-chain smurfing networks such as the so-called cyber burreros or money mules (Merkle Science, 2025), as well as setting up machine learning tools to mitigate the dilution of the efforts and results of the state enforcement capacity when high-volume economic growth periods occur when establishing automated tools for anomaly detection (Loayza et al., 2019; Masciandaro, 2007).

Institutional alignment and co-ordination

To prevent regulatory arbitrage between traditional banking and digital asset platforms, institutional capacity should be strengthened through control of corruption and rule of law quality to coordinate efforts among the different Colombian financial institutions such as DIAN, the Superintendencia Financiera de Colombia (SFC), the Superintendencia de

Sociedades, and commercial banks (Lightspark, 2025; UIAF, 2021). By enhancing unified suspicious transaction reporting (STR) and sharing relevant information among the oversight bodies, combating multi-channel financial digital crimes and eliminating jurisdictional gaps is improved (CMS Law, 2024; North, 1990).

6. Conclusions

This study investigated the structural drivers of cryptocurrency transaction activity in Colombia, employing a dynamic HAC-GMM framework on quarterly time series data (2019–2024). The empirical model reframes the dependent variable from pure illicit volume to a total cryptocurrency transaction volume index ($VTCI_t$) to evaluate cryptocurrency activity as an integrated proxy for market transaction capacity and potential for obfuscation. The empirical estimations provide three core conclusions that contribute to public governance and the literature in digital finance, namely, governance deterrence, technological substitution effect, and the domestic growth vs. enforcement trade-off.

By governance deterrence, we have meant the improvements in institutional quality in Colombia, which were measured through the World Bank control of corruption (CC_t) and rule of law (ROL_t) indicators, having strong short-run reduction effects on transaction volume capacity, evidenced by the ($\beta = -10.0828$ and $\beta = -12.6557, p < 0.01$) coefficients. When assessed in terms of sample variation, a one standard deviation improvement in rule of law or control of corruption reduces the log of the transaction volume index ($\ln VTCI_t$) by 41.5% and 43.1%, respectively, which signifies that the stronger the regulations, the harder it is for illegal financial flows to blend in legitimate business channels in line with institutional governance mechanisms. Furthermore, shifts in public governance and regulatory enforcement across Colombian presidential administrations during the 2019–2024 sample period reflect the impact on the quality of institutions in Colombia through the volatility observed in (CC_t) and (ROL_t). This demonstrates how institutional stability conditions the state's capacity to suppress illicit transaction volume and enforce overall market deterrence.

Also, there is confirmation of the technological substitution effect in Colombia by the inverse relationship between conventional crime rates (TC_t) and digital asset volume. This is reflected in a money laundering adaptation from physical cash dynamics towards pseudonymous digital financial networks in accordance with the rational choice framework predictions. At the same time, the expansion of global cryptocurrency adoption ($\ln CADOP_t = 0.2271, p < 0.01$) complicates the efforts of the financial intelligence units in Colombia to properly identify and isolate suspicious transactions due to the flood of global commercial transactions. Considering Colombia's background of informality in its economy, this adaptation facilitates the camouflage of illicit financial flows and makes it difficult the development of a more trustworthy financial channel supported by the quality of the Colombian financial institutions that provide security and transparency to the population so that formality and legality are ensured, and the tendency to fall into the trap of easy money is, if not restricted, at least reconsidered to be avoided by Colombian citizens.

Finally, the structural counterweight of the Colombian macroeconomic expansion coefficients ($GDPG_t = 0.0092, p < 0.01$) demonstrates that, despite the judicial AML

prosecutions ($\ln AML_t = -0.4351, p < 0.01$) controls the operational transaction volume in the Colombian cryptocurrency market and its capacity, measured by the log of the $\ln VTCL$, the effects of state enforcement are partially diluted and not completely effective due to rapid economic growth that accelerates transaction velocity. This situation delays judicial deterrence in comparison to the legal actions required not only to penalise illegal actors but also to prevent the proliferation of the new digital financial channels' potential for money laundering in Colombia, which are additionally influenced by the Colombian socio-political and economic history of violence and drug trafficking. As a consequence, a lack of dynamic reporting rules supported by real-time automated blockchain intelligence and the sole reliance on manual reports and reactive prosecutions only achieve limited effectiveness when economic booms happen.

7. Limitations and future research

Future scholarly research can be expanded to target the gaps this study does not cover, despite its empirical contributions. Such gaps and limitations are twofold, namely, the single-country scope and sample size on the one hand, and the indirect measure of illicit financial flows on the other hand.

Generalisations of the empirical results of this study are constrained since it only considers Colombian time series specifications that contain solely 24 observations. Although the data were harmonised across macroeconomic, regulatory and institutional data, the same elasticities cannot be applied to other LATAM countries in the region, such as Argentina, Brazil, or Mexico. A multi-country analysis will allow the assessment of institutional variance across countries within the LATAM region to evaluate if the extent of the results in Colombia can apply to or influence neighbouring countries. Within such evaluation, the time series instrument constraints might be resolved when the selection of the standard system GMM panel is decided as a research methodology.

And, although this study framed $VTCL$ as a proxy for obfuscation potential and market capacity, it remains an estimation and does not represent a direct measure of illicit financial flows. Consequently, the data sample should come from entity extraction procedures and tools to isolate illicit transactions coming from unhosted wallets. Future studies should integrate evaluations of the efficacy of smart contract compliance through code regulation, non-custodial wallet screening, and automated RegTech tools and strategies, to evaluate the extent of policy contributions as stated as practical governance potential in section 5.3 of this study.

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