Humanities & Social Sciences Communications

ARTICLE

https://doi.org/10.1057/s41599-025-05148-5 OPEN

Bitcoin adoption and price elasticity of demand: cross-country insights

Shiva Sankari V.[1]✉ & R. Kavitha[1]✉

This study investigates the global adoption of Bitcoin by analyzing its price elasticity of demand (PED) across 46 countries or regions, with a focus on the interplay between economic, regulatory, and technological factors. Utilizing robust econometric techniques, including Huber regression, the research identifies significant variations in Bitcoin demand elasticity between developed and developing economies. The findings reveal that developed economies exhibit a mix of elastic and inelastic demand, driven by market maturity and discretionary consumption, while developing economies predominantly demonstrate inelastic demand, reflecting necessity-driven adoption amidst economic constraints. Key determinants of adoption include regulatory frameworks, such as legality, taxation, and anti-money laundering measures, alongside technological readiness indicators like blockchain infrastructure and internet penetration. These results underscore the critical influence of non-price factors on Bitcoin's adoption dynamics and provide valuable insights for policymakers, investors, and industry stakeholders aiming to balance innovation with market stability. By offering a nuanced understanding of Bitcoin demand, this research contributes to the broader discourse on cryptocurrency adoption and its socioeconomic implications.

[1] Periyar University, Salem, India. ✉email: shivasankariv@gmail.com; kavithayohanmugil@gmail.com

Introduction

Bitcoin, the world's first decentralized cryptocurrency, continues to attract global attention due to its ability to function outside of traditional financial systems and its highly volatile price behaviour. The rapid growth of Bitcoin adoption can be attributed to its potential as a hedge against inflation, a decentralized store of value, and an investment vehicle (Mokni et al., 2021). Understanding how demand responds to price fluctuations is essential for evaluating its role in both developed and developing financial markets. One useful metric is the price elasticity of demand, which measures the degree to which demand for an asset like Bitcoin changes in response to price variations (Joseph et al., 2022).

The global landscape for Bitcoin adoption is diverse, with varying degrees of demand influenced by several factors, including economic stability, regulatory frameworks, and technological infrastructure (Bouri et al., 2017). In countries like Nigeria, where inflation and currency depreciation are prevalent, Bitcoin is seen as a viable alternative to traditional assets. In contrast, in more economically stable nations, Bitcoin functions more as a speculative asset or a hedge against risk (Joseph et al., 2022).

Beyond price, behavioural finance models play a significant role in explaining Bitcoin demand, particularly in regions where speculative investment drives demand. Investor sentiment, risk aversion, and geopolitical uncertainties all shape the way individuals and institutions interact with Bitcoin (Arias-Oliva et al., 2019). Additionally, regulatory and policy environments greatly affect the adoption rates of Bitcoin, as favourable regulations promote integration into mainstream financial markets while restrictive policies can stifle growth (Bhimani et al., 2022).

To address these gaps, this study explores four key research questions: What is the price elasticity of demand (PED) for Bitcoin across various countries or regional markets? Do regulatory factors influence cryptocurrency adoption rankings in different countries or regions? Is there a relation between cryptocurrency adoption rankings and technological advancement rankings among different countries or regions? Is the price elasticity of demand for Bitcoin related to regulatory frameworks, adoption rates, and technological advancement levels of countries or regions?

This study contributes significantly to the growing literature on cryptocurrency adoption and market dynamics. Firstly, it expands the understanding of Bitcoin's price elasticity of demand (PED) by providing a comprehensive global analysis across 46 countries. Prior studies have largely focused on specific regions or contexts, but this research differentiates between developed and developing economies, uncovering distinct demand patterns. The findings indicate that developed economies exhibit a mix of elastic and inelastic demand, influenced by market maturity and discretionary spending habits, whereas developing economies predominantly display inelastic demand due to economic constraints and necessity-driven adoption. Another key contribution is the incorporation of regulatory and technological factors into the analysis. While earlier studies have primarily examined price and trading volume, this research integrates elements such as legality, taxation, anti-money laundering measures, and blockchain infrastructure to understand their impact on Bitcoin's demand elasticity. By quantifying these regulatory and technological variables, the study bridges the gap between economic, regulatory, and technological perspectives in cryptocurrency research.

Furthermore, the study offers actionable insights for policymakers, businesses, and investors. By highlighting the interplay between PED, regulatory environments, and technological advancements, the research provides a foundation for designing effective strategies to promote sustainable cryptocurrency adoption while mitigating associated risks. For policymakers, understanding how regulations influence Bitcoin demand can inform decisions on balancing innovation with market stability. Businesses can use these insights to tailor their strategies in regions where demand is more elastic, while investors can better assess market risks and opportunities.

Lastly, the study contributes to a global perspective on Bitcoin adoption by leveraging data from 46 countries. The comparative analysis between developed and developing economies enriches the understanding of how socio-economic factors influence cryptocurrency demand. This broader perspective enhances the relevance of the findings to a diverse range of stakeholders, including academics, regulators, and industry practitioners. By considering economic, regulatory, and technological dimensions, this study provides a holistic approach to analyzing cryptocurrency adoption and price sensitivity in various market conditions.

As of January 9, 2025, Bitcoin accounted for about 64.65% of the market value of the cryptocurrency market, as seen in Fig. 1. Bitcoin has been dominating the crypto world since its introduction to date (Aysan et al., 2021). So, we take crypto adoption rate instead of the bitcoin adoption rate, as the bitcoin adoption rate for each country is not available, as bitcoin represents the majority of the crypto market.

The remaining of this study is structured as follows. Section 2 deals with the theoretical framework, which explains different theories related to our study. Section 3 describes the methodology, including the data sources, key variables, and econometric models employed, such as the Huber regression framework and Spearman correlation analysis. Section 4 presents the findings, comparing Bitcoin demand dynamics across developed and developing nations, and discusses the implications of regulatory, technological, and market factors. Finally, Section 5 concludes with a summary of key insights, policy recommendations, and practical consequences while identifying avenues for future research in cryptocurrency markets.

The next section explores the theoretical foundations that underpin Bitcoin's price elasticity of demand, drawing from key economic and financial theories.

Theoretical framework

The theoretical foundation of this study is built upon key economic and financial theories that explain Bitcoin's price elasticity of demand (PED). This section explores the application of traditional economic principles, behavioral finance, and network effects in understanding Bitcoin's demand dynamics.

Price elasticity of demand and cryptocurrency markets. The concept of price elasticity of demand (PED) was introduced by Alfred Marshall (1890) as a fundamental principle in economics, describing how the quantity demanded of a good responds to changes in its price. Traditionally, essential goods exhibit inelastic demand, while luxury or speculative assets tend to be more elastic. Bitcoin, as a unique asset, exhibits demand characteristics that vary based on geographic and economic factors.

Several empirical studies have analyzed cryptocurrency demand elasticity. (Joseph et al., 2022) used a log-log regression framework to model cryptocurrency demand as a function of price and other influencing variables, finding that demand remained largely inelastic in the long run. Conversely, Jalan et al. (2022) examined demand elasticities for Bitcoin and Ethereum and found that Bitcoin exhibited positive price elasticity, highlighting its speculative nature. These findings indicate that Bitcoin's demand elasticity deviates from traditional

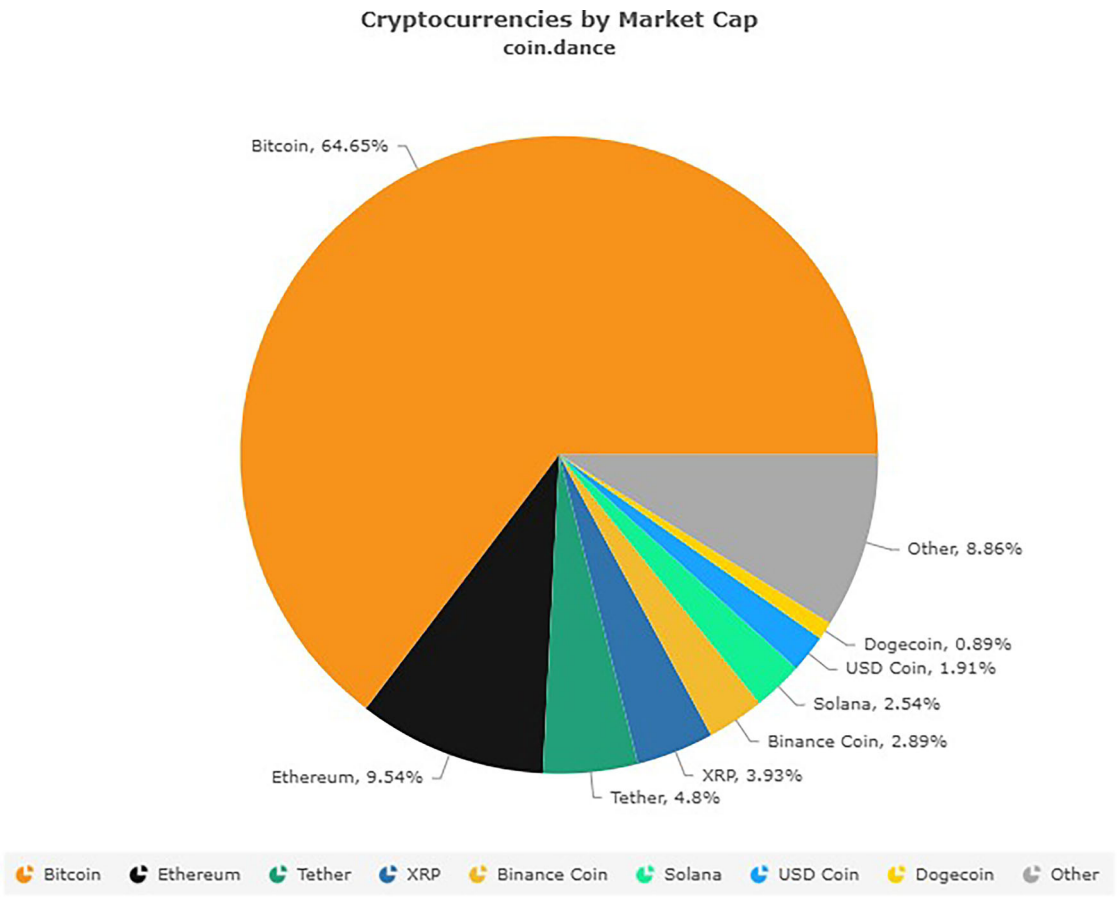

Fig. 1 Cryptocurrencies by market capitalization. The chart shows Bitcoin leading with a market share of 64.65% as of January 2025. Source: coin dance.

market principles, influenced by investor sentiment, regulatory conditions, and market maturity.

Behavioral finance and bitcoin demand. Behavioral finance theories suggest that Bitcoin's demand is driven by psychological biases and speculative behavior. Unlike traditional assets, Bitcoin's price movements often reflect herd behavior, overconfidence, and media influence. Kahneman and Tversky's (1979) Prospect Theory posits that investors tend to make decisions based on perceived gains and losses rather than objective financial analysis, leading to asymmetric responses to price fluctuations.

Empirical evidence supports the role of behavioral biases in Bitcoin demand (Ballis and Verousis, 2022). (Jariyapan et al., 2022) found that during bull markets, Bitcoin demand surges due to FOMO (fear of missing out), whereas in bear markets, demand remains relatively stable, indicating that investors hold onto their assets despite falling prices. This behavior contributes to the observed price elasticity variations across different economic contexts.

Network effects and cryptocurrency adoption. Bitcoin's adoption is also influenced by network effects, where its value increases as more users participate in the ecosystem. Metcalfe's Law states that the value of a network is proportional to the square of its number of users. This principle applies to Bitcoin, where increased adoption leads to higher demand and greater price stability (Publication Bhuvana, 2022). Studies undertaken by (Saiedi et al., 2021; Shahzad et al., 2024) show that countries with higher Bitcoin adoption rates exhibit more inelastic demand, as Bitcoin becomes integrated into everyday transactions rather than being purely speculative.

The interplay between network effects and regulation also affects Bitcoin's demand elasticity. In regions with favorable regulatory environments, Bitcoin functions as a medium of exchange, reducing price sensitivity. Conversely, in countries with strict regulations, Bitcoin demand is driven by speculative motives, making it more elastic (Autore et al., 2021).

Integrating economic, behavioral, and technological factors. This study integrates economic theories of price elasticity, behavioral finance principles, and network effects to provide a comprehensive understanding of Bitcoin's demand elasticity. By considering how price changes, investor psychology, and adoption trends interact, this framework offers a holistic perspective on Bitcoin's role in global financial systems. Furthermore, regulatory and technological advancements are essential moderating factors, shaping how Bitcoin is perceived and utilized in different economies(Ozak and Teker 2023).

By applying this theoretical framework, the present study aims to bridge gaps in the literature by examining Bitcoin's PED across multiple dimensions. This approach allows for a nuanced analysis of how market forces, investor behavior, and technological developments collectively influence Bitcoin adoption and demand patterns.

Methodology

Data sources. The data for this study were drawn from several reputable sources to ensure accuracy and comprehensiveness. Table 1 provides a structured summary of the key data sources used in this study.

Table 1 Source and variables used in the study.

Variables	Description	Source	URL
Bitcoin price data	Data on Bitcoin prices across all countries listed on Coin Dance.	Coin Dance	https://coin.dance/volume/localbitcoins
Bitcoin quantity data	Data on Bitcoin transaction quantities across all countries listed on Coin Dance.	Coin Dance	https://coin.dance/volume/localbitcoins
Country classification	Categorization of countries into "Developed" and "Developing" based on GII 2023 rankings.	Global Innovation Index (GII) 2023	https://www.wipo.int/en/web/global-innovation-index/2023/index
Crypto ownership	Bitcoin usage in various countries.	Triple-A Cryptocurrency Ownership Data	https://www.triple-a.io/cryptocurrency-ownership-data
Regulatory framework	Legal and regulatory insights into Bitcoin usage	Atlantic Council	https://www.atlanticcouncil.org/programs/geoeconomics-center/cryptoregulationtracker/

Methods used. This study applies robust econometric models to understand the pricing dynamics of Bitcoin and its interaction with regulatory factors and technological advancements. Specifically, the Huber Regression model is employed to examine the relationship between Bitcoin's price and quantity demanded. We have used a Python program to calculate the PED from sklearn.linear model. The mathematical expression for calculating PED is as follows.

Huber regression model. Huber regression modifies the standard Ordinary Least Squares (OLS) regression by introducing a robust loss function that limits the impact of outliers. This approach is particularly suited for Bitcoin demand analysis, as cryptocurrency markets exhibit high volatility and irregular trading patterns. Unlike OLS, which assumes normally distributed residuals and is highly sensitive to extreme values, Huber regression minimizes the impact of outliers by applying a quadratic loss for small residuals and a linear loss for large residuals. This ensures more accurate and stable estimates of the price elasticity of demand (PED) (Feng and Wu, 2021).

Robustness is crucial in this context because outliers, often caused by market anomalies or sudden economic events, can distort traditional OLS results. By reducing sensitivity to these extreme values, Huber regression provides reliable PED estimates that reflect underlying market trends. The Huber regression minimizes the following objective function:

$$\beta = \arg\min_{\beta} \sum_{i=1}^{n} L\delta(ri)$$

Where: $\beta = (\beta 0, \beta 1)$ are the model parameters (intercept and slope, respectively). $ri = Yi\text{-}(\beta 0 + \beta 1\ \ Xi)$ is the residual for observation i.$L\delta(ri)$is the Huber loss function, defined as:

$$L_{\delta}(r_i) = \begin{cases} \frac{1}{2} r_i^2 & \text{if} |r_i| \le \delta, \\ \delta \cdot |r_i| - \frac{1}{2}\delta^2 & \text{if} |r_i| > \delta. \end{cases}$$

For small residuals ($|ri| \le \delta|$), the loss function is quadratic, making it behave like OLS. For large residuals ($|ri| > \delta$), the loss function becomes linear, reducing the influence of outliers.

The parameter δ determines the threshold at which the loss function transitions from quadratic to linear, balancing sensitivity to inliers and robustness against outliers.

Relationship to price elasticity of demand (PED). In the context of price elasticity of demand (PED) for Bitcoin trading volumes, the regression model relates the log-transformed trading volume (Y) to the log-transformed price (X):

$$\log(Yi) = \beta 0 + \beta 1 log(Xi) + \epsilon i$$

Where: Yi: Volume of Bitcoin traded (dependent variable). Xi: Price of Bitcoin (independent variable). $\beta 1$: The slope coefficient, representing the elasticity. ϵi: The residual term.

The log-log transformation makes $\beta 1$ directly interpretable as the price elasticity of demand:

$$PED = \beta 1 = \frac{\partial \log(Y)}{\partial \log(X)} = \frac{\%\Delta Y}{\%\Delta X}$$

Calculating PED using Huber regression. To compute PED, the following steps are performed:

- **Log-transformation**: Transform the data into logarithmic form to facilitate elasticity estimation:

$$log(Yi) = log\,(Volume\ of\ \ Bitcoin) \text{ and } log\,(Xi) = log\,(Price\ of\ \ Bitcoin)$$

- **Objective function**: Fit the Huber regression model by solving:

$$L_{\delta}(\beta_0, \beta_1) = \arg\min_{\beta_0, \beta_1} \sum_{i=1}^{n} L_{\delta}(\log(Y_i) - (\beta_0 + \beta_1 \log(X_i)))$$

This minimizes the robust loss function $L\delta$, ensuring reduced sensitivity to outliers in $log(Yi)$ or $log(Xi)$.

- **Estimate coefficients**: The fitted model provides estimates for $\beta 0$ (intercept) and $\beta 1$ (slope). Here, $\beta 1$ directly represents the PED.
- **Robustness and interpretation**

Robustness to outliers: By minimizing the Huber loss function, the model ensures that extreme values in trading volume or price do not disproportionately affect the elasticity estimate.

PED interpretation: The estimated $\beta 1$:
If $|\beta 1| < 1$, demand is inelastic.
If $|\beta 1| < 1$, demand is elastic.
If $|\beta 1| < 1$, demand is unitary elastic.

Correlation analysis. Spearman's Rank correlation is utilized to explore the relationships between regulatory frameworks, adoption rankings, technology advancement, and PED. Sir Francis Galton developed the concept of correlation in the late 19th century. This statistical method sheds light on how socio-economic and regulatory factors interplay to shape the adoption and demand for Bitcoin, underscoring the broader implications for financial systems and economic policy (Aslanidis et al., 2018). The mathematical expression used for correlation purpose is as follows:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2 - 1)}$$

Where: ρ is the Spearman's rank correlation coefficient. d_i is the difference between the ranks of each pair of corresponding values. n is the number of observations.

Variables and quantification. The selected variables were quantified based on standardized criteria to facilitate statistical analysis:

- **Regulatory frameworks**:
  This variable was scored based on legality, taxation, anti-money laundering (AML) measures, and consumer protection. Higher scores indicate greater regulatory maturity, with the scale ranging from 0 to 5. For example: Legality: Fully regulated = 5, Weakly regulated = 3, No framework = 0. AML Compliance: Strong measures = 5, Minimal compliance = 2, None = 0.
- **Technological readiness**:
  Measured through metrics like internet penetration, fintech adoption, and blockchain infrastructure. These indicators assess a country's technological capacity to support digital currencies.
- **Cryptocurrency adoption**:
  Ranked by the percentage of the population actively using or holding cryptocurrencies. This variable reflects public and institutional acceptance of digital currencies.
- **Consumer protection**:

Evaluates policies safeguarding users from fraud, theft, and cyberattacks. Strong consumer protection policies foster trust and encourage adoption.

Scoring system. The qualitative attributes for each country were converted into numeric scores using a standardized scale (e.g., 0–5 for regulatory maturity), ensuring consistency and comparability across different regions.

Hypothesis testing. The existing body of literature has extensively explored the correlation between cryptocurrencies and traditional and conventional assets such as gold, inflation, GDP, crude oil, and exchange rates (Bouri et al., 2017; Ghorbel and Jeribi 2021). However, there is a noticeable gap in research that examines the relationship between cryptocurrencies, regulatory frameworks, and technological advancements. This study aims to address this gap by formulating hypotheses that explore these under-researched areas.

- **Regulatory frameworks**
  Although direct studies linking cryptocurrencies and regulatory frameworks are sparse, the broader financial literature provides substantial evidence of the impact of regulation on market behavior. (Auer et al., 2022) demonstrate that regulatory environments significantly influence financial stability and investor confidence. Drawing from this, it is hypothesized that:
  H1: Regulatory frameworks significantly influence the adoption rate of cryptocurrencies.
  This hypothesis is grounded in the expectation that clear and supportive regulatory policies can foster a conducive environment for cryptocurrency adoption, while stringent or ambiguous regulations may hinder it.
- **Technological advancement**

Similarly, the role of technological infrastructure in the adoption of financial innovations has been highlighted by various studies, though not specifically in the context of cryptocurrencies. The innovation diffusion theory (Bharadwaj and Deka, 2021) suggests that technological readiness is a crucial factor in the adoption of new technologies. Based on this theoretical framework, we hypothesize that:

H1: Technological advancement correlates with the price elasticity of demand for cryptocurrencies.

This hypothesis stems from the understanding that advanced technological infrastructure facilitates easier access to and usage of cryptocurrencies, which could influence consumer responsiveness to price changes.

By integrating insights from general financial and technological adoption literature, this study seeks to provide empirical evidence on the influence of regulatory and technological factors on cryptocurrency markets, thereby filling a significant gap in current research.

Results and discussions

The results from Tables 2, 3 reveal significant differences in the nature of demand, which is influenced by economic development, market conditions, and consumption behaviors. Below, the findings are detailed and discussed for each country, categorized into developed and developing economies.

Developed countries: insights into demand elasticity.

- **Elastic demand (|PED| > 1):**
  Countries such as **Australia (|PED| = 1.14), Czech Republic (|PED| = 1.03), Norway (|PED| = 1.05)**, and the **USA (|PED| = 1.20)** demonstrate elastic demand. In these economies, a 1% increase in price leads to a greater than 1% decline in demand. These results suggest that consumers in these countries are price-sensitive, likely due to greater availability of substitutes and competitive markets.
- **Inelastic demand (|PED| < 1):**
  The majority of developed countries exhibit inelastic demand, where changes in price result in smaller proportional changes in demand. Notable examples include **Canada (|PED| = 0.76), Hong Kong (|PED| = 0.53)**, and **Sweden (|PED| = 0.85)**. This inelasticity often reflects the necessity-driven consumption of goods or limited alternatives in specific markets.
  Interestingly, **Hungary (|PED| = 0.93)** and the **UK (|PED| = 0.90)** are close to the threshold of elastic demand, indicating evolving patterns of price sensitivity.
- **Unique cases with positive PED:**
  Some countries, such as **Japan (PED = 0.44)** and **Saudi Arabia (PED = 0.28)**, exhibit positive PED values. This suggests atypical market dynamics, potentially linked to luxury goods or prestige-driven consumption, where higher prices might enhance perceived value or demand.
- **Key observations across other developed economies:**

Chile (|PED| = 0.16) and **South Korea (|PED| = 0.48)** reflect strongly inelastic demand, indicative of markets with goods considered essential or lacking viable substitutes. Similarly, **New Zealand (|PED| = 0.78), Poland (|PED| = 0.76)**, and **Singapore (|PED| = 0.55)** further reinforce the prevalence of inelastic demand in developed nations. Countries like **Turkey (|PED| = 0.43)** and **UAE (|PED| = 0.56)** show modest responsiveness, signaling market stability and consumer resistance to price changes.

Developing countries: patterns and peculiarities.

- **Dominantly inelastic demand:**
  Developing countries overwhelmingly exhibit inelastic demand. For instance, **India (|PED| = 0.44), Brazil (|PED| = 0.44)**, and **Mexico (|PED| = 0.49)** demonstrate that consumers are less responsive to price changes, reflecting economic constraints and a focus on essential goods. Countries like **Pakistan (|PED| = 0.14), Argentina (|PED| = 0.36)**, and **Ukraine (|PED| = 0.30)** exhibit even lower elasticity, reinforcing the notion that price changes have minimal impact on demand.

Table 2 Bitcoin price elasticity to demand of different regions using Huber regression.

COUNTRY	Intercept	Price elasticity of demand (Coefficient of Log_Price)	Nature of demand
DEVELOPED COUNTRIES			
AUSTRALIA	14.764870490932035	−1.142820197154022	The demand is Elastic (|Elasticity| = 1.14).
CANADA	10.748395559572621	−0.7557145765080493	The demand is Inelastic (|Elasticity| = 0.76).
CHILE	5.4856555391190565	−0.1627920180349784	The demand is Inelastic (|Elasticity| = 0.16).
CZECH REPUBLIC	12.921538642864462	−1.02791758150152	The demand is Elastic (|Elasticity| = 1.03).
HONG KONG	9.134593333138834	−0.5289809441373837	The demand is Inelastic (|Elasticity| = 0.53).
HUNGARY	12.870068400083984	−0.9297263780353044	The demand is Inelastic (|Elasticity| = 0.93).
JAPAN	−5.994065514571715	0.4438239419277404	The demand is Inelastic (|Elasticity| = 0.44).
NEWZEALAND	10.007677577839157	−0.7790534016210636	The demand is Inelastic (|Elasticity| = 0.78).
NORWAY	13.885950668537607	−1.0534728433811427	The demand is Elastic (|Elasticity| = 1.05).
POLAND	9.640107191322732	−0.7603562322618791	The demand is Inelastic (|Elasticity| = 0.76).
SAUDI ARABIA	−0.22247833338825265	0.2808793905096164	The demand is Inelastic (|Elasticity| = 0.28).
SINGAPORE	7.583329469441868	−0.5546987135434377	The demand is Inelastic (|Elasticity| = 0.55).
SOUTH KOREA	−6.764375215581441	0.48478076020911187	The demand is Inelastic (|Elasticity| = 0.48).
SWEDEN	13.260865144544866	−0.8455379157128141	The demand is Inelastic (|Elasticity| = 0.85).
TURKEY	6.424652296724708	−0.4346807336103501	The demand is Inelastic (|Elasticity| = 0.43).
UAE	8.309201050587193	−0.5637079096742567	The demand is Inelastic (|Elasticity| = 0.56).
UK	13.496949095120494	−0.8952343400982098	The demand is Inelastic (|Elasticity| = 0.90).
USA	17.03581888217902	−1.198889654905234	The demand is Elastic (|Elasticity| = 1.20).
DEVELOPING COUNTRIES			
ARGENTIA	7.613189064180337	−0.3596567787768878	The demand is Inelastic (|Elasticity| = 0.36).
BRAZIL	7.956031668995045	−0.43938625172932	The demand is Inelastic (|Elasticity| = 0.44).
CHINA	10.461338559782897	−0.4856176774007197	The demand is Inelastic (|Elasticity| = 0.49).
COLOMBIA	3.811262121353569	0.0512374215519241	The demand is Inelastic (|Elasticity| = 0.05).
CROATIA	−1.933420583603594	0.18457708858349425	The demand is Inelastic (|Elasticity| = 0.18).
DOMINICAN	−5.518175963380912	0.5829373320855709	The demand is Inelastic (|Elasticity| = 0.58).
REPUBLIC			
EGYPT	−6.065936835047663	0.5534043003694322	The demand is Inelastic (|Elasticity| = 0.55).
INDIA	10.412409994403687	−0.44411495305683285	The demand is Inelastic (|Elasticity| = 0.44).
INDONESIA	−7.526877913371196	0.4270732318531305	The demand is Inelastic (|Elasticity| = 0.43).
IRAN	−6.774242130301381	0.44032323861833317	The demand is Inelastic (|Elasticity| = 0.44).
KAZAKHSTAN	−6.275479439454619	0.5359794567250298	The demand is Inelastic (|Elasticity| = 0.54).
KENYA	6.81792871626401	−0.2276968943750166	The demand is Inelastic (|Elasticity| = 0.23).
MALAYSIA	11.080151607174617	−0.7377009927385296	The demand is Inelastic (|Elasticity| = 0.74).
MEXICO	9.233283262082786	−0.4889557444557899	The demand is Inelastic (|Elasticity| = 0.49).
MOROCCO	−4.9030388069196595	0.6262280179551225	The demand is Inelastic (|Elasticity| = 0.63).
NIGERIA	−3.205409329416145	0.5378533617212614	The demand is Inelastic (|Elasticity| = 0.54).
PAKISTAN	4.250335258871633	−0.14132513399706978	The demand is Inelastic (|Elasticity| = 0.14).
PERU	3.3467154381355364	0.003719042267237472	The demand is Inelastic (|Elasticity| = 0.00).
PHILIPPINES	11.27557821429777	−0.7050166171024019	The demand is Inelastic (|Elasticity| = 0.71).
ROMANIA	11.999434820650313	−0.9216712834012274	The demand is Inelastic (|Elasticity| = 0.92).
RUSSIA	15.54727526277579	−0.6690705008045558	The demand is Inelastic (|Elasticity| = 0.67).
SOUTH AFRICA	12.811677119194345	−0.7072095194176068	The demand is Inelastic (|Elasticity| = 0.71).
SWITZERLAND	9.618309110752227	−0.9159160360411625	The demand is Inelastic (|Elasticity| = 0.92).
TANZANIA	−6.916647160418863	0.48197617039494184	The demand is Inelastic (|Elasticity| = 0.48).
THAILAND	12.876620115824077	−0.728942737619763	The demand is Inelastic (|Elasticity| = 0.73).
UKRAINE	6.9919099519267505	−0.3047710001158763	The demand is Inelastic (|Elasticity| = 0.30).
VENEZUEA	8.265516692692826	−0.3730265035563079	The demand is Inelastic (|Elasticity| = 0.37).
VIETNAM	−7.185343510140008	0.4432600578729327	The demand is Inelastic (|Elasticity| = 0.44).

- **Marginally elastic demand:**
  Although no developing country shows elastic demand, **Morocco (|PED| = 0.63), Thailand (|PED| = 0.73)**, and **Russia (|PED | = 0.67)** approach this threshold, suggesting gradual shifts in consumer behavior due to rising income levels or market diversification.
- **Highly inelastic cases:**
  Extremely low elasticity values in **Colombia (|PED| = 0.05)** and **Peru (|PED| = 0.00)** suggest negligible responsiveness to price changes, possibly due to the consumption of necessities or heavily regulated markets.
- **Positive PED values:**
  Similar to developed economies, several developing nations, such as **Egypt (PED = 0.55), Nigeria (PED = 0.54)**, and **Vietnam (PED = 0.44)**, show positive elasticity values. This may reflect unique cultural, economic, or social factors where rising prices stimulate demand through perceived quality or exclusivity.
- **Country-specific observations:**

China (|PED| = 0.49), Indonesia (|PED| = 0.43), and **Philippines (|PED| = 0.71)** exhibit stable inelastic demand, reflecting the interplay of growing consumer markets and essential goods consumption. Countries like **South Africa (|PED| = 0.71)** and **Romania (|PED| = 0.92)** illustrate stronger price resistance, pointing to transitional economies with increasing market diversification. **Kazakhstan (|PED| = 0.54)** and **Tanzania (|PED| = 0.48)** further underline the predominantly inelastic nature of demand in developing economies.

Table 3 Table showing the ped, regulatory frameworks, crypto adoption rank, and tech advancement rank.

Countries	Price elasticity to demand	Legality & regulations	Taxations	AML/CFT	Consumer protection	Crypto adoption rank	Tech advancement rank
DEVELOPED COUNTRIES							
AUSTRALIA	−1.14	5	3	4	4	16	12
CANADA	−0.75	5	3	4	4	9	13
CHILE	−0.16	3	2	2	1	34	46
CZECH REPUBLIC	−1.02	5	2	4	4	35	31
HONG KONG	−0.52	5	1	4	4	21	15
HUNGARY	−0.92	5	2	4	4	42	37
JAPAN	0.44	5	3	4	4	17	14
NEWZEALAND	−0.77	5	2	4	3	33	27
NORWAY	−1.05	5	3	4	4	31	22
POLAND	−0.76	5	3	4	4	38	41
SAUDI ARABIA	0.28	2	0	2	1	40	47
SINGAPORE	−0.55	5	3	4	4	10	9
SOUTH KOREA	0.48	5	3	4	4	7	6
SWEDEN	−0.84	5	3	4	4	22	5
TURKEY	−0.43	5	3	3	3	14	44
UAE	−0.56	5	1	4	3	13	33
UK	−0.89	5	1	4	3	13	33
USA	−1.19	5	3	4	4	3	2
DEVELOPING COUNTRIES							
ARGENTINA	−0.35	5	3	2	2	15	44
BRAZIL	−0.43	5	3	4	2	8	50
CHINA	−0.48	2	0	4	1	5	11
COLOMBIA	0.05	4	2	4	2	28	49
CROATIA	0.18	5	3	4	4	43	42
DOMINICAN	0.58	3	0	1	1	46	61
REPUBLIC							
EGYPT	0.55	2	0	4	1	39	52
INDIA	−0.44	5	4	4	2	4	40
INDONESIA	0.42	5	3	4	3	12	41
IRAN	0.44	2	0	4	1	36	60
KAZAKHSTAN	0.53	5	1	4	1	41	59
KENYA	−0.22	5	1	3	1	11	51
MALAYSIA	−0.73	5	3	4	4	23	32
MEXICO	−0.48	5	2	4	2	30	57
MOROCCO	0.62	2	0	4	1	45	58
NIGERIA	0.53	5	0	4	1	1	62
PAKISTAN	−0.14	2	0	4	1	24	63
PERU	0.003	5	2	4	1	42	48
PHILIPPINES	−0.70	5	3	4	3	19	53
ROMANIA	−0.92	5	3	4	4	44	45
RUSSIA	−0.66	5	2	4	1	25	47
SOUTH AFRICA	−0.70	5	3	4	3	18	56
SWITZERLAND	−0.91	5	3	4	4	20	1
TANZANIA	0.48	2	0	2	1	47	64
THAILAND	−0.72	5	3	4	3	32	39
UKRAINE	−0.30	5	2	3	4	29	38
VENEZUELA	−0.37	5	3	4	1	37	55
VIETNAM	0.44	2	0	4	1	2	43

Comparative insights: developed vs. developing countries.

- **Elasticity differences:**
  Developed countries exhibit greater variability in demand elasticity, with several nations displaying elastic demand. In contrast, developing countries predominantly show inelastic demand, likely tied to lower income levels and necessity-driven consumption.
- **Policy implications:**
  In developed economies with elastic demand, price adjustments could significantly impact consumption and revenue. For example, price increases in the **USA** or **Australia** may lead to substantial declines in demand. In developing nations, inelastic demand suggests that price changes may have minimal effect on consumption volumes but could impact overall affordability and access.
- **Socio-economic factors:**

The prevalence of inelastic demand in developing countries underscores the importance of stable pricing strategies for essential goods. In contrast, the elastic demand observed in several developed nations highlights the competitive nature of

these markets, where substitutes and discretionary spending influence consumer behavior.

Global findings. The global analysis of Price Elasticity of Demand (PED) reveals the following key trends:

- **Dominance of inelastic demand:**
  Across the 46 countries analyzed, the majority exhibit inelastic demand ($|PED| < 1$). This indicates that for most nations, changes in price have a relatively limited impact on demand, reflecting the essential nature of the goods considered and the limited availability of substitutes.
- **Elastic demand in specific developed economies:**
  A small number of developed nations, including the **USA, Australia, Norway**, and the **Czech Republic**, show elastic demand. This trend highlights competitive markets where consumers are more price-sensitive and substitutes are readily available.
- **Developed vs. developing economies:**
  Developed nations show greater variation in elasticity, with both elastic and inelastic demand present, indicative of mature markets and discretionary spending. Developing nations predominantly exhibit inelastic demand, driven by economic constraints and the necessity-driven nature of consumption.
- **Anomalies and positive elasticities:**
  Positive PED values in countries like **Japan, Saudi Arabia**, and **Egypt** suggest unique market dynamics, such as luxury consumption or cultural factors that influence demand despite price increases.
- **Policy implications:**
  For countries with elastic demand, pricing strategies must consider the high sensitivity of consumers to price changes to avoid significant drops in demand. Conversely, in nations with inelastic demand, price adjustments may generate revenue without severely affecting consumption but could impact affordability.
- **Global perspective:**

The prevalence of inelastic demand globally underscores the stability of consumption for essential goods. Exceptions to this trend in developed nations highlight the role of consumer choice and market competition in shaping demand elasticity for bitcoin.

Authors compilation from triple-A Cryptocurrency Ownership Data, Atlantic Council Cryptocurrency Regulation Tracker (GLOBAL INNOVATION INDEX 2023; Innovation in the Face of Uncertainty, 2023)

Correlation analysis results.

- **Legality and regulations:**
  As seen in Table 3 most countries have a high score (5) in legality and regulations, reflecting stringent regulatory frameworks. The exceptions are countries like Saudi Arabia (2), Egypt (2), and China (2), where regulations are either restrictive or less developed, impacting the elasticity as seen in Saudi Arabia's positive PED of 0.28.
- **Taxation:**
  Taxation scores are uniformly moderate to high across the board (2 to 4) as seen in Table 3, indicating that taxation policies are well-established in most of the countries, which might influence demand elasticity indirectly by affecting the overall cost of using Bitcoin.
- **AML/CFT and consumer protection:**
  The results in Table 3 shows that higher scores (4) in AML/CFT and consumer protection are seen in developed countries, ensuring safer and more regulated environments for cryptocurrency transactions. This could correlate with the negative PED in these regions, as better consumer protection might lead to more cautious and price-sensitive consumers.
  Developing countries have varied scores in AML/CFT and consumer protection, with some countries like Venezuela (1) and Nigeria (1) scoring lower, potentially leading to less price sensitivity.
- **Crypto adoption rank:**
  High crypto adoption ranks (closer to 1) in countries like the USA (3) and South Korea (7) correspond to negative PED values, indicating that higher adoption rates might be associated with more elastic demand due to competitive markets and better infrastructure as seen in Table 3. In contrast, lower adoption ranks in countries like Venezuela (37) and Nigeria (1) might reflect niche markets where demand is less sensitive to price changes.
- **Technological advancement rank:**

Technological advancement plays a crucial role in influencing the PED. Countries with high tech ranks like the USA (2) and Switzerland (1) have negative PED, suggesting that advanced technology facilitates easier access and usage, leading to more price-sensitive demand.

Conversely, countries with lower tech ranks, such as Tanzania (64) and Nigeria (62), exhibit more inelastic demand, possibly due to technological barriers limiting market responsiveness to price changes.

The data underscores significant differences between developed and developing countries in terms of how Bitcoin's price changes affect demand. In developed countries, well-established regulatory frameworks, higher consumer protection, and technological infrastructure contribute to higher elasticity, making consumers more responsive to price changes. In developing nations, despite varying regulatory environments and tech advancement levels, the demand tends to be more inelastic in some cases, reflecting either a lack of alternatives or the perception of Bitcoin as a hedge against unstable local currencies.

This disparity suggests that for effective policy-making and market predictions, it's crucial to consider the local context, including regulatory stance, technological capability, and consumer behavior patterns. Such nuanced understanding could help in tailoring strategies for both promoting crypto adoption and ensuring market stability. Table 4 shows that technology boosts crypto adoption, but heavy regulation tends to reduce it, and regulatory restrictions increase the price sensitivity of demand. In contrast, tech advancement decreases it.

The scatter plot shown in Fig. 2 indicates a moderate positive correlation (Spearman's rank coefficient: 0.4109, p value: 0.0046) between a country's crypto adoption rank and its technological

Table 4 Results of correlation analysis.

Description	Correlation coefficient	*P* Value
Crypto adoption and tech advancement	0.4109	0.0046
Crypto adoption and legality	−0.2748	0.0003
Crypto adoption and taxation	−0.2623	0.0000
Crypto adoption and AML/CFT	−0.1978	0.0002
Crypto adoption and consumer protection	−0.1548	0.0001
PED and legality	−0.5854	0.0000
PED and taxation	−0.5326	0.0001
PED and AML/CFT	−0.2712	0.0683
PED and consumer protection	−0.6726	0.0000
PED and crypto adoption	0.0884	0.5592
PED and tech advancement	0.5586	0.0001

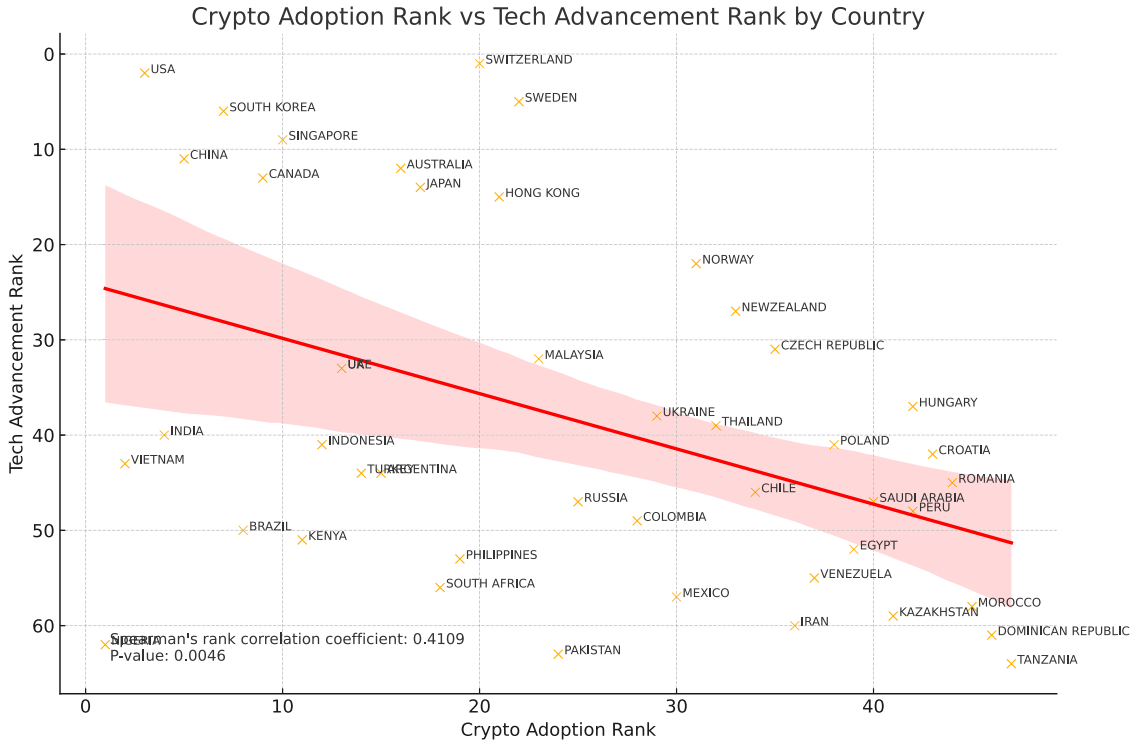

Fig. 2 Correlation of crypto adoption rank and technology advancement rank. Scatter plot showing a positive correlation between technological infrastructure and the extent of crypto adoption across countries.

advancement rank. This indicates that countries with higher technological advancement tend to have higher crypto adoption rates. Top performers like the USA, Switzerland, South Korea, and China excel in both areas, leveraging advanced infrastructure to boost crypto growth. Conversely, underperformers such as Saudi Arabia, Chile, and Hungary exhibit notable crypto adoption but lag in technological advancement, suggesting that limited tech infrastructure or economic factors may hinder further integration.

Figure 3 shows a negative correlation between crypto adoption and regulatory factors: legality (−0.2748), taxation (−0.2623), AML/CFT (−0.1978), and consumer protection (−0.1548). Countries with stronger legality, taxation, AML/CFT, and consumer protection measures tend to have lower crypto adoption rates. Higher regulations create barriers, discouraging crypto use through legal, tax, and compliance challenges. Conversely, lower tax burdens and lenient regulations promote greater adoption, highlighting the trade-off between regulation and growth in crypto markets.

The heatmap illustrates the correlation coefficients between the Price Elasticity of Demand (PED) for Bitcoin and various factors, such as legality, taxation, Anti-Money Laundering/Countering the Financing of Terrorism (AML/CFT) regulations, consumer protection, crypto adoption rank, and technological advancement rank across different countries as seen in Fig. 4. Here is a breakdown of the key findings from this heatmap:

- **PED and legality (−0.59)**: There is a moderate negative correlation between PED and the legality of Bitcoin, indicating that stricter legal environments may correspond to lower price elasticity of demand.
- **PED and taxation (−0.53)**: Similarly, there is a moderate negative correlation between PED and taxation policies, suggesting that higher taxation on Bitcoin could reduce its demand elasticity.
- **PED and AML/CFT (−0.27)**: A weak negative correlation is observed between PED and AML/CFT regulations. This indicates that while these regulations have an effect, it is not as strong as legality or taxation.
- **PED and consumer protection (−0.67)**: The strongest negative correlation in the heatmap is between PED and consumer protection, implying that better consumer protection policies significantly reduce the price elasticity of demand for Bitcoin.
- **PED and crypto adoption rank (0.088)**: There is a very weak positive correlation between PED and the rank of crypto adoption. This indicates that countries with higher adoption rates might have slightly higher PED, but the correlation is not substantial.
- **PED and tech advancement rank (0.56)**: A moderate positive correlation exists between PED and technological advancement, suggesting that more technologically advanced countries might experience higher price elasticity of demand for Bitcoin.

The findings suggest that regulatory factors like legality, taxation, and consumer protection have a notable impact on the price elasticity of demand for Bitcoin, generally reducing it. On the other hand, technological advancement appears to boost PED, indicating that in more technologically advanced environments, the demand for Bitcoin is more sensitive to price changes. The weak correlation with crypto adoption rank suggests that widespread adoption alone does not necessarily make the demand more elastic; other regulatory and technological factors play more significant roles. This analysis is crucial for understanding how various external factors influence Bitcoin's demand dynamics in different countries. It can inform policymakers and businesses about the potential impacts of regulatory changes and technological improvements on the cryptocurrency market.

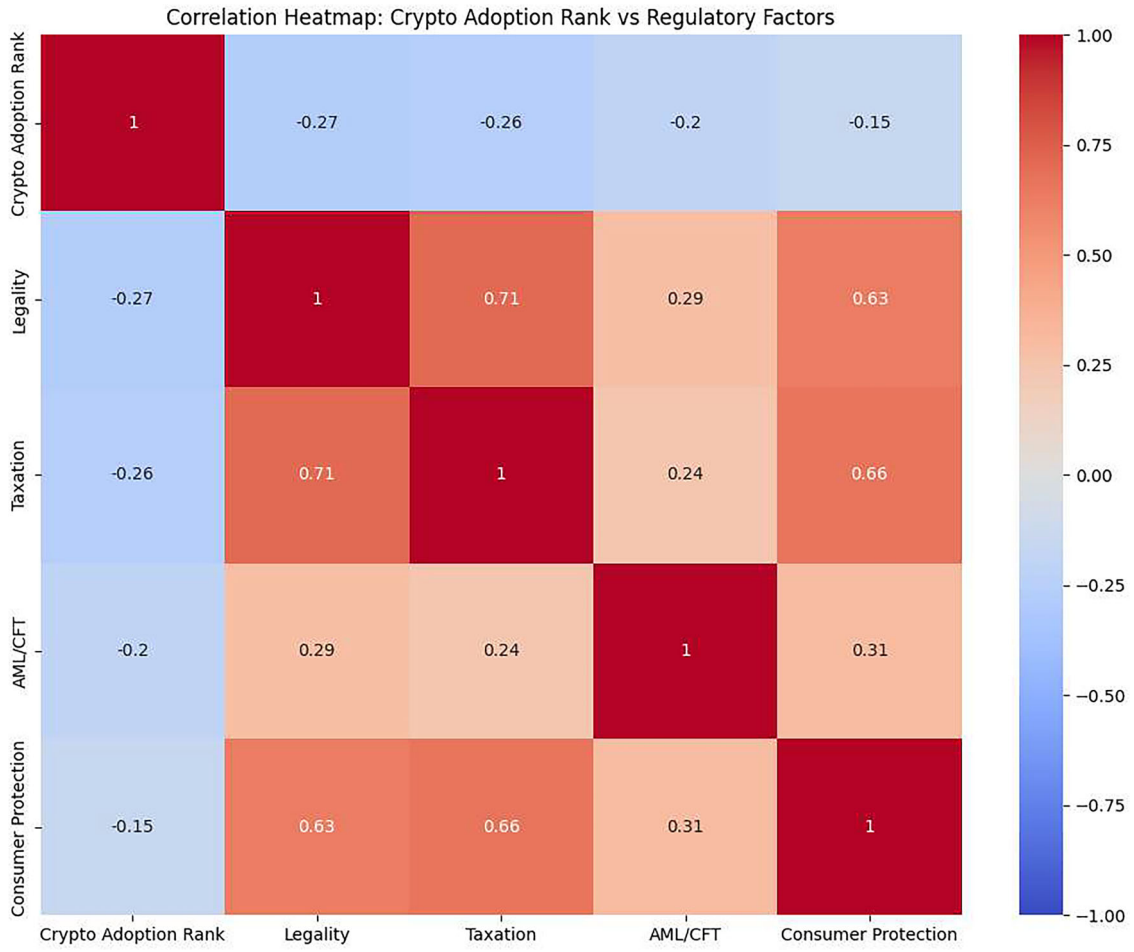

Fig. 3 Correlation heatmap of crypto adoption rank and regulatory factors. Heatmap illustrating negative correlations between crypto adoption rank and regulatory elements such as legality, taxation, AML/CFT, and consumer protection.

Conclusion

This study provides a comprehensive analysis of the price elasticity of demand (PED) for Bitcoin across 46 countries or regions, examining its correlation with regulatory environments, technological advancements, and adoption rankings. The findings reveal substantial differences between developed and developing nations in terms of Bitcoin demand dynamics, with policy, technology, and market factors playing critical roles. The following policy recommendations and practical implications are proposed based on the study's outcomes:

Policy recommendations.

- **Strengthen regulatory frameworks:** Governments should aim to establish clear, consistent, and comprehensive cryptocurrency regulations. Policies that balance security with innovation—such as anti-money laundering (AML) measures, consumer protection frameworks, and fair taxation policies—can enhance public trust while curbing illegal activities. Countries with robust legal environments often exhibit more predictable demand patterns, reducing market volatility.
- **Foster global collaboration:** Cross-border cooperation among regulatory bodies is essential to address the decentralized nature of cryptocurrencies. Harmonizing international standards can mitigate regulatory arbitrage and foster the legitimate use of Bitcoin and other cryptocurrencies. This is especially critical for enhancing compliance with global financial stability norms.
- **Encourage technological investments:** Governments in developing countries should prioritize investments in technological infrastructure, such as blockchain development, internet penetration, and digital payment systems. Enhanced technological readiness can stimulate Bitcoin adoption and increase its utility as a legitimate financial instrument.

Practical implications.

1. **Guidance for policymakers:** The study highlights that regulatory factors such as legality, taxation, and consumer protection strongly influence Bitcoin's PED. Policymakers can use these insights to design frameworks that minimize speculative risks while promoting sustainable growth in cryptocurrency markets. For example, introducing tax incentives for blockchain startups or encouraging financial literacy programs can foster responsible adoption.
2. **Strategic advice for businesses:** Businesses operating in the cryptocurrency ecosystem should consider the varied demand elasticity across regions. For instance, firms in developed countries, where demand is more elastic, should focus on competitive pricing strategies and innovative service offerings. Conversely, in developing nations, where

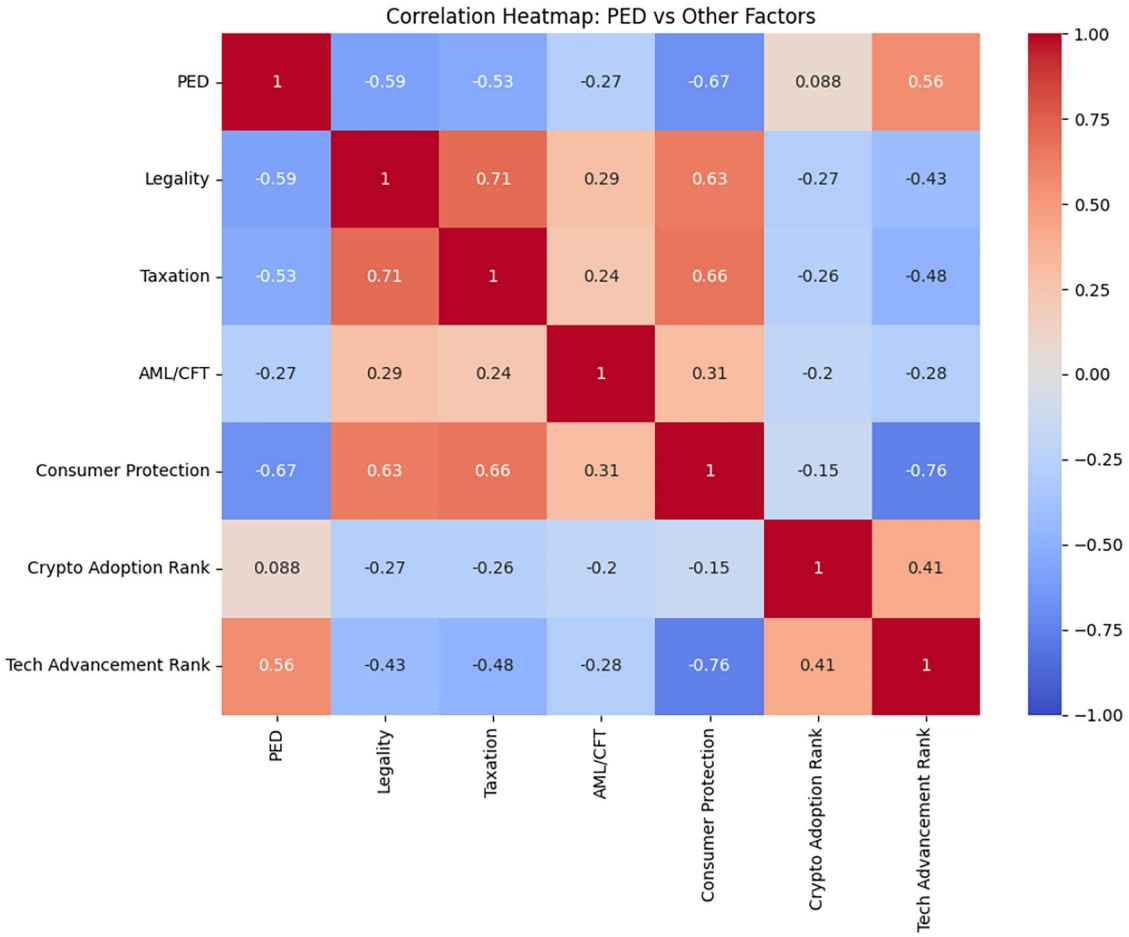

Fig. 4 Correlation heatmap of PED and other factors. Heatmap summarizing the strength and direction of correlation between Price Elasticity of Demand (PED) and multiple external factors, including legality, taxation, AML/CFT, consumer protection, crypto adoption, and technological advancement.

demand is typically inelastic, businesses should emphasize affordability and accessibility.

3. **Insights for investors:** Investors can leverage the findings to identify opportunities and risks associated with Bitcoin markets. In economies with inelastic demand, Bitcoin may serve as a stable hedge against inflation or currency depreciation. On the other hand, in elastic markets, price sensitivity necessitates careful monitoring of market trends and regulatory changes.
4. **Promoting legitimate use of cryptocurrencies:** The study underscores the need to shift the perception of Bitcoin from a speculative asset to a legitimate financial tool. Initiatives such as integrating Bitcoin into mainstream financial services, promoting educational campaigns, and ensuring transparent operations can facilitate this transition.

Future research directions. While this study has focused on Bitcoin, future research could expand the scope to include other cryptocurrencies and explore their unique demand dynamics. Additionally, longitudinal studies examining the evolving impact of emerging technologies and global regulations could offer deeper insights into cryptocurrency adoption trends.

In conclusion, understanding the interplay of economic, regulatory, and technological factors is crucial for shaping the future of cryptocurrency markets. By leveraging these insights, policymakers, businesses, and investors can collectively foster a balanced ecosystem that promotes innovation, ensures market stability, and unlocks the potential of Bitcoin as a transformative financial asset.

Data availability

The datasets analyzed during the current study are available on Coin Dance local bitcoin volume charts: https://coin.dance/volume/localbitcoins and triple-A Cryptocurrency Ownership Data: https://www.triple-a.io/cryptocurrency-ownership-data, Atlantic Council Cryptocurrency Regulation Tracker: https://www.atlanticcouncil.org/programs/geoeconomics-center/cryptoregulationtracker/, and GLOBAL INNOVATION INDEX 2023; Innovation in the Face of Uncertainty, 2023: https://www.wipo.int/web/globalinnovation-index/2023/index.

Received: 12 October 2024; Accepted: 29 May 2025;
Published online: 01 July 2025

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Author contributions

V. Shiva Sankari contributed by retrieving literature, conducting data analysis and writing the paper. R. Kavitha contributed by retrieving literature and participated in its design and coordination.

Competing interests

The authors declare no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

Informed consent was not required as this study did not involve human participants.

Additional information

Correspondence and requests for materials should be addressed to V. Shiva Sankari or R. Kavitha.

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