Disentangling the Relationship between Portfolio Homogenization and Transaction of Non-fungible Tokens

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Abstract

There has been an explosion in the popularity of Non-Fungible Tokens (NFTs), drawing attention from practitioners and scholars alike since 2021. Each NFT denotes a digital asset in the likes of an artwork, a tweet, or a video that is recorded on the blockchain with a unique identifying code. In turn, the emergence of NFTs has transformed the digital asset landscape. With the rapid growth of the NFT market, there is a concern that the market is becoming increasingly homogenized due to readily available blockchain technologies and relatively low costs of NFT mints. To this end, this study attempts to elucidate how NFT portfolio homogenization affects transaction volume and variation in the marketplace. Particularly, we collected and analyzed a dataset of 2,004 collections comprising 7,151,515 NFTs from OpenSea, a leading NFT platform. We discovered significant inverted U-shaped relationships between NFT portfolio homogenization and transaction variation and transaction volume.

Keywords: Non-fungible token; portfolio homogenization; transaction volume; transaction variation; NFT artwork

Introduction

Fueled by the proliferation of blockchain technologies, there has been an explosion in the popularity of Non-Fungible Token (NFT) since 2021, drawing the attention of both practitioners and scholars alike (Pawelzik et al., 2022). By associating a digital asset in the likes of an artwork, a tweet, or a video with a unique identifying code on the blockchain (Sestino et al., 2022; Vasan et al., 2022), NFT not only attests to the immutability of the digital asset, but it can also ascribe a certificate of ownership for the asset (Wang et al., 2021). Indeed, the emergence of NFTs has transformed the digital asset landscape, enabling the creation, ownership, and trading of unique digital assets across multiple domains, including art, collectibles, gaming, and virtual real estate, giving rise to a burgeoning NFT artwork marketplace.

NFT artwork marketplace is a blockchain-based art marketplace that enables creators to mint, publish, and sell their artworks, such as digital pictures, music, and gaming tools (Pawelzik et al., 2022). It has witnessed

tremendous growth in recent years, with several online platforms (e.g., OpenSea and Rarible) catering to the needs of creators, collectors, and traders of these unique digital artworks (Nadini et al., 2021). However, with the phenomenal growth of the NFT market, the market is becoming increasingly homogenized due to readily available blockchain technologies and relatively low costs of NFT mints. Specifically, creators can mint a series of similar NFTs without investing much effort in the NFT creation and minting process. Once a creator has generated the initial digital asset, it is straightforward to produce variations of the asset or create similar assets by making slight modifications on select properties of the original, such as changing the background color. This process can be accomplished rapidly through various design software, and the ensuing NFTs can be quickly minted on the blockchain with only a low fee required by the chain itself.

The above phenomenon in turn gives rise to *NFT portfolio homogenization,* which denotes the situation where a significant number of NFTs within a given collection share similar attributes, such as specific characters, artwork style, subject matter, or artist background. On the one hand, more and more artworks are being added with the same prominent patterns, rendering certain styles or themes to be much more prevalent. For example, the NFT market for digital art has seen a proliferation of NFTs collections featuring vibrant colors, psychedelic patterns, and abstract shapes. This homogenized portfolio may attract investors' and collectors' attention, thereby increasing the transaction volume. On the other hand, a homogenized collection with less diversity and innovations may also lead to criticism because it is hard for investors or collectors to determine its value from the relative comparison with other NFTs. Though it is not certain whether NFTs are the future of art or just a fad, the amount of money changing hands for art backed by NFTs has the art world, financiers, and researchers paying attention. Our research question focuses on how portfolio homogenization is related to transactions of NFT collections.

Until now, there has been limited research on the NFT marketplace. Since this NFT artwork marketplace is still relatively new with unique features from traditional artwork marketplace, prior studies have mainly focused on NFT pricing or cryptocurrency pricing in general (Ante, 2022; Dowling, 2022). Some scholars have investigated specific collection pricing, such as the popular CryptoKitties (Jiang & Liu, 2021). However, there is a dearth of research that examines the NFT market from a collection perspective by considering its NFT portfolio. Specifically, there is a need to understand how NFT transactions can be affected by portfolio homogenization of NFT collections.

Our research seeks to shed light on how the NFT portfolio homogenization is related to transaction volume and variation in the marketplace. We have amassed a comprehensive dataset of 2,004 collections comprising 7,151,515 NFTs on OpenSea, which includes market data (such as descriptions and properties) for the NFTs as well as transaction records (sales). Through data analysis with non-linear regression and U-tests, we found that there are significant inverted U-shaped relationships between NFT portfolio homogenization and transaction variation and volume. Also, creator composition diversity has a significant moderating effect on the relationship between NFT portfolio homogenization and transaction variation and volume. By conducting this research, we hope to provide valuable insights into this emerging marketplace, contribute to a better understanding of its future prospects, and help market participants and platforms make informed decisions. For example, the findings of this study may help NFT issuers and investors better understand the factors that influence NFT prices and demand. Additionally, platforms may use the results of this research to develop policies that promote competition and innovation in the NFT market while also ensuring that market participants are protected from potential risks and abuses.

Theoretical Background

NFT Artwork

NFTs have revolutionized the virtual art transaction market by allowing for the ownership and authentication of digital artworks. In simple terms, an NFT is a unique digital asset that represents ownership of a particular piece of artwork, like an image, music, video, or any other form of digital content. More specifically, each NFT has a specific digital identifier (ID), such that the pair "contract address-token ID" is unique within the reference ecosystem (i.e., the blockchain, like Ethereum). In addition, each transaction related to the NFT artwork is recorded on the blockchain, which provides a clear and transparent history of ownership and provenance. As a result, the higher degree of transparency introduced by the blockchain enhances investment enthusiasm, and NFT artworks attracted millions of art collectors

and investors. Conceivably, the market is highly competitive, with buyers and sellers vying for the most valuable and unique NFTs.

NFT artworks are created through blockchain technology through the following steps (Sestino et al., 2022). First, creators establish an account with profiles and virtual wallets. Second, creators design the prospective NFT and the type of files (like image, video, and audio). Third, creators provide a name and description. Fourth, digital files are uploaded and undergo a blockchain transformation process, which involves paying a fee (known as "gas") in cryptocurrency to create and verify NFT. Finally, NFTs are created with transaction methods (e.g., auction or fixed price) selected by creators. Afterwards, the NFT can be shared, sold, or given away. From the creation process, the transformation step using blockchain ensures the ownership and authentication, not the art properties. That is to say, blockchain cannot guarantee NFTs distinguishability, but it guarantees its low mint fee and transaction transparency.

The value of NFT artworks is not associated with the production costs or objective function but with the reputation of the artist and the innovation they implemented (Beckert & Rössel, 2013; Bsteh, 2021). With NFTs, rarity is relative to the portfolio, which is often determined by the uniqueness of the underlying asset that the NFT represents. For example, collectors or investors often look at the prices of similar NFT artworks to get an idea of the current market value before making a decision.

Product Portfolio

Product portfolio refers to the collection of products offered for sale by a given organization (Jacobs & Swink, 2011). Existing literature has emphasized that the product portfolio can have a salient influence on firms to increase their customer base, better serve customer needs, and maintain strategic flexibility (Rothaermel et al., 2006). Therefore, to better manage a product portfolio, homogenization becomes one of the key considerations, which is the extent of similarities across elements in terms of the attributes of products within the firm, like shapes, materials, or components (Jacobs & Swink, 2011)

To build a competitive product portfolio, scholars have a wide discussion regarding the benefits and costs of product portfolio homogenization (Bowen & Wiersema, 2005; Cassiman & Valentini, 2016; Rothaermel et al., 2006; Sarkar et al., 2009). For instance, a low degree of product portfolio homogenization can not only access a broader range of potential customers but also enable firms to satisfy their heterogeneous needs and demands (Bordley, 2003). Moreover, it can deter new firms from entering the market, which enables remaining firms to charge higher prices and gain more competitive advantages. Besides, it can enhance firm flexibility and increase the resilience of firms in the condition of external environmental threats (Jacobs & Swink, 2011). Nevertheless, other scholars vote for the idea of enhancing product portfolio homogenization. Specifically, high product portfolio homogenization can increase scale economies and lower per-unit production costs (Bordley, 2003). In addition, it can lead to lower design costs, lower inventory holding costs and reduce complexity in assembly (Oke, 2007). Due to potential trade-offs of product portfolio homogenization, scholars have emphasized that it is of great necessity for firms to balance the benefits and costs for delivering an optimal product portfolio homogenization based on firms' characteristics (Rothaermel et al., 2006).

Hypotheses Development

Impact of NFT Portfolio Homogenization on Transaction

NFT portfolio homogenization stands for the degree of the differences between various NFTs' design features within a collection. In the condition of low NFT portfolio homogenization, multiple NFTs within a collection have heterogeneous design patterns. For instance, one group of NFTs may showcase animation like a monkey, while other NFTs may use abstract painting for an apple. Although it can provide various options for investors to choose from in the digital art markets, the excessive unique NFT choices may confuse customers (Wan et al., 2012). Specifically, on the one hand, due to the various unique features designed by the collection, investors may not be able to identify the specialty of the collection and distinguish the NFTs of the focal collection from the offerings of their competitors (Gao & Hitt, 2012). On the other hand, as each NFT has its incomparable features, investors may perceive a high level of difficulty in making decisions when choosing among the NFTs within the collection (Wan et al., 2012), thereby delaying their investment decisions towards the NFTs for the particular collection.

Nevertheless, in the condition of extremely high NFT portfolio homogenization, due to the homogeneous design patterns of NFTs within a collection, it may be insufficient to meet investors' specialized requirements. Moreover, different from the traditional shopping context, investors appreciate digital arts with rarity (Wang et al., 2021). Therefore, collections that hold NFTs with a similar design pattern will be regarded as less valuable for investment. Therefore, high NFT portfolio homogenization also negatively impacts the transaction performance of NFTs within a collection.

Collectively, higher NFT portfolio homogenization can help the NFTs within a collection be more comparable and distinguishable both within the collection and across collections. However, at significantly higher levels, it may reduce the rarity and abilities to meet investors' specialized requirements. Formally, we propose our first hypothesis:

Hypothesis 1*: NFT portfolio homogenization has an inverted-U type relationship with NFTs' transaction volume within the collection.*

With a low level of NFT portfolio homogenization, NFTs within a collection have heterogeneous features, which is detrimental to the distinguishability of NFTs within and across collections. Transaction performance of multiple NFTs within the collection will be at a similarly low level, indicating a low transaction variation. As NFT portfolio homogenization increases, the identity of NFT collections becomes salient, attracting increasing attention from investors. Meanwhile, the distinguishability of individual NFTs is retained, which leads to different transaction performances of NFTs in the same collection. As such, transaction variation within the collection grows as NFT portfolio homogenization increases. However, in the situation of high NFT portfolio homogenization, due to the high overlap of features among each NFT, one NFT within the collection can easily replace the value of other NFTs in the same collection. Therefore, their transaction performance tends to converge, leading to a decreasing level of transaction variation. Taken together, we propose that:

Hypothesis 2*: NFT portfolio homogenization has an inverted-U type relationship with NFTs' transaction variation within the collection.*

Moderating Influence of Creator Composition Diversity

Digital arts' transaction process relies on not only the creator's novelty and ideas but also the legitimization process for which the value of artworks is refined, negotiated, and co-created through the interactions of inner members. In the condition of high creator composition diversity, due to the heterogeneous background and expertise, it is difficult for the collections to highlight the focus of their NFTs (Talke et al., 2010). Moreover, various design logic and perspectives may result in greater variance in refining the meaning of the arts and making it understandable to investors (Van der Vegt & Janssen, 2003). Therefore, in the condition of high creator composition diversity, it becomes more difficult for investors to understand the meaning of the NFTs and evaluate their values, thus resulting in the consequence of low transaction performance for each NFT for the collection. However, when there are limited numbers of creators involved in a collection, their expertise will be more focused, which may eliminate the dilemma that investors cannot appreciate the meaning of NFTs from the collection. Therefore, creator composition diversity can amplify the non-linear role of NFT portfolio heterogeneity on transaction volume.

Similarly, creator composition diversity also strengthens the non-linear impact of NFT portfolio homogeneity on transaction variation. Creator composition diversity increases the difficulties of NFTs within the collection to be understandable and appreciated by investors. Therefore, it further reduces the attractiveness of NFTs with a high degree of overlaps, thereby resulting in the condition that NFTs within the collection have low-level transaction performances without any salient variations.

Taken together, we propose that:

Hypothesis 3*: Creator composition diversity amplifies the inverted U-shaped relationship between NFT portfolio homogenization and (a) transaction volume and (b) transaction variation of NFTs within the collection.*

Methodology

Data Collection

OpenSea, founded in 2017, is the world's largest and most comprehensive decentralized marketplace for trading NFTs. It operates on the Ethereum blockchain, facilitating the creation, buying, selling, and trading of NFTs representing a wide range of digital goods, including digital art, virtual real estate, domain names, and virtual goods from various blockchain-based games. This platform has gained significant popularity due to its user-friendly interface, extensive catalog of digital assets, and the ability to support various token standards, including ERC-721 and ERC-1155. We collected a dataset of 2,004 collections with 7,151,515 NFTs on OpenSea as of February 18, 2022, including NFT market data (description and property) and transaction records (sales). The descriptive information is listed as follows.

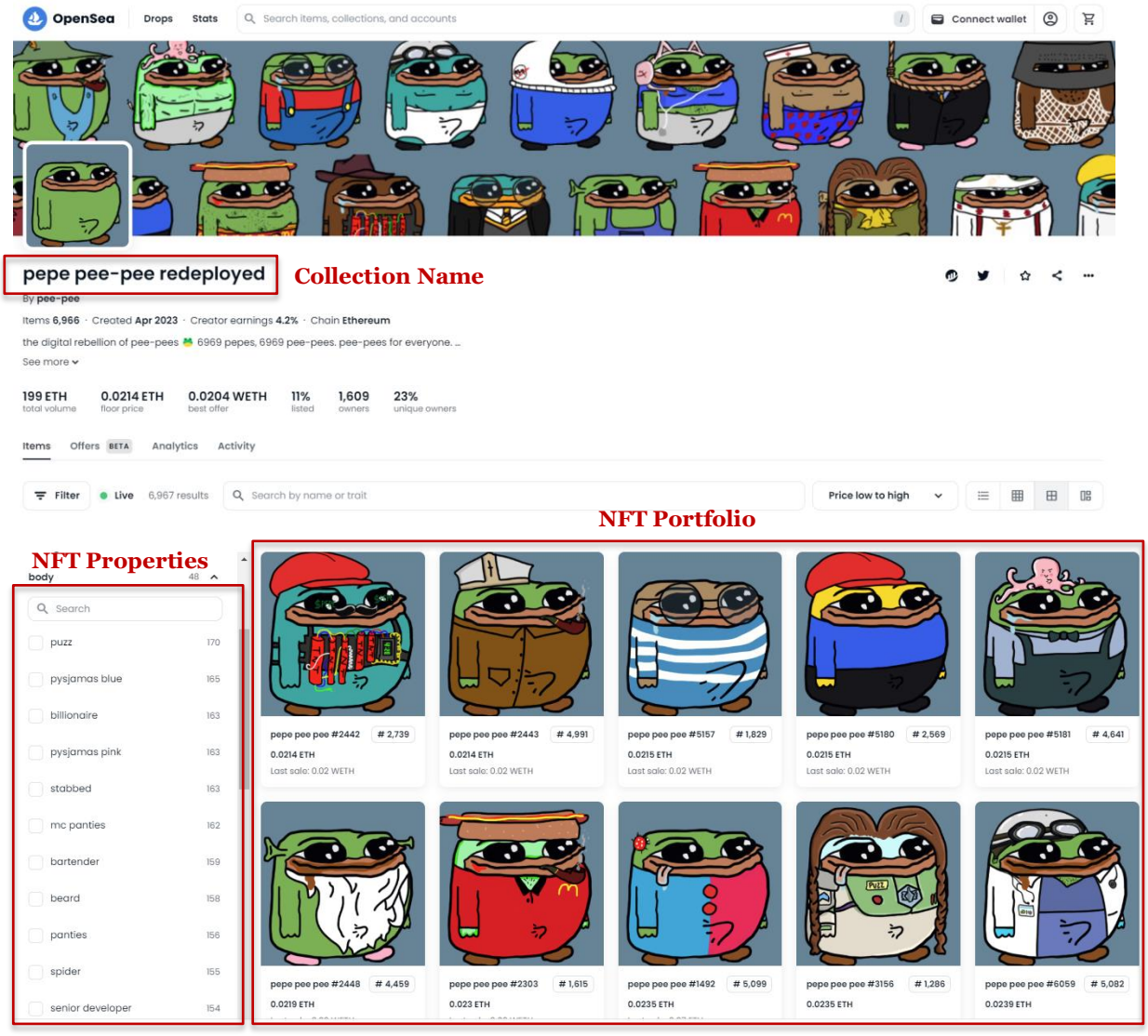

Figure 1. An NFT Collection Portfolio[1] from OpenSea

[1] https://opensea.io/collection/pepepee-pee

Operationalization of Focal Variables

Table 1 shows the definitions of variables used in our data analysis. The dependent variable, transaction variation, is measured by the standard deviation of the NFT's sales quantity within the collection after applying min-max normalization, reflecting the variability of sales quantity. Min-max normalization is used to eliminate the impact of the data scale. Transaction volume is measured by the average sales quantity of the NFTs in the collection.

Variable	**Operationalization**
Transaction variation	The standard deviation of the NFT's sales quantity within the collection after applying min-max normalization
Transaction volume	Average sales quantity of the NFTs in the collection
NFT portfolio homogenization	Similarity of properties' value of NFTs within a collection
Creator composition diversity	The ratio of unique creators in a collection to the number of NFTs in this collection
Property Diversity	Number of properties of a collection
Property Richness	Number of values of a collection
Approved Status	Collection's approval status within OpenSea, including not_requested, requested, approved, and verified.
Description Length (*DescripLength*)	Number of words in the description of a collection.
Ratio of NFTs with animation (*AnimationRatio*)	Ratio of the number of NFTs with animation in the collection
Percentage of Unique Owners (*PCTofUniqueOwners*)	The ratio of unique owners in a collection to the number of NFTs in this collection.
Creating Speed	The ratio of creating time of collection to the number of NFT in this collection.

Table 1. Operationalization of Focal Variables

The independent variable, NFT portfolio homogenization, is measured by the similarities of properties' value of NFTs within a collection. On OpenSea, creators can describe their NFTs using traits that are composed of two levels. The first level is called "property," which describes the features an NFT possesses, such as background, hat, and mouth. The second level is called "value," which is used to specify the particular value that an NFT has for each property, such as "red" for "color" and "Seman's Hat" for "hat." The NFT portfolio homogenization i is computed by the following formula:

$$NFT\ portfolio\ homogenization_i = \frac{\sum_{j=1}^{M_i}(\frac{\sum_{k=1}^{K_{ij}}(PropertyRatioV_{ijk})}{K_{ij}})}{M_i}$$

where $PropertyRatioV_{ijk}$ denotes the number of NFTs with value k of property j in collection i to the number of NFTs in this collection, K_{ij} denotes the number of values of property j in collection i, M_i denotes the number of properties of collection i. We also used min-max normalization to eliminate the influence of the data scale.

We used the creator composition diversity as the moderator in this study, which is measured by the number of unique creators in collection i to the number of NFTs in this collection. The creator composition diversity can be a useful metric for the range of creative input of the collection, which can make the collection more appealing to potential buyers and then lead to increased demand.

Beyond the independent variable and moderating variable, we included seven control variables to account for other factors that might affect the transaction variation and transaction volume. To control for the impact of the number of properties and values, we added property diversity (i.e., the number of properties of collection i) and property richness (i.e., the number of values of collection i). The visibility of the

collection on OpenSea is related to the approved status of the collection. Collections with "not_requested" and "Requested" may not be easily discoverable on the platform, while collections with "Approved" and "Verified" can be found in search results on the platform. Thus, we included approved status as a control variable. Moreover, we also controlled some factors that may affect the attractiveness of NFTs in the collection, such as the length of description (i.e., DescripLength) and the ratio of NFTs with animation in the collection (i.e., AnimationRatio). The percentage of unique owners of a collection on OpenSea can be an indicator of how widely the collection is held and how many people are interested in owning it. A high percentage of unique owners suggests that there is a significant demand for the collection's NFTs, and that may result in a high sales quantity. Therefore, we also included the percentage of unique owners (i.e., PCTofUniqueOwners) as a control variable. In addition, we controlled for creating speed, measured by the collection time to the number of NFTs in this collection. Creating speed reflects the efficiency of NFT collection creation on OpenSea, which may also impact the collection's success.

Descriptive Statistics

Table 2 shows the descriptive statistics of all variables in this study, and Table 3 displays the correlations among these variables. We also tested the VIF of each variable. None is larger than 10, suggesting that there is no severe problem with multicollinearity among these independent variables.

Variable	**Min**	**Max**	**Mean (%)**	**Std. Dev.**
1. Transaction variation	0	0.5	0.179	0.086
2. Transaction volume	0	2769	9.566	99.087
3. NFT portfolio homogenization	0	1	0.155	0.2
4. PropertyDiversity	1	3156	11.928	75.76
5. PropertyRichness	1	25317	509.537	1815.372
6. ApprovedStatus1 (not_requested)	0	1	31.3%	--
7. ApprovedStatus2 (Requested)	0	1	28.5%	--
8. ApprovedStatus3 (Approved)	0	1	39.8%	--
9. ApprovedStatus4 (Verified)	0	1	3%	--
10. DescripLength	0	1029	392.377	271.163
11. AnmiationRatio	0	1	0.21	0.393
12. PCTofUniqueOwners	0	1	0.353	0.25
13. PCTofUniqueCreators	0	1	0.026	0.089
14. CreatingSpeed	0	5.5	0.078	0.302

Table 2. Descriptive Statistics

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1. Transaction variation	--												
2. Transaction volume	0.226	--											
3. NFT portfolio homogenization	0.232	0.045	--										
4. PropertyDivers	-0.047	-0.011	-0.061	--									
5. PropertyRichness	-0.127	-0.025	-0.075	0.171	--								
6. ApprovedStatus1	0.217	-0.045	0.075	-0.026	-0.124	--							
7. ApprovedStatus2	-0.146	0.054	-0.049	-0.015	0.119	-0.426	--						
8. ApprovedStatus3	-0.078	-0.008	-0.021	0.033	0.007	-0.549	-0.514	--					
9. ApprovedStatus4	0.055	0.006	-0.039	0.046	0.001	-0.040	-0.037	-0.048	--				
10. DescripLength	-0.088	0.007	-0.058	0.054	0.031	-0.054	-0.003	0.051	0.023	--			
11. AnmiationRatio	0.119	0.076	0.242	-0.015	0.036	-0.090	0.140	-0.047	0.029	-0.066	--		
12. PCTofUniqueOwner	-0.018	-0.026	0.220	-0.021	-0.016	-0.145	0.041	0.104	-0.037	-0.080	0.181	--	
13. Creator Composition Diversity	0.499	0.311	0.133	0.016	-0.047	0.139	-0.096	-0.048	0.038	-0.079	0.124	-0.037	--
14. CreatingSpeed	0.423	0.405	0.096	-0.023	-0.068	0.086	-0.052	-0.054	0.165	-0.071	0.160	-0.047	0.622

Table 3. Correlations between Variables

Model Specification

We employed the multiple regression model to test our hypotheses. As we hypothesized an inverted U-shape relationship between NFT portfolio homogenization and dependent variables (i.e., transaction variation, transaction volume), a quadratic term of NFT portfolio homogenization is included in the analysis model. The models are specified below:

$$Transaction\ variation_i = \beta_0 + \beta_1 NFT\ portfolio\ homogenization_i^2 + \beta_2 NFT\ portfolio\ homogenization_i + ControlVariables_i + \varepsilon \quad (1)$$

$$Transaction\ volume_i = \beta_0 + \beta_1 NFT\ portfolio\ homogenization_i^2 + \beta_2 NFT\ portfolio\ homogenization_i + ControlVariables_i + \varepsilon \quad (2)$$

$$Transaction\ variation_i = \beta_0 + \beta_1 NFT\ portfolio\ homogenization_i^2 + \beta_2 NFT\ portfolio\ homogenization_i + \beta_3 Creator\ composition\ diversity_i + \gamma_1 NFT\ portfolio\ homogenization_i^2 \times Creator\ composition\ diversity_i + \gamma_2 NFT\ portfolio\ homogenization_i \times Creator\ composition\ diversity_i + ControlVariables_i + \varepsilon \quad (3)$$

$$Transaction\ volume_i = \beta_0 + \beta_1 NFT\ portfolio\ homogenization_i^2 + \beta_2 NFT\ portfolio\ homogenization_i + \beta_3 Creator\ composition\ diversity_i + \gamma_1 NFT\ portfolio\ homogenization_i^2 \times Creator\ composition\ diversity_i + \gamma_2 NFT\ portfolio\ homogenization_i \times Creator\ composition\ diversity_i + ControlVariables_i + \varepsilon \quad (4)$$

Analytical Results

Table 4 reports the multiple regression results. We first tested the inverted U-shaped relationships between NFT portfolio homogenization and our dependent variables (i.e., transaction variation and transaction volume) in Models 1 and 3. Then, we used Models 2 and 4 to examine the moderating effect of creator composition diversity.

Variables	(1) Transaction Variation	(2) Transaction Variation	(3) Transaction Volume	(4) Transaction Volume
NFT portfolio homogenization	0.178***	0.144***	64.79**	5.621
	(0.0240)	(0.0256)	(30.45)	(32.36)
NFT portfolio homogenization²	-0.139***	-0.107***	-73.41**	1.563
	(0.0272)	(0.0294)	(34.58)	(37.18)
Creator composition diversity	0.332***	0.244***	118.7***	24.89
	(0.0229)	(0.0311)	(29.11)	(39.33)
NFT portfolio homogenization * Creator composition diversity		0.811***		1,189***
		(0.197)		(249.8)
NFT portfolio homogenization² * Creator composition diversity		-0.737***		-1,402***
		(0.209)		(265.0)
PropertyDiversity	-2.35e-05	-2.06e-05	-0.000949	0.00200
	(2.13e-05)	(2.12e-05)	(0.0270)	(0.0268)
PropertyRichness	-3.04e-06***	-3.07e-06***	-0.000571	-0.000561

	(8.95e-07)	(8.91e-07)	(0.00114)	(0.00113)
1.ApprovedStatus	-0.0304***	-0.0304***	26.78***	27.70***
	(0.00425)	(0.00424)	(5.397)	(5.368)
2.ApprovedStatus	-0.0213***	-0.0212***	15.90***	16.10***
	(0.00386)	(0.00385)	(4.905)	(4.873)
3.ApprovedStatus	0.0186	0.0227	-79.67**	-76.14**
	(0.0274)	(0.0273)	(34.79)	(34.59)
DescripLength	-9.58e-06	-9.92e-06*	0.0139*	0.0132*
	(5.88e-06)	(5.86e-06)	(0.00747)	(0.00742)
AnmiationRatio	0.00418	0.00446	-2.184	-2.996
	(0.00433)	(0.00432)	(5.502)	(5.477)
PCTofUniqueOwners	-0.00705	-0.00474	-7.668	-4.566
	(0.00665)	(0.00665)	(8.444)	(8.418)
CreatingSpeed	0.0472***	0.0485***	117.3***	119.9***
	(0.00684)	(0.00682)	(8.685)	(8.642)
Constant	0.173***	0.175***	-23.62***	-20.72***
	(0.00467)	(0.00468)	(5.925)	(5.921)
Observations	2,004	2,004	2,004	2,004
R-squared	0.334	0.340	0.187	0.199
Note: ***p<0.01, **p<0.05, *p<0.1				

Table 4. Results of Multiple Regression Analysis

Hypotheses 1 predicted an inverted U-shaped relationship between NFT portfolio homogenization and transaction variation. The results show that the squared term of NFT portfolio homogenization is negative and significant (β=-0.139, p<0.01). To confirm the presence of the inverted U-shaped relationship, we tested the quadratic relationship following the three-step procedure proposed by Lind et al. (2009). The presence of an inverted U-shaped relationship needs to satisfy three conditions: 1) the significant squared term, 2) the turning point within the range of data, and 3) the curve steeply sloping at both ends of the data (Lind and Mehlum, 2010). In the test of the inverted U-shaped relationship between NFT portfolio homogenization and transaction variation, the turning point value is 0.644. The slope of the low end is positive and significant at 0.001 level (β=0.178, p<0.001). However, the slope of the high end is negative and significant at 0.01 level (β=-0.099, p<0.01). Thus, H1 is supported. The results of testing the inverted U-shaped relationship between NFT portfolio homogenization and transaction variation are shown in Table 5. Following the same procedure, we tested the inverted U-shaped relationship between NFT portfolio homogenization and transaction volume. As shown in Table 3, the squared term of NFT portfolio homogenization is negative and significant (β=-73.14, p<0.05). The turning point value is 0.441, and the curve significantly slopes at both ends of the data. The slope of the low end is positive and significant at 0.05 level (β=64.790, p<0.05). However, the slope of the high end is negative and significant at 0.05 level (β=-82.030, p<0.05). Therefore, H2 is supported. The results of testing the inverted U-shaped relationship between NFT portfolio homogenization and transaction volume are shown in Table 6.

	Lower bound	Upper bound
Interval	0.000	1.000
Slope	0.178	-0.099
t-value	7.434	-2.982
P>|t|	7.79e-14	0.001
Overall test of presence of the Inverse U shape: t-value=2.98 P>|t|=0.00145		

Extreme point:0.644 95% Filler interval for extreme point: [0.561; 0.807]

Tabel 5. Results of testing the inverted U-shaped relationship between NFT portfolio homogenization and transaction variation

	Lower bound	Upper bound
Interval	0.000	1.000
Slope	64.790	-82.030
t-value	2.128	-1.952
P>|t|	0.0168	0.026
Overall test of presence of the Inverse U shape: t-value=1.95 P>|t|=0.026		
Extreme point:0.441 95% Filler interval for extreme point: [0.194; 1.026]		

Table 6. Results of testing the inverted U-shaped relationship between NFT portfolio homogenization and transaction volume

The regression results of Model 2 and Model 4 demonstrate the moderating effect of creator composition diversity. As shown in Model 2 of Table 3, the coefficient of the interaction term between creator composition diversity and NFT portfolio homogenization is positive and significant at 0.01 level (β=0.811, p<0.01). The coefficient of the interaction term between creator composition diversity and NFT portfolio homogenization' squared term is -0.737 and significant at 0.01 level. The results suggest that the inverted U-shaped relationship between NFT portfolio homogenization and transaction variation is positively moderated by creator composition diversity. Thus, H3 is supported. Figure 1(a) illustrates the moderating effect of creator composition diversity on the relationship between NFT portfolio homogenization and Transaction variation. As shown in Figure 1(a), the inverted U-shaped relationship becomes more pronounced as creator composition diversity increases. The results of Model 4 demonstrate the moderating effect of creator composition diversity on the relationship between NFT portfolio homogenization and transaction volume. As shown in Column 5 of Table 3, the coefficient of the interaction term between creator composition diversity and NFT portfolio homogenization is positive and significant at 0.01 level (β=1,189, p<0.01). The coefficient of the interaction term between creator composition diversity and NFT portfolio homogenization' squared term is negative and significant at 0.01 level (β=-1,402, p<0.01), suggesting that the creator composition diversity positively moderates the inverted U-shaped relationship between NFT portfolio homogenization and transaction volume. H3b is supported. As shown in Figure 1(b), the inverted U-shaped relationship between NFT portfolio homogenization and transaction volume becomes more pronounced as creator composition diversity increases.

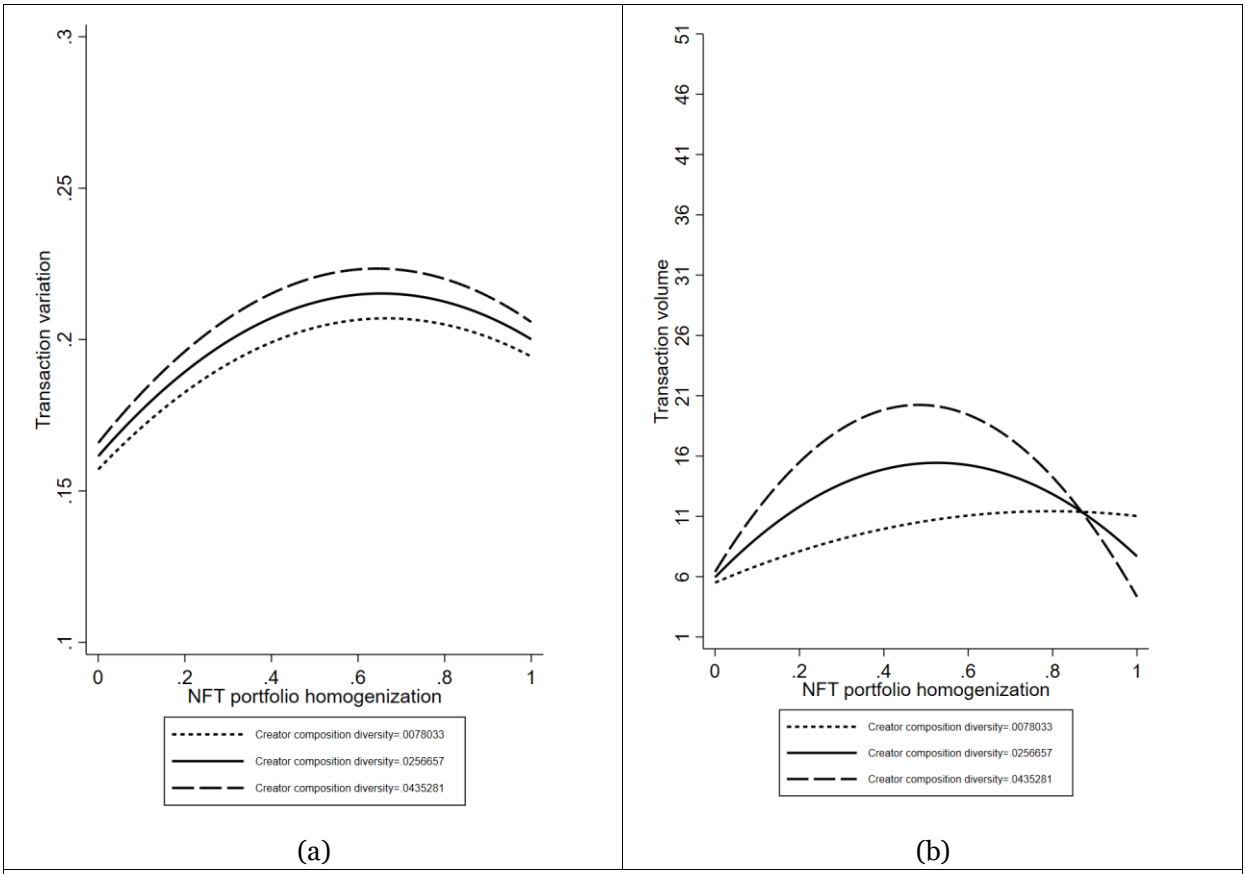

Figure 1. Moderating Effect of Creator Composition Diversity

Conclusion

This study provides empirical evidence of the impact of NFT portfolio homogenization on NFTs collection's transactions. The results confirm the hypothesized inverted U-shaped relationship between NFT portfolio homogenization and NFT transaction performance (i.e., transaction variation and transaction volume). NFTs in collections with low NFT portfolio homogenization have strong substitutability, which may not satisfy investors' pursuit of rarity. However, high NFT portfolio homogenization for collections may make investors become overwhelmed with too many choices, leading to decision fatigue (Wan et al., 2012). Collections with moderate level of NFT portfolio homogenization can not only provide investors with enough options to find their desired product but also make investors not be overwhelmed by too many choices. Thus, there is a sweet spot where a moderate NFT portfolio homogenization leads to the best transaction performance.

Moreover, we found that the creator composition diversity positively moderates the relationship between NFT portfolio homogenization and NFT transaction performance. Creator composition diversity pertains to the range of creative input of the collection, which could help to identify the market demand better and publish innovative NFTs that meet the needs of a diverse customer base (Van der Vegt & Janssen, 2003). Therefore, high creator composition diversity may amplify the benefits of NFT portfolio homogenization, leading to better transaction performance.

Theoretical and Practical Implications

This study contributes to the literature on the NFT marketplace. Firstly, different from previous literature that has focused on the NFTs' price issues (Ante, 2022; Dowling, 2022; Jiang & Liu, 2021), this study is one of the first research investigating the NFT portfolio homogenization from a collection perspective. The

findings of this study can provide novel insights regarding the inverted-U-shaped role of NFT portfolio heterogeneity on transaction volume and variations. Therefore, future studies can build on our work to explore the other impact of NFT portfolio heterogeneity and the antecedents of NFT portfolio heterogeneity. Secondly, besides examining the effect of NFT portfolio heterogeneity, the current study explores the boundary condition of creator composition diversity. The findings of this study enrich prior research on the NFT marketplace by uncovering the distinct roles of creator characteristics. Future studies can expand on our findings by examining the effects of creator composition diversity in influencing NFT transaction performances.

This study provides important practical implications for NFT issuers, investors, and platforms in the NFT marketplace. First, the findings support issuers' concerns regarding the double-edged sword of NFT portfolio heterogeneity on NFTs' transaction performances. Therefore, issuers are suggested to find the optimal similarities between NFTs within the collection. Moreover, issuers with a diverse creator composition should pay more attention to the non-linear impact of NFT portfolio heterogeneity. However, issuers with a limited creator composition can have fewer concerns regarding the degree of portfolio heterogeneity within the collection. Besides, investors can use the information to choose appropriate NFTs and collections for improving investment performance. Additionally, platforms in the NFT marketplace can use the findings to develop policies that promote competition and innovation in the NFT market while ensuring that market participants are protected from potential risks and abuses.

Limitations and Future Research

Despite the insights that were gained from this study, some limitations need to be acknowledged. First, the sample size used in this study was relatively small, which may limit the generalizability of the findings. We collected the top 2,004 NFT collections based on their sales from the ranking list. It would be beneficial to conduct similar studies with larger sample sizes, like all available collections on OpenSea, to further confirm the results found in this study. Second, this study focuses on only one category of NFT transaction, which is the NFT artworks. However, NFTs can be used in various ways, such as in-game assets and profile pictures. Therefore, findings in this study may not be generalized to other categories of NFTs and their transactions. Third, this study does not take into account the impact of external factors, such as the current state of the crypto market or global economic conditions, which could affect NFT transactions. Future studies could include those variables to gain a more comprehensive understanding of the impact of NFT portfolio homogenization on NFT transactions.

Further research could investigate the impact of NFT portfolio homogenization on the overall NFT market or blockchain transactions. This would involve examining how the increasing homogenization of NFT portfolios affects the demand and value of NFTs across collections and different categories of NFTs. Another potential avenue for future research is to investigate how NFT portfolio homogenization affects the incentives of NFT creators within a collection or cross-collections. NFT creators may alter their strategies or focus on different types of NFTs to avoid being overlooked in an increasingly homogenous market. Additionally, future studies could explore the implications of NFT portfolio homogenization on the broader digital asset market, including cryptocurrencies and other digital assets. Understanding the impact of homogenization on digital assets may provide insights into the future of digital asset investment, the role of NFTs in this landscape, and even the development of Metaverse.

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