



Bitcoin-denominated prices can reduce preference for vice products

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Abstract

The growing popularity of bitcoin presents novel research questions related to pricing. Unlike cheques or cards which merely function as alternative methods of payment to cash, bitcoin could also work as an alternative way to denominate prices. In the current research, we examine the effect of price denomination in bitcoin (i.e., setting the price of an item in bitcoin terms rather than in dollars) on purchasing behavior. Specifically, we explore whether denominating prices in bitcoin terms may reduce purchase of non-essential vice items. In a simulated grocery shopping study, we demonstrate that when prices are denominated in bitcoin rather than in dollars, people are less inclined to purchase unhealthy vice food products while equally inclined to purchase virtue food products even when the method of payment accepted by the business is held constant. We further show that the effect stems from participants' anticipation of greater regret.

Keywords Bitcoin · Cryptocurrency · Pricing · Method of payment

1 Introduction

For the first time in many decades, consumer concerns about inflation have accelerated rapidly, with 59% of adults in the USA now indicating that they worry about this issue a great deal (Gallup, 2022). As prices of basic goods increase in dollar terms, there has also been growing interest in reevaluating the role that currency plays in storing wealth and facilitating transactions. Evidenced by countries such as El Salvador and Central African Republic adopting bitcoin as legal tender, growing merchant

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partnerships (Bambysheva, 2022), and wider consumer adoption of cryptocurrencies more generally, digital currencies are quickly entering the marketplace. A large body of existing research has established that non-cash payment methods such as credit and debit cards can indeed change consumer behavior: they increase spending (Banker et al., 2021; Hirschman, 1979; Prelec & Simester, 2001; Raghurir & Srivastava, 2008; Soman, 2003), drive greater purchase of vice goods (Park et al., 2020; Thomas et al., 2011), and decrease post-transactional connection (Shah et al., 2016). Does the growing adoption of bitcoin in the payment system merely mean there is another non-cash payment method or does a unique attribute of bitcoin present researchers with novel hypotheses to test? While bitcoin can function as an alternative form of payment, unlike other non-cash payment methods, bitcoin can also be used to denominate prices of goods. In the current work, we begin to explore this emerging domain by examining how denominating prices in bitcoin can influence preferences for virtue vs. vice goods.

Bitcoin, proposed by the pseudonymous entity Satoshi Nakamoto in 2008, is a decentralized digital currency that relies on a peer-to-peer network for store and transfer of wealth (Nakamoto, 2008). Bitcoin has several characteristics that distinguish it from currencies such as the U.S. dollar and Euro. First, unlike traditional currencies, bitcoin has a fixed maximum supply (capped at 21 million bitcoins), and its issuance is restricted through a “mining” process which imposes limits via algorithmic modulation of the difficulty in the computational problems that validators must complete in order to unearth new bitcoins into the network. Second, the bitcoin protocol is maintained by a decentralized network of validators that records all transactions in a publicly accessible blockchain without any single trusted third party who can unilaterally control the network and the assets on it. Such decentralization makes the bitcoin protocol effectively immutable, meaning the rules of the game cannot be changed, in contrast to currencies controlled by governments or central banking institutions which have, for example, experienced both the creation and collapse of the Bretton Woods System. Third, while the maximum bitcoin supply is capped, exchange rates to traditional currencies can be highly volatile; the bitcoin-dollar exchange rate, for example, may simultaneously be influenced both by structural factors such as the circulating money supply determined by central bank quantitative easing policy as well as by investor market speculation.

Specifically, the fact that bitcoin is a currency that can be used to denominate prices and its exchange rate against fiat currencies is volatile make it different from other non-cash forms of payment studied in prior literature, where credit and debit card transactions may change the payment form but are interpreted by consumers in the same currency. In the current work, we depart from this prior line of research by focusing on the question of whether consumer purchasing behavior can change if businesses choose to denominate the prices of goods in bitcoin rather than in fiat currency like the U.S. dollar. Unlike the predominant experimental paradigm adopted in the prior research where methods of payment participants could use were manipulated, we examine whether consumers’ preferences can change if prices are merely denominated in bitcoin instead of fiat currency even when they are allowed to pay using any method of payment of their choice (e.g., cash, card, bitcoin). Perhaps most closely related to this aspect of novel digital currencies are past studies examining changes in spending behavior when shopping with foreign currencies. For instance, Raghurir and Srivastava (2002) found that consumer valuations of products when

spending with an unfamiliar foreign currency are biased toward nominal values, leading to underspending when face values are multiples of a home currency and overspending when face values are fractions of a home currency. In addition, Okada and Hoch (2004) also found that spending with a volatile hypothetical foreign currency attenuates the happiness or unhappiness people feel after consumption.

Consider a local grocery store where prices of the items are set in bitcoin or in satoshi (i.e., SATs, the smallest denomination of bitcoin where 100 million satoshi is equivalent to one bitcoin). The store owner priced a pint of Ben & Jerry's ice cream at 14,725 SATs but accepts all forms of payment including bitcoin, cash, or card. A consumer can therefore pay either 14,725 SATs using the Bitcoin wallet on her smartphone or pay the equivalent amount in cash or card (the price would be \$5.89 using today's conversion rate of approximately \$40,000 to one bitcoin). Because of high volatility in the bitcoin-dollar exchange rate, if the value of bitcoin appreciated against the dollar by the next time the consumer is in the store for ice cream, she will have to pay an amount greater than \$5.89 when spending with cash or card. Similarly, if the value of bitcoin depreciated against the dollar by the next time the consumer is in the store for ice cream, she will have to pay an amount less than \$5.89 for the item when spending with cash or card.

How does denominating prices of goods in bitcoin influence consumer purchase decisions? Moreover, does the effect of bitcoin denomination on spending behavior differ based on the type of items consumers shop for? Prior research comparing cards to cash has shown that people tend to spend more on unhealthy and impulsive vice food items when shopping with cards versus with cash as the abstract nature of non-cash payments engenders lower pain of paying than the concrete nature of cash payment (Thomas et al., 2011). It has also been documented that compared to concrete cash payments, card payments reduce attention toward decision risks to facilitate increased purchasing of vice food products (Park et al., 2020). We anticipate that denominating prices of goods in bitcoin can also have differential effects on purchases of virtue vs. vice food products but through a mechanism that is distinct from the one discussed in the prior research. Two contrasting predictions could arise. On one hand, one might expect that bitcoin denominated prices may serve to increase purchase of vice goods. It could be argued that because bitcoin is an abstract non-cash payment method, merely denominating prices in bitcoin terms might reduce the concreteness of departing with one's financial resources and increase vice purchase. On the other hand, others could argue that bitcoin price denomination might not necessarily increase vice purchase because the price denomination effect is distinct from method of payment effect. In fact, we hypothesize that when prices are denominated in bitcoin rather than dollars, consumers will actually be less inclined to purchase vice food products while equally inclined to purchase virtue food products, even when their choice of payment method is not restricted.

The rationale behind our prediction stems from the volatility in the bitcoin-dollar exchange rate that is a characteristic of bitcoin but not of more traditional payment methods. Given that we are currently living in a world of dollar denomination, we expect that consumers generally tend to value and price goods in dollar terms. When bitcoin-dollar exchange rates exhibit a high degree of fluctuation, the price that a consumer pays for an item in dollar terms may change significantly from week to

week and could therefore induce feelings of regret if a consumer feels that she has overpaid for the product. Virtue food products (e.g., bread, milk) tend to be necessities for consumers; thus, when priced in bitcoin, regardless of whether the bitcoin-dollar exchange rate is high or low, consumers may need to purchase those products every week. Consequently, consumers may experience little regret when purchasing virtue foods because the purchases were made out of necessity. By contrast, vice food products (e.g., ice cream, donuts) are typically not necessities but instead occasional treats that consumers may be willing to forego until a later time; thus, when priced in bitcoin, consumers may be more concerned about purchasing the item at a favorable bitcoin-dollar exchange rate since such vice foods are not necessities. Consequently, when denominated in bitcoin, consumers may anticipate greater regret when purchasing vice foods because they are more concerned about making the purchases at a favorable exchange rate. That is, bitcoin price denomination could engender greater decision uncertainty and thus reduce impulsive consumption.

Imagine a consumer buying a pint of Ben & Jerry's ice cream today from a bitcoin-denominated grocery store. If the value of bitcoin depreciates against the dollar, the consumer might regret having purchased the ice cream when she could have waited and purchased it cheaper. This experience of regret is less likely for virtue food items which are necessities that consumers purchase regularly. We evaluate this idea in a simulated shopping experiment.

2 Experiment

2.1 Method

Participants Six hundred and one participants located in the USA (257 women, age $M=38.03$, $SD=13.00$) completed the pre-registered study online through Prolific (<https://aspredicted.org/mz6bc.pdf>).

Procedures All participants were first provided with background information on bitcoin which explained that the price can fluctuate over time and is considered both an investment and a digital asset that can also be used to make payments. Participants were also informed that a bitcoin can be broken down into smaller units called satoshis (SATs) such that 1 bitcoin equals 100 million SATs. Next, participants were randomly assigned to one of two pricing scheme conditions for the simulated shopping task: dollar-denomination condition or bitcoin-denomination condition. All participants were told that a new grocery store opened in their neighborhood and we were interested in understanding the kind of products they might buy from the store. Participants in both conditions were also informed that the store accepts all methods of payment including cash, cards, and bitcoins (see Web Appendix 1).

Participants in the dollar-denomination condition were subsequently told that store set the price of each item in U.S. dollars and that the price they would pay if

purchasing with bitcoin would change based on whether the dollar-bitcoin exchange rate went up or down. By contrast, participants in the bitcoin-denomination condition were instead told that the store set the price of each item in bitcoin and the price they would pay if purchasing with U.S. dollars would change based on whether the dollar-bitcoin exchange rate went up or down. In both conditions, examples were provided to help participants understand the pricing schemes (see Web Appendix 2A & 2B). Then, participants were asked a manipulation check question to ensure they understood the pricing scheme in the store. It is important to note that regardless of the currency used to set prices of goods at the store, both stores accepted all methods of payment including cash, cards, and bitcoins. That is, our manipulation did not change or restrict which method of payments participants could choose to use for their purchases.

Next, participants were shown eight food items, four virtue (eggs, yogurt, milk, bread) and four vice (donuts, ice cream, Snickers, Coca-Cola) foods items that were drawn from prior related studies (Park et al., 2020; Thomas et al., 2011). All eight items were shown simultaneously in a randomized order, and for each item, its photo was shown along with its name, size, and the price in the denominator currency (see Web Appendix 3A & 4A). To facilitate price conversions, participants were further informed that they could hover their mouse over the price to see the conversion into bitcoin/satoshis (in the dollar-denominated condition) or into U.S. dollars (in the bitcoin-denominated condition) (see Web Appendix 3B & 4B for examples). We used the conversion rate of $\$1 = 2500$ satoshis (equivalent to $\$40,000 = 1$ bitcoin) which was approximately the market rate on the day the study was conducted. Participants were instructed to click on any item they wanted to purchase.

Following the shopping task, participants were shown all eight food items and were asked to indicate the degree to which they would regret spending money on each item (1 = not at all regret, 5 = definitely regret). Subsequently, they were asked to indicate their perceived healthiness of each item (1 = definitely unhealthy, 5 = definitely healthy).

A manipulation check measure identical to the item administered earlier was administered once again to ensure participants remembered the pricing scheme of the store they shopped in. Finally, participants provided information on their gender, age, household income, number of household members, and education level.

2.2 Results

Response exclusions As pre-registered, responses from participants who did not understand or remember the payment scheme of the grocery store across two manipulation checks were excluded from the analyses. In total, 45 participants were excluded using this criterion. In addition, three participants chose not to respond to certain questions despite our request to fill them out so their responses were further excluded. This exclusion does not affect our main findings in any way. Thus, the responses from remaining 552 participants were used for analyses.

Shopping decision In order to understand how the denomination prices in bitcoin vs. dollars influenced preferences for virtue and vice food products, we analyzed participants' responses using Proc Glimmix analysis with binomial distribution in SAS. Specifically, we predicted participants' purchase decision (coded as 0 for not purchasing, 1 for purchasing) with pricing scheme condition modeled as a between-participants variable (dollar-denomination condition coded as 0, bitcoin-denomination condition coded as 1), food type as a within-participant variable (virtue items coded as 0, vice items coded as 1), and interaction of the two variables. The model controlled for participants' gender, age, household income, number of household members, and education level as per our pre-registration. There was a significant effect of food type $\beta = -1.28$, $p < 0.0001$, such that participants were generally less likely to purchase unhealthy vice food items. The simple effect of pricing scheme condition was not significant, $\beta = 0.08$, $p > 0.33$. Importantly, we found a significant interaction effect of pricing scheme condition and food type, $\beta = -0.63$, $p < 0.0001$. The coefficient suggests that participants were significantly less likely to purchase vice food items when prices were set in bitcoin compared to when prices were set in dollars. This interaction pattern is consistent with our theorization.

To corroborate the result, we conducted an additional analysis at the shopping basket level with the number of purchased vice items and the number of purchased virtue items as the repeated-measure DVs for each participant using Proc Mixed analysis in SAS. This analysis applied identical predictors and controls and resulted in a similar interaction effect, $F(1, 550) = 10.48$, $p = 0.0013$. Further contrast analyses revealed that whereas the bitcoin-denomination of prices did not affect purchase decisions for virtue items compared to dollar-denomination, $M_{\text{Bitcoin-virtue}} = 2.03$, $M_{\text{USD-virtue}} = 1.95$, $F(1, 550) = 0.91$, $p > 0.34$, it did reduce the purchase of vice items, $M_{\text{Bitcoin-vice}} = 0.53$, $M_{\text{USD-vice}} = 0.83$, $F(1, 550) = 13.09$, $p = 0.0003$. In a similar analysis conducted with the total dollar amount spent on virtue items and vice items as the repeated-measure DVs for each participant, we continued to observe a significant interaction effect, $F(1, 550) = 12.45$, $p = 0.0005$. Contrast analyses revealed that whereas the bitcoin-denomination of prices did not affect the total amount spent on virtue items compared to dollar-denomination, $M_{\text{Bitcoin-virtue}} = \6.12 , $M_{\text{USD-virtue}} = \5.95 , $F(1, 550) = 0.25$, $p > 0.61$, it indeed reduced the total amount spent on vice items, $M_{\text{Bitcoin-vice}} = \2.26 , $M_{\text{USD-vice}} = \$3.70$, $F(1, 550) = 20.07$, $p < 0.0001$. To depict this pattern visually, we plotted the values from this supplementary analysis in Fig. 1.

Regret Anticipated regret from spending money on each item was analyzed using Proc Glimmix analysis in SAS. We submitted participants' anticipated regret to the model with identical predictors and covariates as in the main analysis. Not surprisingly, there was a significant effect of food type $\beta = 1.38$, $p < 0.0001$, such that participants anticipated regretting more spending money on vice items. The simple effect of pricing scheme condition was not significant, $\beta = -0.10$, $p > 0.18$. Importantly, we found a significant interaction effect of pricing scheme condition and food type, $\beta = 0.32$, $p < 0.0001$. The coefficient suggests that participants in the

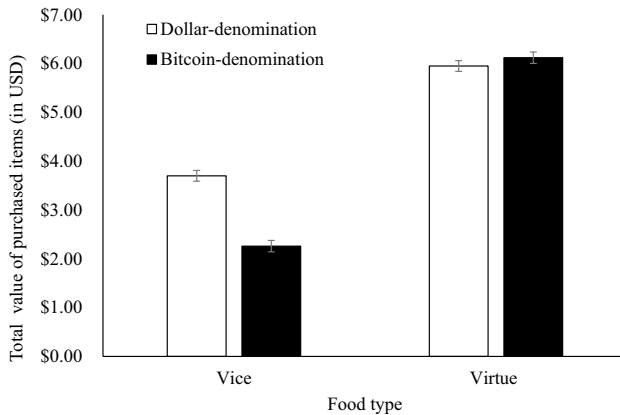


Fig. 1 Bitcoin-denomination of prices reduces spending on vice items but not on virtue items compared to dollar-denomination of prices

bitcoin-denomination condition were significantly more likely to regret spending money on vice items than were participants in the dollar-denomination condition. This interaction pattern is consistent with our theorization.

Mediation by regret To evaluate the role of regret and moderating role of food type on purchase decision, we conducted a moderated mediation analysis using the Model 7 of the PROCESS macro (Hayes, 2017) with 5000 bootstrapped samples. In this model, pricing scheme condition was entered as the independent variable (0=dollar-denomination, 1=bitcoin-denomination), purchase decision as the dependent variable, regret as the mediator, and food type (0=virtue, 1=vice) as the moderator. We again included the same covariates applied in the analyses reported earlier. The index of moderated mediation suggested significant moderated mediation (Index of moderated mediation = -0.296 , 99% CI [$-0.500, -0.110$]). To probe the pattern of moderated mediation, we examined the significance of mediated path across different food types. For virtue food items, regret did not mediate the effect of pricing scheme on purchase decision ($b=0.093$, $SE=0.047$, 99% CI [$-0.027, 0.217$]). However, for vice food times, regret mediated the effect of pricing scheme on purchase decision ($b=-0.202$, $SE=0.058$, 99% CI [$-0.363, -0.058$]). These results suggest that the effect of bitcoin denomination on purchase decisions was mediated by changes in regret for vice products but not for virtue products.

Healthiness Perceived healthiness measure confirmed that the four items chosen as vice items ($M_{\text{vice-healthiness}}=1.33$) were believed to be less healthy than the four items chosen as virtue items ($M_{\text{virtue-healthiness}}=3.95$), $F(1, 550)=3623.97$, $p<0.0001$. Neither simple effect of pricing scheme ($p>0.28$) nor the interaction effect of pricing scheme and food type ($p>0.43$) was significant.

2.3 Discussion

In a simulated grocery shopping study, we demonstrated that merely denominating prices in bitcoin rather than in U.S. dollars changed consumer purchasing behavior, even when people could choose to pay with any payment method. Specifically, when shopping at stores with bitcoin-denominated prices, consumers were significantly less likely to purchase vice food products compared to when shopping at stores with dollar-denominated prices. Reduced purchase of vice vs. virtue products when shopping at bitcoin-denominated stores stemmed from an increased level of regret associated with the purchase, as supported by mediation analysis. These findings are consistent with the idea that price volatility in cryptocurrencies may reduce purchase of non-essential items, due to decision uncertainty. The data, SAS code used for analyses, and the outcomes of our analyses are publicly accessible on OSF (<https://osf.io/7a5yk/>) along with stimuli in the Web Appendix.

To establish the robustness of our finding, we conducted a similar shopping study ($N=601$, responses from 547 used for analyses after following identical response exclusion procedure) only with the vice items used as the stimuli. Consistent with the results reported in our study, participants assigned to the bitcoin-denomination condition bought a smaller number of vice products than participants assigned to the dollar-denomination, $F(1, 545)=5.21$, $p=0.023$ and spent a lower total amount of money purchasing vice products, $F(1, 545)=6.05$, $p=0.014$.

3 General discussion

Our knowledge of cash vs. noncash payment methods has accumulated over several decades of research that coincided with the rapid adoption of credit and debit cards. Prior work has established that cash vs. card payments can influence attention (Chatterjee & Rose, 2012), memory (Soman, 2001), reward sensitivity (Banker et al., 2021), willingness to pay (Boden et al., 2020; Feinberg, 1986; Prelec & Simester, 2001; Raghurir & Srivastava, 2008), basket size (Hirschman, 1979; Soman, 2003), basket composition (Park et al., 2020; Thomas et al., 2011), and post-transactional connection (Shah et al., 2016). However, as cryptocurrencies now take on the role of the fast-rising form of payment, we believe that our understanding of them also must develop. A handful of novel propositions have been presented in the literature, positing that bitcoin can be understood as a virtual currency with bidirectional flow (Scheidegger & Raghurir, 2022), may serve to make money abstract (Macdonnell & White, 2015), is less material (Morewedge et al., 2021), or results in a contracted scale (Wilcox & Prokopec, 2019). Yet, there is currently a lack of empirical evidence documenting effects on spending behavior; we add to ideas mentioned by examining how a unique property of bitcoin payments can influence preferences for vice vs. virtue goods.

Our findings provide several novel insights that add to the existing body of work in the payments literature. First, prior findings have shown that people purchase vice products more frequently when shopping with noncash payment methods such as

credit and debit cards rather than cash (Park et al., 2020; Thomas et al., 2011). Our findings suggest that the adoption of novel convenient method of payment and potential consequence of such adoption in the form of novel price denomination scheme will not always result in the lapse in consumer prudence. In fact, we show that bitcoin adoption, at some stage, could promote more prudent consumption decisions if prices of goods are denominated in bitcoin terms regardless of method of payment consumers pay with. Our findings suggest that decision uncertainty engendered by bitcoin price denomination could provide a novel process through which impulsive consumption can be curbed. We also add to prior payments work that has examined denomination effects. For instance, our findings may qualify past findings on both foreign currency denominated prices (Okada & Hoch, 2004; Raghurib & Srivastava, 2002) and large vs. small bill denominations (Mishra et al., 2006; Raghurib & Srivastava, 2009), where we find differences between virtue and vice food products. These departures from prior work also present unique opportunities for future research as consumers are likely to have new psychological reference points, in contrast to physical bills and coins, for digital-first currencies.

The current research does have limitations that are lined with the lack of widespread adoption of bitcoin as a method of payment. Despite the growing adoption, it is still a rarity than a norm to find a business that accepts bitcoin payment let alone to find a business that denominates the price of its products in bitcoin. While there are numerous examples of businesses accepting bitcoin as payment (e.g., Starbucks, Burger King, Chipotle, Whole Foods), in most of these businesses, the prices of the goods are still denominated in fiat currency like the U.S. dollar. Although the amount of bitcoin that matches the fiat price at the real-time exchange rate can be sent to pay for the goods, it is still rare to find everyday businesses such as grocery stores that denominate their price in bitcoin terms. In this sense, the bitcoin price denomination tested in our studies is more of a possible futuristic situation rather than a representation of the current business practice. This introduces a confound that is difficult to tease apart at the current stage: Is the effect demonstrated in the current research driven by uncertainty stemming from price volatility or uncertainty stemming from lack of familiarity? With the price of bitcoin still volatile and consumers unfamiliar with bitcoin as a method of payment, we think it is difficult to provide a clear-cut answer to this question. The lack of bitcoin price denomination at the current stage of adoption also makes it extremely difficult to find real-life data or to conduct a field study. However, given the fast adoption of bitcoin from being magic internet money to being a method of payment adopted by growing number of consumers, we do think bitcoin price denomination is a plausible future scenario. We believe further adoption of bitcoin as a payment method will provide us with a better stage to test these questions to find answers in the future. Despite these limitations, we believe the current work contributes to the literature by bringing into conversation a novel method of payment, demonstrating what could happen at a certain stage of its adoption, and, importantly, inviting further academic conversation and investigation on this topic.

The current work explored the idea that bitcoin price volatility may serve to facilitate greater regret when prices of non-essential vice items are set in bitcoin. We believe that there are a number of promising directions for further research when

appreciating the unique properties of these new payment methods. Importantly, while traditional research on credit card vs. cash payments typically grouped all credit card networks together (e.g., Visa, Mastercard, American Express), decentralized cryptocurrency networks each have different properties that could influence the spending experience that can shape consumer behavior. For example, it may be valuable to understand how aspects such as the time to finality (e.g., where transactions are resolved on the order of seconds or minutes rather than months in the case of credit cards), the extent of decentralization (e.g., number of network validators or participants), or even the size of the meme culture (e.g., total value of NFTs on the network), properties that vary on major platforms such as Ethereum, Solana, and Avalanche, may influence risk-perceptions, spending decisions, and post-transactional hedonics.

In short, given the dearth of research in bitcoin or cryptocurrencies as a method of payment, there exist an endless array of areas for further exploration. We hope that this paper provides a groundwork for healthy academic discussion of potential consequences of a novel technology the popularity and adoption of which are growing exponentially across the world.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s11002-022-09651-6>.

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Declarations

Ethics approval Please see below the ethical approval obtained by each author.

- Joowon Park: (The University of Utah, IRB_00136063: Consumers' subjective experience).
- Sachin Banker: (The University of Utah, IRB_00084467: Consumer Preference).

Consent to participate The consent cover letter applied by the first author and approved by The University of Utah IRB was presented to the participants in the beginning of the studies.

Conflict of interest The authors declare no competing interests.

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