



Does unit of account affect willingness to pay? Evidence from metaverse LAND transactions[☆]

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ARTICLE INFO

Keywords:

Metaverse

NFT

Unit of account

Willingness to pay

ABSTRACT

LAND is a non-fungible token (NFT) representing virtual real estate ownership in The Sandbox metaverse, a digital world built on the Ethereum blockchain. The open nature of a blockchain-based metaverses like The Sandbox allows users to transact in multiple denominations/currencies. We analyze more than 71,000 transactions and find that when transactions are settled in The Sandbox's native utility token (SAND), users pay 3.4% more compared to ETH (in effective USD prices). There are also evidences that users pay less when transactions are settled in WETH and USD-pegged stablecoins (USDC). Thus, the cryptocurrency/token settlement choice (i.e., unit of account) matters for willingness to pay.

1. Introduction

A metaverse is a digital world where users' avatars can interact and socialize with one another. What distinguishes these new-generation digital worlds from existing game platforms like Second Life, Roblox, or Minecraft is the fact that they are built on open blockchains. The word metaverse has recently caught public attention since the announcement by Facebook (in October 2021) on changing its name to Meta and transforming into a metaverse company. The assets in the metaverses are Non-Fungible Tokens or NFTs which are digital assets on blockchains that can be used to represent ownership of unique items such as arts, collectibles, etc. Blockchains allow the metaverses to have their own cryptocurrencies and thus their own financial ecosystems, providing a novel setting to test monetary theories. Due to the open structure of blockchain-based metaverses, users are much less restricted in the means of payments that they use. The main objective of our paper is to investigate whether settlement choice affects willingness to pay.

The Sandbox was originally launched in 2012 as a game on iOS and Android. In 2018, it was rebranded and rebuilt on the Ethereum blockchain. It became one of the most popular metaverses and users can purchase LAND and create ASSET to be used in the ecosystem. LANDs are NFTs representing unique digital pieces of real estate (identified by coordinates) and 166,464 LANDs (408 × 408) form the map of The Sandbox metaverse. Each LAND can be bought and sold separately or together as an ESTATE. The LAND/ESTATE presale events (primary market sales) are held in rounds by The Sandbox. Users may purchase LAND for two reasons: (i) hoping to generate revenue streams by building games or interactive experiences on LAND and earning revenues from visitors, or (ii) hoping to resell at a

[☆]An earlier version of this paper circulated under the title "Is Metaverse LAND a good investment? It depends on your unit of account!". The authors thank the editor, anonymous referees, Krislert Samphantharak and Archawa Paweenawat for their helpful comments.

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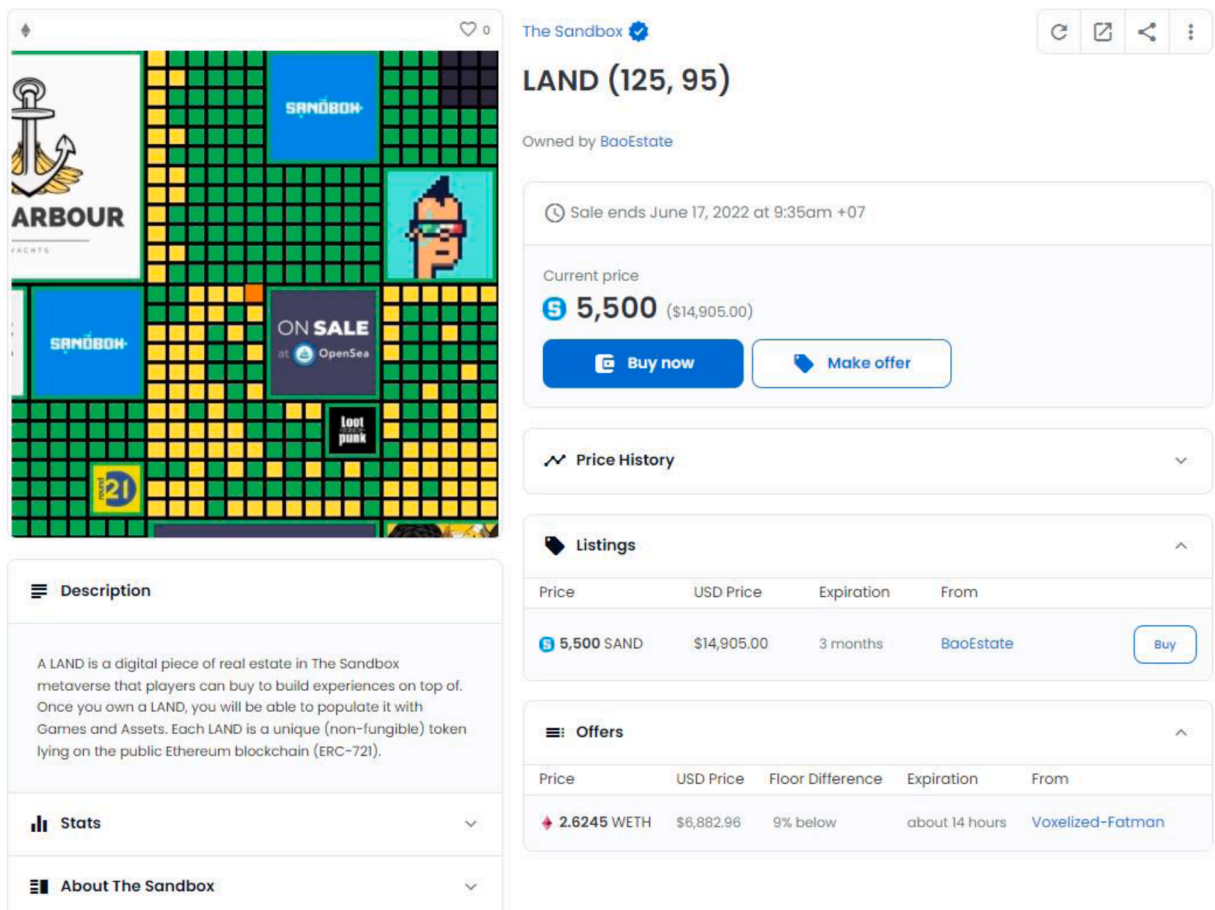


Fig. 1. LAND sales on OpenSea. This figure is the screenshot of OpenSea listing of LAND located at (125, 95) captured at 04:24:32 UTC, Wednesday, 16 March 2022. User BaoEstate lists LAND located at (125, 95) for sale at SAND 5500 (USD 14,905 then), but user Voxlized-Fatman makes an offer of wETH 2.6245 (USD 6882.96). If BaoEstate accepts the offer, the transaction will be settled in wETH. If another user matches the ask at SAND 5500, the transaction will be settled in SAND. Because wETH is an ERC-20 smart contract but ETH is not (and thus their programming properties are different), users who want to make offers that do not match the ask price on OpenSea must use wETH rather than ETH. wETH can also be used to make unsolicited offers on unlisted LAND. Listing source: <https://opensea.io/assets/0x5cc5b05a8a13e3fbd0bb9fccd98d38e50f90c38/122,321>.

higher price in secondary markets such as OpenSea (a peer-to-peer marketplace for NFTs). Currently, various companies (e.g., Adidas, Atari, PwC Hong Kong, Binance, South China Morning Post) and celebrities (e.g., Snoop Dogg, Pranksy) are reported to own LAND in The Sandbox. The most expensive sale was recorded at USD 4.3 million.¹

Within the Sandbox metaverse, SAND is a utility token used as the native currency. Users need SAND to transact within the ecosystem, including the primary LAND sales. However, on a marketplace like OpenSea, users can denominate their LAND listing prices and transact using various cryptocurrencies/tokens. The main tokens used are ETH, wETH (tokenized or wrapped version of ETH), DAI and USDC (stablecoins pegged to USD), and SAND.² There is a specific reason why wETH must be used under certain circumstances (when making unsolicited offers or placing below-ask bids) but there are no documented reasons why sellers would list

¹ <https://www.wsj.com/articles/metaverse-real-estate-piles-up-record-sales-in-sandbox-and-other-virtual-realms-11638268380>, accessed on February 1, 2022.

² ETH and wETH are structurally different because ETH is a native coin which is part the Ethereum blockchain, while wETH is a fungible token (under ERC-20 standard) created from a wETH smart contract by depositing ETH in exchange for a “wrapped” version wETH. Consequently, wETH can be viewed as a synthetic ETH pegged 1:1. In our sample, the price correlation between ETH and wETH is 0.99997. Most smart contract transactions on the Ethereum blockchain involve ERC-20 tokens, so developers often ask users to use wETH rather than ETH for coding simplicity. Because wETH is a smart contract, this exposes wETH to any risk associated with smart contracts such as attacks and failures. The cost of wrapping ETH into wETH is gas, which is not based on the nominal value, so it can be costly to obtain wETH in small amount. For The Sandbox’s LAND, users can use ETH, wETH, USDC, DAI, SAND and ATRI (AtariToken, a native coin of the Atari blockchain owned by Atari, a game developer that partners with The Sandbox, but is bridged to the Ethereum network for interoperability). ATRI is hardly used on OpenSea so we exclude sales settled in ATRI in our analysis.

Table 1

Summary statistics. Panel A reports the token denomination of sale by type. Primary sales are LAND minted directly from The Sandbox and secondary sales are auctioned/sold on OpenSea. ETH is the Ethereum blockchain's native coin, which is also used to pay gas, wETH is an ERC-20 token (wrapped) version of ETH, SAND is The Sandbox's ERC-20 utility token that is used to purchase in-game LAND and ASSET introduced in August 2020, and DAI and USDC are ERC-20 token with prices pegged to USD (stablecoins). Prior to SAND's introduction, LAND was minted with DAI. Panel B reports summary statistics of primary and secondary LAND sold. Prices are converted to USD using daily prices obtained from CoinGecko. Lot size is the number of LAND parcels that are combined into a bundle. Only transactions involving contiguous parcels are included in the sample. Age is the number of days between the transaction date and the LAND mint date. Panel C reports the proportion of secondary sales that were transacted on round numbers in their respective denomination. We exclude transactions settled in DAI and USDC. Panel A: Denomination of sales by type. Panel B: LAND characteristics at primary and secondary sale.

Denomination	Primary	%	Secondary	%	Total	%
ETH	0	0.0%	30,654	74.0%	30,654	43.1%
wETH	0	0.0%	6753	16.3%	6753	9.5%
SAND	29,587	99.4%	3848	9.3%	33,435	47.0%
DAI	176	0.6%	18	0.0%	194	0.3%
USDC	0	0.0%	169	0.4%	169	0.2%
Total	29,763	100.0%	41,442	100.0%	71,205	100.0%
Primary: N = 29,763			Secondary: N = 41,442			
	USD price	Lot size		USD price	Lot size	Age (days)
Mean	947.35	1.38	Mean	8898.79	1.48	272.65
StdDev	2615.81	6.12	StdDev	16,511.83	2.07	202.94
Skewness	7.81	61.41	Skewness	8.72	5.65	0.35
Kurtosis	74.97	5341.77	Kurtosis	132.72	44.75	2.06
p5	38.65	1	p5	126.63	1	3
p50	254.89	1	p50	5207.59	1	262
p95	3195.16	1	p95	20,268.21	4	634

their LAND under certain cryptocurrency/token choice. The majority of users, however, use ETH, likely because it is the native coin that most participants on the Ethereum blockchain would hold.

Fig. 1 shows a screenshot of a sample LAND sales on OpenSea. User BaoEstate lists LAND located at (125, 95) for sale at SAND 5500 (USD 14,905 then), but user Voxlized-Fatman makes an offer of wETH 2.6245 (USD 6882.96). If BaoEstate accepts the offer, the transaction will be settled in wETH. If another user matches the ask at SAND 5500, the transaction will be settled in SAND. This highlights the role of wETH on OpenSea.

Recent papers on NFTs have explored their characteristics and their economic value (e.g., [Bamakan et al., 2022](#); [Ko et al., 2022](#)). Some have investigated their trends and relationships with other traditional and digital assets (e.g., [Pinto-Gutiérrez et al., 2022](#); [Karim et al., 2022](#); [Dowling, 2022b](#); [Nadini et al., 2022](#)). However, very few papers have examined metaverse real estate NFT that typically allow owners to build games or stores on the corresponding metaverse. So far, only [Goldberg et al. \(2021\)](#) and [Dowling \(2022a\)](#) have investigated real estate NFT in another metaverse called Decentraland and base their analyses in USD.

In fact, blockchain-based assets can be traded using any cryptocurrency/token, each with a different price trajectory relative to the USD. In this paper, we study whether “unit of account” (as reflected in the settlement cryptocurrency/token choice) can affect willingness to pay using the hedonic pricing model to see the impact that settlement cryptocurrency/token choice has on the effective USD price paid. To the best of our knowledge, this is the first paper that utilizes LAND transactions to investigate this issue. In addition, our paper is the first to attempt analyzing LAND on The Sandbox metaverse.

Our results revealed that unit of account does matter. When transactions are settled in SAND, users pay 3.4% more compared to ETH. There are also evidences that users pay less when transactions are settled in wETH and USD-pegged stablecoins (such as DAI and USDC). One reason that could have driven the results is the fact that SAND has appreciated significantly against other cryptocurrencies/tokens during the period of our study. People who already held SAND may feel richer and thus are willing to pay more. Another interesting result revealed from our analyses is that ETH and wETH are not perfect substitute. People are willing to pay more using ETH compared to wETH. This could perhaps be explained by Gresham's law – a situation where two types of money with fixed exchange ratio are not viewed as perfect substitutes. The classic example is gold coins vs. silver coins, where gold coins (preferred, or “good” money) are hoarded and silver coins (“bad” money) spent, potentially leading to deviation from the fixed exchange rate.

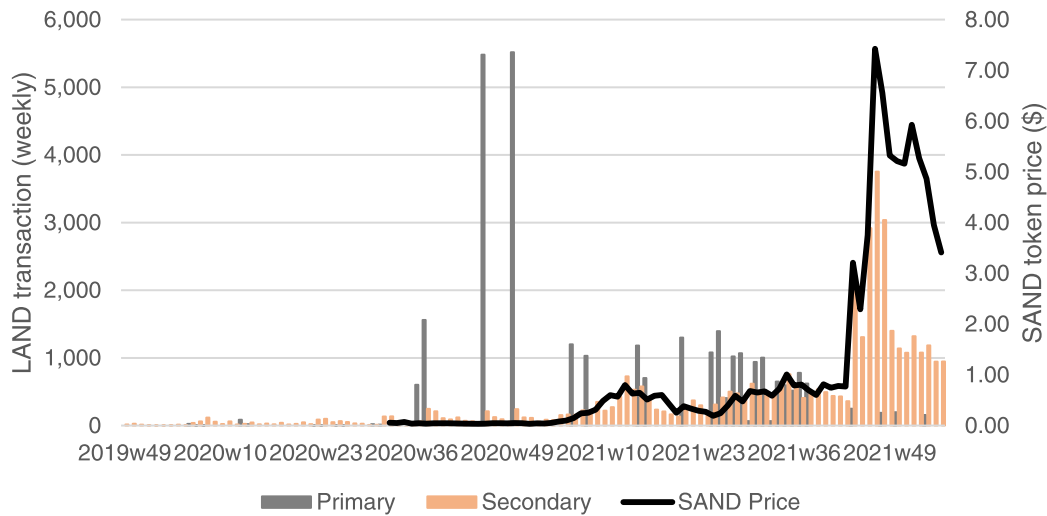
2. Data and methodology

We obtain all LAND sale transactions from the Ethereum blockchain and supplement each LAND with data obtained from The Sandbox's API, allowing us to track the contiguity of LAND parcels which can be formed into bundles or ESTATES.³ The transactions occurred between December 5, 2019 and January 28, 2022, comprising both primary sales (minted directly from The Sandbox) and secondary sales (via OpenSea). Prior to the introduction of SAND in August 2020, LAND was said to be minted and sold in either ETH or DAI.⁴ However, we find that only DAI is used in our primary sales records. Daily token price data is obtained from CoinGecko and used

³ The Ethereum address for the LAND contract is ‘0x50f5474724e0ee42d9a4e711ccfb275809fd6d4a’.

⁴ <https://medium.com/sandbox-game/blockchain-101-how-to-buy-eth-7d653e5074dc>

Panel A: Weekly LAND transactions



Panel B: Weekly share of secondary LAND transactions settled in SAND versus ETH/SAND index

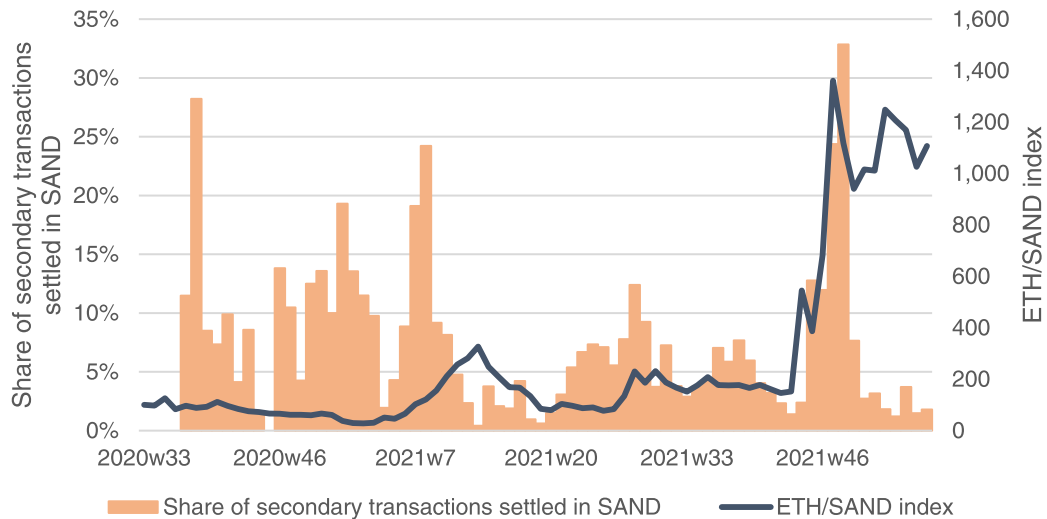


Fig. 2. LAND transactions.

as exchange rates to convert transactions to a common denomination. We winsorize prices at thresholds of 0.1% and 99.9% to limit the influence of outliers. There are 116,767 unique transactions when counted at parcel level, but when aggregated into bundles, the number of unique transactions is reduced to 71,205, with lot size ranging between 1 and 576 parcels. LAND age is computed as the difference in days between mint date and transaction date.

Table 1 shows different cryptocurrencies/tokens used for LAND transactions and summary statistics. The time series of LAND transactions are plotted in Fig. 2A, which shows that activity increased in late 2021, coinciding with Facebook's announcement of name change. Prior to this announcement, ETH and SAND prices were more highly correlated, as evident in the relative prices shown in Fig. 2B. When SAND appreciated relative to ETH, the share of secondary transactions settled in SAND increased.

Weekly LAND transactions and SAND prices are reported in Panel A. Sales include both primary sales (minted directly from The Sandbox) and secondary sales (on OpenSea). SAND is The Sandbox's ERC-20 utility token that is used to purchase in-game LAND and ASSET, so primary sales of LAND are settled in SAND. Panel B reports the weekly share of secondary sales that are settled in SAND against an index of relative price between ETH and SAND. Higher index means SAND price has appreciated relative to ETH. The series in panel A begins at week 49 of 2019 but the series in panel B begins at week 33 of 2020 because SAND was introduced in August 2020. Panel A: Weekly LAND transactions. Panel B: Weekly share of secondary LAND transactions settled in SAND versus ETH/SAND index

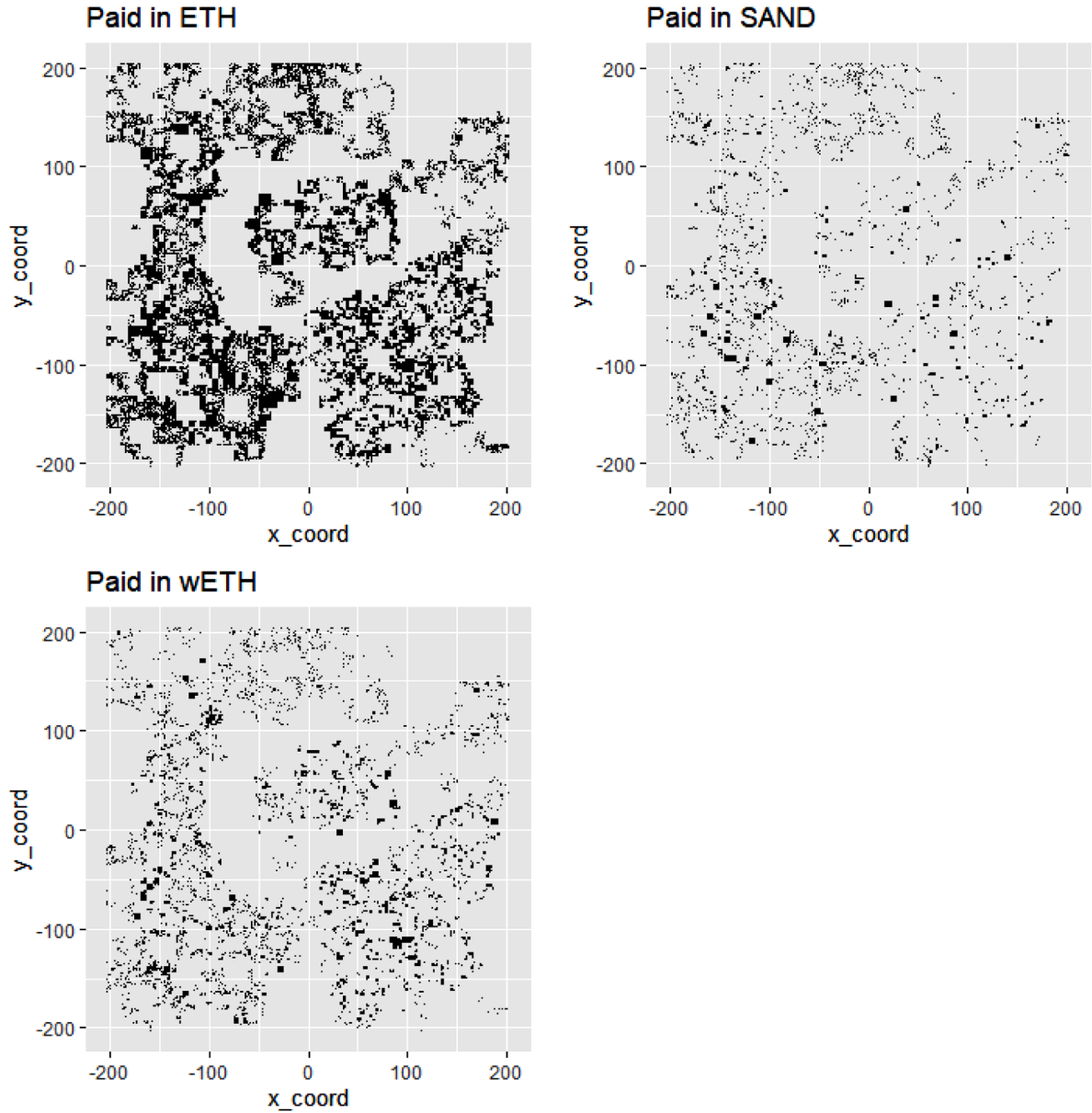


Fig. 3. Secondary LAND transactions by token paid. This figure shows the locations of secondary LAND transactions (listed on OpenSea) settled in ETH, SAND and wETH during the sample period. Users can list LAND for sale in ETH, wETH, SAND, DAI, and ATRI, and buyers can bid in wETH (due to its smart contract functionality that allows sellers to accept the bid and automatically settle the transaction) or pay the asking price in the listed denomination.

Traditional real estate pricing models rely on the revealed preference assumption that prices reflect willingness to pay, so we employ hedonic pricing model that is used to construct real estate price indices (Fisher et al., 1994; Hill, 2013). The inclusion of time fixed effects (whose coefficients are used to construct the index) controls for unobservable factors that vary across time. We regress log prices on controls and indicator variables δ_t for each week-year as specified in Eq. (1). In all regressions, we also include Bitcoin price on the day of the transaction to control more precisely for market conditions.

$$p_{it} = \sum_t \delta_t + \sum_j \beta_j x_{jt} + \varepsilon_{it} \quad (1)$$

We include indicator variables for different settlement tokens with ETH (43.1% of all transactions and 74% of secondary transactions) as the omitted category. Other control variables include the natural log of lot size, LAND age, and indicator variable for primary sale (99.4% occurred in SAND). The type of cryptocurrency/token used to settle can represent the unit of account used by the

Table 2

Hedonic regressions of LAND prices. This table reports the results from the hedonic pricing regressions of the natural log of LAND prices (denominated in various units) on control variables: natural log of lot size, natural log of LAND age, indicator variable for primary sale (minted from The Sandbox) [omitted category is secondary sale], and indicator variables for different tokens used to settle the sale [omitted category is ETH]. For model 2 to 5, indicator variables for year-week of transaction are included. From model 3, only secondary transactions are included. In model 4 and 5, transactions settled in DAI and USDC are excluded. An indicator variable for rounded price transactions is added in model 5. Standard errors are adjusted for heteroskedasticity and reported in parenthesis. Stars correspond to statistical significance level, with *, ** and *** representing 10%, 5% and 1% respectively.

	(1) All	(2) All	(3) Secondary	(4) Secondary*	(5) Secondary*	(6) Pre-Meta	(7) Post-Meta
Primary sale [mint]	−0.398*** (0.02)	−0.336*** (0.02)					
Rounded price					0.161*** (0.01)	0.229*** (0.01)	0.114*** (0.01)
ln (lot size)	0.838*** (0.01)	0.988*** (0.01)	1.038*** (0.01)	1.038*** (0.01)	1.008*** (0.01)	1.024*** (0.01)	0.965*** (0.01)
ln (age)	0.271*** (0.00)	−0.016*** (0.00)	0.003 (0.00)	0.002 (0.00)	0.003 (0.00)	0.008*** (0.00)	−0.009* (0.01)
Paid in SAND	0.415*** (0.02)	0.037*** (0.01)	0.033*** (0.01)	0.034*** (0.01)	0.046*** (0.01)	0.026 (0.02)	0.033*** (0.01)
Paid in wETH	−0.238*** (0.02)	−0.303*** (0.01)	−0.292*** (0.01)	−0.292*** (0.01)	−0.272*** (0.01)	−0.307*** (0.01)	−0.257*** (0.01)
Paid in DAI	1.202*** (0.08)	−0.070 (0.13)	−0.940 (0.61)				
Paid in USDC	−0.303*** (0.10)	−0.250*** (0.07)	−0.247*** (0.07)				
ln (BTC price)	2.275*** (0.01)	1.627*** (0.08)	0.657*** (0.08)	0.655*** (0.07)	0.651*** (0.07)	1.041*** (0.10)	0.011 (0.11)
Constant	−17.695*** (0.07)						
Year-week indicator variables	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	71,205	71,205	41,442	41,255	41,255	19,089	22,166
Adj R-squared	0.489	0.929	0.900	0.902	0.904	0.796	0.608

user behind the transaction. Since our objective is to investigate whether different unit of account affects willingness to pay, therefore, we are interested in the coefficients of SAND and other cryptocurrencies/tokens.

We will start our initial analysis by utilizing all the data (both primary sales and secondary sales). We will then shift our focus to secondary sales only (since most of the primary sales prices are fixed and set by The Sandbox). Additional analyses are conducted for robustness tests: (i) we drop transactions with DAI and USDC since there are very few of them, (ii) we then add rounded price variable, as rounded prices are often related to psychological barriers in finance (e.g. [Mitchell, 2001](#)), and (iii) we segregate the analyses into pre- and post-Meta announcements.

3. Results

We begin by visually inspecting the geographical distribution of LAND. [Fig. 3](#) plots the locations of secondary LAND sales settled in ETH, SAND and wETH and there appears to be no noticeable difference. This alleviates the concern that variations in willingness to pay is driven by unobservable location-specific factors. [Table 2](#) reports the coefficients of the hedonic regression ([Eq. \(1\)](#)). The first column does not include the time fixed effects; the addition of year-week indicators (column 2) increases the adjusted R-squared from 48.9% to 92.9%, suggesting that time trends play an important role.⁵ Primary sale prices in USD are 33.6% lower on average, reflecting early buyer advantage as The Sandbox primarily sells LAND at fixed prices.

The settlement token variables are the main objectives of our investigation. Compared to ETH, transactions settled in wETH and USDC are priced significantly lower (25–30%), while SAND settlements are priced higher (3.7%).⁶ [Fig. 2B](#) also shows that there are more SAND-settled transactions when SAND prices are high. On OpenSea, users who make unsolicited offers or place below-ask bids must use wETH, so the price discount is justifiable. If USDC (hence USD) were viewed as the benchmark, then one could also say that users who paid in ETH and SAND (that have appreciated relative to USD) have higher willingness to pay. The coefficients remain similar when the sample is restricted to secondary sales only (column 3).

Subsequent regressions are conducted as robustness tests. In column 4, we drop transactions settled in stablecoins (DAI and USDC). The coefficients remain similar to those in column 3. In column 5, we add the rounded price indicator, which 34% of transactions are settled in round prices. It appears that transactions in rounded prices are settled 16.1% higher in USD. In column 6 and 7, we further

⁵ The hedonic price index – the byproduct of this regression – is reported in the Appendix

⁶ DAI is primarily used to mint LAND, so there is little variation left for secondary transactions.

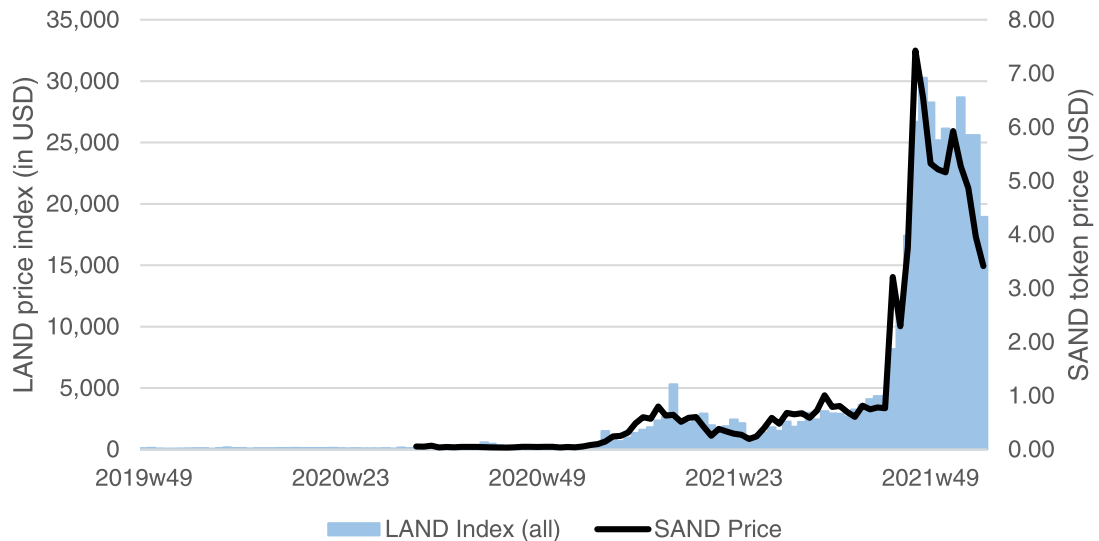


Fig. A1. LAND all-sales price index. Weekly LAND all-sales price index is constructed using the hedonic price index method (Fisher et al., 1994; Hill, 2013). Both primary sales (minted directly from The Sandbox) and secondary sales (on OpenSea) are included in the index construction. Transaction prices are converted to USD. The correlation between the index level and SAND – The Sandbox’s ERC-20 utility token that is used to purchase in-game LAND and ASSET – during the sample is 0.9779.

separate the samples to pre- and post-Meta announcement periods. The results show that SAND premium is present only in the post-Meta announcement sample, coinciding with the period that SAND significantly appreciated against ETH (Fig. 2B), which can represent general market conditions.

4. Conclusion

In this paper, we study whether “unit of account” (as reflected in the settlement cryptocurrency/token choice) can affect willingness to pay. The hedonic pricing model is used to examine whether the settlement cryptocurrency/token choice can affect the effective USD price paid. Using ETH settlement as benchmark, SAND-settled transactions are priced 3.4% higher (in effective USD prices). One reason that could have driven the results is the fact that SAND has appreciated against ETH and other cryptocurrencies/tokens during the period of our study, particularly post-Meta announcement. People who already held SAND may feel richer and thus are willing to pay more. In addition, transactions settled in wETH (a synthetic, ERC-20 version of ETH) are priced lower compared to ETH, as wETH and ETH serve different roles in OpenSea. In the context of Brunnermeier et al. (2019), the wETH-ETH differential is an example of “digital Gresham’s law” – a situation where two types of money with fixed exchange ratio are not viewed as perfect substitutes.

Metaverses are virtual economies whose ecosystems require careful management. Virtual world developers should carefully design and closely monitor the balance of the economy. The introduction of unintended wealth such as real-money trading (the practice of purchasing in-game items with real-world monetary side agreements) can lead to price inflation and upset the economic incentives and users’ experiences, as discussed by Knowles and Castranova (2016). In this regard, The Sandbox can be considered an open economy with no capital control and fully flexible exchange rate, as the permissionless convertibility of blockchain tokens effectively allows perfect capital mobility. Under the Mundell-Fleming view of the “Impossible Trinity” (formalized by Dornbusch, 1976), this virtual economy has no monetary sovereignty and has a fully liberalized financial system, which can be hard to manage. Also, the inability to meaningfully restrict the medium of exchange for secondary transactions means virtual economies’ own currencies can easily be supplanted (or “dollarized”), as illustrated by The Sandbox’s OpenSea auctions/sales that are more frequently conducted in ETH/wETH than SAND.

CRedit authorship contribution statement

Voraprapa Nakavachara: Conceptualization, Methodology, Writing – review & editing. **Kanis Saengchote:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing.

Appendix

In this appendix, we report the price indices which are the byproducts of the hedonic price models used in the main analysis. From Eq. (1) (repeated below), the exponents of δ_t (the year-week fixed effects) are the index levels for each period.

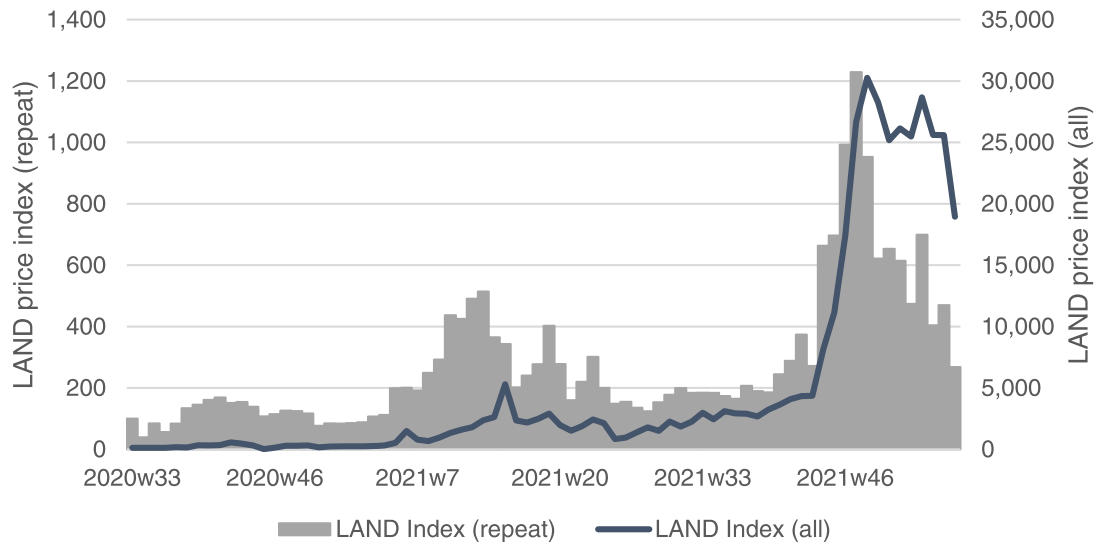


Fig. A2. LAND price indices from all sales and repeat sales. Weekly LAND price index is constructed from repeat sales transactions using the [Case and Shiller \(1987\)](#) method. Only secondary sales (on OpenSea) that have identifiable previous transactions are included in the index construction. The correlation coefficient between the repeat-sales index level (left scale, bars shaded in grey) and the all-sales index (right scale, line) level is 0.7828.

$$p_{it} = \sum_i \delta_i + \sum_j \beta_j x_j + \varepsilon_{it} \quad (1)$$

If we include all transactions (primary and secondary), the result is an all-sales price index, which is reported along with SAND price in [Fig. A1](#). During the sample period, LAND price appreciated by more than 300 times in USD, and the correlation between index level and SAND price are 0.9779.

$$\Delta p_{it} = \sum_i \delta_i + u_{it} \quad (2)$$

However, because each real estate sold can be different and the inability to explicitly control for the differences can influence the estimation of the index. The real estate literature uses repeat sales first-differencing to eliminate time-invariant unobservable characteristics to construct a repeat-sales price index. We use the [Case and Shiller \(1987\)](#) method which requires three steps. First, time indicators are regressed on price changes ([Eq. \(2\)](#)) to generate residuals. Second, the squared residuals are regressed on holding periods (in weeks) to generate predicted residuals. Third, the predicted residuals are used as weights to re-estimate [Eq. \(2\)](#). The repeat sales index begins at week 33 of 2020 to allow for sufficient repeat sales in each week and to coincide with the introduction of SAND in August 2020. The index is reported in [Fig. A2](#) along with the all-sales index from [Fig. A1](#). The repeat-sales index level is much higher, peaking at 11.6 times, with correlation of 0.7828.

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