Regulation, Tax, and Cryptocurrency Pricing*

by

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Abstract

This paper examines whether and how jurisdictional gaps in crypto regulations explain the price differentials of the same underlying cryptocurrency across different jurisdictions. Variations in the regulatory framework and specific crypto policies, including tax treatment, anti–money laundering laws, and enforcement, have significant incremental explanatory power for the cross-jurisdiction disparity in Bitcoin prices. Utilizing staggered adoptions of specific cryptocurrency policies, we identify the influence of regulation on crypto pricing using both the difference-in-differences design and the regulatory event study methodology. The evidence highlights the importance of regulatory certainty and tax policies for the development of a digital economy and addresses the controversy surrounding the proposed crypto tax provision in the U.S. infrastructure bill.

Keywords: cryptocurrency; regulation; tax; law of one price; blockchain; Bitcoin

I. Introduction

The cryptocurrency market has emerged as a potentially important nontraditional financial market that uses blockchain technology to enable the creation of decentralized digital assets. A cryptocurrency (or crypto coin) is a digital asset designed to work as a medium of exchange using cryptography to secure transactions, to control the creation of additional value units, and to verify the transfer of assets (Härdle, Harvey, and Reule 2020). During the period from July 2019 to June 2020, the total global value of cryptocurrencies sent and received on-chain was $340 billion (Chainalysis 2020). Cryptocurrencies represented an overall market capitalization of about $2 trillion in August 2021 with participation from both institutional and retail investors (Ossinger 2021). Recent developments demonstrate that cryptocurrencies have made some successful moves toward mainstream adoption. Survey evidence suggests that, out of 800 institutional investors in North America and Western Europe, 36% of institutional investors are currently investing in digital assets and 60% believe that crypto assets have a place in their portfolio (Fidelity Investment Survey 2020). Coinbase, one of the largest crypto exchange platforms, alone has 2.8 million monthly users and 7,000 institutional users and supports trading in 45 different cryptocurrencies (Coinbase 2021). The number of cryptocurrency users has increased from 5 million in 2016 to 101 million in the third quarter of 2020 globally (Blandin et al. 2020).

Despite the exponential growth and institutionalization of cryptocurrency transactions, an important feature of the cryptocurrency market is the absence of formal regulation or oversight of the creation and trading of crypto coins and of the issuance of crypto tokens for financing of growth opportunities. Lack of regulatory certainty and the absence of regulation substantially increase risks for individuals as well as businesses who want to participate in this market as investors, customers, or service providers. The lack of regulation in crypto markets, however, increases the ability of privacy-seeking market participants to remain anonymous and provides opportunities for illicit activities such as money laundering.

Another feature of the cryptocurrency market is that trading occurs 24 hours a day, 7 days a week, and can occur in multiple countries and on various crypto exchanges. Unlike equities that trade on a centralized exchange, cryptocurrencies operate on a decentralized basis (Yermack 2017). A stock that trades on the

New York Stock Exchange, for example, has the same price quote at a given time no matter where investors purchase the stock. However, the same cryptocurrency can have different prices quoted across various countries and exchanges at the same time. For instance, Makarov and Schoar (2020) document that the daily average price of Bitcoin in the Republic of Korea was 15% higher than that in the United States from December 2017 to February 2018. This large price differential implies a minimum of $2 billion of *potential* arbitrage profit for the corresponding period.[3] Makarov and Schoar (2020) suggest that cross-border capital flow controls discourage or increase the cost of moving cryptocurrencies from one country to another, which further limits arbitrage. Capital controls and limits to arbitrage in cryptocurrency trading result in mildly segmented crypto markets and therefore the price could deviate from the law of one price (e.g., Errunza and Losq 1985).

This study is interested in whether and how jurisdictional gaps in certain forms of crypto regulation, conceptually another type of friction, affect cross-jurisdictional variation in cryptocurrency prices. Regulatory uncertainty and lack of regulation have received mixed responses from market participants. For instance, nearly half of survey respondents rank regulatory uncertainty as a top barrier to crypto adoption, while a quarter of professional investors cite *lack of regulation* as an appealing aspect of cryptocurrency as an asset class. As cryptocurrencies largely serve as a medium of exchange for *cross-border* transactions, jurisdictional gaps in regulation are likely to create critical cross-border challenges and give rise to regulatory arbitrage (Financial Stability Board 2019; Poster 2019). For instance, market participants could move from jurisdictions with stronger domestic anti–money laundering (AML) and consumer and investor protection laws to countries and regions with less stringent regulations.

Because no global regulatory framework on cryptocurrency has yet emerged, we take the first exploratory step of *systematically characterizing* crypto regulations across different jurisdictions. Given mixed responses from market participants on the regulatory landscape, we differentiate between regulatory

[3] Makarov and Schoar (2020) indicate that transaction costs and the technology risk of cryptocurrencies cannot completely explain the price differential. For instance, on leading exchanges, Bitcoin commonly trades with a $0.01 spread on an approximately $4,000 price quote with significant volume (Bitwise Asset Management 2019).

uncertainty and the receptiveness to cryptocurrencies of specific polices in the classification. Regulatory uncertainty is high (low) if regulators have (not) clearly communicated their position on whether cryptocurrencies satisfy the criteria to be classified as money. The question of what function cryptocurrencies perform is the most fundamental question in the regulatory framework, and regulators' answers to this question underscore some major differences in crypto-related policies across jurisdictions, such as the applicability of AML laws to crypto exchanges and the tax treatment of crypto transactions. The legal standing of cryptocurrencies defines and sets the appropriate *legal* framework. The legal status of cryptocurrencies varies significantly among countries: cryptocurrencies are legal in most jurisdictions, but several jurisdictions have imposed full or partial bans on cryptocurrencies. An effective crypto regulation should strike a balance between fostering innovation and protecting investors and consumers by putting safeguards in place. We gauge the receptiveness of crypto regulation in four dimensions: (1) the tax treatment of cryptocurrencies, including the income tax and value-added tax (VAT) treatment of the creation, exchange, and holding of cryptocurrencies; (2) exchange-based regulation, especially the applicability of AML and counter-terrorism financing (CTF) laws to cryptocurrency exchanges; and (3) enforcement actions against violations of crypto-based regulations; and (4) anonymity in crypto accounts and crypto trading.

Specifically, this study examines whether and how jurisdictional gaps in both the regulatory framework and specific crypto polices provide significant explanatory power for the variation in cryptocurrency prices across jurisdictions incremental to capital controls and economic fundamentals. To examine the research question, we use for the empirical analysis the daily prices of Bitcoin, the dominant cryptocurrency, obtained from eighteen exchanges whose servers are located in twelve countries during the period from January 2017 to December 2020.[4]

[4] We choose the location of the server rather than the location of an exchange's operations because an exchange operates in multiple countries by marketing its services to investors in those countries, but its server is located in a single country or region.

For the baseline analysis, we find that the crypto-related regulation along with capital controls and economic fundamentals explain about 59% of the cross-jurisdiction variation in daily Bitcoin prices for the corresponding period, which is about 32% increase from that of the benchmark model without regulatory variables. The incremental explanatory power of jurisdictional gaps in the regulatory framework is 12.3%, and the incremental explanatory power of jurisdictional gaps in specific dimensions of crypto policies and enforcement ranges from 14.1% to 14.7%, respectively. The signs of the association between crypto-related regulation and Bitcoin prices are consistent with economic explanations. Specifically, after controlling for economic activity, inflation, stock market returns, capital controls, and damages from hacks on exchanges, Bitcoin prices (denominated in U.S. dollars) are higher in jurisdictions with a clearly communicated regulatory position on whether cryptocurrencies satisfy the criteria of money and jurisdictions that impose some restrictions on cryptocurrencies. The positive association suggests that regulatory uncertainty substantially impairs the ease of doing business and increases regulatory risks for individuals and institutions who want to participate in the crypto market either as investors and customers or as service providers, which lowers the price of cryptocurrencies.

Furthermore, for specific crypto policies, Bitcoin prices are lower in jurisdictions that impose heavier income tax burdens on crypto transactions and that apply AML/CTF laws directly to crypto exchanges. The finding is consistent with interpretations that investors and consumers price in the tax burdens of crypto transactions and that the applicability of AML/CTF laws and the associated registration and reporting requirements triggers a decline in Bitcoin demand for illicit activities. Given the significant increase in the incremental explanatory power of the income tax treatment of cryptocurrencies, we break down income tax burdens into tax burdens on the creation of cryptocurrencies and tax burdens on the exchanges of cryptocurrencies and find that each of the two components is negatively associated with Bitcoin prices in the cross section. Furthermore, as we further break down income tax burdens on exchanges of cryptocurrencies, we find that the Bitcoin price decreases with the number of taxable exchanges and decreases with the range of its applicability with respect to personal (occasional) and business (habitual) exchanges.

To mitigate concerns about omitted correlated variables at the jurisdiction level, we take advantage of the rapidly changing regulatory landscape on the crypto market. Specifically, following Bertrand, Duflo, and Mullainathan (2004) and Armstrong, Balakrishnan, and Cohen (2012), we exploit the staggered adoption of specific cryptocurrency policies and use a difference-in-differences design to identify the pricing effect of crypto-related regulation. The results from the difference-in-differences design are consistent with the baseline cross-jurisdictional results for daily Bitcoin prices, which helps identify the effect of regulation on Bitcoin prices. As an alternative way to identify the effect of regulation on cryptocurrency prices, we also use regulatory event study methodology (e.g., Schipper and Thompson 1983; Binder 1985). Specifically, we identify the economic impact of regulatory updates by examining the changes in cryptocurrency prices in countries or regions that have material changes in cryptocurrency policies. We find that the event-day return for Bitcoin is consistent with the expected sign and is statistically significant. Both the difference-in-differences and the regulatory event study analyses provide corroborating evidence that jurisdictional gaps in crypto regulation influence cross-jurisdictional variations in cryptocurrency prices.

Jurisdictional gaps in crypto regulation influence the relative demand and supply of crypto-based activities and could result in varied crypto prices across jurisdictions. The Bitcoin price captures the equilibrium derived from the demand and supply sides, and the explanatory power of regulation and tax for cross-jurisdictional variation in Bitcoin prices could come either from the demand side or from the supply side or both sides. In the supplemental analysis, we use Bitcoins purchased with domestic currencies through online platforms as a proxy for investor demand for investment or speculation purposes and use the number of business entities that either have a cryptocurrency ATM or offer crypto as an in-store payment method as a measure of supply of goods and services with a cryptocurrency solution. The supplemental analyses suggest that clarity in the regulatory framework and the receptiveness of tax-related and exchange-based regulations and enforcement indeed explain a significant portion of the cross-

jurisdictional variation in both investor demand for Bitcoin and the supply of goods and services by businesses that offer a cryptocurrency solution.

This study contributes to two strands of literature. It is the first to provide systematic empirical evidence regarding regulation and pricing of cryptocurrencies. Both the cross-country analysis and the difference-in-differences design suggest that jurisdictional gaps in regulatory uncertainty and certain forms of crypto regulation are associated with cross-jurisdictional variation in Bitcoin prices. This study is closely related to and complementary to Makarov and Schoar (2020), who find a significant positive relation between the correlation of arbitrage spreads (relative to the world market prices) and capital controls. This study finds the complementary evidence that regulatory technologies provide significant explanatory power for the cross-jurisdiction price differentials of the same underlying cryptocurrency incremental to liquidity and capital controls. Broadly, this study contributes to the literature on the influence of laws and regulation on finance (e.g., La Porta et al. 1998) and the literature on deviations from one price in different markets (e.g., Rosenthal and Young 1990; Froot and Dabora 1999). For its practical implications, the association between jurisdictional gaps in crypto regulation and cross-jurisdictional variation in Bitcoin prices provides some rationale for a harmonized approach toward crypto regulation. [5]

Second, this study contributes to the understanding of crypto taxation by systematically characterizing various dimensions of tax-related regulation. Despite the lack of comprehensive guidance or a framework for the tax treatment of crypto transactions, this study takes a deep dive into each country's income tax and VAT treatment of cryptocurrencies and finds that consumers and investors price in the income tax burdens of crypto transactions. Specifically, ceteris paribus, Bitcoin prices are lower in countries and regions that impose heavier income tax burdens on both the creation and exchanges of cryptocurrencies. Furthermore, the Bitcoin price decreases with the number of taxable exchanges and decreases with the range of its applicability with respect to personal (occasional) and business (habitual) exchanges. The evidence

[5] Valdis Dombrovskis, European Union (EU) Commissioner for Financial Services Policy, expressed serious concern that the absence of an EU-wide regulatory framework on cryptocurrency created critical cross-border challenges and gave rise to regulatory arbitrage, both of which threatened the viability of crypto asset activities in the region (Poster 2019).

highlights the importance of tax policy for crypto pricing, and thus, the demand and supply side of crypto-based activities. The importance of tax policies provides timely guidance for the evolving legislative process for cryptocurrencies that is currently under way in many countries and regions. For instance, it speaks directly to the controversy surrounding the crypto tax provision in the infrastructure bill in the United States.

Third, this study contributes to the debate on crypto regulation. This study systematically characterizes both uncertainty in the regulatory framework and the receptiveness of tax-related and exchange-based regulations and enforcement. Despite the widespread discourse that cryptocurrencies can function without institutional backing and are intrinsically borderless, this study provides the first set of empirical evidence that regulatory uncertainty impairs the ease of doing business and increases regulatory risks for individuals and institutions who want to participate in the crypto market. The evidence also highlights the importance of regulatory certainty and provides timely policy guidance for those countries and regions that aspire to lead the way toward a more developed crypto economy or to becoming hubs for blockchain-enabled innovations. With respect to the ongoing crypto legislation process, this study provides timely support for the proposed Digital Asset Market Structure and Investor Protection Act in the United States, which seeks to address regulatory clarity and the bolstering of tax data collection for reporting purposes.[6]

II. Background on cryptocurrencies, related literature, and hypothesis development

A crypto asset is "a digital representation of value that can be digitally traded or transferred and used for payment or investment purposes" (Financial Action Task Force 2019). The two most common blockchain-based crypto assets are cryptocurrencies (also known as crypto coins) and crypto tokens. The biggest difference between the two is that cryptocurrencies have their own blockchains, whereas crypto tokens are created as part of a platform that is built on an existing blockchain. A cryptocurrency is issued directly by the blockchain protocol on which it runs and is the currency native to the specific blockchain.

[6] The U.S. Congress has introduced eighteen bills on cryptocurrencies and blockchain in 2021 alone (Brett 2021).

Therefore, cryptocurrencies (crypto coins) like Bitcoin have their own blockchain and can be used as a medium of exchange, store of value, or for speculative investments as an alternative to fiat currencies. Crypto tokens, on the other hand, are units of value that blockchain-based organizations or projects develop on top of existing blockchain networks. Crypto tokens like DAI and COMP use an existing blockchain, such as Ethereum, to enable customers to access some current or future products or services (classifying them as utility tokens) or to enable investors to generate a financial return by providing certain rights or ownership similar to securities (potentially classifying them as security tokens).[7] Another major difference is that, unlike crypto tokens, which are issued through an initial coin offering (ICO) to raise capital, cryptocurrencies such as Bitcoin are not issued through an ICO, and, therefore, have never been classified as security tokens by regulators. Based on their economic functions, regulators and researchers classify crypto assets broadly into three main categories: payment tokens, utility tokens, and security tokens (Global Digital Finance 2019; European Banking Authority 2019).[8]

This study focuses on crypto coins, and Bitcoin in particular. The economic value of crypto assets depends on both type and use. Accordingly, the economic value of Bitcoin reflects its use as a medium of exchange, store of value, and as a vehicle of investment and speculation. Valuation of Bitcoin, not collateralized or linked to physical assets, is particularly challenging. The valuation of Bitcoin as a medium of exchange assumes that there is at least some baseline value to cryptocurrencies relative to traditional fiat currencies given, for example, their ability to power microtransactions and decentralized exchange. As a vehicle of investment, with the basic notion that price is where demand meets supply, speculation that Bitcoin will become more widely adopted also implies an increase in the price of Bitcoin because the supply of Bitcoin is limited by design. Like fiat currencies, payment tokens gain or lose value based on the laws of supply and demand. Greater demand and lower supply increase value, while lower demand and greater supply decrease value.

[7] An example of utility token is the Golem token (GNT) and an example of security token is INX.
[8] An emerging category of crypto assets is the nonfungible token (NFT).

There is an emerging literature on cryptocurrencies. For instance, Easley, O'Hara, and Basu (2019) and Cong, He, and Li (2020) study Bitcoin mining and the incentives for mining. Unlike equities that trade on a central exchange, cryptocurrencies like Bitcoin operate on a decentralized basis (Yermack 2017). A stock that trades on the New York Stock Exchange has the same price no matter where the stock is purchased. However, the same underlying cryptocurrency can have different prices quoted across various countries and their exchanges at the same time (e.g., Makarov and Schoar 2020). Makarov and Schoar (2020) examine co-movement of arbitrage spreads relative to world market prices and find a significant positive relation between the correlation of arbitrage spreads and capital controls.[9]

An important feature of the cryptocurrency market is the absence of formal regulation or oversight of the creation and trading of crypto coins. The absence of regulation substantially increases the risks for individuals who want to participate in this market either as investors or as customers. The lack of regulation in crypto markets, however, increases the ability of privacy-seeking market participants to remain anonymous and provides opportunities to engage in illicit activities such as money laundering. Regulatory uncertainty and lack of regulation have received mixed responses from market participants. For instance, 48% of survey respondents rank *regulatory uncertainty* as a top barrier to crypto adoption (PwC 2018), whereas 25% of professional investors cite *lack of regulation* as an appealing aspect of cryptocurrency as an asset class (Fidelity 2020). Therefore, this study is interested in whether and how certain forms of crypto regulation, conceptually another type of friction, affect cross-sectional variation in cryptocurrency prices.

Given the mixed responses from market participants on the regulatory landscape, this study differentiates between regulatory uncertainty and jurisdictional gaps in crypto regulations. Regulatory *uncertainty* substantially impairs the ease of doing business and increases regulatory risks for individuals

[9] There is a significant positive relation between the correlation of arbitrage spreads and capital controls. For a typical Bitcoin exchange, investors deposit assets held by the exchanges (in fiat or crypto currencies) and then start trading. Investors can realize arbitrage profits by buying Bitcoins in regions with a low Bitcoin price, say 10,000 in country *A*, and *immediately* selling in regions with a higher Bitcoin price, say 11,000 in country *B*. However, investors cannot instantly transfer Bitcoins from country *A* to country *B*. By the design of Bitcoin, a trade can take a minimum of one hour to confirm to assure finality of the transaction, during which the opportunity for arbitrage can disappear. This arbitrage trade requires capital in country *A* and generates profits in fiat currency in country *B*. If this profit cannot be repatriated seamlessly from country *B* to country *A*, arbitrage capital can be "stuck" in country *B*.

and institutions who want to participate in this market as service providers, investors, or customers. In addition to regulatory uncertainty, as cryptocurrencies largely serve as a medium of exchange for *cross-border* transactions, jurisdictional gaps in regulation of cryptocurrencies and crypto businesses are likely to create critical cross-border challenges and give rise to regulatory arbitrage (Financial Stability Board 2019; Poster 2019). For instance, some countries shore up their domestic AML and consumer and investor protection laws, whereas others do not. Accordingly, market participants could move from jurisdictions with stronger domestic AML and consumer and investor protection laws to countries and regions with less stringent regulations.

Given that no global regulatory framework on cryptocurrencies has emerged yet, we take the first exploratory step of *systematically characterizing* both uncertainty in the regulatory framework and specific crypto policies across different jurisdictions. A *fundamental* question in the regulatory framework is what function cryptocurrencies perform and whether cryptocurrencies satisfy the formal definition of "virtual money." To satisfy the formal definition of money, cryptocurrencies must meet three criteria, including unit of account, store of value, and medium of exchange. Regulators' answer to this fundamental question underscores some major differences in crypto policies across jurisdictions. If regulators formally define cryptocurrencies as virtual money, entities involved in crypto activities, such as crypto exchanges, are *money transmitters* or money service businesses (MSBs), a status that entails the broad know-your-customer (KYC) compliance obligations common to the banking industry. KYC obligations focus on verifying the identity of customers and sufficiently understanding their backgrounds and risk profiles. Moreover, the tax treatment of cryptocurrencies depends critically on whether regulators define cryptocurrencies as virtual money. Some jurisdictions take a clear stance on this fundamental question. For instance, the Bank of England states explicitly that cryptocurrencies are not virtual money because cryptocurrencies are too volatile to be a good store of value and are not widely accepted as means of exchange. In jurisdictions, such as the Republic of Korea, the regulator's stance is ambiguous. Without a clearly communicated position by regulators on whether cryptocurrencies satisfy the criteria of money, substantial uncertainty remains on the regulatory framework for cryptocurrencies and crypto businesses.

Regulatory uncertainty substantially increases regulatory risks for crypto market participants either as investors or as customers and impairs the ease of doing business for institutions who want to participate in the crypto market as service providers. The increased regulatory risk dampens the demand for cryptocurrencies and the supply of crypto-related services, which is likely to lower the price of cryptocurrencies.

Receptiveness of the regulatory framework manifests itself in the legal status of cryptocurrencies. The legal standing of cryptocurrencies defines and sets the appropriate *legal* framework. The legal status of cryptocurrencies varies significantly among countries. The vast majority of jurisdictions consider crypto-assets and in particular cryptocurrencies to be "legal" to the extent that those jurisdictions do not prohibit the purchase and sale of crypto assets, or their use for the purchase of goods and services. In contrast, several jurisdictions have imposed full or partial bans on cryptocurrencies. For instance, Russia (in 2020) and Saudi Arabia (in 2018) banned the use of cryptocurrencies and any transaction involving cryptocurrencies, whereas China (in 2017) banned commercial cryptocurrency trading platforms and ICOs, and prohibited regulated financial institutions from engaging directly or indirectly in crypto-related activities. The relation between the legal status of cryptocurrencies and crypto adoption is complicated. On the one hand, regulators' negative stance is clear when cryptocurrencies are banned, and therefore, regulatory uncertainty is low in countries where cryptocurrencies are banned fully or partially. On the other hand, most of the restrictions are imposed on crypto exchange platforms and other related service providers, which curb the supply side. This leads to the first hypothesis on the regulatory framework and cryptocurrency pricing:

H1: Ceteris paribus, cryptocurrency prices are lower in countries with higher regulatory uncertainty.

Next, we examine the influence of jurisdictional gaps in certain crypto policies on cryptocurrency prices. An effective crypto regulation should strike a balance between fostering innovation and protecting investors and consumers by putting safeguards in place. We develop hypotheses on how jurisdictional gaps in crypto regulation in *four* broad dimensions explain the cross-country price differentials of the same

underlying cryptocurrency. Jurisdictional gaps in crypto regulation influence the relative demand and supply of crypto-based activities and could result in varied crypto prices across jurisdictions. More receptive regulatory climates are likely to attract more consumers and investors as well as crypto businesses, which increases the value of cryptocurrency as a medium of exchange.

The first dimension is the tax treatment of cryptocurrencies, including the income tax and VAT treatment of the creation, exchange, and holding of cryptocurrencies. Conceptually, the tax treatment of cryptocurrencies flows from the specific definition of cryptocurrency that each country adopts. All countries that have issued a statement on the tax treatment of cryptocurrencies have declared cryptocurrencies to be some form of *property* for tax purposes except Italy and Belgium, which consider cryptocurrencies to be *currency* for tax purposes. Although cryptocurrencies might not fit perfectly into existing asset classes, several major accounting firms propose to classify crypto assets as "intangible assets other than goodwill," instead of creating a new asset class (Smith and Castonguay 2019). Similarly, the International Financial Reporting Interpretations Committee notes that cryptocurrencies meet the definition of an intangible asset under International Financial Reporting Standards (IFRS).

Most tax administrations have not yet created specific and ring-fenced tax regimes to tax the creation, mining, exchange, and storage of cryptocurrencies. Based on its definition of cryptocurrency for tax purposes, each jurisdiction imposes different tax rules on cryptocurrencies and crypto transactions. When cryptocurrency is declared to be a form of property, income from crypto transactions is classified as either capital gains or other income and is taxable in the usual way for that form of income. For instance, in the United States, Internal Revenue Service Notice 2014-21 states that cryptocurrency is a digital representation of value that functions as a medium of exchange but does not have all the attributes of real currency, such as legal tender status. Accordingly, the income tax treatment of crypto transactions distinguishes between two types of transactions in the United States (KPMG 2020). When a transaction represents a sale or an exchange of cryptocurrency for a good or service, it is taxable. However, if the transaction is merely a transfer into another account that the taxpayer controls, such as another wallet or a payment channel, it is

not taxable. Furthermore, the fair market value of crypto received from airdrops or mining activity is also taxable as gross income on the date received.

If market participants consider the tax consequences of cryptocurrency transactions, a tax-friendly climate is likely to attract more market participants. We gauge the favorableness of the income tax treatment and the VAT treatment of crypto transactions by the number of events classified as taxable and by the applicability of taxable events to distinct groups of market participants. In particular, the favorableness of the income tax treatment decreases with the number of income tax burdens on both the creation (mining) and exchanges of cryptocurrencies and decreases with the extent of its applicability. For instance, the income tax treatment of cryptocurrencies is *least favorable* if both the creation and the exchange of cryptocurrencies are subject to income taxes for all market participants, including both businesses and individuals, as in the United States. The income tax treatment is *most favorable* if neither corporations nor individuals are subject to income taxes for any crypto transaction, such as in the Republic of Korea. Similarly, the favorableness of VAT treatment decreases with the number of crypto transactions and service providers that are subject to VAT. Sialm (2009) finds a negative relation between equity valuations and tax rates, which is consistent with the tax capitalization hypothesis that investors in equity securities price in the tax burdens of equity transactions. Accordingly, the tax treatment of crypto transactions is relevant for cryptocurrency pricing if market participants price in the tax burdens of crypto transactions. This leads to the hypothesis on tax treatment and crypto pricing:

H2: Ceteris paribus, less favorable tax treatment of crypto transactions is associated with lower cryptocurrency prices.

It is important to point out that, at this stage, most countries do not regulate the type or use of cryptocurrencies directly, but rather impose regulatory obligations on crypto exchange platforms and other businesses engaged in crypto-asset-based activities. Accordingly, the second dimension is regulatory requirements for cryptocurrency exchanges and other businesses engaged in crypto activities. Exchange-based regulation primarily aims at protecting market integrity, investors, and consumers and fighting illegal activities such as money laundering. The most salient aspect of the jurisdictional gaps in exchange-based

regulation is whether AML and CTF laws apply directly to cryptocurrency exchanges. This aspect of exchange-based regulation is relevant for cryptocurrency pricing if some portion of investors or consumers demand cryptocurrencies for illegal transactions (e.g., Foley, Karlsen, and Putniņš 2019; Härdle, Harvey, and Reule 2020). Cryptocurrency remains appealing for illicit activities, primarily due to its anonymity and the ease with which it allows users to send funds anywhere in the world. The applicability of the AML and CTF rules to cryptocurrencies depends on regulators' answer to the fundamental question of whether or cryptocurrencies are money. If regulators view cryptocurrencies as virtual money, crypto exchanges are money transmitters or MSBs, which are subject to the broad KYC compliance obligations common to the banking industry. Crypto exchanges are thus required to register with regulators and establish AML programs similar to those of traditional financial institutions, including but not limited to KYC obligations, transaction monitoring for suspicious activities, and sanctions screening capabilities. Several countries, including the United States and Singapore, have made it explicit that existing AML/CTF laws apply to cryptocurrency exchanges. Other jurisdictions, such as Japan and Estonia, have made specific legislative changes to bring crypto exchanges under relevant laws. For instance, Japan's Virtual Currency Act imposed registration requirements for exchange platforms and imposed AML laws and additional registration, reporting, and auditing requirements on crypto exchanges. In 2018, EU Directive 2018/843 (AMLD5) amended the Anti-Money Laundering Directive (AMLD) and brought custodian wallet providers and cryptocurrency exchange platforms within the scope of the AMLD effective January 10, 2020. On the other hand, the AML laws are not directly applicable to crypto exchanges in, for example, Malta and Poland.

A less stringent regulatory environment for crypto exchanges, especially a lack of mandatory AML programs, is likely to encourage the use of cryptocurrencies for illicit activities. Foley, Karlsen, and Putniņš (2019) find that approximately one-quarter of Bitcoin users were involved in illegal activities during the period from 2014 to 2017. When a government imposes AML/CTF laws explicitly directed toward crypto exchanges, it dampens the demand for Bitcoins from the *illegal* sector of the economy in the country or region. However, the applicability of AML/CTF laws to crypto exchanges, and the related registration, reporting, and transaction monitoring obligations, improve the overall governance of crypto exchanges and

enhance overall investor (consumer) protection. The enhanced investor (consumer) protection could attract more mainstream adoption of Bitcoin, which is likely to increase the demand for Bitcoin from a broader base of market participants for *legitimate* transactions and investment. The net effect of the applicability of AML/CTF laws to cryptocurrency exchanges on pricing of cryptocurrencies ultimately depends on which effect dominates. This leads to the hypothesis on exchange-based AML/CTF laws and crypto pricing:

H3: Ceteris paribus, cryptocurrency prices vary with the applicability of AML laws to crypto exchanges.

The third dimension is the enforcement of crypto-related regulation. Consistent with the characterization of existing crypto regulations, we classify all enforcement actions broadly as either exchange-based enforcement or tax-related enforcement.[10] As Makoto Sakuma, a research fellow at NLI Research Institute said, "Until the security of asset flows on cryptocurrency exchanges can be guaranteed, the market can't be trusted" (Reuters 2018). Hacks on crypto exchanges and misuse and appropriation of customer funds will likely cause concerns over cybersecurity and exchange governance among consumers and investors, potentially pressuring the price of cryptocurrencies. The Financial Service Agency (FSA) in Japan took a series of enforcement actions against crypto exchanges in 2018. The FSA investigated all cryptocurrency exchanges in the country for security gaps, ordered Coincheck to raise its cybersecurity standards after a hack of $530 million of digital money, and suspended trading activities on BitStation and FSHO after discovering BitStation's misuse of customer funds for executives' personal transactions and FSHO's failure to protect customer information. Notably, in March 2018, the FSA also ordered Binance, the world's largest cryptocurrency exchange at the time, to stop operating in Japan without a license. Similarly, the Estonian government revoked over 1,000 operating licenses after discoveries of noncompliance with crypto laws in 2020. In October 2013, in a major enforcement action in the United States, the FBI shut down Silkroad,[11] an online black market best known as a platform for selling illegal

[10] Partially due to the anonymity of crypto transactions, enforcement actions against violations of crypto tax laws did not occur until very recently. For example, in March 2021, a Japanese court sentenced a person to one year in prison and the payment of tax arrears of $680,000 for deliberately evading Bitcoin taxes.

[11] As part of the dark web, Silk Road operated as a Tor hidden service, meaning that online users were able to browse it anonymously and securely without potential traffic monitoring. Buyers and sellers conducted all transactions with

drugs, and seized 144,000 bitcoins worth $28.5 million. In 2015, Silkroad's founder was convicted of narcotics trafficking, money laundering, and computer hacking and sentenced to two terms of life imprisonment and forfeiture of Bitcoins worth $183 million. While the presence of regulation provides insights on the extensive margin, regulatory enforcement could provide additional insights on the intensive margin. On the one hand, strong enforcement of exchange-based regulation raises the bar for operating as a crypto exchange and ensures better investor (consumer) protection. On the other hand, strong enforcement of exchange-based regulation effectively thwarts the use of cryptocurrencies for illicit activities such as money laundering. Just like the net effect of the applicability of AML/CTF laws, the net effect of enforcement of exchange-based regulation on pricing of cryptocurrencies ultimately depends on which effect dominates. This leads to the hypothesis on exchange-based regulation and crypto pricing:

H4: Ceteris paribus, cryptocurrency prices vary with enforcement of exchange-based regulation.

The fourth dimension is anonymity in crypto accounts and crypto trading. In most jurisdictions market participants carry out crypto transactions, including trading on cryptocurrencies, with a high degree of anonymity. Crypto owners are identified not by name or account number but by cryptographic addresses that can be created at any time and by anyone. A degree of anonymity does not mean that transactions in cryptocurrencies are inherently illegal or malicious, but it certainly attracts privacy-seeking users and imposes unique challenges in implementing the KYC requirements. In January 2018, the Financial Services Commission (FSC) of the Republic of Korea implemented a real-name verification system for crypto accounts and imposed tighter reporting obligations on banks with accounts held by crypto exchanges. The system requires that fiat withdrawals from and deposits to a cryptocurrency exchange are available only if the trader's (customer's) bank account is verified under the real-name verification system provided by financial institutions (such as banks) linked with cryptocurrency exchanges. In practice, the new rule

Bitcoins. Based on a system image of the Silk Road server, the FBI found that "[f]rom February 6, 2011 to July 23, 2013 there were approximately 1,229,465 transactions completed on the site. The total revenue generated from these sales was 9,519,664 Bitcoins, and the total commissions collected by Silk Road from the sales amounted to 614,305 Bitcoins." Total sales were equivalent to roughly $183 million and involved 146,946 buyers and 3,877 vendors.

implies that a trader (customer) must open a real-name account at the same bank as that used by their cryptocurrency dealers in order to make a deposit or extract funds from their e-wallet. Both the bank and the crypto exchange must check the trader's real identity in crypto trading. The real-name verification system effectively thwarts the use of cryptocurrency for illicit activities and takes away the anonymity in crypto trading that is valued by a subset of users of cryptocurrencies. Both factors put a downward pressure on cryptocurrency prices. This leads to the hypothesis on anonymity and cryptocurrency pricing:

H5: Ceteris paribus, cryptocurrency prices are lower in jurisdictions that implement a real-name verification system in crypto accounts and trading.

III. Data, descriptive statistics, and the baseline cross-country analysis

The panel data set is a comprehensive collection of price information for Bitcoin traded on crypto exchanges across the world. We source the Bitcoin price data series from exchanges' orderbooks through the application programming interfaces (APIs) provided by the crypto exchanges, such as Okcoin and Bitstamp. The sample consists of daily Bitcoin prices from January 2017 through December 2020 for eighteen exchanges whose servers are located in twelve countries and regions. According to www.CoinMarketCap.com, there are over 300 crypto exchanges specializing in spot markets as of March 2021. However, the vast majority of those exchanges have rather limited or low trading activity (less than 100 BTC traded per trading day). [12] Although our dataset covers only 18 exchanges, in terms of the economic significance, the total Bitcoin trading volumes of all 18 exchanges combined accounts for *85%* of trading volume in Bitcoin as of December 31, 2020, the last day of the sample period. Furthermore, 8 out of the 18 exchanges in the sample rank among the top 20 exchanges by Nomics, a data provider that claims to be less likely to include wash trading volume in exchange ranking criteria. As most cryptocurrencies trade 24 hours a day, daily token prices are observed at 12:00 a.m. Coordinated Universal Time (UTC) of the day to ensure that there are no time lags or leads in cryptocurrency prices across all countries or regions. Exchange platforms operate and market to investors in many countries and regions

[12] See details at https://coinmarketcap.com/rankings/exchanges.

simultaneously, and therefore, we use the country or region in which the exchange's server is located to identify the specific jurisdiction. To facilitate consistent comparisons, Bitcoin prices based on local fiat currencies are converted to U.S. dollars using official exchange rates.

Bitwise Asset Management reported to the U.S. Securities and Exchange Commission (SEC) that 95% of trading volume reported in Bitcoin is fake and identifies just 10 of the 81 top exchanges as having real trading volume.[13] Bitwise claims that "crypto exchanges that fake their way to the top exchange ranking lists in CoinMarketCap are financially motivated and can go on to charge high fees to companies seeking to list coins for trading."[14] Academic studies also provide evidence of fake trading volumes reported by crypto exchanges (e.g., Aloosh and Li 2021; Cong et al. 2021; Amiram, Lyandres, and Rabetti 2021). Compared with the quality issue in reported trading volumes, the quality issue in Bitcoin prices quoted in exchange orderbooks is expected to be less severe for two reasons. First, crypto exchanges have strong economic incentives to inflate reported trading volumes to increase brand awareness and ranks on third-party aggregator websites or media such as CoinMarketCap, CoinGecko, Bitcointalk, and Reddit. Crypto exchanges with larger self-reported trading volumes are likely to attract more new users, which in turn increases the exchanges' profits from transaction fees. In contrast, exchanges have lower financial incentives to fake prices because exchange-owned accounts (possibly using algorithm trading robots) have to execute Bitcoin trades at the quoted price. Second, although our dataset covers only 18 exchanges, it includes 7 of the 10 exchanges identified by Bitwise Asset Management as having real Bitcoin trading volume (Bitwise Asset Management 2019), for which the quality of data is of less concern.

We use the following specification to examine whether and how certain forms of cryptocurrency regulation explain the price differentials for Bitcoins traded in various jurisdictions:

[13]For instance, in the Bitwise study, Binance ranked as the largest exchange with authentic trading volume, though it ranked 15th overall when exchanges reporting fake volumes were included. The ten exchanges identified by Bitwise Asset Management as having real trading volume of Bitcoin are, in descending order of actual trading volume, Binance, Bifinex, Kraken, Bitstamp, Coinbase, BitFlyer, Gemini, ItBit, Bittrex, and Poloniex.

[14] Cali Haan, CoinMarketCap Admits It Has Data Accuracy Problems Regarding Crypto Exchance Reporting, *CrowdFund Insider*, March 27, 2019. https://www.crowdfundinsider.com/2019/03/145745-coinmarketcap-admits-it-has-accuracy-problems-regarding-crypto-exchange-reporting/.

$$Ln\,(BTCPRICE) = \alpha + \boldsymbol{\beta 1} * \boldsymbol{REGCLARITY} + \boldsymbol{\beta 2} * \boldsymbol{LEGALITY} + \boldsymbol{\beta 3} * \boldsymbol{INCOMETAX} + \boldsymbol{\beta 4} * \boldsymbol{VAT} + \boldsymbol{\beta 5} * \boldsymbol{AMLCTF} + \boldsymbol{\beta 6} * \boldsymbol{ENFORCEMENT} + \boldsymbol{\beta 7} * \boldsymbol{REALNAME} + \beta 8 * Ln(GDPpercapita) + \beta 9 * GDPGROWTH + \beta 10 * INFLATION + \beta 11 * STOCKRETURN + \beta 12 * Ln(HACKDAMAGE) + \beta 13 * CAPITALCONTROL + \beta 14 * Ln(TRADEVOLUME) + YEAR\ FIXED\ EFFECTS + \varepsilon \qquad Equation\ (1)$$

Panel A and panel B of table 1 summarize the regulatory landscape in the above listed dimensions for the twelve jurisdictions as of December 2018, the middle point of the sample period from January 2017 to December 2020. Figure 1 is a graphic presentation of the global regulatory landscape (excluding the United States). In equation (1), we define the regulatory variables as follows. *REGCLARITY* is an indicator variable that takes the value of 1 when regulators have clearly communicated their position on whether cryptocurrencies satisfy the criteria of virtual money, and 0 otherwise. *LEGALITY* is the legal status of cryptocurrencies that takes the value ranging from 0 to 5 depending on the number of restrictions imposed on cryptocurrencies or businesses engaged in crypto transactions. *LEGALITY* takes the value of 0 if the legal status of cryptocurrencies is most receptive, that is, jurisdictions do not prohibit the purchase and sale of crypto assets or their use for the purchase of goods and services. The value of *LEGALITY* increases by 1 from the baseline value of 0 for each additional restriction on cryptocurrencies or businesses engaged in crypto transactions. For instance, starting September 2017, China has banned commercial cryptocurrency trading platforms, ICOs, and prohibited regulated financial institutions from engaging directly in crypto-related activities or indirectly facilitating other parties engaged in such activities. Accordingly, *LEGALITY* is 3 for China. *LEGALITY* takes the value of 5 if the legal status of cryptocurrencies is least receptive, that is, if a country imposes a general ban on cryptocurrencies. *AMLCTF* is an indicator variable that takes the value of 1 when the AML/CTF laws apply to cryptocurrency exchange platforms, and 0 otherwise. *REALNAME* is an indicator variable that takes the value of 1 when the government imposes a real-name verification system on crypto accounts and trading, and 0 otherwise. *ENFORCEMENT* is an indicator variable that takes the value of 1 when the regulators have taken enforcement actions against violations of exchange-based regulations, and 0 otherwise.

Given the importance of tax policies of crypto transactions, we take a deep dive into the tax treatment of cryptocurrencies and characterize the tax treatment by the income tax and VAT burdens of crypto

transactions and businesses. *INCOMETAX* is a composite measure of the income tax burdens on transactions, which measures the income tax burden on both the creation (mining) and exchanges of cryptocurrencies. First, *EXCHANGEINCOMETAX* captures the income tax burdens on exchanges of cryptocurrencies. Broadly speaking, there are three types of exchanges of cryptocurrencies: (1) the exchange of cryptocurrencies for fiat currencies; (2) the exchange of cryptocurrencies for other types of cryptocurrencies; (3) the exchange of cryptocurrencies for goods and services. *TAXABLEEXCHANGES* is the number of the types of exchanges that are subject to income taxes, which could take a value of between 0 and 3. Among jurisdictions that impose income taxes on any type of exchange of cryptocurrencies, some jurisdictions apply the same income tax treatment for personal and business exchanges, whereas others apply lower income tax rates or more income tax exemptions to personal exchanges than business exchanges. *TAXAPPLICABILITY* is 2 if the income tax treatment of crypto exchanges is identical for the two group of users, 1 if the income tax imposed on nonbusiness entities for exchanges is lower for personal exchanges and 0 if income taxes are applicable to neither personal or business exchanges. Accordingly, *EXCHANGEINCOMETAX* is equal to the number of types of exchanges that are subject to income taxes multiplied by the indicator variable for the lower tax rates or more exemptions for personal (occasional) exchanges. Naturally, the minimum value for *EXCHANGEINCOMETAX* is 0 when no income taxes apply to any type of exchange and the maximum value is 6 when income taxes are applicable to all three types of exchanges and income taxes are applied equally to personal (occasional) and business (habitual) exchanges. Second, *MININGINCOMETAX* captures the income tax burdens on mined (created) cryptocurrencies. *MININGINCOMETAX* takes the value of 3 if the first taxable event is the receipt of mined cryptocurrencies and the income tax is based on the fair market value of mined cryptocurrencies on the receipt date. *MININGINCOMETAX* takes the value of 2 if the first taxable event for mined cryptocurrencies is the disposal of mined cryptocurrency and the disposal of mined cryptocurrencies is taxed as capital gains with reduced rates and more exemptions. *MININGINCOMETAX* takes the value of 1 if the income tax treatment of mined cryptocurrencies is applicable only to business mining. *MININGINCOMETAX* takes the value of 0 if mined cryptocurrencies are not subject to income taxes. Accordingly, *INCOMETAX* is a composite

measure that combines the two components by adding each country's score scaled by the maximum score for each category. For instance, if country *A* has a score of 1 for *MININGINCOMETAX* and a score of 2 for *EXCHANGETAX*, its score for *INCOMETAXBURDEN* is one-third plus one-third, which is equal to two-thirds. A higher score for INCOMETAX implies more income tax burdens on cryptocurrency transactions and less favorable income tax treatment. The maximum value for *INCOMETAXBURDEN* is 2.

Similarly, *VAT* is a composite measure of the VAT burdens of crypto transactions, which measures VAT burdens on various types of crypto transactions and crypto service platforms. *VAT* takes the value of 0 when there is no VAT in the country's existing tax system or the tax authorities have explicitly stated that crypto transactions are not subject to VAT. The value of *VAT* increases by one additional point from the baseline of 0 if VAT is applicable to one of the following transactions or crypto business entities: the mining of cryptocurrencies, the exchange of cryptocurrency for other virtual or fiat currencies, the supply of goods and services paid for using cryptocurrencies, exchange platforms, and digital wallets. For instance, if a country applies VAT both to the supply of goods and services paid for in cryptocurrency and to exchange platforms, its score for *VAT* is 2. The maximum score for *VAT* is 5. A higher score for *VAT* implies a higher VAT burden on cryptocurrency transactions and less favorable VAT treatment.

We include a set of control variables in equation (1). The first two are gross domestic product (GDP) per capita (*GDPpercapita*) and its growth rate (*GDPGROWTH*). These two variables capture the level and growth of economic development and activity, and thus, the innate demand for cryptocurrencies as a medium of exchange. To be consistent with the denomination for Bitcoin prices, *GDPpercapita* in local fiat currency is converted into U.S. dollars using purchase power parity. The third control variable is the aggregate stock return (*STOCKRETURN*), which is included to account for correlation with other asset classes as a vehicle for investment or speculation. The fourth control variable is the inflation rate (*INFLATION*). As pundits in Bitcoin claim, Bitcoin could serve as a store value and hedge against debasement of fiat currencies and inflation. If so, the higher the inflation rate, the higher the value of Bitcoin as a store of value, the higher the Bitcoin price. Building on the finding from Makarov and Schoar (2020) that capital control is a reason for the variation in Bitcoin prices, we control for the extent of capital control

imposed by each jurisdiction (*CAPITALCONTROL*). Specifically, we use the capital control measure from Fernández et al. (2016), which is the same measure as that used by Makarov and Schoar (2020). The more open a country's capital policies, the fewer restrictions imposed on inflows and outflows, the lower limits to arbitrage, the lower the repatriation risk, and the higher Bitcoin price. The control variable (*HACKDAMAGE*) is included to capture the technology risk of exchanges at the country level, which is measured as the damage in U.S. dollars caused by hacks on exchanges located in the country. The last control variable is for the daily Bitcoin trading volume (in U.S. dollars) on the specific crypto exchange platform (*TRADEVOLUME)*, which controls for the liquidity at the *exchange* level.

Table 2 presents the descriptive statistics of Bitcoin prices by country from January 2017 through December 2020. Panel A of table 2 suggests that, on average, regulators have clearly communicated their position on whether cryptocurrencies satisfy the criteria of money. For a representative jurisdiction, some forms of income taxes are applicable to crypto transactions, AML/CTF laws are directly applicable to crypto exchanges, and investors carry out crypto trading with a large degree of anonymity. Furthermore, most jurisdictions have not taken any regulatory actions against violations of crypto-related laws. *VAT* is highly correlated with the applicability of AML/CTF laws and *ENFORCEMENT* as evident from the high correlations shown in panel B of table 2. The correlation coefficients validate the empirical approach of examining specific dimensions of regulation on a stand-alone basis due to high collinearity.

Table 3 presents the regression results when the dependent variable is the log of the daily Bitcoin price. All standard errors are cluster-adjusted by both exchange and year. As shown in column 1 of table 3, we first gauge the explanatory power of control variables for explaining price differentials. We find that control variables, including economic activity, inflation, damages from exchange hacks, and capital controls, collectively explain about 44.5% of the variation in cross-jurisdiction in Bitcoin price differentials. Using the 44.5% explanatory power as the benchmark, we find that the incremental explanatory power of cross-jurisdiction variation in cryptocurrency-related regulation and taxation increases significantly. The signs on control variables are consistent with economic intuition. First, the price for Bitcoin is higher in exchanges reporting higher trading volumes, suggesting a liquidity premium for Bitcoin prices. Second, the price for

Bitcoin is lower in countries and regions with higher inflation rate, suggesting a negative correlation between Bitcoin prices and inflation in the country or region. Third, the price for Bitcoin is lower in countries and regions with greater damage from hacks on crypto exchange platforms, suggesting investors price in cybersecurity risk. Last, consistent with Makarov and Schoar (2000), the price for Bitcoin is lower in countries and regions that impose more capital controls.

The remaining columns of table 3 present the incremental explanatory power for various aspects of regulation. As shown in column 2, the combination of the uncertainty in the regulatory framework for cryptocurrencies and control variables explains 56.8% of the cross-jurisdiction variation in Bitcoin prices, which is a 27.6% increase compared with that of the bench model without variables for the regulatory framework. In particular, Bitcoin prices are higher in where regulators have clearly communicated their stance on whether cryptocurrency satisfies the definition of money, thereby mitigating uncertainty in the regulatory framework of cryptocurrency. Interestingly, Bitcoin prices are also higher in countries and regions that impose some restrictions on cryptocurrencies, suggesting that the regulatory certainty effect dominates the dampening effect on the supply of cryptocurrency services from businesses.

Because specific regulatory policies depend on the regulators' stance on whether cryptocurrencies satisfy the criteria of money and the receptiveness of the legal framework, different dimensions of crypto regulation are highly correlated. Therefore, we examine the influence of the four dimensions of regulation on a stand-alone basis. Column 3 of table 3 presents the implications of tax policies on Bitcoin prices. A combination of the tax treatment of crypto policies and control variables explains 58.6% of the cross-jurisdiction variation in Bitcoin prices, which implies a 32% increase in the explanatory power of the model for cross-jurisdiction Bitcoin price differentials. In particular, the negative slope coefficient on *INCOMETAX* suggest that the Bitcoin price is lower in countries or regions that impose heavier income tax burdens on, and thus have less favorable income tax treatment of, crypto transactions. The lower Bitcoin prices for countries that impose heavier income tax burdens on crypto transactions is consistent with the tax capitalization hypothesis. It implies that, just like investors in equity securities (e.g., Sialm 2009), cryptocurrency investors incorporate the income tax consequences of cryptocurrency transactions and need

to be compensated for income taxes paid on crypto transactions. The slope coefficient on *VAT* is statistically insignificant. Column 4 of table 3 presents the implications of exchange-based regulation and enforcement on Bitcoin prices. The explanatory power of the model increases to 59.2% after the inclusion of AML/CTF laws and exchange-related enforcement. Specifically, the Bitcoin price is lower in countries where the AML/CTF laws apply directly to crypto exchanges. The net *negative* effect of the applicability of AML/CTF laws to crypto exchanges on pricing of Bitcoins suggests that the applicability of AML/CTF laws to cryptocurrency exchanges dampens the demand for Bitcoins from the *illegal* sector of the economy. Furthermore, the decline in *illicit* use of Bitcoin is, on average, more than the potential increase in demand for Bitcoin from a broader base of market participants for *legitimate* transactions as a result of enhanced investor (consumer) protection. As shown in column 5, the slope coefficient on *REALNAME* is statistically insignificant. The lack of statistical significance may be because the Republic of Korea is the only country that imposes the policy of the real-name verification of crypto accounts.

Table 4 takes a deep dive into the income tax treatment of crypto transactions and the association between the components of income tax burdens and crypto pricing. All standard errors are cluster-adjusted by both exchange and year. As shown in column 1 of table 4, without *VAT* in the regression, the slope coefficient on *INCOMETAX* is -0.214 and statistically significant with a *p*-value of 0.001, suggesting that the Bitcoin price is lower in jurisdictions that apply heavier income tax burdens on crypto transactions. The adjusted *R*-squared is 58.3%. We next examine whether the two components of the income tax burden, namely *MININGINCOMETAX* and *EXCHANGEINCOMETAX*, are associated with the jurisdictional gap in Bitcoin prices. As shown in panel A of table 2, on average, income tax burdens on the creation of cryptocurrencies (*MININGINCOMETAX*) is 1.91 out of 3 and income tax burdens on exchanges of cryptocurrencies (*EXCHANGEINCOMETAX*) is 2.34 out of 6. Per column 2 of table 4, when both components are included in *equation (1)* jointly, the slope coefficient on the income tax treatment of the creation of cryptocurrencies is -0.280 and statistically significant with a *p*-value of 0.02, whereas the slope coefficient on the income tax treatment of the exchange of cryptocurrencies is statistically insignificant. As shown in column 3 (4), on a standalone basis, the slope coefficient on *MININGINCOMETAX*

(*EXCHANGEINCOMETAX)* is negative and statistically significant, suggesting that the Bitcoin price is lower in jurisdictions that apply heavier income tax burdens on both the creation and exchange of cryptocurrencies. We further break down the income tax treatment of exchanges of cryptocurrencies into the number of exchanges classified as taxable (*TAXABLEEXCHANGES*) and the applicability of taxable exchanges to distinct groups of market participants (*TAXAPPLICABILITY*). As shown in column 5 and column 6, the Bitcoin price decreases with the number of taxable exchanges and decreases with the range of its applicability with respect to personal (occasional) and business (habitual) exchanges.

Overall, jurisdictional gaps in both uncertainty in the regulatory framework and specific crypto policies partially explain differential cryptocurrency prices across different jurisdictions incremental to capital controls and economic fundamentals. Out of various aspects of crypto-related regulation, the regulatory framework, the tax treatment of cryptocurrencies, and the exchange-based regulation all have significant explanatory power for cross-jurisdiction price differentials of Bitcoins, as evident from the much-increased *R*-squared of equation (1) relative to the benchmark model without regulatory variables.

IV. Difference-in-differences analysis around major regulatory changes on cryptocurrencies

Some may argue that some country-level differences not considered in the specifications could drive the baseline cross-country association between jurisdictional differences in regulatory technology and between-jurisdiction price differentials in Bitcoin. For instance, a country's existing banking system matters to the marginal investor or user of cryptocurrencies because a payment system using cryptocurrencies challenges the traditional roles that banks have always played. The existing banking system also matters because using cryptocurrencies could enable a large portion of the unbanked population to join the modern world of internet commerce (e.g., Howell, Niessner, and Yermack 2020). To address the endogeneity of regulatory technologies adopted by different jurisdictions (an omitted correlated variable problem) and identify the effect of regulation on cryptocurrency prices, we use a difference-in-differences design that includes country-specific and time-specific fixed effects and compares Bitcoin prices before and after the major regulatory update on cryptocurrencies within a specific country or region.

A *patchwork* of regulations based on the type or use of cryptocurrencies has emerged and continues to evolve concurrent with the rapid development of the crypto market. In the initial stage, many jurisdictions issued statements and guidance regarding cryptocurrencies, including warnings to the public about the risks of acquiring or transacting with cryptocurrencies and the risks of investing in cryptocurrencies. In the next stage, some countries enacted legislative amendments to the tax treatment of cryptocurrencies and the application of AML/CTF laws to cryptocurrency exchanges. Table 5 summarizes major regulatory updates on cryptocurrencies during the sample period.

As Bertrand, Duflo, and Mullainathan (2004) discuss, the differences-in-differences approach has become an increasingly popular research design for identifying causal effects. We utilize the staged adoptions of specific cryptocurrency policies in the difference-in-differences design. Specifically, to control for omitted correlated variables (both observable and unobservable), we use the following difference-in-differences design to identify the effect of regulation on cryptocurrency prices:

$$Ln(BTCPRICE)it \text{ or } PRICEDEVIATIONit = \alpha + \boldsymbol{\beta 1} * \boldsymbol{POSTTAXit} + \boldsymbol{\beta 2} * \boldsymbol{POSTAMLCTF}it + \boldsymbol{\beta 3} * \boldsymbol{POSTRESTRICTION}it + \boldsymbol{\beta 4} * \boldsymbol{POSTENFORCEMENTit} + \beta 5 * Ln(TRADEVOLUME) + YEARt + COUNTRYi + \varepsilon \quad \textit{Equation (2)}$$

where *i* indexes countries and *t* indexes time. The dependent variable is the natural log of daily Bitcoin prices (*BTCPRICE*) or the daily Bitcoin price deviation in the country from the world average price (*PRICEDEVIATION*). *PRICEDEVIATION* is measured as the daily price of Bitcoin in each country or region minus the average daily prices across all sample exchanges as a percentage of the world average price. *COUNTRY* is the country fixed effect and *YEAR* is the time fixed effect. *POSTTAX* is an indicator variable that takes a value of 1 if tax liabilities are imposed on cryptocurrencies in country *i* at time *t* and 0 otherwise. *POSTAMLCTF* is an indicator variable that takes the value of 1 after the application of AML/CTF laws to cryptocurrency exchange platforms and other crypto businesses, and 0 otherwise. *POSTRESTRICTION* is an indicator variable set to 1 after the regulator imposes at least one restriction on cryptocurrency transactions or crypto-related businesses, and 0 otherwise. *POSTENFORCEMENT* is an indicator variable set equal to 1 after the regulator takes regulatory action against violations of exchange-based regulation, and 0 otherwise.

The identifying assumption in this research design is that the daily price (the daily price deviation relative to the world price) would have been the same absent the passage of cryptocurrency rules and laws. Accordingly, the difference-in-differences design identifies the causal effect of regulation and taxation on cryptocurrency prices by using the trend in the Bitcoin price (the Bitcoin price deviation relative to the world price) in countries and regions that did not have a specific policy on cryptocurrencies in effect during a given period as the counterfactual outcome. As discussed in Armstrong, Balakrishnan, and Cohen (2012), estimating equation (2) allows for different jurisdictions that passed different laws on cryptocurrencies at different times. The staggered passage of the laws means that our control group is not restricted to jurisdictions that never passed laws on cryptocurrencies. Instead, the control group includes all countries without a cryptocurrency law at time *t*, even if the jurisdiction has since passed, or will pass (sometime after time *t*), cryptocurrency-related laws. Following Bertrand, Duflo, and Mullainathan (2004) and Armstrong, Balakrishan, and Cohen (2012), we add country and year indicators to control for time and country fixed effects. We cluster adjust standard errors by country and by year. Together with the country and year fixed effects, this approach accounts for correlations of the error terms within the same country over time (Petersen 2009). Furthermore, we include the daily trading volume at the exchange (*TRADEVOLUME*) as an additional explanatory variable to control for *exchange-level* liquidity in equation (2).

Panel A of Table 6 presents the descriptive statistics on the daily Bitcoin price during the sample period by jurisdiction. It is worth noting that the daily Bitcoin series is not a balanced dataset largely due to two factors. First, commercial crypto exchange platforms are new forms of business entities that started operations in different countries at different times, which results in the varying lengths of daily Bitcoin time series in different countries. Second, when China banned all domestic cryptocurrency exchanges in September 2017, 88 exchange platforms withdrew from the market and moved to other countries, including Okcoin that moved from China to the Republic of Korea. Due to varying time periods that various crypto exchange platforms are in operation, the number of observations and the average Bitcoin price by country vary significantly. Seven out of the 18 exchanges are located in the United States and the United Kingdom, and therefore, those two countries have the largest number of country-day observations.

Panel B of table 6 presents the descriptive statistics on the daily price deviation from the world price as a percentage of the world average Bitcoin price by jurisdiction. As evident from the median value of 0.01% for the daily price deviation from the world average price in the United Kingdom, Bitcoin prices there are close to the world average price during the period from January 2017 to December 2020. On average, Bitcoin prices in Malta, Poland, and Singapore are at least 1% higher than the world price in the corresponding period, whereas Bitcoin prices in Russia are, on average, about 2% lower than the world price. Furthermore, while Bitcoin prices in China are slightly higher than the world price, Bitcoin prices in the United States, Estonia, Hong Kong (China), Japan, Luxembourg, and the Republic of Korea are slightly lower than the world price during the period from January 2017 to December 2020.[15]

Table 7 presents the results on the difference-in-differences design for daily Bitcoin prices and for Bitcoin price deviations from the world price. The difference-in-differences results are largely consistent with the baseline results as reported in table 3 and table 4. As shown in column 1 of table 7, Bitcoin prices are lower after the country or region imposes taxes on crypto transactions. Bitcoin prices are higher after the jurisdiction imposes some restriction on cryptocurrencies or businesses engaged in crypto transactions. Overall, the country indicators, the time indicators, and the change in crypto regulation explain about 52.7% of the variation in daily Bitcoin prices from January 2017 to December 2020. Column 2 of table 7 presents the results on the difference-in-differences design for daily Bitcoin price deviations. The results are largely similar. The Bitcoin price deviation in a country relative to the world price is lower after the country or region imposes taxes on crypto transactions and after the jurisdiction imposes some restriction on cryptocurrencies or businesses engaged in crypto transactions. The slope coefficients on *POSTRESTRICTION* have opposite signs for explaining the price level and the price deviation relative to the world price. Bitcoin prices increase in a country or region after it imposes additional restrictions on

[15] Makarov and Schoar [2020] document a substantially higher Bitcoin price in the Republic of Korea than that in other countries (a Kimchi *premium*) from December 2017 until the beginning of February 2018. In contrast, we observe Bitcoin prices in the Republic of Korea are slightly lower than the world price from October 2018 to September 2019 (the period during which daily Bitcoin prices are available for exchanges located in the country). The results suggest that the Bitcoin price deviation relative to the world average price is dynamic and varies over time.

crypto transactions. However, if those countries that impose additional restrictions on cryptocurrencies, on average, have lower Bitcoin prices relative to the world price prior to the change, the increase in Bitcoin prices in the particular country could translate into a lower price differential relative to the world average price. Overall, the country indicators, the time indicators, and the change in crypto regulation explain about 14.3% of the variation in Bitcoin price deviations from the world price from January 2017 to December 2020.

To summarize, utilizing the staggered-adoption of specific cryptocurrency polices, the results from the difference-in-differences design for Bitcoin prices (price deviations from the average world price) are consistent with the baseline cross-sectional results for Bitcoin prices, which helps identify the effect of regulation and taxation on Bitcoin prices.

V. Regulatory event studies

As an alternative way to identify the effect of regulatory technology on cryptocurrency prices, we also use regulatory event study methodology (e.g., Schipper and Thompson 1983; Binder 1985). Specifically, we identify the economic impact of regulatory technology on cryptocurrencies by examining the changes in cryptocurrency prices in countries or regions that have material changes in regulation of cryptocurrencies. A material change in regulatory policy is defined as an event in the policy formation process that significantly altered expectations either about the effects of possible outcomes or about the likelihood of a given outcome or both. We consider the announcements of the regulatory changes themselves to be the events of interest. Regulatory event studies have the following two characteristics: first, there could be multiple announcement events for a given policy change; and second, there are relatively small sample sizes.

If market agents expect the regulations to increase (reduce) the estimated net benefits associated with cryptocurrencies, Bitcoin prices would increase (decline) if the regulations had not already been fully anticipated in the pricing process. We use the word regulation in a general sense to mean *an enforceable rule or standard for which noncompliance is costly, in particular laws and quasi-legal rules such as SEC*

requirements. We identify country-days where a major regulatory update occurs and delineate days as either "positive" or "negative" event days. For a specific country or region, a positive event day is one during which a policy update is expected to increase the price of cryptocurrency, and a negative event day is one in which a policy update is expected to decrease the price of cryptocurrency. For instance, based on the cross-sectional results, we view a day as a negative event day when the jurisdiction specifically applies AML/CTF laws to cryptocurrency exchanges or when a country imposes additional tax liabilities on crypto transactions. In contrast, we view a week as a positive event day when the jurisdiction clarifies its position on whether cryptocurrencies satisfy the criteria to be defined as "money" or when enforcement actions are taken to ensure better investor/consumer protection. All other days are classified as nonevent days. Only a limited number of days during the sample period contained material changes in the regulatory environment for cryptocurrencies. To be consistent across countries, a day in which an announcement of the regulatory change as a new rule or law or of a major enforcement action is viewed as a day of material change.[16] Each country or region has about one or two key regulatory events. The regulatory event study has one caveat, however. Some rules may be anticipated leading up to the actual announcement date, which could potentially reduce the power of the event study, therefore biasing against findings of statistically significant price changes to major regulatory updates.

Auer and Claessens (2018) also use the event study methodology to assess cryptocurrency market reactions to regulatory news. Our approach is distinct in four dimensions. First, Auer and Claessens (2018) are interested in the average world price response to regulatory news, whereas our study is interested in the price reaction on exchanges located in the country or region that implements a particular regulatory change. Second, while the time period for Auer and Claessens (2018) includes regulatory events from the start of 2015 to the end of June 2018, our study extends the time period from January 2017 to December 2020. There have been some major and new developments in the regulatory space from the middle 2018 to the

[16] The results are quantitatively similar if we define a week of material change as one that contains one or more of the following kinds of announcements: (1) authoritative support for the regulation; (2) modification of an existing proposal for regulatory change; or (3) announcement of the change as a new rule or law.

end of 2020. Third, this paper characterizes regulatory uncertainty and the receptiveness to cryptocurrencies of specific polices across different jurisdictions in a systematically different manner from that of Auer and Claessens (2018). Fourth, we use bootstrapping methods to evaluate the statistical significance between the difference in returns for event days and nonevent days. Specifically, we compare the event day return with a random draw of 1,000 daily returns from the exchange and compute the frequency in which it is higher (lower) than the randomly drawn value.

Table 8 summarizes the results from event studies and presents the Bitcoin return for each event day and bootstrapping *t*-statistics for those event returns. For virtually every country with days of material regulatory updates, the event day return for Bitcoin is consistent with the expected sign. Overall, for Bitcoin, the mean positive-event-day return is 1.50% higher than the mean nonevent-day return, and the difference is statistically significant with a *p*-value of 0.02. Furthermore, the mean negative-event-day return is 1.01% lower than the mean nonevent day return, and the difference is statistically significant with a *p*-value of 0.01.

VI. Supplemental analyses

Jurisdictional gaps in crypto regulation influence the relative demand and supply of crypto-based activities and could result in varied crypto prices across jurisdictions. The Bitcoin price captures the equilibrium derived from demand and supply sides, and the explanatory power of regulation and tax for cross-jurisdictional variation in Bitcoin prices could come either from the demand side or from the supply side or both sides. In this section, we use distinct measures for the demand side and the supply side of Bitcoins and provide some preliminary evidence on whether the effect is dominated by one or the other.

On the demand side, we use Bitcoins purchased with domestic currencies through online platforms as a proxy for investor demand for investment or speculation purposes. Statista analyzes Bitcoin trading volume against domestic currencies used for Bitcoin transactions and aggregates Bitcoin trading volumes on online exchanges for 44 countries and regions during 2020 (the last year of the sample period). Bitcoin trading volumes are all converted to U.S. dollars for comparability. Out of the 44 countries and regions, we

are able to obtain information for both control variables and regulatory variables for 38 countries. As shown in panel A of table 9, both clarity in the regulatory framework and tax-related and exchange-based regulations continue to explain a significant portion (between 20% to 34%) of the cross-jurisdictional variation in Bitcoins purchased with domestic currencies through online platforms.

On the supply side, in addition to crypto exchanges and wallets that specialize in providing crypto trading services, a growing number of business entities have either a cryptocurrency ATM or offer crypto as an in-store payment method. As of March 9, 2021, close to 30,000 businesses entities accept crypto payments globally, among which Tesla, Coca-Cola, Microsoft, and BMW are notable examples (Statista 2021). Convenience-oriented businesses, such as casual dining restaurants, accommodations, and gas stations, account for about 10% of business entities that accept cryptocurrencies as a payment method, whereas cryptocurrency exchanges and wallets account for about 3% of those business entities. An interesting question is to what extent geographical location, and thus, crypto-related regulation and tax in the country or region, affects the operation of business that offers a cryptocurrency solution in the supply of goods services. For instance, crypto exchanges may be headquartered in one location but have operations in several other places. Accordingly, we use the number of business entities that either have a cryptocurrency ATM or offer crypto as an in-store payment method as a measure of supply of goods and services by businesses that offer a cryptocurrency solution. Statista (2021) published the number of business entities have either a cryptocurrency ATM or offer crypto as an in-store payment method in 145 countries on March 2021. Out of the 145 countries and regions, we are able to obtain information on both control variables and regulatory variables for 61 countries. As shown in panel B of table 9, both clarity in the regulatory framework and tax-related and exchange-based regulations explain a significant portion (between 15% to 32%) of the cross-jurisdictional variation in the number of business entities that offer a cryptocurrency solution in the supply of goods and services. Not surprisingly, the number of business entities that offer a cryptocurrency solution is lower in countries or regions that impose VAT burdens on the supply of goods and services paid for using cryptocurrencies and crypto exchanges and wallets.

The supplementary analyses provide some preliminary evidence that clarity in the regulatory framework and the receptiveness of tax-related and exchange-based regulations and enforcement are positively associated with both investor demand for Bitcoin and the supply of goods and services offering a cryptocurrency solution.

VII. Conclusion

Using Bitcoin prices from eighteen crypto exchanges with servers located in twelve different jurisdictions, we find that variations in regulatory technology account for a significant portion of the cross-jurisdiction disparity in Bitcoin prices incrementally. After the inclusion of a set of control variables, both clarity in the regulatory framework and the receptiveness of crypto regulations explain a significant proportion of differential pricing of Bitcoin across jurisdictions. The incremental explanatory power is about 30% higher than that of the benchmark model without regulatory variables. For the regulatory framework, Bitcoin prices are higher in countries where regulators have clearly communicated their position on whether cryptocurrencies satisfy the definition of money. For specific regulatory policies, Bitcoin prices are lower in jurisdictions that impose income taxes on crypto transactions and apply AML laws directly to crypto exchanges. To identify the effect of regulatory technology on crypto pricing and address the omitted correlated variable problem, we utilize the staggered adoption of specific cryptocurrency polices, and the difference-in-differences design yields results similar to the baseline cross-sectional results. Regulatory event study analyses also yield similar results—crypto prices respond negatively to regulatory updates that impose tax liabilities on crypto transactions.

This study is the first to provide systematic empirical evidence regarding regulation, tax, and pricing of cryptocurrencies. Future studies could explore the economic consequences of the harmonization of international standards on cryptocurrency, a process that is lately gaining steam. As cryptocurrencies gain more mainstream adoption, a promising area for future research might be the accounting and financial reporting implications for crypto businesses.

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Table 1
Summary of the Regulatory Framework and the Receptiveness of Crypto Policies

Panel A: The Regulatory Framework for Cryptocurrencies as of December 2018

Country /Region	**Exchanges**	**Clarity on whether cryptocurrency satisfies the definition of money**	**Legal status of Cryptocurrencies**
China	Okcoin/Lakebtc	Yes	Partially restricted
Estonia	Coinsbank	Yes	Legal
Hong Kong (China)	Bitfinex/Hitbit	No	Legal
Japan	Bitflyer	No	Legal
Luxembourg	Bitstamp	No	Legal
Malta	Therocktrading	Yes	Legal
Poland	Bitbay	Yes	Legal
Republic of Korea	Okcoin	No	Partially restricted
Russia	BTCE	No	Illegal
Singapore	Coinfit	Yes	Legal
UK	Bit-X/CEX.IO/EXMO	Yes	Legal
US	Kraken/Coinbase/Gemini/Itbit	Yes	Legal

Panel B: Receptiveness of Crypto Regulation as of December 2018

Country /Region	**Income Tax**	**VAT**	**Applicability of AML/CTF to cryptocurrency exchanges**	**Real name verification**
China	Unclear	Unclear	No	No
Estonia	Imposed only on Bitcoin mining	YES	YES	No
Hong Kong (China)	Not applicable for individuals	Not applicable	YES	No
Japan	Imposed both on mining and exchange	YES	Yes	No
Luxembourg	Imposed both on mining and exchange	YES	YES	No
Malta	Not applicable	YES	NO	No
Poland	Imposed both on mining and exchange	YES	NO	No
Republic of Korea	Not applicable	Not applicable	YES	Yes
Russia	Imposed only on exchange	Unclear		No
Singapore	No capital gain taxes for occasional exchange	YES	YES	No
UK	Imposed both on mining and exchange	YES	No	No
US	Imposed both on mining and exchange	Not applicable	YES	No

Table 2

Descriptive Statistics and Correlation Tables

Panel A: Descriptive statistics

Variables	N	Mean	Median	Std. dev.	Min	Max
BTCPRICE	10,682	5916.9	6140.0	3565.9	761.6	20748.0
REGCLARITY	10,682	0.734	1.0	0.442	0	1.0
LEGALITY	10,682	0.261	0	0.685	0	5.0
INCOMETAX	10,682	1.024	1.500	0.753	0	2
MININGINCOMETAX	10,682	1.91	3.00	1.303	0	3
EXCHANGEINCOMETAX	10,682	2.34	3.00	2.176	0	6
TAXABLEEXCHANGES	10,682	1.78	3.00	1.460	0	3
TAXAPPLICABILITY	10,682	0.79	1.00	0.740	0	2
VAT	10,682	0.870	0	1.169	0	5
AMLCTF	10,682	0.657	1.0	0.475	0	1.0
ENFORCEMENT	10,682	0.268	0	0.443	0	1.0
REALNAME	10,682	0.171	0	.376	0	1.0
GDPpercapita	10,682	58524.9	45740.8	9223.4	34156.9	103181.2
GDPGROWTH	10,682	3.125%	3.351%	3.124%	-2.320%	12.007%
STOCKRETURN	10,682	6.216%	7.670%	13.216%	-17.801%	28.900%
INFLATION	10,682	1.161%	0.571%	0.904%	0.300%	3.400%
HACKDAMAGE	10,682	123.106	3.100	265.052	0	865.40
CAPITALCONTROL	10,682	0.257	0	0.384	0	1.0
TRADEVOLUME	10,682	40,437,247	10,200,810	107,920,684	25	2,249,196,050

Table 2
(continued)

Panel B: Pearson correlation (upper diagonal) and Spearman correlation (lower diagonal) between prices and regulation

	Ln (BTCPRICE)	REGCLARITY	LEGALITY	INCOME TAX	VAT	AMLCTF	ENFORCEMENT	REALNAME
Ln(BTCPRICE)	1	0.056***	-0.038***	0.258***	0.016	0.046***	0.278***	0.023***
REGCLARITY	0.062***	1	-0.173**	0.410**	0.312**	-0.309**	0.194**	-0.322**
LEGALITY	0.206***	-0.032***	1	0.170***	0.083***	-0.362**	-0.186**	0.172**
INCOMETAX	0.298***	0.332**	0.432***	1	-0.137***	0.071***	0.300***	-0.219***
VAT	0.002	0.333**	0.328***	-0.062**	1	-0.691**	-0.379**	-0.120**
AMLCTF	0.025***	-0.309**	-0.469**	0.040**	-0.841**	1	0.404**	0.124***
ENFORCEMENT	0.195***	0.124**	-0.339**	0.273**	-0.527**	0.548**	1	-0.085***
REALNAME	0.001	-0.322**	0.331**	-0.226**	-0.130**	0.124**	-0.115**	1

* *p*-value is significant at 0.05 level; ***p*-value is significant at 0.01 level.

Table 3

Baseline Cross-jurisdictional Results on Regulation, Tax, and Daily Bitcoin Prices

		Dependent variable = Ln (BTCPRICE)				
		Column 1	Column 2	Column 3	Column 4	Column 5
Explanatory variables	Predicted sign	coefficient (*t-value*)	coefficient (*t-value*)	coefficient (*t-value*)	coefficient (*t-value*)	coefficient (*t-value*)
Intercept		Included	Included	Included	Included	Included
Ln (TRADEVOLUME)	**(+)**	0.144*** (7.333)	0.148*** (7.026)	0.164*** (5.779)	0.179*** (6.026)	0.151*** (6.235)
Ln (GDPpercapita)	(+)	1.191 (-0.506)	-0.785** (-1.909)	-1.655*** (-2.862)	-0.141 (-0.195)	-0.717 (-1.616)
GDPGROWTH	(+)	0.305 (1.458)	0.664*** (2.954)	1.201*** (3.965)	0.607* (1.703)	0.693*** (2.944)
INFLATION	(-)	-0.208*** (-3.694)	-0.395*** (-3.964)	-0.599*** (-4.562)	-0.351* (-1.933)	-0.424*** (-3.964)
STOCKRETURN	(+)	-0.004 (-0.623)	-0.005 (-0.792)	-0.007 (-1.436)	0.005 (0.702)	-0.007 (-0.945)
CAPITALCONTROL		-0.248** (-0.369)	-1.562* (-1.822)	-3.470*** (-2.864)	-0.756 (-0.589)	-1.208 (-1.076)
Ln(HACKDAMAGE)		-0.078*** (-3.437)	-0.117*** (-4.615)	-0.117*** (-4.615)	-0.060 (-0.840)	-0.113*** (-4.126)
REGCLARITY	**(+)**		0.230* (1.832)	0.302** (2.468)	-0.014 (-0.088)	-0.014 (-0.088)
LEGALITY	**(-)**		0.164** (2.149)	0.312*** (3.865)	0.110 (1.019)	0.110 (1.019)
INCOMETAX	**(-)**			-0.171** (-2.404)		
VAT	**(?)**			0.063 (1.116)		
AMLCTF	**(?)**				-0.503*** (-3.340)	
ENFORCEMENT	**(?)**				-0.010 (-0.089)	
REALNAME						-0.406 (0.686)
Year fixed effect		Included	Included	Included	Included	Included
Cluster-adjusted standard deviation		By exchanges and year	By exchanges and year	By exchanges and year	By exchanges and year	By exchanges and year
N		10,682	10,682	10,682	10,682	10,682
Adjusted R-squared		44.5%	56.8%	58.6%	59.2%	56.9%

*** p<0.01, ** p<0.05, * p<0.10.

Table 4

Baseline Cross-Jurisdictional Results on the Breakdown of Income Tax Burdens and Daily Bitcoin Prices

		Dependent Variable = Ln (BTCPRICE)					
		Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Explanatory variables	Predicted sign	coefficient (*t-value*)	coefficient (*t-value*)	coefficient (*t-value*)	coefficient (*t-value*)	coefficient (*t-value*)	coefficient (*t-value*)
Intercept		Included	Included	Included	Included	Included	Included
Ln (TRADEVOLUME)	**(+)**	0.149*** (5.779)	0.169*** (6.111)	0.158*** (6.845)	0.164*** (5.779)	0.159*** (6.872)	0.146*** (6.994)
Ln (GDPpercapita)	(+)	-1.439*** (-2.862)	-1.281* (-1.877)	-1.507** (-2.304)	-1.655*** (-2.862)	-1.352** (-2.448)	-1.321** (-2.392)
GDPGROWTH	(+)	1.041*** (3.965)	1.056*** (3.134)	1.079*** (3.441)	1.201*** (3.965)	0.922*** (3.501)	0.914*** (3.424)
INFLATION	(-)	-0.570*** (-4.562)	-0.598*** (-3.676)	-0.601*** (-3.948)	-0.599*** (-4.562)	-0.545*** (-4.319)	-0.522*** (-4.397)
STOCKRETURN	(+)	-0.005 (-1.436)	0.001 (0.153)	-0.002 (-0.295)	-0.007 (-1.436)	-0.001 (-0.199)	-0.003 (-0.490)
CAPITALCONTROL		-3.037** (-2.211)	-3.278** (-2.293)	-3.464** (-2.561)	-3.470*** (-2.864)	-3.020** (-2.674)	-2.749** (-2.450)
Ln(HACKDAMAGE)		-0.152*** (-4.615)	-0.114*** (-3.797)	-0.132*** (-4.533)	-0.117*** (-4.615)	-0.110*** (-4.050)	-0.138*** (-5.159)
REGCLARITY	**(+)**	0.366*** (3.056)	0.357** (2.786)	0.431*** (3.714)	0.302** (2.468)	0.472*** (4.012)	0.386*** (3.626)
LEGALITY	**(-)**	0.314*** (3.489)	0.208* (1.854)	0.319*** (3.576)	0.312*** (3.865)	0.360*** (3.812)	0.320*** (3.738)
INCOMETAX		***-0.214*** (-2.920)***					
MININGINCOMETAX	***(-)***		***-0.280** (-2.572)***	***-0.139*** (-3.044)***			
EXCHANGEINCOMETAX	***(?)***		***0.097 (1.656)***		***-0.067*** (-2.689)***		
TAXABLEEXCHANGES						***-0.125*** (-2.930)***	
TAXAPPLICABILITY							***-0.157** (-2.115)***
Year fixed Effects		Included	Included	Included	Included	Included	Included
Cluster-adjusted standard deviation		By exchange and year	By exchange and year	By exchange and year	By exchange and year	By exchange and year	By exchange and year
N		10,682	10,682	10,682	10,682	10,682	10,682
Adjusted R-squared		58.3%	59.0%	58.7%	57.9%	58.7%	57.6%

*** p<0.01, ** p<0.05, * p<0.10.

Table 5

Key Regulatory Updates on Cryptocurrencies for Sample Jurisdictions from January 2017 to December 2020

Country/Region	Date	Key update summary	Expected sign of price reaction
Japan	4/1/2017	The Virtual Currency Act, Japan's first crypto law, became effective, imposing registration requirements, AML laws, and additional cybersecurity and reporting requirements on crypto exchanges	Decrease (application of AML/CTF laws)
	12/27/2017	The National Tax Agency ruled that gains on cryptocurrencies should be categorized as "miscellaneous income" and taxed	Decrease (imposition of taxes)
	05/01/2020	An amendment bill to the Payment Services Act (the "PSA") and the Financial Instruments and Exchange Act (the "FIEA") become effective starting May 2020. Under the amendment, crypto custodian services will be subject to licensing.	Increase (better investor/consumer protection)
United Kingdom	03/07/2019	Financial Conduct Authority (FCA) is proposing a prohibition on cryptocurrency-based derivatives.	Uncertain
	12/19/2019	Her Majesty's Revenue & Customs (HMRC) issued a policy paper on the taxation of crypto-assets for individuals and only addresses the taxation implications for individuals.	Decrease (imposition of taxes)
	03/06/2020	HM Treasury "has implemented the Fifth Money Laundering Directive (5MLD) through amending the UK's Money Laundering Regulations (MLRs); this designated the FCA as the AML supervisor for specific cryptoasset activities. The FCA's AML regime extends to specific activities, such as exchange, custody, ICO's, and crypto-ATMs.	Decrease (application of AML/CTF)
Republic of Korea	01/23/2018	The FSC formally mandated a real-name verification system for cryptocurrency accounts and trading	Decrease (removal of anonymity in crypto transactions)
	03.06.2020	The South Korean National Assembly passed a broad framework for regulation of cryptocurrencies and crypto exchanges. The framework ensures cryptocurrency companies, including exchanges, are subject to equivalent anti-money laundering measures and tax obligations as other forms of financial intermediaries.	Decrease (application of AML/CTF laws)

Country/Region	Date	Key update summary	Expected sign of price reaction
Singapore	01/2020	The Payment Service Act becomes effective. It establishes a comprehensive framework for all crypto-related enterprises and expands the scope of payment services regulated by the Monetary Authority of Singapore (MAS) to include digital payments. The Act requires companies to obtain a license to provide specified payment services.	Decrease **(**application of AML/CTF laws)
	04/17/2020	Inland Revenue Authority of Singapore (IRAS) has published guidance on the tax treatment of income from transactions involving digital tokens. Under the guidance, virtual currencies are now treated as exempt supplies if exchanged for other virtual currencies or for fiat currencies, and are an excluded transaction if used as payment for goods and services.	Increase (lower VAT burdens)
Hong Kong (China)	02/09/2018	Regulatory actions against seven cryptocurrency exchanges that operate in Hong Kong (China) without a license	Increase (enhanced investor/consumer protection)
China	09/04/2017	Ban domestic commercial crypto trading platforms	Decrease (decreased liquidity in crypto transactions)
Estonia	10/26/2017	Money Laundering and Terrorism Financing Prevention Act was enacted, applying robust AML/CTF laws to crypto exchanges	Decrease (application of AML/CTF to crypto exchanges)
Russia	02/06/2020	The Russian Supreme Court has added the *illicit* use of cryptocurrencies to the list of criminal offenses related to money laundering, which effectively poses a full ban on cryptocurrency in Russia	Uncertain
	07/22/2020	Give legal status to cryptocurrency but banned them from being used to pay for goods and services	Uncertain
Poland	11.02.2016	Ministry of Finance concluded that virtual currencies are subject to income tax.	Decrease (imposition of taxes)

Table 6

Descriptive Statistics by Jurisdiction

Panel A: Descriptive Statistics on Daily Bitcoin Prices by Jurisdiction

Country/Region	N	Mean	Median	Standard deviation	Min	Max
China	323	2103.1	1385.7	1267.5	761.6	4905.6
Estonia	360	6637.7	6204.1	2833.5	3180.5	12916.2
Hong Kong	1334	5766.9	6185.7	3863.1	784.8	19270.7
Japan	200	4491.7	3958.8	1104.8	3194.5	6607.7
Luxembourg	1095	6274.6	6426.1	3482.8	782.6	19184.7
Malta	368	4089.8	2678.8	4066.4	791.4	19498.7
Poland	267	2164.2	1774.5	1200.4	819.7	4861.3
Russia	206	1560.3	1224.1	649.2	776.4	2832.8
Singapore	360	6700.9	6371.3	2788.4	3280.0	13011.0
South Korea	357	6622.7	6181.5	2841.5	3176.9	12920.0
UK	2464	6340.7	6461.7	3559.7	772.2	20748.0
US	3350	6305.5	6434.2	3489.9	784.8	19532.7

Panel B: Descriptive Statistics on Daily Bitcoin Price Deviations as a Percentage of World Average Price by Jurisdiction

Country/Region	N	Mean	Median	Standard deviation	Min	Max
China	323	0.79%	0.40%	2.74%	-7.88%	10.26%
Estonia	360	-0.36%	-0.29%	1.72%	-8.11%	6.01%
Hong Kong	1334	-0.17%	-0.11%	1.98%	-18.36%	7.83%
Japan	200	-0.60%	-0.54%	1.37%	-8.10%	3.49%
Luxembourg	1095	-0.43%	-0.37%	0.61%	-3.01%	2.27%
Malta	368	1.10%	0.74%	1.36%	-3.63%	7.22%
Poland	267	2.16%	1.88%	2.58%	-3.06%	19.13%
Russia	206	-1.99%	-1.89%	1.57%	-6.40%	2.57%
Singapore	360	1.05%	1.14%	2.15%	-11.13%	6.19%
South Korea	357	-0.40%	-0.36%	1.71%	-8.46%	5.73%
UK	2464	0.41%	0.01%	2.01%	-5.87%	12.84%
US	3350	-0.33%	-0.31%	0.68%	-3.13%	4.70%
Total		0%	-0.18%	1.67%	-18.36%	19.13%

Table 7

Identifying the Effects of Regulation on Bitcoin Price Using Difference-in-Differences Design

		Column 1	Column 2
	Predicted sign	**Dependent Variable = Ln (BTCPRICE)**	**Dependent Variable = PRICEDEVIATION**
Explanatory variables		coefficient (*t*-value)	coefficient (*t*-value)
Intercept		Yes	Yes
POSTINCOMETAX	***(-)***	***-0.707*** (-13.954)***	***-0.004** (-2.562)***
POSTENFORCEMENT	***(+)***	***-0.113 (-1.224)***	***-0.007 (-0.765)***
POSTRESTRICTION	***(+)***	***0.762*** (28.756)***	***-0.007** (-2.306)***
Ln(TRADEVOLUME)		0.001*** (4.630)	0.001** (2.22)
Country/region fixed effects		Included	Included
Year fixed effects		Included	Included
Cluster-adjusted standard errors		By exchange and year	By exchange and year
N		10,682	10,682
Adjusted R-squared		52.7%	14.3%

*** p<0.01, ** p<0.05, * p<0.1

Table 8

Regulatory Event Study Around Key Cryptocurrency Regulation Updates

Country/Region	**Announcement Date of the Regulatory Update**	**Expected Sign of Price Reaction**	**Exchange**	**Event-day return (%)**	**Bootstrapping *p*-value**
UK	03/07/2019	Positive	BIT-X	*0.31*	0.19
UK	03/07/2019	Positive	CEX.IO	*0.28*	0.23
UK	03/07/2019	Positive	EXMO	*0.28*	0.23
UK	12/19/2019	Negative	BIT-X	0.10	0.45
UK	12/19/2019	Negative	CEX.IO	0.19	0.33
UK	12/19/2019	Negative	EXMO	-0.15***	0.01
UK	03/06/2020	Negative	BIT-X	*-0.64****	0.01
UK	03/06/2020	Negative	CEX.IO	*-0.47****	0.03
UK	03/06/2020	Negative	EXMO	*-0.59****	0.02
China	09/04/2017	Negative	OKCOIN	-4.22***	0.001
Hong Kong	02/09/2018	Positive	BIFINEX	*4.39****	*0.001*
Hong Kong	02/09/2018	Positive	HITBTC	*3.60****	0.001
Poland	11/2/2016	Negative	BITBAY	*-0.27****	0.01
Average nonevent day returns				0.27%	
Difference between average event-day returns that are expected to be negative and average nonevent day returns				***-1.01%***	***0.01***
Difference between average event-day returns that are expected to be positive and average nonevent day returns				***1.50%***	***0.02***

*** p<0.01, ** p<0.05, * p<0.10

Table 9

Supplementary Analysis on the Demand Side and the Supply Side

Panel A: Regulation, Tax, and Investor Demand for Bitcoins

		Dependent variable = Ln (Bitcoins purchased with domestic currencies through online platforms)		
		Column 1	Column 2	Column 3
Explanatory variables	Predicted sign	Coefficient (*T*-value)	Coefficient (*T*-value)	Coefficient (*T*-value)
Intercept		Included	Included	Included
Ln(GDPpercapita)		-0.569** (-2.320)	-0.125*** (-3.854)	-0.841*** (-4.728)
GDPGROWTH		-0.089 (-1.223)	-0.003 (-1.461)	0.002 (0.409)
INFLATION		0.004 (0.239)	0.008* (1.738)	-0.087 (-1.186)
STOCKRETURN		-0.005 (-0.792)	-0.007 (-1.436)	0.005 (0.702)
CAPITALCONTROL		-1.562* (-1.822)	-3.470*** (-2.864)	-0.756 (-0.589)
Ln (HACKDAMAGE)		-0.117*** (-4.615)	-0.117*** (-4.615)	-0.060 (-0.840)
REGCLARITY	***(+)***	***0.975** (2.263)***		
LEGALITY		***0.544 (0.914)***		
INCOMETAX			***-1.016*** (-2.976)***	
VAT	***(-)***		***0.802*** (3.163)***	
AMLCTF				***0.389 (0.871)***
ENFORCEMENT				***0.652*** (5.575)***
N		38	38	38
Adjusted R-squared		20.3%	34.1%	22.5%

Table 9

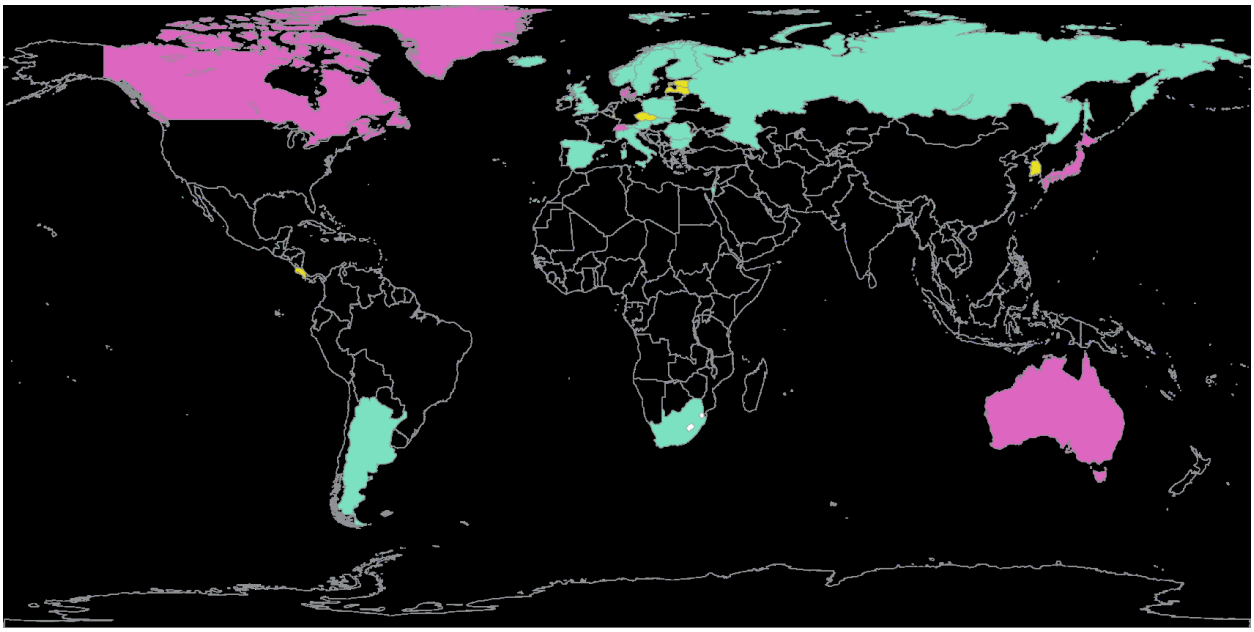
(Continued)

Panel B: Regulation, Tax, and Supply of Bitcoin-related Goods and Services

		Dependent variable = Ln (Number of Businesses that either have a Bitcoin ATM or accept Bitcoin as in-store payment method)		
		Column 1	Column 2	Column 3
Explanatory variables	Predicted sign	Coefficient (*T*-value)	Coefficient (*T*-value)	Coefficient (*T*-value)
Intercept		Included	Included	Included
Ln(GDPpercapita)		0.127 (0.571)	-0.064 (-0.251)	-0.044 (-0.703))
GDPGROWTH		-0.121** (-2.385)	-0.152*** (-3.774)	-0.117** (-2.554)
INFLATION		0.027* (1.881)	0.004 (0.321)	0.048*** (3.380)
REGCLARITY	***(+)***	***0.437* (1.908)***		
LEGALITY		***0.048 (0.881)***		
INCOMETAX			***0.590*** (3.242)***	
VAT	***(-)***		***-0.212* (-1.742)***	
AMLCTF				***1.165** (4.175)***
ENFORCEMENT				***0.504*** (6.875)***
N		61	61	61
Adjusted R-squared		14.7%	26.5%	31.6%

Figure 1

Application of Tax Laws and AML/CTF Laws, or Both to Cryptocurrencies (not including the United States) as of December 2018 (the middle point of the sample period)



Green: Application of Tax laws to cryptocurrencies

Yellow: Application of AML/CTF laws to cryptocurrencies

Purple: Both to cryptocurrencies