Pakistan Journal of Applied Economics, Vol.35 No.1, (43-53), Summer 2025

TRADING, THE LOSS OF TRANSACTIONAL BENEFITS, AND THE PRICING OF A CRYPTOCURRENCY

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Abstract

This study explores a critical and under-examined issue in cryptocurrency economics: the forfeiture of transactional benefits—such as lower costs, global accessibility, and anonymity—when cryptocurrencies are used for trading rather than for transactions. We question why rational investors engage in cryptocurrency trading despite this loss, and how such behaviour affects price dynamics. Departing from traditional literature that attributes cryptocurrency valuation to fundamentals and sentiment, we develop a single-agent model—drawing from Biais et al, (2023)—to explicitly incorporate the loss of transactional benefits. Our model reveals that for trading to occur, investors must hold a minimum level of optimism regarding future prices, making this sentiment a prerequisite rather than a consequence of market behaviour. We demonstrate that increased trading, relative to transactional use, elevates cryptocurrency prices only if sentiment surpasses this critical threshold. Conversely, under constant price equilibria, heightened investor allocation to cryptocurrency trading leads to declining crypto prices and rising standard currency prices. This work presents a novel theoretical framework for understanding the role of optimism and lost utility in cryptocurrency markets, paving the way for empirical validation and future multi-agent extensions.

Keywords: Cryptocurrency, Asset Pricing, Transactional Benefit and Sentiments.
JEL Classification: G1, G2, L86.

I. Introduction

Using cryptocurrency to buy goods and services or other financial assets, such as Initial Coin Offerings (ICOs), brings transactional benefits, including lower transaction costs, global accessibility, and anonymity. These transactional benefits are lost when a cryptocurrency is purchased with the intention of selling it in the future for trading purposes, which raises fundamental questions. Why will an investor buy a cryptocurrency for trading purposes, given the loss of the transactional benefits? How will the price of a cryptocurrency be adjusted in response to the loss of transactional benefits to traders?

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Although a considerable amount of literature demonstrates that the pricing of a cryptocurrency is driven by fundamentals, i.e., transactional benefits and investors' sentiments, our study addresses the roles of transactional benefits and sentiments in pricing from an entirely different perspective. Using the model of Biais et al. (2023), we demonstrate that the loss of transactional benefits in trading must be compensated with a minimum level of optimism about price expectations as a participatory condition for trading. Hence, trading in cryptocurrency comes along with an optimistic sentiment in the market, which is not a necessary condition in the existing literature.

Unlike other literature where users and noise traders are treated as different agents, we deliberately choose a single-agent investor model to model the loss of transactional benefits explicitly. We also show that the loss of transactional benefits will be compensated for by an optimistic take on prices in each period, leading to the formation of an asset price bubble in the cryptocurrency. We also show that an increase in the trading of the cryptocurrency, overusing it for transactions, will increase its price if only the level of investor sentiments is above the minimum optimism; otherwise, it has no impact.

Under constant price equilibria, we demonstrate that cryptocurrency prices fall, and the prices of a standard currency increase as investors' allocation to cryptocurrency for trading purposes increases.

Section II provides a concise theoretical and empirical review of the relevant literature. Section III develops the theoretical framework and model. Section IV introduces the pricing of cryptocurrency under general preferences, with Section V extending and refining this analysis of loss transactional benefits and optimism. Section VI examines the constant price equilibrium in the presence of risk-averse agents. Finally, Section VII concludes the paper by summarising the main insights drawn from the analysis.

II. Literature Review

Initially, a cryptocurrency was viewed as an alternative currency; Nakamoto (2008) defines a bitcoin as a peer-to-peer electronic cash system facilitating direct online payments between parties without involving financial institutions. However, it also functions as a financial asset. While a currency has properties of the medium of exchange, a unit of account, and value storage, financial assets lack the first two traits, setting them apart.

The appeal of using virtual currencies (such as Bitcoin) as a medium of exchange lies in their low transaction costs, global accessibility, and anonymity, especially for purchasing specific goods, including those that are illegal. Nevertheless, factors such as low confidence, unacceptability, or high price volatility can deter potential users. When viewed as an investment, demand for Bitcoin influences its price volatility, impacting user adoption.

The key question is not whether cryptocurrency functions as money or as an investment asset, but to what extent it fulfills each role. Baur et al. (2018) demonstrate that the predominant use of Bitcoins is for speculative investment rather than as a viable alternative currency or medium of exchange, based on an examination of transaction data.

However, classifying a cryptocurrency into a specific asset category poses a challenge. There are many studies that indicate that bitcoin exhibits a weak correlation with both high-risk financial assets and safe-haven assets, implying its position in a distinct and uncorrelated asset class (Bouri et al., 2017; Bouri et al., 2017; Corbet et al., 2018). Additionally, Kristoufek (2013) argues that bitcoin cannot be priced through the conventional financial model, i.e., the future cash flow model.

Nonetheless, the emerging literature agrees on some stylised facts of a cryptocurrency. The first and foremost empirical stylised fact is that cryptocurrency market returns can only be explained by crypto market-specific factors, not by any other market (i.e., stocks, bonds, commodities, or currencies) or economic factors (Liu & Tsyvinski, 2021). There is also no role of supply-side factors, such as the cost of mining, in explaining the return; this has emerged as a second stylised fact (Liu & Tsyvinski, 2021). The third fact is the presence of high volatility and non-normality of the returns of cryptocurrencies (Kim et al., 2021). The fourth fact is the presence of momentum in cryptocurrency prices, which is also widely supported by the literature (Liu & Tsyvinski, 2021).

In a recent study, Liu et al. (2022) conducted a comprehensive study of factors that could explain the crypto market returns and identified three factors — crypto market, size, and momentum — that fully explain the returns. They show that the momentum effect is driven by speculation.

A cryptocurrency is also susceptible to price bubbles, driven by investors seeking speculative profits through currency exchange. Investor speculation, often disconnected from a currency's intrinsic value, can significantly impact the price that non-investors (users) must pay to use the currency for transactions. Unlike traditional currencies, which governments can adjust the supply to counter bubbles, cryptocurrencies typically follow a predetermined supply trajectory, making them more vulnerable to price bubbles (Yermack, 2015; Kjaerland et al., 2018; Patel et al., 2020).

To sum up, Cryptocurrency serves both as currency and as a financial asset. It offers low-cost transactions but faces volatility and acceptance issues. Primarily used for investment, its classification remains challenging. The prices of cryptocurrencies are primarily driven by speculative behaviour, exposing them to asset price bubbles.

III. Theoretical Framework and Model

Our theoretical framework is an extension of the basic model of Biais et al. (2023), which is itself built upon the work of Garratt and Wallace (2018). They employ Wallace's (1981) multi-currency model to investigate how the prices of a cryptocurrency and a traditional currency are jointly determined. Their analysis considers the occurrence of a potential market crash triggered by a sunspot, which Biais et al. (2023) exploited to drive constant price equilibria. We also limit our analysis to constant price equilibria, as the transactional benefit is lost when investors use some of the currency for non-transactional purposes.

We built on the model of Biais et al. (2023). We introduce noise trading behaviour in cryptocurrency investors. We explicitly model the speculative behaviour of the investors based on their noisy expectations about future cryptocurrency prices. In our model, investors purchase cryptocurrency for both transactional and speculative purposes. In contrast, the Biais et al. (2023) model indicates that they only buy for transactional purposes.

We use the overlapping generation model, in which time is divided into discrete periods, allowing for infinite time. The overlapping generations (OLG) framework, initially developed in foundational works, has long been a cornerstone of microfounded models (Samuelson, 1958; Wallace, 1980; Tirole, 1985). More recently, it has also been applied to the study of cryptocurrencies (Biais et al., 2023; Saleh, 2020; Garratt & Wallace, 2018).

There is one consumption good and three assets a cryptocurrency, a standard currency, and a risk-free asset. There are three types of agents in the market: investors, minors, and hackers and all agents are price takers. At the beginning of the model, there is a generation of old investors, miners, and hackers, holding the supply of cryptocurrency X_1, and standard currency m.

A representative investor is born with the endowment of et units of consumption goods in period one, subject to the following budget constraint, as shown in Equation (1). From the endowment, he buys q_t units of cryptocurrency at the price of p_t, $\hat{q}_t$ units of standard currency at the price of $\hat{p}_t$, and saves s_t. Whatever is left is his consumption in period one, c_t^u. The cost of buying cryptocurrency is φ_t, directly proportional to its value.

$$c_t^y = e_t - s_t - q_t p_t (1 + \varphi_t) - \hat{q}_t \hat{p}_t \tag{1}$$

He buys the coins in the proportion of $(1 - \tau_t)$ for transactional purposes and others in proportion τ_t, for speculative purposes. We assume that the investor perceives these two allocations for the coins as separate accounts. He expects to get φ_{t+1} transactional benefit on the quantity that he buys for this purpose. We assume that these transactional benefits stem from the transactions of the common goods among the network of cryptocurrency users (Sockin & Xiong 2023). We assume $\varphi_{t+1} \geq -1$ avoid the degenerate case (Biais et al., 2023).

As an incentive to speculate, he expects the future price to be higher by ρ_{t+1}, which represents over-optimism on his part. h_{t+1} is the proportion of the coins expected to be stolen by the hackers during the period *t* to *t+1*. Hence, his budget constraint when he becomes old at *t+1* as shown in Equation (2).

$$c^o_{t+1} = s_t(1 + r_t) + (1 - h_{\tau+1})(1 + \rho_{t+1}) \{(1 - \tau_t) + q_t p_t(1 + \theta_{t+1}) + \tau_t q_t p_t\} + \hat{q}_t \hat{p}_t \quad (2)$$

The budget constraints of miners and hackers are shown in Equations (3) and (4), respectively. The introduction of miners accounts for the creation of new coins (supply side), whereas hackers pose a threat to the security of the system. However, their actions are kept minimal because our primary focus is on the investors' behaviour. Thus, new miners and hackers are born, perform their activities, and consume after selling their cryptocurrencies.

$$c^m_{t+1} = (X_{t+1} - X_t)p_{t+1} + \varphi_{t+1} q_{t+1} p_{t+1} \quad (3)$$

$$c^h_{t+1} = h_{t+1} q_{t+1} p_{t+1} \quad (4)$$

We assume that utilities in two different periods are addictive and separable, with $\grave{u} > 0$ and $\H{u} \leq 0$. $\{X_t\}_{t>0}$, $\{\varphi_t\}_{t>0}$, $\{\varphi_t\}_{t>0}$, $\&\{\pi_t\}_{t>0}$, are assumed to be exogenous processes, following Biais et al. (2023). We also assume $\{\tau_t\}_{t>0}$, as the exogenous process refers to the extent to which investors purchase cryptocurrency for transactional or trading purposes in each period, which is influenced by exogenous factors such as government regulations.

π_t is the probability of a crash when the cryptocurrency price permanently falls to zero. It is assumed to be a purely extrinsic random variable, caused by an extrinsic change in beliefs due to a sunspot, as in the model of Garratt and Wallace (2018).

IV. Pricing Cryptocurrency under General Preferences

We are driving the equilibrium price of cryptocurrency in a general equilibrium setting, given the noise-trading behaviour of investors.

In the equilibrium setting, a young investor in period t solves in Equations (5) and (6):

$$max_{qt,\, st,\, \hat{p}t}, \{u(c^y_t) + \beta E_t u(c^o_{t+1})\} \quad (5)$$

$$\text{Subject to} \qquad c^y_t \geq 0, \text{(1) and (2)} \quad (6)$$

In each period *t*, the market clears at: $q_t = X_t$, $\hat{q}_t = m$, and $s_t = 0$

The first order optimality condition, first partial derivative of Equation (5), with respect to q_t results in Equation (7):

$$p_t = \beta E_t \left[\frac{\grave{u}(c^o_{t+1})}{\grave{u}(c^y_{t+1})} (1 + p_{t+1})(1 - h_{t+1}) \frac{\{1+\theta_{t+1}(1-\tau_t)\}}{(1+\varphi_{t+1})} p_{t+1} \right] \tag{7}$$

Equation (7) also holds when the condition that $c^y_t \geq 0$ also binds, in other words, if $c^y_t \geq 0$.

When crash risk is considered, Equation (7) results in Equation (8):

$$p_t = \beta (1 - \pi_t) E_t \left\langle \frac{\grave{u}(c^o_{t+1})}{\grave{u}(c^y_{t+1})} (1 - h_{t+1})(1 + p_{t+1}) \frac{\{1+\theta_{t+1}(1-\tau_t)\}}{(1+\varphi_{t+1})} p_{t+1} \middle| \text{ no crash} \right\rangle \tag{8}$$

It is important to note that the price at period t in Equation (8) above is conditional on a no-cash environment, whereas it is not in Equation (7).

The first order optimality condition with respect to s_t turns out to be in Equation (9):

$$\beta = \frac{1}{1 + r_t} \frac{\grave{u}(c^y_t)}{E[\grave{u}(c^o_{t+1})]} \tag{9}$$

Substituting β,from Equation (9) into (8) yields our first proposition:

PROPOSITION 1: In period t, the equilibrium price of the cryptocurrency is in Equation (10):

$$p_t = \frac{1}{1 + r_t} E_t \left[\frac{\grave{u}(c^o_{t+1})}{E[\grave{u}(c^o_{t+1})]} (1 - h_{t+1})(1 + p_{t+1})(p_{t+1} + \theta_{t+1} (1 - \tau_t) p_{t+1}) \right] \tag{10}$$

or for an arbitrary K>1 in Equation (11),

$$p_t = E_t \left[\left[\left\{ \left(\prod_{J=1}^{K} \frac{(1+p_{t+j})(1-h_{t+j})}{(1+r_{t+j-1})(1+\varphi_{t+j-1})} \frac{\grave{u}(c^o_{t+j})}{E[\grave{u}(c^o_{t+j})]} \right) p_{t+K} \right\} + \left\{ \sum_{h=1}^{K} \left(\prod_{J=1}^{K} \frac{(1+p_{t+j})(1-h_{t+j})}{(1+r_{t+j-1})(1+\varphi_{t+j-1})} \frac{\grave{u}(c^o_{t+j})}{E[\grave{u}(c^o_{t+j})]} \varphi_{t+k} (1-\tau_{t+k-1}) p_{t+k} \right) \right\} \right] \right] \tag{11}$$

When Equation (10) is replaced with a formula for the period-ahead future value of the cryptocurrency, and this process is done iteratively, Equation (10) turns into Equation (11).

Equation (10) says the price of cryptocurrency in period t is the present value of the expectation of the product of four terms. The first component represents the pricing kernel, indicating the relationship between the marginal utility of consumption and the cryptocurrency price. The second element accounts for the vulnerability to hacks, whereas the third term accounts for the optimism. Lastly, the fourth term represents the total cryptocurrency price in period *t+ 1* and its adjusted net transactional benefit, adjusted for transactional benefit loss.

When an investor buys some portion of cryptocurrency for trading purposes, it affects the price in two ways in each period. Firstly, he loses the transactional benefit in proportion to his investment for trading purposes, $\theta_{t+1}(\tau_t)$. As a result, he receives the adjusted transactional benefits, equal to $\theta_{t+1}(1-\tau_t)$ as shown in Equation (10). Secondly, as an incentive to participate in trading, he takes the optimistic view that the expected price of cryptocurrency is determined by the factor of p_{t+1}. In the next section, we will discuss these in detail.

V. Loss of Transactional Benefits and Optimism

As can be seen in Equation (10), when some fraction of cryptocurrency (τ_t) is used for trading by an investor, the investors lose the transactional benefit on that proportion, resulting in an adjusted transactional benefit of $\theta_{t+1}(1-\tau_t)$. In other words, this adjusted transactional benefit represents the benefit derived from the proportion of investment allocated to transactional purposes.

It is essential to realise that an investor expects to get different benefits from the same currency depending on how it is used. He receives transactional benefits only when using cryptocurrency for transactions. If used for trading, he will not receive any transactional benefit; instead, he will lose it. This raises the question: why would the investor buy the cryptocurrency for trading purposes, given that he will lose the transactional benefit?

Before answering this question, we need to consider two facts. Firstly, the transactional benefits of cryptocurrency are very limited, questioning the viability of cryptocurrency as a widely accepted medium of exchange. One of the reasons for the limited usage is that its adoption is limited to common goods that can be traded with it (Sockin and Xiong, 2023). Another primary reason is the government restrictions. Secondly, cryptocurrency is often used for speculative purposes rather than as a medium of exchange (Baur et al., 2018).

Given these two facts, it becomes quite sensible to assume that investors buy the cryptocurrency in excess of what is required for transactional purposes. However, to compensate for the loss of transactional benefit on the proportion of trading purpose, the investor would overestimate the future price of the cryptocurrency by $(1+pt+1)$ as an optimism adjustment, which results in proposition 2.

PROPOSITION 2:

In each period, the minimum optimistic adjustment is an incentive to the investors for the loss of transactional benefit when using cryptocurrency for trading purposes in τ_t proportion is:

$$1+\overline{pt} = \frac{(1+\theta_t)}{\{1+\theta_t(1-\tau_t)\}} \tag{12}$$

Where $\overline{p_t} > 0 \Leftarrow \theta_t > 0$ *&* $0 \leq \tau_t \leq 1$ *in the case where transaction benefits are positive, with no short selling of the cryptocurrency and borrowing allowed.*

Proposition 2 can also be interpreted as the participation constraint for buying the cryptocurrency for trading purposes. Moreover, since the loss of transactional benefits will be compensated with an optimistic take on prices in each period, an asset price bubble will form, and it will explode at the rate of $\overline{p_t}$ per period.

PROPOSITION 3:

The change in the proportion of τ_t *has no impact on the price of cryptocurrency if* $p_t = \overline{p_t}$.

However, in the case of $p_t > \overline{p_t}$, *the higher the* τ_t, *the higher the price.*

Proposition 3 states that the impact of cryptocurrency usage for trading purposes on its price depends on the prevailing market sentiment. If the overall investor sentiment is above a minimum optimistic threshold, an increase in trading proportion drives up the cryptocurrency's price.

However, if investor sentiment is at a minimum optimistic level, the increased trading proportion will not impact its price. Instead, during this period, the price remains the same, irrespective of how much the trading proportion changes.

This observation underscores the critical role of investor sentiments in dictating the relationship between trading volumes and the price of a cryptocurrency. It suggests that investor perceptions, emotions, and prevailing market sentiments play a substantial role in determining the price movements based on the nature of cryptocurrency usage—whether primarily for trading or actual transactions.

VI. Constant Price Equilibrium with Risk Averse Agents

Following Biais et al. (2023), we drive the constant price equilibria. In which the prices of cryptocurrency and a standard currency are constant until a crash happens, the probability of a crash is also constant π. For simplicity, we also assume that the utility function of an investor is logarithmic; this assumption won't affect the relationships that we want to draw. Moreover, the results are also valid for volatile price equilibria, where the prices of cryptocurrency and a standard currency are not constant, and the probability of a crash is stochastic.

To simplify our analysis, we also assume that endowments, cryptocurrency supply, proportion invested for trading purposes, costs, and benefits remain constant. The constant price of a cryptocurrency and a standard currency is shown by p and $\hat{p}$ respectively; whereas $\widehat{pc}$, represents the price of a standard currency after the crash happens.

Under the constant price conditions, the solution to equation (5) subject to equation (6) follows.

1st order condition with respect to cryptocurrency,

$$\dot{u}(e-X(1+\varphi)-m\hat{p})=\beta\,(1-\pi)(1-h)(1+p)\,\frac{(1+\theta\,(1-\tau))}{(1+\varphi)}\,\dot{u}\Big((1-h)(1+p)\,Xp(1+\theta\,(1-\tau))+m\hat{p}\Big) \quad (13)$$

1st order condition with respect to the standard currency

$$\dot{u}(e-X(1+\varphi)-m\hat{p})\hat{p}=\beta\,[(1-\pi)\dot{u}\Big((1-h)(1+p)Xp(1+\theta\,(1-\tau))+m\hat{p}\Big)\hat{p}+\pi\,\dot{u}(m\hat{p})\,\hat{p}_c \quad (14)$$

Substituting the right side of (13) in the left side of (14) results in

$$\dot{u}\Big((1-h)(1+p)Xp(1+\theta\,(1-\tau))+m\hat{p}\Big)=\frac{\pi}{(1-\pi)}\,\frac{\hat{p}_c}{\hat{p}}\,\frac{(1+\varphi)}{(1-h)(1+p)\,((1+\theta\,(1-\tau))-(1+\varphi)}\,\dot{u}(m\hat{p}) \quad (15)$$

Rearranging Equation (13) results in

$$\dot{u}\Big((1-h)(1+p)Xp(1+\theta\,(1-\tau))+m\hat{p}\Big)=\frac{(1+\varphi)}{\beta(1-\pi)(1+p)\,((1+\theta\,(1-\tau))}\,\dot{u}(e-X(1-\varphi)-m\hat{p}) \quad (16)$$

After the crash, $\hat{p}_c$ is defined by the following equilibrium condition

$$\dot{u}\,(e-m\hat{p}_c)=\beta\dot{u}\,(m\hat{p}_c) \quad (17)$$

The solution to Equations 15 and 16 under log utility is given by the following proposition.

PROPOSITION 4:

Under the conditions, if the investors have log utility and

$$(1+\theta\,(1-\tau)\,(1-\pi)>1 \quad (18)$$

There is an equilibrium where capitalisation of cryptocurrency as a percentage of total endowment is:

$$\frac{Xp}{e}=\frac{\beta}{1+\beta}\left(1-\pi\,\left(1+\frac{1}{\theta\,(1-\tau)}\right)\right) \quad (19)$$

Whereas the capitalisation of a standard currency is

$$\frac{m\hat{p}}{e}=\frac{\beta}{1+\beta}\left(\frac{\pi\,(1+\theta\,(1-\tau)}{\theta\,(1-\tau)}\right) \quad (20)$$

Proposition 4 demonstrates that as crash risk (π) increases, the cryptocurrency price declines, whereas the standard currency price rises. On the other hand, with increasing adjusted transactional benefits $\theta\ (1 - \tau)$ the cryptocurrency price increases, whereas the standard currency price falls.

What is particularly intriguing to our analysis is that when investors allocate more to cryptocurrency for trading, the cryptocurrency prices drop while the prices of a standard currency rise.

More interestingly, as investors' allocation to cryptocurrency for trading purposes increases, the prices of cryptocurrencies fall, and the prices of standard currencies increase.

VII. Conclusion

Cryptocurrency offers transactional benefits when used as currency to buy goods and assets. However, when used for trading purposes, these benefits are forfeited, prompting questions about the rationale behind trading in it. While existing studies attribute cryptocurrency pricing to fundamentals and sentiment, our research takes a unique perspective, highlighting the need for a minimum optimistic view of the future price of a cryptocurrency due to the loss of transactional benefits. This optimism, contrary to prior literature, becomes an integral part of cryptocurrency trading.

In our study, we model the explicit loss of transactional benefits using a single-agent investor approach, revealing that this loss is compensated for by an optimistic outlook on prices, leading to potential asset price bubbles. We demonstrate that increased cryptocurrency trading, as opposed to transactional use, positively affects its price only when investor sentiment surpasses a minimum threshold. Under constant price equilibria, our findings reveal that increased investor allocation to cryptocurrency trading leads to declining cryptocurrency prices and increasing standard currency prices.

This study is an initial theoretical attempt to model the loss of transactional benefits. It can be extended to the multi-agent model, and its propositions can also be empirically tested in future studies.

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