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On the transaction cost of Bitcoin

Thomas Kim

Collins College of Business, University of Tulsa, Tulsa, OK, USA

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ABSTRACT

Using a unique data on Bitcoin quotes in 16 different currencies, this paper examines the empirical transaction costs of Bitcoin in international transactions. We find that the transaction cost of Bitcoin is lower than that of retail foreign exchange markets. Bitcoin markets have, on average, 2% narrower bid-ask spreads than retail foreign exchange markets and, when the U.S. dollar is converted to other currencies via Bitcoin, the resulting exchange rates are, on average, 5% better than the retail foreign exchange rate. We find that Bitcoin's simpler infrastructure is a source of the cost advantage.

1. Introduction

As of 2015, Bitcoin is the most popular electronic currency in the world. Bitcoin is traded with at least 16 different real currencies and its average trading volume in U.S. dollars is more than $17 million per day.[1] While Bitcoin supporters argue that electronic currency will play a significant role in the economy (Bernanke, 2013; Harvey, 2015), its critics note that the majority of this popularity is related to speculative trades (Krugman, 2013; Yermack, 2013; Glaser et al., 2014).

Recent research on Bitcoin focuses on providing a better understanding about this new asset or currency.[2] Major works include estimating Bitcoin's impact on the existing monetary system (Böhme et al., 2015; Dwyer 2015; Harvey 2015) and examining Bitcoin's price movements (Yermack 2013; Brandvold et al., 2015; Cheah and Fry 2015; Dyhrberg 2016; Kim 2015). Yet, few papers look at a major issue related to the long term potential of Bitcoin – whether this new currency can generate some economic benefits. While Bitcoin supporters argue that the decentralized and deregulated feature of Bitcoin will provide lower transaction costs to its users, this claim has not been empirically tested thus far (Böhme et al., 2015). Further, the fact that it is deregulated is often thought of regarding its potential to save transaction costs only in illegal transactions. In order to be widely accepted as a method of payment, Bitcoin must provide lower transaction costs in above board and legal transactions.

E-mail addresses: sthomas.kim@utulsa.edu, sukwonk@ucr.edu

[1] See Table 1 for an overview of Bitcoin transaction cost.

[2] There are debates on whether Bitcoin is a currency or an asset. See Glaser et al. (2014) for example. This paper views Bitcoin as a method of transaction, which is closer to a definition of a currency. Whether Bitcoin satisfies three main characteristics of a currency – method of transaction, unit of account, and store of value – is beyond the scope of this paper.

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We have access to a unique dataset that contains daily Bitcoin quotes and price in 16 different currencies. While most of existing datasets on Bitcoin provides only price and volume information in USD (United States Dollars), our dataset can reveal the actual transaction costs of a Bitcoin trader executing international transactions. According to the large literature of market microstructure, market quotes and prices should reflect all the real, information, and inventory cost of trading an asset.[3] See Stoll (2000) for a detailed discussion of the literature. The basic idea is that value maximizing traders adjust market prices and quotes such that they are compensated for any risk or costs of transactions. Even if some traders may not be completely rational, those less efficient traders will lose money to more efficient traders and get wiped out from the market. Thus, transaction costs measured using market quotes and prices would be inclusive of all the difficulties in using Bitcoin in international transactions.[4]

Using the quotes and prices data, we calculate the volume and bid-ask spread of Bitcoin in 16 different currencies. We also examine whether Bitcoin can be used in foreign exchange transactions. As Bitcoin is traded in multiple different currencies, we examine the transaction cost of buying and selling Bitcoin simultaneously in different currencies. The result of such transaction is converting one currency to the other using Bitcoin as the intermediary.

We find that Bitcoin markets have bid-ask spreads about 2% lower than that of the retail foreign exchange rates applied to ATM (Automated Teller Machine) transactions, which is the best rate available for foreign exchange transactions that are less than $1 million. Transactions that convert USD to other currencies via Bitcoin exhibit a 0.4%−9.8% cost advantage over the best foreign exchange rates applied to retail-level traders. The results demonstrate that Bitcoin can be used as a cost-effective alternative to current foreign exchange markets.

We examine the sources of Bitcoin cost advantage. One factor can be the structure of Bitcoin. The currency exits in cyber space only and its users do not need to be equipped with complicated trading systems. On the other hand, interbank transactions in the foreign exchange markets require each bank to have a considerable amount of infrastructure, such as trading systems and employee salaries. Another factor related to Bitcoin's cost advantage can be insufficient competition in foreign exchange markets. The infrastructure to execute foreign exchange transactions may act as a barrier to entry and a few large banks could be charging higher transaction costs in the retail foreign exchange markets. Bitcoin may have the cost advantage because Bitcoin transactions bypass banks' market power.

We find that the cost advantage of Bitcoin is statistically significantly correlated with the transaction costs of the Bitcoin markets, while uncorrelated with the transaction costs of the foreign exchange markets. The results show that the evasion of existing foreign exchange markets is not a significant source of the Bitcoin's cost advantage. Another implication is that Bitcoin's economic benefits do not necessarily come from operating in grey areas.

2. Data

Daily Bitcoin transaction data from April 2014–April 2015 is acquired from Quandl.com.[5] There are other data sources for Bitcoin prices, with longer time series, but our data is unique because it contains Bitcoin quotes in 16 different currencies. As there are no official holidays or weekends in Bitcoin transactions, daily transaction data can exist for every seven days of a week. The transaction data summarizes daily last prices, bid and ask quotes, and volume collected from multiple Bitcoin exchanges. A Bitcoin exchange is a website that trades Bitcoin with a real currency, such as USD. The prices, quotes, and volume in the data are the averages by currency. For example, transaction data in USD is the average of Bitcoin exchanges that trade Bitcoin using USD.

Note that our data does not include all of the Bitcoin exchanges in operation. Such a limit would under estimate the actual liquidity of Bitcoin. This paper uses 16 different currencies traded with Bitcoin, but our data does not include several currencies that have Bitcoin exchanges. Some of these omitted currencies include Japanese Yen, Swiss Francs, and South Korean Won. Also, a trader does not have to use a Bitcoin exchange to trade Bitcoin if he can find a counter party on his own.[6] Overall, actual transaction costs could be lower than what is measured from this data.

Foreign exchange rates data is acquired from Oanda.com and Bloomberg. The Oanda.com data has weekly prices and bid-ask quotes. Bloomberg has daily bid-ask quotes data, but the daily data is limited to a few major currencies such as EUR. Therefore, we use the Oanda.com quotes as the main source and supplement the data with the Bloomberg quotes.

There are several versions of the quotes in the foreign exchange markets. The quote with the narrowest spread is called the inter-bank rate and applies to transactions between large financial institutions. The minimum unit of trade to obtain an inter-bank exchange rate is over $1 million. Retail exchange rates that apply to smaller customers have 2%−5% wider spreads than the inter-bank rate. According to Oanda.com, ATM transactions have a 2% wider spread, foreign credit card transactions have a 3% wider spread, and cash exchanges at an exchange kiosk have a 5% wider spread. We use the ATM rate as the

[3] Real cost means real economic resources – labor and capital – required to exchange assets. Information cost include compensation for the possibility of trading at a worse price due to lack of information about the asset. Inventory cost is compensation for the possibility of asset price fluctuation while the asset is held in the middle of a transaction.

[4] Recent empirical studies such as Glaser et al. (2014) or Cheah and Fry (2015) have shown that Bitcoin has a long-term fundamental value of zero and is suffering from speculative bubbles. Significant negative events such as the closure of Mt. Gox Bitcoin exchange harmed confidence in Bitcoin. Transaction costs derived from prices and quotes will reflect the magnitude of these obstacles.

[5] Quandl.com stopped distributing this data after April 2015.

[6] Bitcoin exchanges only facilitates Bitcoin trading; they are not necessary to transfer Bitcoin from one trader to the other.

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Table 1
Bitcoin markets in various currencies.
This table presents an overview of the international Bitcoin markets used in this paper from April 2014–April 2015. Volume and bid-ask spread are the averages of daily observations during the sample period. The number of trading days is the number of days with non-zero trading volume. Volume in USD is the product of volume in Bitcoin with Bitcoin price in USD. Bid-ask spread is normalized by the daily mid-quote price.

Currency	Daily volume (Bitcoin)	Daily volume (in USD)	Spread to price (Simple average)	Spread to price (Volume weighted)	FX with USD spread: ATM rate
USD (US Dollar)	52,869	$17,597,862	0.040%	0.038%	
EUR (Euro)	3315	$1161,808	0.070%	0.081%	2.006%
CNY (Chinese Yuan)	7052	$3253,182	0.096%	0.043%	2.032%
AUD (Australian Dollar)	162	$58,669	0.153%	0.139%	2.013%
BRL (Brazilian Real)	76	$27,550	0.353%	0.386%	2.092%
GBP (Great Britain Pound)	715	$260,985	0.067%	0.085%	2.008%
HKD (Hong Kong Dollar)	392	$314,198	0.285%	0.284%	2.002%
ILS (Israeli Shekel)	13	$5409	0.843%	0.978%	2.063%
NOK (Norwegian Krone)	9	$3359	0.601%	0.677%	2.029%
NZD (New Zealand Dollar)	12	$6438	0.462%	0.454%	2.024%
PLN (Polish Zloty)	71	$40,665	0.203%	0.207%	2.063%
RUB (Russian Ruble)	285	$97,570	0.148%	0.147%	2.052%
SEK (Swedish Krona)	31	$11,584	0.638%	0.631%	2.022%
SGD (Singapore Dollar)	152	$47,037	0.178%	0.061%	2.015%
TRY (Turkish Lira)	34	$24,176	0.322%	0.350%	2.028%
ZAR (South African Rand)	33	$11,981	0.539%	0.589%	2.042%

retail foreign exchange rate in this paper, but actual costs to a retail customer would be higher as the ATM rate is the best rate available at the retail level.

3. Transaction costs

3.1. Volume and bid-ask spread

Table 1 provides an overview of Bitcoin transaction costs. Volume and bid-ask spread are two widely used variables to measure transaction costs (see Stoll 2000 for a survey of the transaction cost literature). Bid-ask spreads are calculated from the difference between the ask quote and the bid quote, divided by the midpoint of the two quotes. Column 2 and 3 report daily transaction volume in Bitcoin and USD, column 4 and 5 show the bid-ask spread of Bitcoin markets, and column 6 presents the bid-ask spread in the foreign exchange market between a currency and USD.

Average daily trading volume of Bitcoin using USD is over $17 million. Transactions in EUR (Euro) or CNY (Chinese Yuan) also exceed $1 million or $3 million per day. Is this amount of volume high or low? Weber (2014) shows 70% of Bitcoins are held in dormant accounts and argues the currency is not frequently traded. At the end of 2015, there were approximately 15 million Bitcoins outstanding and the daily volume shown in Table 1 is about 60,000 Bitcoins (0.4% of outstanding). We compare this figure with those of the publicly traded stocks in the Center for Research in Security Prices (CRSP) data from University of Chicago. The data contains all publicly traded stocks in the US, and as of December 2015, the stocks' ratio of daily volume to number of shares outstanding had an interquartile range of 0.3% $\sim$ 1.1%. The median was 0.6%. Thus, Bitcoin is more frequently traded than at least one quarter of publicly traded stocks in the US.

As Bitcoin has a considerable amount of trading volume in multiple currencies, a trader can buy and sell Bitcoin almost simultaneously if he is to pay the cost of immediacy. The cost of immediacy and other transaction costs would be reflected on bid-ask spreads in Bitcoin markets as a trader who needs to execute orders immediately places market orders that accept existing quotes. We find that the bid-ask spreads of Bitcoin exchanges are 1.2%−1.9% narrower than the spreads of the best retail foreign exchange rates (ATM transaction rates). These figures indicate that the transaction costs using Bitcoin can be lower than that of the retail foreign exchange market.

3.2. Bitcoin versus FX

Inspired by these narrow bid-ask spreads, we calculate the cost of converting one currency to another using Bitcoin as intermediary. The process begins by a trader acquiring access to two different Bitcoin markets traded in different currencies, such as USD and EUR. A prerequisite of this transaction is to have two bank accounts designated in different currencies. Note that converting currencies with a traditional wire transfer process has the same requirement.[7] Then the trader buys Bitcoin at one market in USD and sells it at another website in EUR. We assume that a trader is using market orders to execute orders immediately. Thus, a trader is buying Bitcoin with a currency at the ask quote of the currency's Bitcoin

[7] When switching exchanges, a trader is not required to transfer his Bitcoin from one account to the other as Bitcoin is stored in a universal account called a "wallet".

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Table 2
Currency exchange via Bitcoin – From USD to other currencies.
This table exhibits the results of currency conversion using Bitcoin as an intermediary. We present the results when one USD is converted to other currencies. In this case, a customer buys Bitcoin at the ask price of the USD market and sells Bitcoin at the bid price of a foreign currency market in the same day. The conversion processes using Bitcoin reflects a 0.5% transaction fee in addition to spreads. The case of foreign exchange markets reflects the bid-ask spread of retail exchange rates applied to ATM transactions and does not include additional fees. The first cost advantage column reports the average difference in amounts relative to the FX retail exchange rate. The second cost advantage column presents volume-weighted averages. Statistically significant cost effectiveness different from zero at the 1% level is marked with *.

Currency	Amount obtained by Bitcoin (A)	Amount obtained from FX retail (B)	Cost advantage: average of (A – B) / B	Cost advantage (Volume-weighted)	Cost advantage (High volatility)	Cost advantage (Low volatility)
EUR (Euro)	0.80	0.79	2.66%*	2.86%*	2.91%*	2.43%*
CNY (Chinese Yuan)	6.12	6.02	2.15%*	1.92%*	2.12%*	2.21%*
AUD (Australian Dollar)	1.22	1.14	7.39%*	7.95%*	8.51%*	6.36%*
BRL (Brazilian Real)	2.68	2.45	9.78%*	9.70%*	9.95%*	9.65%*
GBP (Great Britain Pound)	0.65	0.61	5.89%*	6.20%*	6.53%*	5.31%*
HKD (Hong Kong Dollar)	7.71	7.60	1.93%*	1.57%*	1.61%*	2.24%*
ILS (Israeli Shekel)	3.63	3.63	0.37%	0.30%	0.77%	−0.01%
NOK (Norwegian Krone)	7.07	6.66	6.49%*	5.98%*	6.89%*	6.11%*
NZD (New Zealand Dollar)	1.26	1.22	4.04%*	2.86%*	6.23%*	1.75%*
PLN (Polish Zloty)	3.30	3.27	1.59%	0.96%	2.40%*	0.82%
RUB (Russian Ruble)	47.31	45.16	5.91%*	5.13%*	5.87%*	6.02%*
SEK (Swedish Krona)	7.74	7.24	7.25%*	7.03%*	8.60%*	6.07%*
SGD (Singapore Dollar)	1.29	1.27	2.35%*	1.84%*	3.05%*	1.75%*
TRY (Turkish Lira)	2.14	2.09	2.86%*	0.68%	4.42%*	1.92%*
ZAR (South African Rand)	11.60	10.88	6.95%*	7.48%*	7.90%*	6.07%*

exchange and selling Bitcoin at the bid quote of the other currency's Bitcoin exchange. The total holding period of Bitcoin is approximately 20 min, as a Bitcoin transaction takes on average 10 min as of 2015 (See for example, www.coindesk.com/information/how-do-bitcoin-transactions-work/). The resultant transaction converts USD to EUR after the transaction costs paid to the Bitcoin exchanges. This Bitcoin-based exchange rate between USD and EUR is compared with the corresponding bid or ask quotes of the foreign exchange market.

In addition to the spreads paid by placing market orders, we subtract 0.5% from the acquired exchange rates from Bitcoin, as many Bitcoin exchanges charge fees in addition to spread. These fees include trading fee, withdrawal fee, or wiring fee to bank accounts. According to Bitcoin wiki (en.bitcoin.it), 0.5% is the maximum fee charged by Bitcoin exchanges. Most of exchanges charge 0.2% ∼ 0.25% fee, and some exchanges even waive fees for traders who take existing quotes, i.e. place market orders. Such fee structure shows that the bid-ask spreads are the exchanges' main source of revenue. Note that the Bitcoin transaction in this paper is based on market orders only.

Including the 0.5% fee, the cost advantage of Bitcoin-involved transactions is calculated as:

$$Cost\ advantage = \frac{\text{Amount of target currency obtained by Bitcoin} \times 0.995 - \text{Amount of target currency obtained by FX market}}{\text{Amount of target currency obtained by FX market}} \quad (1)$$

A positive number indicates that a trader can acquire more target currency using Bitcoin than using ATM foreign exchange rates.

To check for the possibility of scarce trading, we calculate another version of cost advantage. We use volume-weighted exchange rates in Eq. (1) and report the resulting cost advantage. The volume is the minimum of two Bitcoin exchanges involved in the transaction.

Many of the earlier papers on Bitcoin document the high volatility of Bitcoin prices (e.g. Yermack 2013). While the transaction in this paper requires only 20 min of Bitcoin holding period, the high volatility may act as hidden costs. To address this concern, we collect intraday Bitcoin prices in USD from a top-5 large Bitcoin exchange called BTCe. We separate the sample by the size of intraday price change. Let the days when intraday price change is larger than its time-series median be "high volatility days", and the rest be "low volatility days". We report the cost advantage figures by sub-sample.

Table 2 presents the cost advantage of converting one USD to other currencies. We find that the cost advantage of converting USD to other currencies is often larger than the difference in the bid-ask spread. By using Bitcoin, a trader can obtain from plus 0.4% to plus 9.8% more of other currencies when compared to the retail foreign exchange market (column 3). This cost advantage exists in both raw quotes (column 3) and volume-weighted quotes (column 4). We do not find cost advantage vanishing or systematically changing by intraday volatility (column 5, 6). Thus, Bitcoin can provide lower transaction costs to retail foreign exchange market customers who are converting USD to another currency.

There are $16 \times 15 = 240$ combinations of currency exchanges in our dataset. It would be repetitive to check all of the cases as, at this point, we already know there are many cases where Bitcoin can be less costly than the retail foreign exchange market. The results with other combinations are available upon request.

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Table 3
Sources of cost advantage.
This table exhibits the results of the following regression model:

$$\text{Cost Advantage}_t = a + \gamma_1 \times \text{Spread in FX}_t + \gamma_2 \times \text{Spread in USD}_t + \gamma_3 \times \text{Spread in EUR}_t + \gamma_4 \times \text{Volume in USD}_t + \gamma_5 \times \text{Volume in EUR}_t + \theta_1 \times \text{Cost Advantage}_{t-1} + \varepsilon_t \quad (2)$$

Cost Advantage$_t$ is the amount of additional EUR at day t a trader can obtain from USD by using Bitcoin as the intermediary. *Spread in FX* is the bid-ask spread to mid-quote price in the EUR/USD foreign exchange market. *Spread in USD* and *spread in EUR* are the bid-ask spreads to mid-quote price in the USD-Bitcoin market and EUR-Bitcoin market, respectively. Similarly, *volume in USD* and *volume in EUR* are the volumes in the Bitcoin markets. Lag 1 of *Cost Advantage* variable controls auto-correlation. Phillips–Perron tests reject the possibility of unit root at the 1% significance level. The estimation method is Generalized Method of Moments (GMM) with corrections for heteroscedasticity. T-values are in parentheses and statistically significant coefficients at the 10%, 5%, and 1% level are marked with small a, b, and c, respectively.

Explanatory variables	Model 1	Model 2	Model 3	Model 4
Intercept	**0.007[a]**	**0.007[a]**	**0.009[a]**	**0.006[a]**
	(4.04)	**(4.45)**	**(6.45)**	**(4.48)**
Bid-ask spread in EUR/USD FX market	12.168	12.094		15.666
	(1.05)	(1.05)		(1.40)
Bid-ask spread in USD Bitcoin market	**−0.879[b]**	**−0.868[b]**	**−1.059[b]**	
	(−2.07)	**(−2.11)**	**(−2.69)**	
Bid-ask spread in EUR Bitcoin market	0.023			
	(0.06)			
Volume in USD Bitcoin market	1.339	**1.719[c]**		
	(0.42)	**(1.72)**		
Volume in EUR Bitcoin market	7.381			
	(0.12)			
Lag 1 of daily cost advantage	**0.701[a]**	**0.701[a]**	**0.721**	**0.717[a]**
	(15.98)	**(16.42)**	**(16.95)**	**(16.71)**
Adjusted R^2	53.1%	53.3%	53.0%	52.6%

3.3. Sources of cost advantage

Two factors may contribute to the cost advantage of Bitcoin. The first is the structure of Bitcoin. The currency exits in cyber space only and its users do not need to be equipped with complicated trading systems. On the other hand, interbank transactions in the foreign exchange markets require each bank to have a considerable amount of infrastructure, such as trading systems and employee salaries.

An additional factor concerns a bank's market power in the foreign exchange markets. The infrastructure to execute foreign exchange transactions may act as a barrier to entry and a few large banks can charge higher transaction costs. This infrastructure can be also viewed as costs to operate publicly in foreign exchange market. Bitcoin may exhibit the cost advantage as Bitcoin transactions bypass banks' market power or public exchanges.

To better identify the determinants of Bitcoin's cost advantages, we employ a multivariate regression framework. We investigate whether the amount of the cost advantage can be explained by the transaction costs in the Bitcoin market or the foreign exchange market. If the source of the cost advantage is Bitcoin's low transaction costs, the cost advantage will have a relationship with the transaction costs of the Bitcoin markets. Alternatively, if the source of the cost advantage is evading banks' market power or publicity, the cost advantage will have a correlation with the transaction costs in the foreign exchange market, as the transaction costs would reflect bank's market power or costs required to be a public trader.

Let *Cost Advantage*$_t$ be the additional amount of currency a trader can obtain at day t by using Bitcoin as the intermediary (see Eq. (1) for the definition). We report the results on converting USD to EUR, as the two currencies are frequently traded in both the Bitcoin markets and the foreign exchange markets. Tests employing other major currencies, such as GBP, HKD, and AUD, yield qualitatively similar results. We estimate the following regression model:

$$\text{Cost Advantage}_t = a + \gamma_1 \times \text{Spread in FX}_t + \gamma_2 \times \text{Spread in USD}_t + \gamma_3 \times \text{Spread in EUR}_t + \gamma_4 \times \text{Volume in USD}_t + \gamma_5 \times \text{Volume in EUR}_t + \theta_1 \times \text{Cost Advantage}_{t-1} + \varepsilon_t \quad (2)$$

Cost Advantage$_t$ is equal to the amount of additional EUR a trader can obtain from USD using Bitcoin when compared to the foreign exchange markets at day t (see Eq. (1) for the definition). *Spread in FX*$_t$ is the daily bid-ask spread normalized by the mid-quote price in the EUR/USD foreign exchange market, *Spread in USD*$_t$ is the daily bid-ask spread normalized by the mid-quote price in the USD-Bitcoin market, *Spread in EUR*$_t$ is the daily bid-ask spread normalized by the mid-quote price in the EUR-Bitcoin market, *Volume in USD*$_t$ is the daily volume in the USD-Bitcoin market, *Volume in EUR*$_t$ is the daily volume in the EUR-Bitcoin market, and *Cost Advantage*$_{t-1}$ is the Lag 1 (one day) of the Cost Advantage variable.

Since the *Cost Advantage* variable can be auto-correlated, we include Lag 1 of the *Cost Advantage* variable as a control. We verify that Lag 2 and beyond do not have significant explanatory powers. In addition, Phillips–Perron tests reject the possibility of unit root at the 1% significance level. The estimation method is a generalized method of moments (GMM) that corrects for heteroscedasticity.

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The results are presented in Table 3. Regardless of the model specifications, the spread in a Bitcoin market is a significant explanatory variable. Thus, the cost advantage is a result of the lower transaction costs in the Bitcoin markets. Alternatively, we do not find evidence that the transaction costs in the foreign exchange markets are related to the daily cost advantage. It could be that banks are unable to extract economic rents from today's competitive foreign exchange markets. Another interpretation would be that the cost advantage of Bitcoin does not come from avoiding operating in public.

4. Conclusion

This paper examines whether Bitcoin can be a lower cost alternative to the foreign exchange market using empirical price and quotes data. We find that the bid-ask spreads of Bitcoin exchanges are typically lower than that of the retail foreign exchange market. As a result, trader can convert one currency to another using Bitcoin as intermediary, often at a better rate than the retail foreign exchange rate. We find evidence that the efficiency of Bitcoin markets is a source of the cost advantage. Meanwhile, our results do not support the hypothesis on banks' market power or evasion of publicity.

A major contribution of this paper lies in demonstrating that Bitcoin can provide lower transaction costs to individuals than one of the most efficient financial markets. Many of the economic entities involved in currency exchanges, including merchants, banks, and credit card companies, may seek to utilize this lower cost alternative to the FX market. The growth of this new type of currency in international transactions may generate opportunities, as well as challenges, to foreign exchange businesses, as well as governments.

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