RESEARCH ARTICLE SUMMARY

BITCOIN

Are cryptocurrencies currencies? Bitcoin as legal tender in El Salvador

Fernando Alvarez*, David Argente*, Diana Van Patten*

INTRODUCTION: The introduction of digital currencies is perhaps the most important development in monetary economics in the past decade. However, a currency's defining role is to serve as a medium of exchange, and cryptocurrencies have yet to be widely adopted as such. This study leverages a unique quasinatural experiment that can shed light on the reasons behind this lack of adoption. El Salvador became the first country to make bitcoin legal tender; not only must bitcoin be accepted as a means of payment for taxes and debts, but also businesses are required to accept bitcoin as a medium of exchange. The government also launched an app called "Chivo Wallet," which allows users to digitally trade both bitcoins and US dollars (USD, the official currency in El Salvador) without paying transaction fees, and provided major adoption incentives such as a large bonus for downloaders. Moreover, the pandemic provided an additional incentive to adopt touchless payments; if bitcoin has a chance to be used as a medium of exchange, then this setting gave the cryptocurrency a prime opportunity. Furthermore, the study of Chivo Wallet, a digital currency backed by a central bank, is informative to the debate surrounding central bank digital currencies (CBDCs).

RATIONALE: We conducted a nationally representative face-to-face survey involving 1800 households in El Salvador and complemented its results with an analysis using all transactions identified as involving Chivo Wallet leveraging data from the blockchain. We explored whether Chivo Wallet and bitcoin were adopted after the government's "Big Push," what factors deterred adoption by individuals and firms, and what insights can be obtained from blockchain data. We also analyzed the broader lessons learned from this example.

RESULTS: We found that bitcoin was not widely used as a medium of exchange and usage of Chivo Wallet was low. Most downloads took place just as the app was launched. Since then, adoption and remittances using Chivo Wallet have been decreasing over time. These results suggest that it is unlikely that the usage of bitcoin and Chivo Wallet will increase. Privacy and transparency concerns appear to be key barriers to adoption. We also documented that this technology involves a large initial adoption cost, has benefits that significantly increase as more people use it, and faces resistance from firms in terms of its adoption. These findings are relevant for countries studying the viability of CBDCs and of crypto as a currency. Further, our survey sheds light on how it is the already wealthy and banked who use crypto, which stands in stark contrast with recurrent hypotheses claiming that the use of crypto may particularly help the poor and unbanked. An analysis relying on all blockchain transaction–level data from Chivo allowed us to validate and better understand our survey results and provided new insights on the dynamics of the use of Chivo Wallet.

CONCLUSION: Despite bitcoin's legal tender status and the large incentives to promote Chivo Wallet in El Salvador, the cryptocurrency was not adopted at large as a medium of exchange, and digital payments were scarce and concentrated. These findings are informative about the intrinsic value of cryptocurrencies as means of payments and about the scope of CBDCs in developing countries. ■

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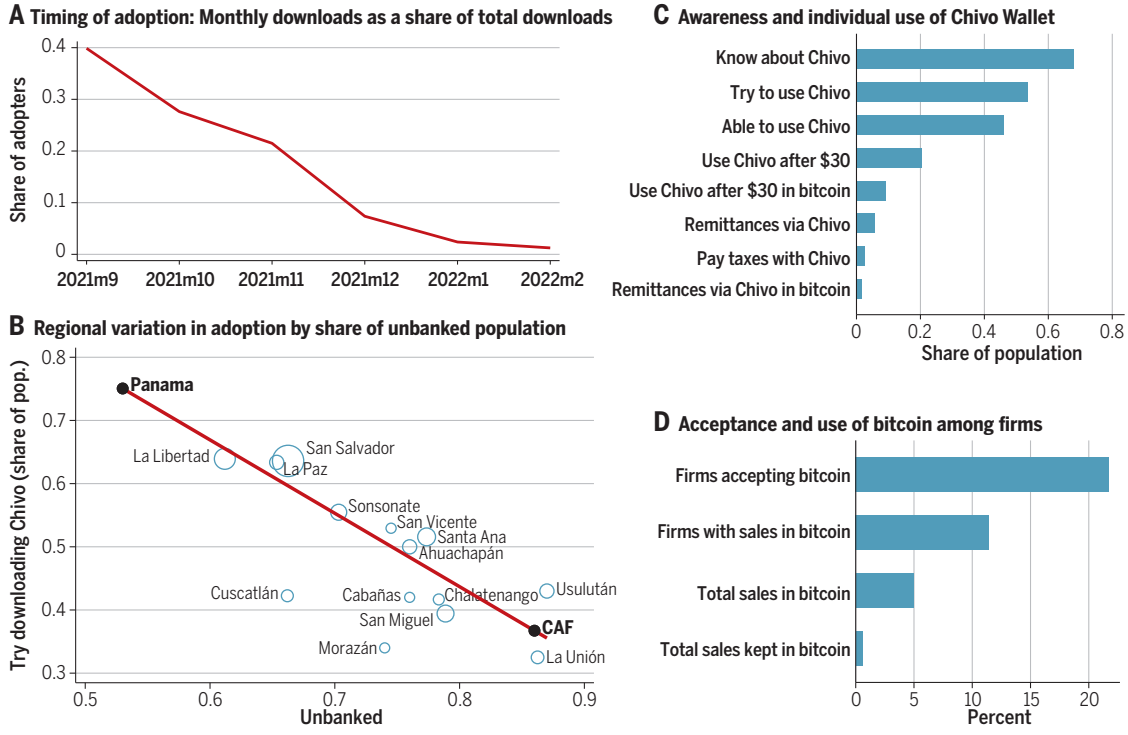

Adoption of Chivo Wallet in El Salvador. (**A**) Dynamics of Chivo Wallet downloads and (**B**) regional variations in adoption across El Salvadoran regions by shares of unbanked. (**C** and **D**) Summary of the survey's results on adoption by individuals and firms, respectively.

RESEARCH ARTICLE

BITCOIN

Are cryptocurrencies currencies? Bitcoin as legal tender in El Salvador

Fernando Alvarez[1]*, David Argente[2]*, Diana Van Patten[2]*

A currency's essential feature is to be a medium of exchange. This study explores the potential of cryptocurrencies to be used in daily transactions in El Salvador, the first country to make bitcoin legal tender. The government's "big push" introduced "Chivo Wallet," a digital wallet sharing features with Central Bank Digital Currencies (CBDCs), with perks to use it for trading bitcoins and US dollars. Through a nationally representative, face-to-face survey of 1800 households and blockchain data encompassing all Chivo Wallet transactions, we document a pattern of low and decreasing usage of digital payments and bitcoin. Privacy and security concerns are key adoption barriers, which speaks to a policy debate on crypto and CBDCs with anonymity at its core. Additionally, we estimate Chivo Wallet's adoption cost and complementarities among adopters.

In its first form money is simply any commodity … which any person will readily receive, and which, therefore, every person desires to have by him in greater or less quantity, in order that he may have the means of procuring necessaries of life at any time.
– William Stanley Jevons

The introduction of digital currencies in general, and of cryptocurrencies in particular, is perhaps the most important development in monetary economics in the past decade. Cryptocurrencies such as bitcoin differ markedly from traditional banks. Bitcoin relies on cryptography for security and operates on a decentralized network with verifiable transactions, contrasting with centralized banks governed by regulations. For the unbanked and those reliant on remittances, bitcoin presents a potential solution by enabling financial transactions, bridging the gap left by traditional banking systems. However, a currency's key and defining role is to serve as a medium of exchange (*1*, *2*), and cryptocurrencies have yet to be widely adopted for this purpose (*3*).

This study leverages a unique quasinatural experiment that can shed light on the reasons behind bitcoin's lack of adoption. On 7 September 2021, El Salvador became the first country to make bitcoin legal tender through the "Bitcoin Law." A legal tender refers to a form of payment that is recognized by law as valid for settling financial obligations within a particular jurisdiction. According to the Bitcoin Law, not only must bitcoin be accepted as a means of payment for taxes and outstanding debts, but also all businesses are required to accept bitcoin as a medium of exchange for all transactions (*4*). The Salvadoran government also launched an app called "Chivo Wallet," a custodial wallet app that allows users to digitally trade both bitcoins and US dollars (USD) without paying any transaction fees. The government also provided major adoption incentives, such as a large bonus for downloaders that could potentially solve the coordination failure, and also subsidized fees. Moreover, the COVID-19 pandemic provided an additional incentive to adopt touchless payment methods. If bitcoin has a chance to be used in transactions as a medium of exchange, then this setting gave the cryptocurrency a prime opportunity.

Furthermore, central banks are considering alternatives to enter the era of digital payments. Nine of 10 central banks are exploring central bank digital currencies (CBDCs), and more than half are developing them or running concrete experiments (*5*). A retail CBDC, a digital currency backed by a central bank with legal tender status, shares many features with a fast payment system such as Chivo Wallet. Moreover, because Chivo Wallet allows for payments both in bitcoins and in USD, an analysis of its implementation is informative to the debate surrounding CBDCs, and a comparison between bitcoin and USD usage within the app is informative about the use of crypto in particular.

Situating the current study and key contributions

Unique monetary episodes can provide valuable insights into the workings of the economy and inform future policy-making. Sargent's seminal work on hyperinflations is a prime example of this research tradition (*6*). Our study of the Salvadorean experience follows in this tradition by studying an unprecedented monetary experiment in which bitcoin became legal tender and digital currency started being traded through Chivo Wallet. Our examination shows that the designation of bitcoin as legal tender does not imply that it becomes a general medium of exchange as defined by previous work, i.e., an object "which is habitually, and without hesitation, taken by anybody in exchange for any commodity" (*7*). Important references in the literature argue that "acceptability" makes an object more likely to become a medium of exchange and can be influenced by government policies (*2*, *8*, *9*), and that the state can give a currency value by allowing the public to use it to pay taxes (*1*, *10*–*13*). We contribute to this long-standing work by documenting that accepting a digital currency to pay for taxes is not a sufficient condition for it to become widely accepted.

Our work also contributes to the study of cryptocurrencies. Empirically, the literature has focused on the risks faced by individuals (*14*, *15*), arbitrage opportunities and price manipulation (*16*, *17*), bitcoin network participants (*18*, *19*), bitcoin's price fluctuations (*3*, *62*), the determinants of asset pricing (*20*), and developing the notion that bitcoin seems to function more like a speculative investment than a bona fide currency (*3*). Our results provide insights on the characteristics of adopters and the bottlenecks of adoption in a setting where incentives to adopt are high, fees are subsidized, and we have measurable variation in determinants such as income and financial literacy. This study is also related to the growing theoretical literature on cryptocurrencies, which has built models stressing the network effects of its adoption (*18*, *21*, *22*) and the cost of its production (*23*, *24*). Complementary to these studies, our work quantifies the fixed costs of adoption along with the network effects.

Further, through the study of Chivo Wallet payments in USD, we address the literature on CBDCs, in which empirical evidence is scarce (*25*) (*26*). As in the case of Chivo Wallet, recent policy briefs argue that CBDCs should not be bearer instruments (*27*). This is the case, for instance, for China's CBDC (*28*), and is also the case of Chivo Wallet. Moreover, whereas Chivo Wallet is not backed by a central bank, it is backed by the government and is not required to be linked to a bank account, just as would be the case with a CBDC. Our work highlights several challenges to the implementation of CBDCs, such as the role of privacy and transparency concerns, while suggesting there is a role for policies that incentivize adoption given the presence of strong complementarities among adopters. More broadly, our study relates to work on the adoption of payment methods beyond cash (*29*–*32*).

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Research questions

RQ 1: Were Chivo Wallet and bitcoin actually adopted after the government's "big push"?
RQ 2: What factors deterred the adoption of Chivo Wallet and bitcoin by individuals?
RQ 3: What other broader lessons can be drawn from this experiment?
RQ 4: What were the drivers of adoption by firms?
RQ 5: What insights can be obtained from blockchain data?

Methods

The context

El Salvador has been the stage for several monetary experiments. In 2001, the USD became legal tender and the country's only official currency (*33*). Later, on 7 September 2021, El Salvador became the first country to make bitcoin legal tender through the Bitcoin Law. Although there might be many reasons behind the decision, when the policy was announced, the president stated that it would generate jobs, provide financial inclusion, and facilitate sending remittances (*34*). In addition, bitcoin was seen as a mechanism to introduce people into financial services. For context, only one-third of the Salvadorian adult population had a bank account at a financial institution in 2017 (*35*). Moreover, our survey's background questions show that in El Salvador, most transactions are paid in cash; in fact, >50% of people only use cash, >70% of adults are unbanked, and almost 90% of them do not use mobile banking, as reported in fig. S7 (*36*). We found that 64.6% of Salvadorans have access to a mobile phone with internet, a prerequisite to adopt Chivo Wallet (*37*).

The Bitcoin Law

The first article of the Bitcoin Law describes its main objective and endows bitcoin with a legal tender status (*38*). It also makes bitcoin a unit of account within the country and, according to the theory of chartalism, endows it with value by accepting it as a means of payment for tax purposes. The Bitcoin Law also goes beyond the usual provisions of a legal tender, making bitcoin a medium of exchange of mandatory acceptance nationwide. Article 7 reads: "Every economic agent must accept bitcoin as payment when offered to him by whoever acquires a good or service." Another relevant article of the law is related to how bitcoin usage will be implemented in the country. In particular, Article 8 mandates the government to provide the means to conduct transactions using bitcoin. How was the adoption of bitcoin facilitated and promoted by the state? The government's answer was "Chivo Wallet" (*39*).

The Chivo Wallet app

Just as bitcoin became legal tender, the government launched Chivo Wallet and an educational campaign on how to use it. This digital wallet allows users to convert bitcoins into USD and vice versa without a fee and to send or receive either currency (*40*). As shown in fig. S4, payments are made through the application by entering the recipient's identification number or phone number and the payment amount (*41*). The app can also be used to pay at local establishments, is compatible with other bitcoin on-chain and Lightning wallets, and connects with El Salvador's banking system to deposit or withdraw USD from a bank account (*42*). Chivo Wallet can be used by registered Salvadorans even if they reside abroad to facilitate sending remittances potentially faster and at a lower cost than alternative services. Chivo Wallet also has a version intended for firms, which allows them to charge their clients and pay taxes. It does not provide users with the key to their bitcoin, which makes it a "custodial" wallet in which transactions are not anonymous; users are required to enter their personal information after downloading the app, just as in the case of several CBDCs (*27*, *28*).

Adoption incentives

Usage of bitcoin in El Salvador is related to Chivo Wallet's adoption, and as an adoption incentive, citizens who downloaded the app could receive a $30 bitcoin bonus from the government, which is a substantial amount in this Central American country with a GDP per capita of $4131 (*43*). These $30 bonuses were automatically deposited in their wallets; however, the money could not be withdrawn as cash before first being transferred to another Chivo Wallet because the bonus was intended to promote bitcoin usage. As another government incentive, users could get a significant discount on gasoline if they paid using Chivo Wallet (*44*). Moreover, transactions in bitcoin usually involve substantial fees. For instance, bitcoin ATM fees can range from 5% to over 20%, with an average of about 8.5%, and transactions in bitcoin reached a fee of >$60 USD per transaction in April 2021 and an average value of $1.8 USD in February 2022. Transactions in bitcoin and conversions from bitcoins to USD using Chivo Wallet and cash withdrawals at Chivo Wallet ATMs do not incur any fees. This can be interpreted as an additional government subsidy. In El Salvador, payments of public salaries and pensions remain in USD. Allowing for these payments to be in bitcoins could have provided another adoption incentive (*45*).

Bitcoin in other countries

The lack of access to banking services and infrastructure increases the potential of digital payments to promote financial inclusion. Consistent with this, most of the top 20 countries in the 2021 Global Crypto Adoption Index are emerging economies. The Central African Republic (CAF) was the second country, after El Salvador, to make bitcoin legal tender in April 2022, the same month in which Panama approved its own Crypto Law (*46*). High-income countries have not been absent from the crypto stage. For instance, an Arizona senator proposed a bill to make bitcoin legal tender in that state in January 2022 (*47*).

Measures

In the midst of a growing interest to promote digital currencies among monetary authorities, El Salvador offers a rare opportunity to learn about the potential of cryptocurrencies to become a widely used payment method. However, access to data poses a challenge because El Salvador's government reveals only selected information (*48*). To overcome this challenge, we conducted surveys to generate data that would be otherwise unobtainable. This allowed us to measure the adoption of respondents based on their characteristics, focusing not only on downloads but also on usage.

The survey was face-to-face, nationally representative, and spanned 1800 households during February 2022 (*49*), leading to results with a 95% confidence interval and a 1.94% margin of error. Respondents were all >18 years old, as this is a prerequisite to be eligible to use Chivo Wallet. The national survey was conducted in partnership with CID-Gallup (*50*). Interviewers were trained a week in advance to conduct the survey, and we implemented a pilot interviewing 50 people to ensure that survey questions were clear. Our sample validation can be found in table S2; the sample almost exactly matches total population shares in terms of gender, age, districts, and education levels.

The sample is also representative in terms of bank account ownership (*51*). The national-scale and face-to-face nature of the survey posed a challenge compared with an internet or phone survey. However, both features are important in our setting. First, understanding adoption patterns requires a sample that includes small cities and rural areas; focusing on main population centers may bias results. Second, because bitcoin's adoption through Chivo Wallet requires access to both a cell phone and an internet connection, a survey by phone or internet, which relies on respondents having access to either communication method would mechanically underestimate adoption costs. Finally, the face-to-face format of our survey preserves data quality while allowing us to conduct a longer survey with more detailed questions than would be feasible through the phone or internet (*52*). The survey measures sociodemographic variables, knowledge about Chivo Wallet, downloads of the app, and usage both in bitcoins

and USD. We include details on the specific questions in the supplementary materials, section D.

We complement our survey results with an analysis using all transactions identified as involving Chivo Wallet, leveraging data from the blockchain, a distributed public ledger. We not only studied overall volumes transacted through Chivo Wallet, but separately analyzed the patterns of deposits and withdrawals, and identified consistencies between the survey outcomes and the blockchain results.

Results

RQ 1: Were Chivo Wallet and bitcoin actually adopted after the government's "big push"?

Awareness

We found that 68% of potential users knew about the app's existence. Most of those who were aware of the app learned about it through social media, followed by television and radio, news, and friends and family, as summarized by fig. S8. Almost 78% of those who were aware of the app had tried to download it. Most downloads happened just as Chivo Wallet was launched. Figure 1A shows that 40% of all downloads occurred in September 2021 and there were virtually no downloads in 2022. The latter suggests that our survey was already capturing the most relevant share of adopters of this digital wallet.

In terms of heterogeneity, we found that banked, educated, and young men were more likely to know about Chivo Wallet (table S3), as were people who owned a cell phone with internet. Moreover, conditional on knowing about Chivo Wallet, these characteristics also make a person more likely to try to adopt it, as documented in Table 1 (*53*). People with these demographics also tended to download the app on their own without help (table S4). These findings suggest that the introduction of Chivo Wallet mainly provided an additional means of payment among those already banked instead of stimulating more financial inclusion among the unbanked.

Not all users agreed with the widespread use of Chivo Wallet. Individuals who agreed tended to own a mobile phone with internet, and were younger and male. Columns 1 to 3 in table S5 show that people who agreed with the use of Chivo Wallet were 0.3 percentage points more likely to download the app, and columns 4 to 6 show that individuals who were less likely to agree also tended to be those who needed help installing the app.

Reasons to download Chivo Wallet

The key incentive for downloading the app was the $30 bonus, which is equivalent to 0.7% of annual income per capita. Other reasons deemed as the most important were the contactless nature of the payment method in the midst of the pandemic and the potential to receive remittances; fig. S11 summarizes all reasons regarded as most important.

Chivo Wallet usage by households

Most respondents spent their $30 bonus to pay for expenses in bitcoins, and almost 20% of those who downloaded the app had not yet used their bonus (*54*). However, most users did not keep using Chivo Wallet after spending their bonus. Table 2 presents descriptive statistics on Chivo Wallet's usage among those who downloaded it and who reported using the app after spending the bonus. A salient feature of people who downloaded Chivo Wallet and kept using it after spending their bonus is that they were more likely to be young, educated, male, banked, and much more likely (26%) to be using other digital wallets in addition to Chivo Wallet to conduct transfers (*55*). Distance to a Chivo Wallet ATM and facing issues with the app, however, were not good predictors of whether the user remained active, suggesting that these were not the binding barriers to sustain usage (*56*).

More than half of these "active users" had not made a cash withdrawal from a Chivo Wallet ATM, although the mean number of withdrawals was 2.59, given the presence of extreme values in the right tail (*57*). The number of payments and transfers received or sent was also largely driven by very active users in the right tail. Deposits in USD is the only statistic in which users in the 25th percentile have a nonzero value. We can conclude that active Chivo Wallet users transact in USD more than bitcoins, because the average amount of payments and transfers, sent or received, was consistently larger in USD.

Regional variation

Figure 1B shows important regional variation in the probability of downloading Chivo Wallet depending on the share of unbanked population in each department. It also benchmarks the CAF, the second country to make bitcoin legal tender, and Panama, which enacted a crypto law in April 2022, with respect to departments in El Salvador given our estimates and their share of unbanked. Figures S18 and S19 also show regional differences in adoption and

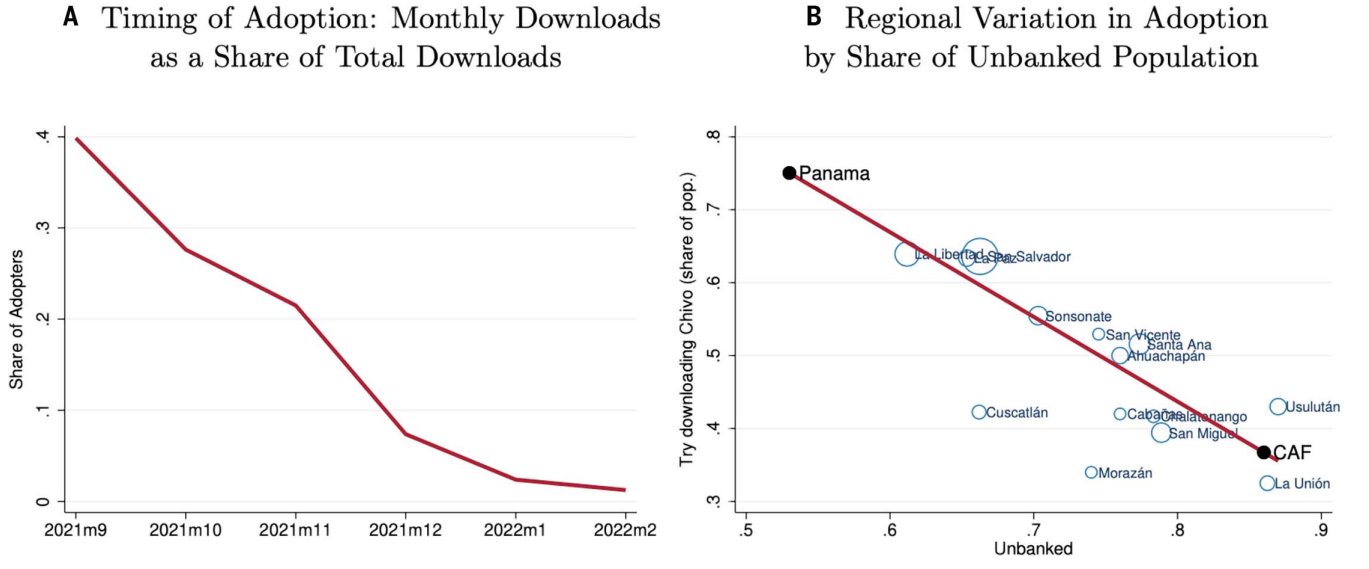

Fig. 1. Chivo Wallet's adoption. (**A**) Timing of adoption: Monthly downloads. (**B**) Regional variation in adoption as a share of total downloads by share of unbanked population. (A) shows the month in which each user in our sample downloaded Chivo Wallet as a share of total downloads. (B) shows the relationship between the share of people who have tried to use Chivo Wallet and the fraction of people who do not have access to a bank account in El Salvador, by department. (B) also includes, for comparison, the shares of unbanked in Panama and the CAF.

Table 1. Adoption of Chivo Wallet. The dependent variable was "have you tried to download Chivo Wallet?"

	(1)	(2)	(3)	(4)
Cell phone with internet	0.1085***			0.0757**
	(0.036)			(0.035)
Unbanked		−0.1132***		−0.0815***
		(0.023)		(0.026)
Years of schooling				
Middle school			0.0849***	0.0676**
			(0.023)	(0.024)
High school+			0.1168***	0.0832**
			(0.029)	(0.036)
Age				
Age 25 to 34			−0.0236	−0.0241*
			(0.014)	(0.013)
Age 35 to 44			−0.0480	−0.0473
			(0.032)	(0.032)
Age 45 to 54			−0.0969*	−0.0888*
			(0.045)	(0.041)
Age 55+			−0.1349***	−0.1238***
			(0.029)	(0.028)
Gender				
Female			−0.0292	−0.0089
			(0.021)	(0.020)
Single			−0.0567**	−0.0528**
			(0.023)	(0.023)
Observations	1224	1224	1224	1224
R^2	0.023	0.019	0.041	0.055
Department	Yes	Yes	Yes	Yes

The sample only includes respondents who knew about the existence of Chivo Wallet. Results in this table rely on a linear probability model. Results are robust to other specifications, in particular, columns (1) and (3) of table S12 show the marginal effects under a logit model. The regression includes department fixed effects, and each of the controls is obtained from survey questions on whether a person owns a financial instrument (unbanked), years of schooling, age, gender, and marital status. Standard errors are clustered by department.

awareness about Chivo Wallet depending both on the average income and the share of unbanked per "department," with departments being similar to counties. Regions with higher levels of development tended to be more active using Chivo Wallet. The share of users who continued using the application after spending the $30 USD bonus in departments such as San Salvador and La Libertad, which have the highest income per capita in the country, was twice as large as in departments with low income per capita, such as Usulután and Chalatenango (*58*). Similarly, departments with a larger share of unbanked population had as little as half the adoption levels as departments in which most of the population had access to banking services.

Along similar lines, assuming that the implementation of a digital wallet is similar in other contexts, our estimates allow us to explore how other features of adoption would manifest in other countries, which could prove valuable to policy makers. Given our estimates, in the CAF, only 37 to 45% of the population would have been aware of the app's existence, 8 to 14% would continue using the app given similar adoption incentives as in El Salvador, and <2% would use the app for remittances. In the case of Panama, income per capita is higher than in El Salvador, as is access to banking services. We estimate that >95% of the adult population in Panama would be aware of the technology, between 30 and 56% would continue using it after spending the adoption incentives, and 10 to 30% would use it for remittances. The last two estimates are cut in half when considering payments in bitcoins in either country.

Role of taxes and remittances

By law, bitcoin can be used to pay taxes. Chartalism implies that endowing a currency with the power to pay taxes gives it value as a means of exchange. However, only 5% of Salvadorans have paid taxes using Chivo Wallet. Moreover, in El Salvador, some households receive >60% of their income from remittances, as summarized in fig. S15. Chivo Wallet is not widely used to receive remittances from abroad; only 3% (8%) of people have received remittances in bitcoins (USD) using the app. This finding aligns with reports from the Central Reserve Bank of El Salvador, which found that only 1.45% of remittances were received through digital wallets in March 2022, and provides external validation to our survey (*59*).

RQ 2: What factors deterred the adoption of Chivo Wallet and bitcoin by individuals?

Chivo Wallet adoption deterrents

More than 21% of respondents knew about Chivo Wallet but did not try to download it. The reasons not to download it are summarized in fig. S13A. The most important reason was that users preferred to use cash. The second most relevant reason not to download Chivo Wallet were trust issues: Respondents did not trust the system or bitcoin itself (*60*). Privacy and security are at the heart of the debate around CBDCs and bitcoin. Concerns regarding lack of anonymity and secure transactions could then explain, at least partially, the main two reasons not to download the app, because cash is an anonymous payment method (*61*). The next most frequent reason mentioned was not owning a phone with internet, followed by the technology being complicated. In sixth place, Salvadorans mentioned technical difficulties using the app; fig. S14 summarizes the main reported problems.

Bitcoin adoption deterrents

Figure S13B reports the main reasons why individuals do not use bitcoin. For >50% of respondents, the main reason not to use bitcoin was that they did not understand it nor trust it. Although the volatility of bitcoin has potential as a deterrent (*62*), trust and transparency seem to be more salient than uncertainty, because bitcoin's volatility was mentioned by <10% of respondents. If volatility were the main deterrent from using Chivo Wallet, then we should then see people downloading the app and transacting in USD, which are very stable; however, this was not the case, as explained in the previous paragraph.

Taking stock

Figure 2A summarizes results from our first two research questions. We documented that more than two-thirds of Salvadorans were aware that Chivo Wallet exists. However, not all of those who knew about the app have tried to download it; just over half of all respondents did so. The main reason not to download Chivo Wallet was that individuals prefer to pay in cash, followed by mistrust; these motifs may be related to privacy concerns. The main reason that they downloaded the app was to use the $30 bonus offered by the government, but less than half of those who were able to download Chivo Wallet, 20% of adult citizens, continued to use it after spending the bonus and they mostly used it to transact in USD, not in bitcoins.

Table 2. Descriptive statistics: Active Chivo Wallet users.

	(1) Mean	(2) SD	(3) 10th	(4) 25th	(5) Median	(6) 75th	(7) 90th
ATM withdrawals	2.5	8.7	0	0	0	2	4
Average amount of ATM withdrawals (in USD)	54.9	65.6	10	20	30	60	120
Payments/transfers sent in bitcoins	2.3	7.8	0	0	0	2	5
Payments/transfers sent in USD	9.2	24.8	0	0	1	5	20
Average amount of payments/transfers sent in bitcoin (in USD)	32.5	38.2	3	10	20	42.5	80
Average amount of payments/transfers sent in dollars (in USD)	39.6	47.1	7	12	20	50	100
Payments/transfers received in bitcoins	2.1	7	0	0	0	1	4
Payments/transfers received in USD	6.2	18	0	0	0	2	15
Average amount of payments/transfers received in bitcoin (in USD)	51.3	77	2	10	25	55	100
Average amount of payments/transfers received in dollars (in USD)	55.3	78.9	5	15	30	70	120
Deposits in bitcoins	1.31	3.9	0	0	0	1	2.5
Deposits in USD	4.4	13.8	0	0	1	2	10

The table shows distribution of responses to the questions: (i) How many times per month do you withdraw money from Chivo Wallet ATMs?; (ii) What is the average amount of your ATM withdrawals?; (iii) How many payments or transfers do you perform per month using Chivo Wallet in bitcoins or in USD?; (iv) What is the average amount of your payments or transfers in bitcoins or in USD?; (v) How many payments or transfers did you receive per month using Chivo Wallet in bitcoins or in USD?; (vi) What is the average amount of your payments or transfers you received in bitcoins or in USD?; and (vii) How many times have you deposited money to your Chivo Wallet in bitcoins or in USD? We divided the number of deposits by the months a person was active in Chivo Wallet to convert them to a monthly variable and rounded the values to the closest integer. The sample includes those who kept using Chivo Wallet after spending their $30 bonus (20.6% of respondents). We dropped observations above the 99th percentile to avoid extreme outliers.

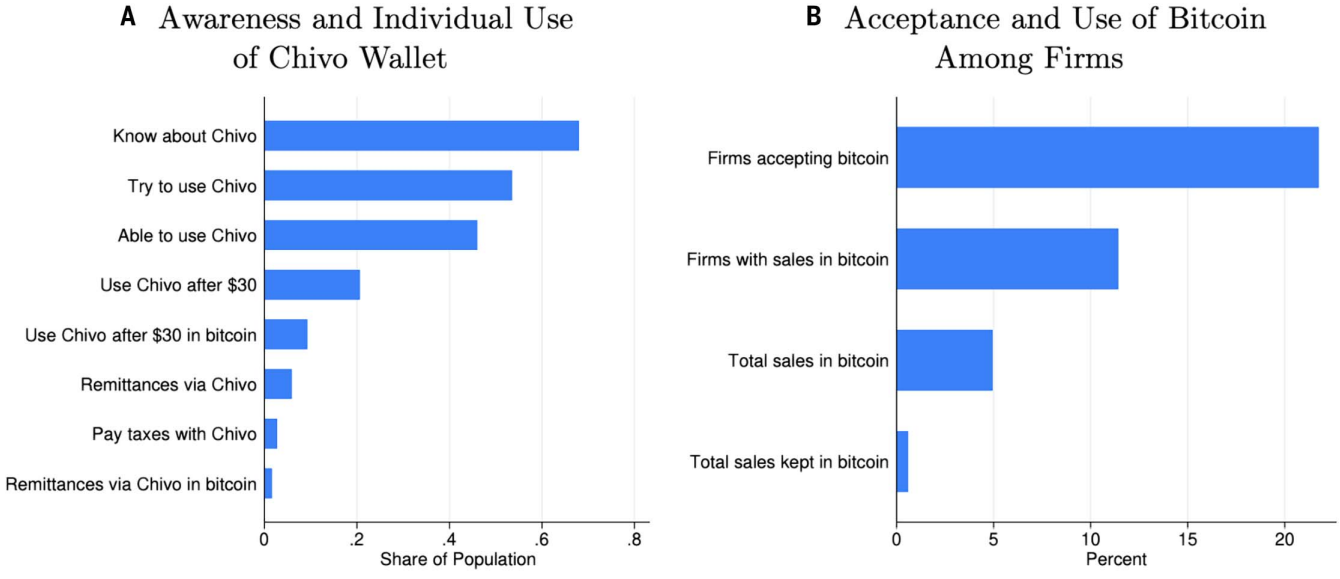

Fig. 2. Taking stock. (**A**) Awareness and individual use. (**B**) Acceptance and use of bitcoin with Chivo Wallet among firms. (A) shows shares with respect to the entire sample, so it is subject to a 1.94% margin of error. In (B), the top two bars show percentages with respect to all surveyed owners and employees who knew about payment methods at the firm. The bottom two bars show percentages with respect to total sales.

Moreover, most individuals who used Chivo Wallet after spending the bonus did not engage with the app intensively; the median user reported no ATM withdrawals and no payments, sent or received, in bitcoin in a given month. To put this in perspective, the median number of daily transactions per person across means of payments was between 1.3 and 1.4 in several countries (*63*), and Chivo Wallet's developer indicates that there are 0.001 to 0.003 daily transactions per adult (*64*). Further, we did not find evidence of Chivo Wallet being used to pay for taxes or to send remittances at a substantial scale. Figure S20 replicates Fig. 2A for the share of the banked and unbanked population, respectively.

Overall, we have documented that bitcoin is not being widely used as a medium of exchange and that Chivo Wallet's usage is low in El Salvador. The latter stands despite the "big push" exerted by the government, which involved endowing bitcoin with legal tender status through the Bitcoin Law, the $30 bonus, gas discounts, and no fees, and despite the pandemic's incentive to use touchless payment methods.

RQ 3: What other broader lessons can be drawn from this experiment?

Complementarities

For some technologies, the benefit of adopting increases as more people adopt (*65*). Arguably, such complementarities, also called network externalities, are an inherent feature of digital payment methods and give a potential role for policy to improve allocations (*66*). Thus, we can draw broad lessons applicable to other payment technologies from the analysis of Chivo Wallet. We found evidence of complementarities, both in the decision to adopt the app and on how intensively people used it, as reported in the supplementary materials, section C.

Adoption and variable costs

We leveraged the familiarity with the $30 introductory bonus and asked two questions to estimate the distribution of (self-reported)

adoption costs. The first question was: "How large does the bonus need to be to convince you to download Chivo Wallet?," which was directed to people who had not downloaded the app, but knew about it (14.5% of respondents). The second question was: "What is the minimum bonus that would have convinced you to download Chivo Wallet?," which was directed to people who had downloaded the app (53.5% of respondents). Table S7 displays our results. Although the mean reported value was $30, the median user would have accepted $20 USD, and there were people in the 10th percentile who would have adopted it even without a bonus. The adoption cost was larger for individuals with certain demographics: Unbanked respondents reported $6.9 USD higher cost than those who were banked, people without a cellphone with internet reported a $8.6 USD higher cost than those with one, it was $2.9 USD costlier for households with only elementary education to adopt compared with those with education beyond elementary, and finally, women reported a $8.9 USD higher cost than men.

Chivo Wallet allows users to withdraw cash from Chivo Wallet ATMs and convert bitcoin into USD without a fee. However, outside of Chivo Wallet, most providers charge significant fees. Table S8 shows the maximum reported willingness to pay to withdraw $100 USD at a Chivo Wallet ATM was $3.3 USD on average. This amount is less than half of the mean fee to purchase cash at bitcoin ATMs outside of El Salvador. Moreover, the median respondent was willing to pay only $1 USD. These findings suggest that Chivo Wallet users would not engage in cash withdrawals if they faced nonsubsidized fees. Table S8 also reports that the average willingness to pay to convert bitcoins into USD was $2.9 USD, and the median user would be willing to pay only $0.05 USD. These amounts are much smaller than any transaction cost of exchanges, indicating that Chivo Wallet would not be used in the absence of the subsidies.

Impact on usage of other payment methods

If users adopt Chivo Wallet, then they might substitute it for other payment methods such as cash and cards. We found some evidence consistent with this substitution. We documented that 10% of users who downloaded Chivo Wallet decreased their use of cash and 11% reduced their use of debit cards (*67*). The government also offered a discount of ~8% per gallon for gas purchases with Chivo Wallet, which allowed us to measure the elasticity of substitution, which measures how easily people switch between Chivo Wallet and other payment methods, as detailed in the supplementary materials, section C. Although the sample size is small, the estimated elasticities of substitution are positive and large, which suggests that the welfare costs of policies disincentivizing other payment methods (such as cash) are lower if digital payments are available.

RQ 4: What were the drivers of adoption by firms?

The Bitcoin Law states that all economic agents must accept bitcoin, but this does not necessarily translate into all firms effectively doing so (*68*). To study the extent to which firms accepted bitcoin, we relied on a subset of respondents who identified themselves as owners of firms or as employees who knew about the payment methods accepted by their employer, who then answered a series of questions about their business. Results are summarized in Fig. 2B.

First, we documented that whereas almost all firms accepted cash, slightly over 20% accepted bitcoin (*69*). Among those that did accept bitcoin, 75% started accepting it just as the law was enacted. Only 11.4% of firms had positive sales in bitcoin. This estimate aligns with results from two independent surveys targeting firms of all sizes and across sectors (*70*). Further, our survey indicates that 81% of firms accepting bitcoin have not seen a change in their sales since starting to accept it, and whereas the median firm made no sales in bitcoin, 4.9% of all sales were paid in bitcoin through Chivo Wallet, mainly to large firms. These estimates align with those by two independent local surveys (*71*).

Second, we documented that firms accepting bitcoin were mostly large and in the fifth quintile of the firm size distribution (*72*). These large firms were also more likely to accept cards. Third, most firms reporting sales in bitcoin converted them into USD: 71% converted sales into USD and then withdrew them as cash, 17% converted sales into USD and kept them in Chivo Wallet, and only 12% of firms stored their sales in bitcoin within Chivo Wallet. Finally, we found that 11% of firms have increased prices since bitcoin became legal tender, which is consistent with the hypothesis that firms might be transferring costs related to the cryptocurrency (e.g., volatility) to customers (*73*).

RQ 5: What insights can be obtained from blockchain data?

So far, our conclusions discussed have been drawn from the survey data that we collected. This section leverages that all bitcoin transactions are recorded on the blockchain, a distributed public ledger, to analyze Chivo Wallet's activity based on actual transaction data. This exercise allowed us to validate and better understand our survey results. The analysis using transaction-level data for all of Chivo Wallet's transactions on the blockchain also provides new insights into how bitcoin transactions are carried out in El Salvador and by whom. Data sources are detailed in the supplementary materials, section E.

It is important to understand which Chivo Wallet transactions would surface in the blockchain and which ones would not. As of today, verifying a bitcoin transaction on the blockchain is both costly and takes several hours (*74*). Given this constraint, many wallets that use bitcoin for relatively small payments do not verify all transactions on the blockchain. Instead, they are custodial wallets and rely on a clearing house. Chivo Wallet is no exception; therefore, transactions from one Chivo Wallet to another one, in general, would not register on the blockchain. Transactions between different addresses owned by Chivo Wallet as an entity do appear on the blockchain, and we label them as internal transactions (*75*). Transactions from Chivo Wallet to external crypto wallets also surface in the public ledger. These would include, for example, payments from tourists visiting El Salvador and paying in bitcoin from their foreign wallets.

According to our data, as of 3 November 2022, Chivo Wallet was associated with 142,148 addresses, which were involved in 425,514 transactions and a total of 3,424 bitcoins deposited into Chivo Wallet. These are all the transactions that can be identified as involving Chivo Wallet either as a buyer or a seller of bitcoin. Figure 3 summarizes some of the observed dynamics. As shown in Fig. 3A, the total transactions in bitcoins, expressed in USD, reached their peak between October and December 2021 and decreased significantly thereafter. The latter is consistent with the results of our survey, which document high activity within the first months of Chivo Wallet's operation and a sharp decrease thereafter.

Figure 3A shows all activity, whereas Fig. 3B considers only external transactions and decomposes them as total deposits into and withdrawals from Chivo Wallet (*76*). First, the co-movement between both types of external transactions was substantial. Second, an analysis of the average size of each type of transaction, reported in fig. S24, shows that deposits were composed by many small and relatively frequent transactions; for example, these could be transactions from tourists visiting El Salvador to use bitcoin or residents from El Salvador who had bitcoin in other wallets (*77*). Their active behavior resembles the one by the right tail of Chivo Wallet users who were extremely active, as documented in table S6. The magnitude of inflows of bitcoin in the survey and on the blockchain data also align. According to our survey, between $221,000 and $334,000 USD flowed into Chivo Wallet per day, whereas according to blockchain data, this amount was ~$245,000 USD per day (*78*). Third, a joint analysis of Fig. 3B and fig. S24 shows that withdrawals (i.e., sales of bitcoin by Chivo Wallet) tended to be large and happen rarely, and in synchrony, with the pace of accumulated deposits. This pattern suggests that withdrawals

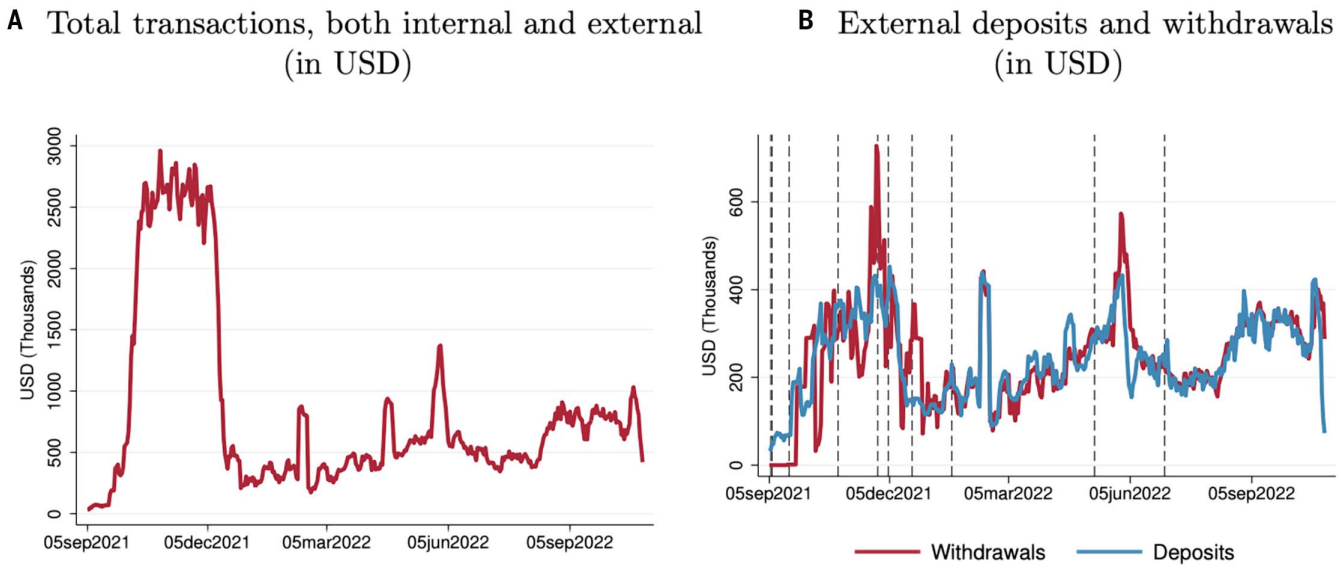

Fig. 3. Chivo Wallet's blockchain transactions. (**A**) Total transactions, both internal and external. (**B**) External deposits and withdrawals (in USD). (A) shows the total number of transactions in Chivo Wallet, including internal transactions and external withdrawals and deposits in USD. We converted bitcoin's value into USD because otherwise the patterns would also reflect bitcoin's price changes, which were substantial in this period. (B) shows the dynamics of external withdrawals and deposits. The vertical dashed lines date moments when El Salvador's government announced a bitcoin purchase.

occured as part of Chivo Wallet's bitcoin inventory management, such that Chivo Wallet accumulated balances of bitcoin to lower the transaction cost of selling them. This behavior is consistent with the almost zero net accumulation of bitcoin within the wallet shown in fig. S25. This behavior resembles the one displayed by firms in El Salvador, which tended to convert all of the bitcoin they received into USD almost immediately. Finally, the data verify that trading volumes in Chivo Wallet are uncorrelated with bitcoin prices; thus, Chivo Wallet trading volumes seem to be driven by idiosyncratic reasons rather than by bitcoin market prices; section E of the supplementary materials provides more details on this relationship.

Discussion

Following the tradition of studying unique monetary episodes to inform policymaking, our analysis of the Salvadorean experience with bitcoin as legal tender offers valuable insights into the complexities of the adoption of cryptocurrencies as a medium of exchange and the implementation of CBDCs. El Salvador's government provided a "big push" to incentivize the use of digital payments and bitcoin, including a large sign-up bonus and subsidized fees. Bitcoin is not only endowed with legal tender status, allowing the currency to be used to pay taxes and debts, but also must be accepted by any economic agent by law. Monetary theories such as chartalism suggest that these conditions should be sufficient for bitcoin to become a medium of exchange.

However, our results show that, despite all incentives and the enhanced attractiveness of contactless payments in the midst of the pandemic, bitcoin is being not widely used as a medium of exchange and usage of Chivo Wallet is low. Most downloads took place just as Chivo Wallet was launched. Since then, adoption and levels of remittances through Chivo Wallet have been decreasing over time. These results suggest that it is unlikely that usage of bitcoin and Chivo Wallet will increase. Our empirical results challenge the implications of chartalism.

Privacy and transparency concerns appear to be key barriers to adoption; unexpectedly, these are the two concerns that decentralized currencies such as crypto aim to address. Moreover, we document that this payment technology involves a large initial adoption cost, has benefits that significantly increase as more people use it (i.e., complementarities), and faces resistance from firms in terms of its adoption. Our findings lay out the challenges faced by digital payments and cryptocurrencies to become widely accepted, and are relevant for countries studying the viability of CBDCs and of crypto as a currency. Moreover, our survey work using a representative sample sheds light on how it is the already wealthy and banked who use crypto, which stands in stark contrast with recurrent hypotheses claiming that the use of crypto may help the poor and unbanked the most.

There is substantial heterogeneity across demographic groups in the likelihood of adopting and using bitcoin as a means of payment. The reasons that young, educated men are more likely to use bitcoin for transactions remain an open question. One hypothesis is that this group has higher financial literacy. We found that, even conditional on access to financial services and education, young men were still more likely to use bitcoin. However, financial literacy encompasses several other areas of knowledge that are not captured by these controls. An alternative hypothesis is that young, educated men have a higher propensity to adopt new technologies in general. The literature on payment methods has documented that young individuals have a greater propensity to adopt means of payment beyond cash, such as cards (*87*). Nevertheless, further research is necessary to causally identify the factors contributing to the observed heterogeneity across demographic groups. An analysis relying on all blockchain transaction-level data from Chivo Wallet allowed us to validate and better understand our survey results and is a unique opportunity to provide new insights on the dynamics of Chivo Wallet's activity. The latter is valuable because the app is a unique exchange in that it can also be used as means of payment by law.

Furthermore, the results carry policy implications for other countries. A study of this experience is informative in drawing broader lessons on the likelihood of success of CBDCs and cryptocurrencies in contexts outside of El Salvador. Assuming that the implementation of a digital wallet is similar in other contexts, our estimates allow us to explore what would be the adoption of the technology in other countries, which can prove valuable to policy makers. Two interesting cases are the CAF, which recently made bitcoin legal tender and has a stable local currency, as well as Panama, which also enacted a Crypto Law and where the USD is the official currency, as in El Salvador. El Salvador falls in between these

countries in terms of both income per capita and access to banking services (*79*). The introduction of a cryptocurrency could lead to outcomes different from the ones we documented in countries where the local currency is unstable and there are restrictions on capital mobility, such as Argentina and Turkey. Thus, an analysis of these contexts may offer fertile ground for future research to explore.

Overall, we conclude that despite bitcoin's legal tender status and the large incentives to promote Chivo Wallet, the cryptocurrency is not adopted at large by the population as a medium of exchange and digital payments are scarce and concentrated. These findings are informative about the intrinsic value of cryptocurrencies as means of payments, as viewed in the larger context of monetary models in economics and about the scope of CBDCs in developing countries.

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33. The former currency is no longer circulated; therefore, prices, accounts, and transactions were converted into USD (*85*).
34. For instance, in terms of job generation, as a way to encourage investments from bitcoin entrepreneurs, the government offered permanent residency to anyone who spends three bitcoin in the country and explained that, since bitcoin is legal tender, foreigners would not have to pay capital gains tax in El Salvador on profits made if bitcoin's value goes up. Moreover, remittances make up 22% of El Salvador's GDP, and bitcoin could potentially be a channel to send these remittances while paying lower fees.
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36. More details on financial inclusion in El Salvador are provided in table S1.
37. We collected data on access to a cell phone with internet ourselves, because information on cell phone and internet access was only available for each one separately in household surveys. Fig. S9 and Fig. 10 provide details on these measures separately and other demographics relying on survey data.
38. Article 1 reads: "The purpose of this law is to regulate bitcoin as unrestricted legal tender with liberating power, unlimited in any transaction, and to any title that public or private natural or legal persons require carrying out."
39. In El Salvador, "chivo" is a slang term meaning "cool."
40. El Salvador established a trust fund, which is known to have a limit of $150 million, to allow for the automatic conversion of bitcoin into USD without fees. Official details on the trust fund or Salvadoran bitcoin purchases have not been disclosed. Hitherto, the only sources of information have been the president's Twitter posts, which indicate that the country had acquired approximately ,800 bitcoin as of April 2022.
41. Users can withdraw USD from their wallet either by doing a transfer from their bank account or by withdrawing cash from a Chivo Wallet ATM without a fee. As of September 2021, there were 200 Chivo Wallet ATMs in El Salvador (see figs. S5 and S6), and 51 in the US. Similarly, users can load money into their wallets through an official website using a credit or debit card or with cash through Chivo Wallet ATMs. Although funds remain in Chivo Wallet, they represent a claim to either USD or bitcoins, which is not uncommon in payment platforms. In other words, both USD and bitcoins are a parallel digital asset with a fixed exchange rate. In Chivo Wallet, the price of bitcoin is adjusted in real time to its market price. For instance, a customer could pay a firm or another user the USD price of an item in bitcoins, and the app would use the real-time exchange rate to charge her.
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43. World Bank, "GDP per capita (current US$)" (2020); https://data.worldbank.org/indicator/NY.GDP.PCAP.CD.
44. Major gas stations dropped the gallon price by $0.20 for customers who paid with Chivo Wallet between September and October, and another drop of $0.30 per gallon was announced in November.
45. For instance, during the 2001–2002 Argentinean crisis, several provinces introduced low- denomination bonds ("quasi money") and used them to pay wages and other inputs (*86*). It is worth noting that El Salvador is relatively small and is therefore a bitcoin price-taker; indeed, fig. S3 shows there were no large changes in the (global) price of bitcoin after the Bitcoin Law or Chivo Wallet's launching. Thus, the experiment speaks about whether bitcoin is used as a means of payment given the above-described incentives despite the fact that it has a given resale value.
46. Panama and CAF are benchmarked against regions in El Salvador in Fig. 1B.
47. Bill SB 1341 was introduced by state Sen. Wendy Rogers.
48. Most information comes from the president's Twitter account. We tried, unsuccessfully, to contact multiple government entities, including Chivo Wallet customer service, El Salvador's Superintendency of the Financial System, Central Bank, and Casa Presidencial, to receive more quantitative information.
49. In terms of the timing of the survey, information was collected across several weeks always including weekends; weekends were important in reaching a representative sample of profiles.
50. CID-Gallup has been conducting surveys in Latin America for >40 years. It has an office in El Salvador that periodically conducts large-scale surveys.
51. Total population shares match the General Directorate of Statistics and Censuses' 2021 projections.
52. Approximate survey length was 27 min. To obtain candid responses, respondents were guaranteed confidentiality and notified that the survey aimed to inform academic research.
53. Table 1 relies on a linear probability model. Results are robust to other specifications, in particular, columns (1) and (3) of table S12 show the marginal effects under a logit model.
54. According to Chivo Wallet's regulations, users must spend their bonus in bitcoins to incentivize its usage. Some people found ways to circumvent this restriction; for instance, sending the bonus to a family member and asking her to withdraw the money from a Chivo Wallet ATM.
55. These findings regarding the prominence of young adoption is consistent with (*87*).
56. Table S6 shows no evidence of technical issues with the app being a concern by constructing a dummy equal to one if the user faced problems using the app.
57. Figs. S5 and S6 show Chivo Wallet ATM locations. Fig. S12 displays mean distances to a Chivo Wallet ATM across population shares.
58. In general, extending income adoption relations requires caution, as countries with higher income, such as Panama, may have higher adoption of digital payments (e.g., card or mobile) and, thus, lower incentives to adopt a Chivo Wallet type of service (*88*). However, the adoption of digital payments in Panama was similar to that in El Salvador; in Panama, 13.3% of people over 15 years of age report having borrowed from a financial institution or used a credit card, whereas 11.5% is the corresponding percentage in El Salvador. Moreover, in both countries, 6.5% of people over 15 years of age have made a payment using their mobile phone or internet according to the World Bank's G20 Financial Inclusion Indicators.
59. Fig. S2 reports official monthly data on remittances in bitcoins, and fig. S17 summarizes our results.

60. Mistrust is also the main reason not to agree with the use of Chivo Wallet (fig. S16).
61. Note that, in the US, apps to trade bitcoin are required to gather information on the identity of the trader, so bitcoin is not associated with anonymity in the US, just as in El Salvador's case.
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67. More details are reported in fig. S21.
68. Businesses that refuse to accept bitcoin are operating in violation of local regulations and exposed to sanctions under the Consumer Protection Law; our survey points to enforcement on firm adoption being imperfect.
69. The share that accepts cards is only a little over 25%. Even among firms that accept bitcoin, prices were quoted in USD and the Chivo Wallet app provided real-time bitcoin equivalents.
70. First, a survey ran by the Salvadoran Foundation for Economic and Social Development (FU- SADES) toward the end of 2021 indicates that 10% of businesses have made sales in bitcoin ("Institutional Position N.106," FUSADES, December 2021). Second, the Chamber of Commerce and Industry of El Salvador (Camarasal) conducted a survey in February 2022 reporting that 13.9% of businesses have made sales in bitcoin ("First Business Survey 2022," Camarasal, March 2022).
71. The Chamber of Commerce and Industry of El Salvador reports a similar estimate of firms that have not changed their sales, and (91.7%) the Salvadoran Foundation for Economic and Social Development estimates that the share of sales paid in bitcoin is between 1 and 5%.
72. Table S9 shows results robust to controlling for the sector of the firm. Findings are very similar if only including responses from the firm's owner or from an employee who reports to work in sales.
73. Fig. S22 shows (i) a summary of the results on prices from the consumer's perspective (21% have encountered higher prices at some businesses) and (ii) the full distribution of shares of sales in bitcoin across firms. Fig. S23 summarizes findings on firms.
74. Although it can be verified faster, this extra speed incurs an additional cost.
75. Although one entity can own several addresses, these are not transactions between Chivo Wallets owned by individuals.
76. Thus, this figure considers transactions that involve an address that can be identified as Chivo Wallet and another address.
77. The fees paid for these deposits tended to be higher closer to Chivo Wallet's launch (see fig. S26), which would be consistent with more urgency from bitcoiners trying to pay for goods and services when Chivo Wallet's hype was at its peak. Throughout the period, fees for deposits into Chivo Wallet tended to be higher than those paid for withdrawals, which also points to more urgency on the deposits' front compared with withdrawals. The data indicate that Chivo Wallet mostly transacted with well-known exchanges; the main one being Binance (12% of all the volume transacted), followed by Bitso, OKX, and Coinbase.
78. Flows from the blockchain data have a standard deviation of 184,300. To calculate these flows using our survey, we focused on inflows of bitcoin into Chivo Wallet from other wallets, because these are the transactions recorded on the blockchain. Thus, our population of interest consists of individuals who have deposited bitcoin into Chivo Wallet and have transferred bitcoins to wallets other than Chivo Wallet, ~2% of the adult population of El Salvador. For this sample, we computed total deposits per day as the difference between the total amount sent per day and the total amount received per day in the app, including transactions in both USD and bitcoins, because convertibility across currencies is free within the app. To estimate the total deposits in bitcoins per day, we multiplied total deposits times the share of deposits in bitcoins (17.3%).
79. The CAF has an income per capita of ~$418 USD and Panama of approximately $12,172 USD, and as in El Salvador, the alternative to bitcoin is a stable currency. Approximately 13.7% of the population in the CAF has access to a bank account, whereas in Panama this number is ~46.5% (Fig. 1B).
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SUPPLEMENTARY MATERIALS

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Supplementary Text
Figs. S1 to S27
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References (*93*–*96*)

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