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Resale Royalty in Non-Fungible Token Marketplaces: Blessing or Burden for Creators and Platforms?

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Abstract. Non-fungible token (NFT) marketplaces enable users to mint and trade digital assets, such as collectibles, trading cards, and digital artwork. Many of these platforms accommodate resale royalties, which return a predetermined percentage of the proceeds from future resales of the digital asset to the creator. Although the adoption of resale royalties may seem beneficial for NFT creators by providing a recurring source of income, it could have unintended consequences on the sales price and the liquidity of the underlying NFT, potentially affecting both the platform's commission revenue and the creator's short-term return. In this paper, we aim to understand the antecedents and consequences of resale royalties. Specifically, we empirically investigate the impact of minting costs on royalty rates and subsequently, the effects of resale royalties on primary market sales prices and liquidity. Our identification strategy combines a difference-in-differences model that leverages a policy change that eliminated up-front minting fees for creators and an instrumental variables approach. We find that NFT creators reduce royalty rates when they mint an NFT without incurring minting costs. Furthermore, we observe that higher royalty rates lead to reduced sales prices in the primary market, suggesting the presence of a *delayed gratification effect* as creators hope for future royalty payments. We also investigate the underlying mechanisms, and we find that NFT creators who are more confident about future resales tend to lower their primary sale prices but are unable to recoup those losses in the short term, providing evidence of an *overconfidence effect*. Surprisingly, we find that the presence of resale royalties also negatively affects market liquidity despite reduced sales prices. Our findings offer immediate implications for creators and platforms regarding resale royalty strategies and whether to enforce royalties.

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1. Introduction

A non-fungible token (NFT) represents a unique asset in the form of a smart contract identification stored on a blockchain. With NFTs, assets, such as fine artwork, video game items, trading cards, or photographs, are transformed into tradable digital assets, often following protocols like Ethereum's ERC-721 (Ethereum Request for Comments (ERC)) standard. Recently, many NFT marketplaces have emerged where users mint and trade collectible assets, virtual worlds, fantasy sports, and digital artworks in the form of NFTs. Although some question the sustainability and utility of NFTs (Fortis 2022), venture capital firms have made substantial investments in the NFT ecosystem, reflecting their confidence in the prospects of the NFT market (Young 2021). Notable deals by Sorare, Dapper Labs, and OpenSea have collectively raised more than $1 billion (Dillet 2021a, b; Finzer 2021). NFT trading volume reached $10.7 billion in the third quarter of 2021 (Locke 2021), with the cumulative NFT trade volume growing to roughly $73 billion by February 2023 (Barbon and Ranaldo 2023). Cryptocurrency exchange platforms, such as Coinbase, have entered the space and announced their NFT marketplaces (Matney 2021). Despite a recent cooling in the crypto markets, NFT adoption is expected to continue growing (Morris 2022).

NFT marketplaces facilitate the creation and trading of NFTs, but they differ in several operational characteristics. First, a platform must select a blockchain network (e.g., Ethereum, Solana, etc.) and a corresponding cryptocurrency to conduct and record transactions. As of 2024, Ethereum remains the most popular blockchain

for NFTs. Second, NFT platforms vary in the commission fees charged to sellers and buyers for each transaction. Third, platforms may allow creators to set a resale royalty rate. Resale royalties involve transferring a fixed percentage of the proceeds from future sales of the NFT to its creator. The concept of resale royalties was introduced as *droit de suite* (French for "right to follow") in France in 1920s, granting artists the right to receive a fee from the resale of their artworks (Price 1968).

NFT platforms adopt a wide range of approaches when implementing resale royalty rates. For instance, Binance and KnownOrigin use a fixed resale royalty strategy in which creators cannot alter the royalty rate set by the platform. On KnownOrigin, the royalty rate is fixed at 12.5%, whereas it is only 1% on Binance. In contrast, OpenSea and Rarible allow creators to specify their own resale royalty rates, although there are differences in the maximum rate allowed. OpenSea imposes a maximum royalty rate of 10%, whereas Rarible has no such limit, allowing creators to set any resale royalty rate they choose. Table 1 summarizes the various resale royalty strategies across popular NFT marketplaces.

Given the diversity of NFT marketplaces, creators must carefully select a platform for minting their NFTs by assessing these aspects of available platforms. This decision is critical because the resale royalty is set at the time of minting and cannot be adjusted afterward. Hence, a platform's resale royalty strategy is a significant factor for creators to consider before committing to the platform. Moreover, the transaction costs associated with the minting process are likely to influence the royalty rate. At the time of minting, an NFT creator sets the royalty rate and pays the transaction fee (i.e., gas fee) to miners.[1] The transaction fees vary depending on the traffic on the blockchain. When a creator incurs a high transaction cost, she is motivated to recoup the cost by setting an appropriate price and resale royalty rate for the NFT. In this study, we are interested in examining the impact of minting costs on creators' resale royalty strategies.

A resale royalty is generally considered beneficial to NFT creators as it generates recurrent cash flow from subsequent sales (i.e., secondary sales). However, setting a high resale royalty could reduce the future profit for prospective buyers, impeding the likelihood of a sale. Anecdotal evidence suggests that NFT creators take the purchasing behavior of resellers into account when determining a royalty rate. For instance, an NFT artist noted in an online blog: "A big drawback for me here was the 10% royalty fee on transactions. As an artist, that would obviously be amazing for me if my project took off, but it's a bit high. … up to 5% would be reasonable to me, but 10% is a bit much. Pay me a fair price for the piece, and I won't have to leech off royalties forever" (James 2021). In this paper, we empirically examine the relationship between resale royalties and sales prices. Furthermore, given that the resale royalties enable creators to generate ongoing revenue form future sales, we investigate whether creators are better off in the long run following the initial sale of their NFT with a certain level of resale royalty.

From a platform's perspective, resale royalties have an indirect effect. Platforms rely on commission revenue to sustain their operations and typically charge a fixed percentage of the sales price (e.g., Rarible charges 1% to both the buyer and the seller[2]). Because commission revenue is determined by the average price and frequency of sales, understanding the impact of resale royalties on market liquidity is crucial for platform managers. Without resale royalties, NFT creators collect a one-time payment upon the first sale and may, therefore, be inclined to set a higher price for their NFTs. A higher sales price, however, could discourage potential buyers, impeding market liquidity. On the other hand, with resale royalties, creators may be more willing to lower their sales prices in anticipation of future royalty payments. Lower sales prices attract more potential buyers, likely enhancing market liquidity. At first glance, resale royalties seem beneficial for market liquidity. However, they may drive out potential buyers and resellers because they only profit after the royalty premiums are paid to creators. Buyers might perceive the resale royalty as a tax or a form of perpetual partial ownership, which could make them uncomfortable with the idea of "co-ownership" with NFT creators. Thus, they may be unwilling to invest in NFTs with higher resale royalties, thereby hindering market liquidity. Hence, the net impact of resale royalties on market

Table 1. Resale Royalty Strategies Across Leading NFT Marketplaces

	Resale royalty strategy			
NFT marketplace	Fixed rate, %	Max limit	Set by platform	Set by creator
KnownOrigin	12.5	—	Yes	—
Foundation SuperRare	10	—	Yes	—
Binance	1	—	Yes	—
Rarible	—	No max limit	—	Yes
OpenSea	—	Max limit 10%	—	Yes

liquidity is unclear. Although lower initial prices may increase the likelihood of a sale, this effect might not fully offset losses caused by the perception of partial ownership. This motivates our investigation into the impact of resale royalties on the liquidity of NFT marketplaces. We proxy market liquidity by examining the success rate and duration of sale listings.

Our main focus in this paper is to empirically investigate the antecedents and consequences of resale royalties. First, we examine the relationship between the cost to mint an NFT and its royalty rate. Second, we investigate the impact of resale royalties on the sales price of an NFT and the market liquidity. To address these research questions, we construct a longitudinal data set from the popular NFT marketplace, Rarible. This platform allows creators to set the royalty rate for each NFT that they mint. Our identification strategy leverages a policy change implemented by Rarible regarding how creators pay the minting cost. Before October 2021, creators had to pay the minting cost up front when creating an NFT. In October 2021, Rarible introduced a new minting method called "lazy minting." Under this approach, creators can mint their NFTs without incurring up-front minting costs instead deferring the recording of the NFT onto the blockchain until a sales transaction is executed. The sales transaction triggers the token creation as well as its transfer to the buyer. This innovation aims to lower the barrier to entry for digital art creators, particularly given that significant proportions of NFTs are never sold and that the majority of sales are for less than $15 (Nadini et al. 2021, Lim et al. 2022).

Our analysis reveals that NFT creators significantly lower the royalty rates that they set when minting NFTs without incurring up-front minting costs. Furthermore, we find a significant and negative relationship between resale royalties and the sales prices. Specifically, higher royalty rates are associated with lower sales prices on the primary market, where NFTs are sold for the first time by their creators. Moreover, the decrease in sales prices was not offset by royalty commissions from subsequent sales within the four years following the initial sale. Finally, we find that higher resale royalties negatively influence the success of a sale listing and increase the time required for a sale to occur (hereafter, duration to the sale), ultimately reducing market liquidity.

Our findings suggest that resale royalties have unintended consequences for NFT creators. Contrary to the conventional wisdom that resale royalties benefit creators by providing ongoing revenue from secondary sales, our analysis reveals that if an NFT is sold with a higher resale royalty, the creator is worse off within the four years following the initial sale. Surprisingly, we find that resale royalties impede market liquidity, despite significantly lower sales prices. Moreover, our results indicate that resale royalties can harm the bottom line of NFT platforms as lower sales prices yield to reduced sale commission revenue. Finally, NFTs with higher resale royalties are less likely to be sold and take longer to sell. Platform managers, however, may benefit from subsidizing the minting cost, such as in the case of lazy minting, to reduce the average royalty rate and mitigate its negative effects on market liquidity.

Our findings contribute to existing theories in information systems (IS) and related disciplines in several ways. First, we provide empirical evidence that NFT minting fees can trigger the sunk-cost fallacy, extending prior work on the influence of sunk costs in consumer and managerial behavior (Keil et al. 2000, Ho et al. 2018). Second, we observe a delayed gratification effect, where NFT creators forgo immediate rewards in the primary market for potential future benefits in the secondary market, which builds on the self-control literature examining the effect of delayed gratification on future outcomes (Mischel et al. 1989, Meier and Sprenger 2010). In addition, our analyses revealed that the delayed gratification effect persists only for highly confident NFT creators, uncovering an intriguing "overconfidence effect." NFT creators who are highly confident about the future resales of their NFTs reduce up-front prices in the primary market but are unlikely to be offset by future royalties for at least four years. Furthermore, we tested for the high-tax effect of high royalty NFTs and found that it does not play a significant role. This suggests that the partial ownership effect appears more plausible in explaining the effect of royalties, which contributes to growing IS research on psychological ownership of digital artifacts (Pierce et al. 2001, Cichy et al. 2021). We outline the managerial implications of resale royalties for NFT platforms and provide guidance for future research.

1.1. Relationship to the Literature

1.1.1. Resale Royalties. Resale royalty rights appeared in various forms (Schulder 1966, Duchemin 1967). The first act of its kind was introduced in France in the 1920s, stipulating a fixed royalty rate of 3% payable for all public artwork sales above 100 francs. Similarly, California enacted a law in 1976 mandating that 5% of the sales price be paid to the artist (Bolch et al. 1977). However, Italy's 1941 law based the royalty on a percentage of the increased value at public sales. Similarly, Portugal's 1966 resale royalty rights act applied a sliding scale royalty rate between 10% and 20% if there was an increase in sales value. Under Directive 2001/84/EC, the European Union harmonized resale royalty rights across Europe, establishing a scale that decreases from 4% to 0.25% with a maximum royalty cap of 12,500 Euro € (EUR). Although these laws are presumably introduced to fairly compensate the creators and support the flourish of the art markets, the differences among them suggest that there is no clear consensus on what resale royalty

percentage is efficient for the arts markets. To contribute to addressing this policy issue, we aim to shed light on how different resale royalty rates impact the sales price and market liquidity in the NFT marketplace.

The economic value of resale royalties for artists has long been debated in academia. The extant literature is inconclusive on whether original creators or resellers are financially better off with resale royalties (Camp 1980, Filer 1984, McCain 1989, Stanford 2003, Banternghansa and Graddy 2011). Filer (1984) argues that introducing a resale royalty is akin to an excise tax, shifting demand away from the art subject to this "tax" toward art that is not. Moreover, paying a royalty upon resale makes the artwork less attractive to collectors who would "buy the work at an initial price low enough to compensate for the disadvantages imposed by the royalties provision" (Filer 1984, p. 13). McCain (1989) argues that resale royalties could be inefficient for an art market and that their impact depends critically on factors such as market speculation levels and the artists' liquidity constraints. Camp (1980) provides empirical evidence that art resale rights only benefit a few artists while potentially harming the broader art market. The resale right could discourage many potential buyers who might then prefer markets without resale royalties. Similarly, in an empirical study of art sales prices in Australia, Stanford (2003) finds that few artworks achieve capital gains in the secondary market; hence, many resellers do not make profit from their investments.

On the contrary, Banternghansa and Graddy (2011), in an analysis of the impact of resale royalties on the United Kingdom's art market, find no reduction in price growth for artworks subject to resale royalties. Given the mixed findings in the extant literature and the new context of NFT markets, it is unclear what the economic value of resale royalties would be for NFT creators and resellers. We contribute to this stream of literature by examining the impact of resale royalties on sales prices and market liquidity in NFT marketplaces.

1.1.2. Digital Art and NFT Marketplaces. NFT marketplaces challenge the traditional art markets by leveraging the blockchain technology, which reduces the risks of incomplete contracting and lowers the transaction costs (van Haaften-Schick and Whitaker 2022). Whitaker and Kraussl (2020) model a hypothetical scenario where early artists retained 10% equity in their work when it was first sold, and they find that the artists' earnings would have vastly outperformed gains from equity markets, such as Standards and Poors (S&P) 500. However, it is not clear whether such a resale royalty strategy leads to strategic changes in the seller's pricing strategy or the buyer's purchasing decisions. Kireyev and Lin (2020) studies whether the valuations of NFTs exhibit significant biases using a structural model and shows that sellers value NFTs suboptimally, potentially leading to market inefficiencies. Kireyev (2022) examines how NFT marketplace design influences market participants' decisions and analyzes how the bidding costs affect sales prices using a structural model. They find that a decrease in bidding costs increases sales prices as sellers expect more sales to originate from bids. Kanellopoulos et al. (2021), focusing on the impact of the introduction of an NFT market on the physical counterpart, finds that the introduction of an NFT collectible marketplace leads to a decrease in the prices of physical collectibles by about 5%. We add to this literature by analyzing both the antecedents and consequences of NFT resale royalties.

Finally, we contribute to the stream of literature on the investment value of art (Goetzmann 1993, Mei and Moses 2002, Renneboog and Spaenjers 2013). Goetzmann (1993) constructs an art return index using transaction prices of paintings between 1715 and 1986 and finds that the art index is highly correlated with the London Stock Exchange index. Similarly, Mei and Moses (2002) estimates the annual index of art prices for the period between 1875 and 2000, finding that art has been a better investment than some fixed-income securities, although it underperformed stocks. Renneboog and Spaenjers (2013) estimates that art appreciated by 4% per year between 1957 and 2007. Although art has an investment value, transaction costs are substantial (Penasse and Renneboog 2021). As an emerging fintech phenomenon, NFT marketplaces could disrupt the traditional art markets (Hendershott et al. 2021). We contribute to this stream of research by examining the value of resale royalties as a form of transaction cost for buyers, impacting the investment value of NFTs as an emerging phenomenon of digital art. We summarize the extant literature and our contribution in Online Appendix A.

1.1.3. Sunk-Cost Fallacy and Delayed Gratification. Our study draws upon two well-established behavioral economics concepts—the sunk-cost fallacy and delayed gratification—to shed light on the antecedents and consequences of NFT royalty rates. The sunk-cost fallacy refers to the tendency for people to continue an endeavor if they have already invested time, effort, or money into it, even when continuing is not the rational decision (Arkes and Blumer 1985). This fallacy has been documented in various domains, such as medical treatment decisions (Bornstein et al. 1999), software project management (Keil et al. 2000), and consumer behavior (Just and Wansink 2011, Ho et al. 2018). For instance, Bornstein et al. (1999) show that sunk costs influence treatment decisions, leading to the continued use of less effective treatments. Keil et al. (2000) demonstrate that software project managers' decisions are driven by the desire not to waste resources already

invested. Ho et al. (2018) find that consumers are more likely to continue using cars with higher sunk costs, even when a cheaper alternative was available. Just and Wansink (2011) reveal that sunk costs lead to overeating in "all-you-can-eat" buffet settings. We contribute to this literature by providing evidence of the sunk-cost fallacy in the novel context of digital art and NFTs when minting is costly and costs are unrecoverable.

Delayed gratification, on the other hand, is the ability to resist a smaller immediate reward in order to receive a larger reward later (Singer 1955). This concept has been extensively studied in psychology, with the classic "marshmallow experiment" demonstrating that children who could delay gratification experience better life outcomes as adults (Mischel et al. 1989). Delayed gratification has been explored in various domains, including health behavior (Forstmeier et al. 2011), education (Duckworth and Seligman 2005), and financial decision making (Meier and Sprenger 2010). For example, Forstmeier et al. (2011) shows that older adults with greater self-regulation and delayed gratification abilities are more likely to engage in healthy behaviors, such as exercise and healthy eating. Duckworth and Seligman (2005) find that self-discipline, closely related to delayed gratification, is a stronger predictor of academic performance than IQ. Meier and Sprenger (2010) show that individuals who are more present biased, meaning that they have a stronger preference for immediate gratification, are more likely to have credit card debt. However, the application of delayed gratification to the creator economy and information goods markets remains unexplored. We investigate whether the theory of delayed gratification, which implies that creators will set lower prices in anticipation of future royalties, also applies to the new domain of digital art and NFT marketplaces.

2. Hypotheses Development

2.1. Antecedents of Resale Royalty

First, we examine the antecedents of the resale royalty rate set by an NFT creator. That is, what leads an NFT creator to specify a particular resale royalty rate at the time of minting?[3] Once set, the royalty rate cannot be altered. Hence, economic factors at the time of minting fundamentally influence the creator's royalty-setting strategy. One such key determinant is the *gas fee*. The gas fee is paid to miners by the creator for the token minted on the Ethereum blockchain. It is algorithmically determined by the number of pending transactions and the number of miners on the blockchain. Gas fees have generally been trending upward because of increasing traffic on the Ethereum network.[4]

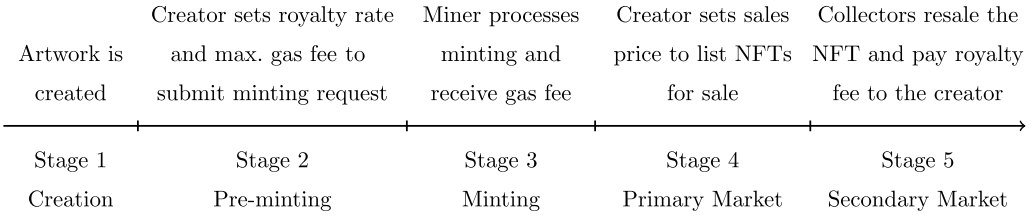
As the gas fee constitutes the main tangible cost that an NFT creator bears, she must weigh the minting cost in her pricing and royalty-setting strategy. For instance, she could increase the sales price of her NFT when facing a high minting cost. Alternatively, she could raise the royalty rate to recoup more revenue from subsequent sales of the NFT. These two strategies are fundamentally different. NFT creators set the royalty rate and pay the gas fee at the time of minting (in the conventional minting process before the introduction of lazy minting). Once the royalty fee is set, it cannot be altered. In contrast, the actual sales price is only determined after the NFT is minted, and the owner can update the price any time before the NFT is sold. Hence, it is more critical for the creator to set the right royalty rate at the time of minting. Everything else being equal,[5] we would expect a rational creator to set a higher royalty fee when minting costs are higher to recoup this expenditure as we conjecture in Hypothesis 1a (Figure 1).[6]

Hypothesis 1a ("Rational Expectation"). *An increase in the cost of minting an NFT leads its creator to set a higher resale royalty rate for future resales.*

Creators typically produce not just a single NFT but multiple NFTs within a short period of time (e.g., a week).[7] However, it is known that the majority of NFTs will never be sold. It is understandable that the minting cost of an NFT should have a bearing on the royalty rate set for that (same) NFT as stated in Hypothesis 1a. But, could a creator's royalty-setting behavior also be influenced by other (unrelated) NFTs created by the same creator around the same time? It is reasonable to assume that a creator may take a holistic approach and factor in the minting costs of all recent NFTs that she minted when setting the royalty rates for a specific NFT, even if these NFTs are totally unrelated.

This behavior is explained by the *sunk-cost fallacy* (Arkes and Blumer 1985) which asserts that people's decisions are often (irrationally) influenced by the (unrelated) sunk costs. We argue that, knowing that the majority of NFTs will not be sold, an NFT creator who

Figure 1. Conventional NFT Minting Process



has paid minting costs for recent NFTs that she minted may seek to recover some of those sunk minting costs by setting a higher royalty rate for a focal NFT. Accordingly, we postulate the following in Hypothesis 1b.

Hypothesis 1b ("Sunk-Cost Fallacy"). *An increase in the minting costs of other NFTs created by the same creator leads the creator to set a higher resale royalty rate for the focal NFT.*

2.2. Consequences of Resale Royalty

We investigate the consequences of resale royalties on various outcomes. First, we examine the impact of resale royalties on the average sales price of NFTs in the primary market. The primary market consists of transactions initiated by NFT creators as the first sale of the NFT. Subsequent sales of the NFT occur in the secondary market, in which the seller is not the creator. Although both primary and secondary sales take place on the same platform, the two markets fundamentally differ in several important ways. First, in the primary market, the NFT creator—who is also the royalty recipient—sets the sales price. In contrast, a reseller, who is responsible for the royalty, sets the price on the secondary market. Second, resellers incur a cost when purchasing the NFT and must sell it at a higher price than their purchase price to make a profit. For creators, the only monetary cost of an NFT is the gas fee at the creation.[8] Finally, NFT creators receive a perpetual royalty premium from secondary sales. Hence, they face an opportunity cost in terms of future royalty commissions if the NFT is not quickly sold in the primary market.

We argue that resale royalties would have a diminishing effect on the average sales price in the primary market. From the creators' perspective, they would be willing to set a lower price for NFTs with a higher resale royalty on the primary market because they expect a recurrent revenue stream from future royalty commissions, akin to passive income. This is consistent with the *delayed gratification effect* (Singer 1955), which suggests that participants can forgo instant gratification in exchange for future benefits. Accordingly, NFT creators who set higher resale royalties anticipate delayed monetary gratification and can afford to set lower prices in the primary market. From the buyers' perspective, an NFT with a high royalty fee means an extra "tax" imposed on any future resale of the NFT, and thus, the value of the NFT is discounted ceteris paribus. Even if the buyer does not intend to resell the NFT and plans to hold it as a collectible, a high royalty rate implies a high shared ownership with the original creator. This diminishes the value of owning the NFT with a high royalty rate. Consequently, buyers would be less willing to pay a high price for an NFT with a high royalty rate, leading to lower prices. Hence, we postulate the following in Hypothesis 2a.

Hypothesis 2a ("Delayed Gratification"). *An increase in resale royalty leads to a decrease in the average sales price of NFTs in the primary market.*

Finally, we investigate the impact of resale royalties on the liquidity of the NFT marketplace. An NFT platform's revenue stream is composed of the commission earned from each sale and the frequency of these commission payments. Hence, market liquidity is crucial for NFT platforms to sustain their business. We proxy the market liquidity with two outcome measures: (i) the success rate of a sale listing and (ii) the duration that it takes for an NFT to sell. First, we argue that NFTs with higher royalty rates are less likely to sell compared with those with lower royalty rates, all else being equal. This is because the resale royalties reduce the future monetary proceeds for the buyer. When the buyer resells the NFT in the secondary market, a certain portion of the corresponding sales price, in accordance with the royalty rate, is shared with the NFT creator. An investment in an NFT with a higher resale royalty, ceteris paribus, would yield less revenue for the reseller than an NFT with a lower resale royalty. This, in turn, deters prospective buyers from purchasing an NFT with a higher royalty rate. Because of the *partial monetary ownership effect*, buyers would be less likely to purchase an NFT listed for sale if it has a higher royalty rate. Consequently, NFTs with higher resale royalty rates are likely to remain unsold longer in the market as the prospective buyers are less inclined to purchase them. That is, the higher the resale royalty rate, the longer it takes the sale to materialize. The success rate of a sale listing captures the likelihood of successfully completing the sale of an NFT listing. The duration to sale captures the time from listing an NFT to its successful sale. Hence, we formulate the hypothesis in relation to success rate and duration to sell as follows.

Hypothesis 2b ("Partial Ownership Effect"). *A higher resale royalty leads to a decrease in the average success rate of a sale listing and an increase in the average duration to sell an NFT.*

3. Data and Model

We utilize a longitudinal data set of NFTs minted, listed, and traded on a leading NFT marketplace, Rarible.[9] Our data set spans a three-year period from May 2020 to May 2023 and includes 4,777,374 NFTs from all royalty-discretionary ERC-721 collections[10] on the condition that the collection has recorded at least one sale.[11] The average resale royalty rate set by creators was 10.21%, with an average gas fee of $43.84. Only 0.5% of sale listings were successfully sold with an average price of $1,279.55. Descriptive statistics of the variables are provided in Table 2.

Our empirical analyses for testing the hypotheses were conducted at different levels of data granularity. For the first hypothesis (Hypothesis 1a), we identified

Table 2. Descriptive Statistics

	Mean	Standard deviation	Min	Max	*N*
Resale Royalty (%)	10.21	7.59	0	100	4,777,365
Lazy Minted (Dummy)	0.91	0.29	0	1	4,777,365
GIF (Dummy)	0.04	0.2	0	1	4,777,365
Sales Price (Ether (ETH))	0.81	3.04	0	187.87	32,362
Sales Price (USD)	1,279.55	6,963.04	0	404,667	32,362
Minting Cost (ETH)	0.02	0.02	0.001	0.41	172,833
Minting Cost (USD)	43.83	47.36	0.43	1,201.71	172,833
Is Sale Successful?	0.005	0.068	0	1	4,336,943
Sale Duration (Days)	368.8	220.51	0	1,010.3	4,336,943

two groups of creators: those who stopped conventional minting and switched to lazy minting after treatment (i.e., the treatment group) and those who continued with conventional minting without adopting lazy minting after treatment (i.e., the control group). The unit of analysis is NFTs minted by these creators. The dependent variable is the resale royalty rate, whereas the main independent variable is whether the NFT was minted under lazy minting. In testing Hypothesis 1b (sunk-cost fallacy), we estimate the impact of the minting costs of other NFTs (minted by the same creator during a specific time period) on the royalty rate of the focal NFT. As a robustness check, we also conduct both the creator-level and NFT-level analyses for all creators who minted NFTs within the 12-month period before and after the policy change as well as using the full sample. For Hypothesis 2a, we utilize NFT sales observations from the primary market with the log-transformed sales prices as the dependent variable and the royalty rate as the independent variable. To test the hypothesis related to market liquidity (Hypothesis 2b), we employ NFT listing observations and investigate two dependent variables: a binary dependent variable indicating whether the listing is successful and the duration of the sale. We control for time-invariant characteristics of tokens, such as whether the NFT is lockable or unlockable and whether the NFT is an animated image (Graphics Interchange Format (GIF)). The empirical models to be estimated are presented below:

$$
\begin{aligned}
&\text{Hypothesis 1a}: \; Royalty_{i,j} = \beta_0 + \beta_1 Lazy\ Minted_i \\
&\qquad\qquad + \beta_2 x_i + \gamma_j + \tau_t + \epsilon_{i,j,t} \\
&\text{Hypothesis 1b}: \; Royalty_{i,j} = \beta_0 + \beta_1 \ln\left(\sum_{i-\Delta}^{i-1} Minting\ Cost_{i,j,t}\right) \\
&\qquad\qquad + \beta_2 x_i + \gamma_j + \tau_t + \epsilon_{i,j,t} \\
&\text{Hypothesis 2a}: \; \ln(Sales\ Price_{i,j,t}) = \beta_0 + \beta_1 \ln(Royalty_i) \\
&\qquad\qquad + \beta_2 x_i + \gamma_j + \tau_t + \epsilon_{i,j,t} \\
&\text{Hypothesis 2b}: \; \text{logit}(Is\ Listing\ Successful?_{i,j,t}) \\
&\qquad = \beta_0 + \beta_1 \ln(Royalty_i) + \beta_2 x_i + \beta_3 x_{i,t} + \gamma_j + \epsilon_{i,j,t} \\
&\text{Hypothesis 2b}: \; h(Duration\ to\ Sale_i) \\
&\qquad = h_0(t)\exp(\beta_1 Royalty_i + \beta_2 x_i + \beta_3 x_{i,t}), \qquad (1)
\end{aligned}
$$

where i, j, and t denote NFT, user, and time, respectively. The term x_i represents a set of control variables that are fixed over time, and $x_{i,t}$ indicates time-varying control variables. The term h is the hazard function, and $\Delta \in \{2, 3, \ldots, \infty\}$. We also control for creator fixed effects γ_j and time fixed effects τ_t.[12]

4. Identification Strategy

In our empirical analysis for testing Hypothesis 1a, we utilize a policy intervention known as the introduction of lazy minting. This policy allows NFT creators to mint their NFTs without incurring an up-front gas fee. Under lazy minting, newly generated NFTs can be exhibited on the platform without a blockchain identifier as they have not yet been officially recorded on the blockchain. Hence, NFT creators are not required to pay a gas fee to blockchain miners at the time of minting. Upon the sale, the buyer pays the gas fee required to imprint the NFT on the blockchain. Rarible implemented the lazy minting feature on October 18, 2021.[13]

We follow the design of DID_M as proposed in De Chaisemartin and d'Haultfoeuille (2020)[14] and identify creators who switched from traditional minting to lazy minting after the policy change as the treatment group.[15] We identified 2,446 creators who transitioned from traditional minting to lazy minting after the policy intervention. Meanwhile, we identified a control group of 953 creators who continued using the traditional minting option even after the policy change. Utilizing mint-level data for all NFTs minted by 3,399 creators, we aim to determine whether NFTs that are lazily minted display lower (or higher) resale royalty rates.

In our examination of a hypothesis related to the sunk cost of minting other NFTs within a given time period (Hypothesis 1b), we estimate a fixed effects regression model that incorporates creator-level fixed effects to control for time-invariant unobservables and daily time fixed effects to account for daily price fluctuations. Subsequently, to test a hypothesis related to sales prices (Hypothesis 2a), we again employ a fixed effects regression model that includes creator-level fixed effects and daily time fixed effects. To analyze a

hypothesis concerning market liquidity (Hypothesis 2b), we utilize NFT listing data and employ a logistic regression model with seller fixed effects and survival analysis to estimate the relevant coefficients.

As a robustness check for hypotheses related to consequences (i.e., Hypotheses 2a and 2b), we utilize the instrumental variable approach to supplement our analyses. To construct an instrumental variable, we draw upon the historical behavior of NFT creators by following a common Hausman-type approach used in the literature (Burtch et al. 2016). Because NFT creators determine the royalty rate, we calculate the average royalty rate that they set prior to minting the focal NFT. Our rationale is that NFT creators tend to be relatively persistent in their selection of royalty rates, and their past patterns in setting such rates are likely to be strongly correlated with the royalty rate of the focal NFT. In contrast, the royalty rates of other NFTs do not have a direct effect on the sales price of the focal NFT, nor do they have a straightforward relationship with the success of sale listings or the time to sell.

5. Results

5.1. Antecedents of Resale Royalty

First, we empirically investigate the impact of minting costs on the royalty rates by evaluating the effects of the minting policy change implemented by Rarible.[16] We compiled data on all NFTs minted from May 2020 until May 2023. The three-year window surrounding the policy change in October 2021 allows us to capture the impact of the policy introduction. We also incorporate creator and time fixed effects in our analyses.

We formally estimate the impact of the cost of minting an NFT on the royalty rate. Hypothesis 1a postulates a positive relationship between minting cost and royalty rate. If this hypothesis holds, we would expect lazy minting to have a negative impact on royalty rates because it reduces up-front costs for creators. The results of this analysis are presented in Table 3. In column (1) in Table 3, we test Hypothesis 1a using the full sample of 4,777,365 NFT mints over the three-year window surrounding the introduction of lazy minting (18 months before and 18 months after the policy change) with the log-transformed dependent variable. In column (2) in Table 3, we augment this analysis by incorporating additional NFT control variables, specifically whether an NFT is a moving image or not (i.e., GIF), and include collection fixed effects. In columns (3) and (4) in Table 3, we use NFT mints over a 12-month window surrounding the policy change (i.e., 6 months before and 6 months after). In all cases, we find that NFTs minted via the lazy minting approach exhibit significantly lower royalty rates compared with those minted with the traditional minting approach where creators incur immediate gas fee payments.

Next, we estimate the impact of the minting cost of other NFTs created around the same time as the focal NFT on the royalty rate. Hypothesis 1b posits a positive relationship between these costs and the royalty rate. This suggests that the higher minting costs of other NFTs should lead to higher royalty rates for the focal NFT because of the sunk-cost fallacy. The results of this analysis are presented in Table 4. In column (1) in Table 4, we test Hypothesis 1b using NFTs minted within a one-day window (i.e., the 24 hours preceding the creation time of the focal NFT). To identify other NFTs created by the creator within a given time window, we utilize the creation time stamps. In columns (2), (3), and (4) in Table 4, we replicate the analysis using different time periods (i.e., 3, 7, and 15 days preceding the creation time of the focal NFT, respectively). We find that the minting costs of other NFTs minted within shorter time periods (e.g., 1 day or 3 days) significantly increase the royalty rate of the focal NFT. This provides empirical evidence of the existence of the sunk-cost fallacy in NFT marketplaces. Specifically, the minting costs of other NFTs, despite being sunk costs, drive up the royalty rate of the focal NFT.

Table 3. Impact of Lazy Minting on Resale Royalty

	ln(*Royalty*)			
	Full sample		12-months window	
Dependent variable	(1)	(2)	(3)	(4)
Lazy Minted	−0.042***	−0.048***	−0.032***	−0.038***
	(0.008)	(0.008)	(0.011)	(0.011)
Creator FE	✓	✓	✓	✓
Mint day FE	✓	✓	✓	✓
GIF		✓		✓
Collection FE		✓		✓
N	4,546,885	4,546,885	3,281,270	3,281,270
Adjusted R^2	0.772	0.772	0.774	0.774

Notes. Robust standard errors are clustered at the creator level and presented in parentheses. FE, fixed effect.
***$p < 0.01$.

Table 4. Impact of the Minting Cost of Other NFTs That the Creator Minted of a Time Period on Resale Royalty ("Sunk-Cost Fallacy")

	Sunk-cost fallacy			
Dependent variable: *Royalty*	(1) 1 day	(2) 3 days	(3) 7 days	(4) 15 days
$\ln(\sum_{i-\Delta}^{i-1} Minting\ Cost)$	0.042***	0.033**	0.011	−0.013
	(0.015)	(0.016)	(0.016)	(0.017)
Creator FE	✓	✓	✓	✓
Mint day FE	✓	✓	✓	✓
Collection FE	✓	✓	✓	✓
GIF	✓	✓	✓	✓
N	4,587,641	4,587,641	4,587,641	4,587,641
Adjusted R^2	0.296	0.296	0.296	0.296

Notes. The minting cost of other NFTs is log transformed. Robust standard errors are clustered at the creator level and presented in parentheses. FE, fixed effect.
**$p < 0.05$; ***$p < 0.01$.

5.2. Impact of Resale Royalty on Sales Prices

We then examine the impact of resale royalties on an NFT's sales price in the primary market. Unlike the secondary market, where resellers set prices, the primary market is driven by creators who determine the sales price. We are interested in the creators' price-setting behavior and whether NFT creators delay their monetary gain in anticipation of receiving future proceeds from resale royalties. We control for unobserved and time-invariant seller characteristics through the use of seller fixed effects. We also include time dummies to account for daily fluctuations in the NFT marketplace and control for various NFT characteristics, such as the presence of unlockable features that become available after the first purchase and whether the NFT is an animated image (i.e., GIF). The estimates are presented in Table 5. Our results indicate that on average, a 1% increase in the royalty rate is associated with a 3%–3.5% decrease in the sales price in the primary market.

Our results indicate that resale royalties have a negative impact on the sales prices of NFTs, supporting Hypothesis 2a. NFT creators are willing to accept lower primary sales prices in exchange for the prospect of future proceeds from resale royalties. As a result, NFTs with higher royalty rates tend to have reduced sales prices in the primary market.

5.3. Impact of Resale Royalty on Market Liquidity

Platform managers are particularly interested in not only sales prices but also, the frequency of sales (henceforth referred to as sale frequency). Because the platform's commission revenue is a percentage of sales price, managers would ideally aim for frequent sales at higher prices. In financial markets, liquidity is defined as the ease and speed with which securities can be bought or sold (Amihud and Mendelson 1986). Consistent with this perspective, we define market liquidity on an NFT platform as the speed at which an NFT listed is sold. In this section, we analyze the impact of

Table 5. Fixed Effects Regression Estimation Results of the NFT Sales in the Primary Market

	Sales on the primary market		
Dependent variable: $\ln(Sales\ price\ ETH)$	(1)	(2)	(3)
$\ln(Royalty)$	−0.035**	−0.035**	−0.03**
	(0.016)	(0.016)	(0.015)
Lazy Minted	−0.076**	−0.074**	−0.159*
	(0.037)	(0.037)	(0.083)
Creator FE	✓	✓	✓
Mint day FE	✓	✓	✓
Sale day FE	✓	✓	✓
GIF		✓	✓
Collection FE			✓
N	21,953	21,953	21,953
Adjusted R^2	0.781	0.781	0.793

Notes. The dependent variable is the log of sales price in ETH. Robust standard errors are clustered at creator level and presented in parentheses. The difference in the number of observations between Table 2 and this table is because of fixed effects (FEs) and secondary market sales.
*$p < 0.1$; **$p < 0.05$.

Table 6. Conditional Logit Fixed Effects Regression for the Sale Listings

Dependent variable: *Is Listing Successful?*	Sale listings: Logistic regression			
	(1)	(2)	(3)	(4)
ln(*Royalty*)	−0.322***	−0.344***	0.724***	0.709***
	(0.016)	(0.017)	(0.012)	(0.012)
ln(*Price*)	−0.763***	−0.765***	0.466***	0.465***
	(0.039)	(0.039)	(0.018)	(0.018)
Seller FE	✓	✓	✓	✓
GIF		✓		✓
N	534,399	534,399	534,399	534,399

Notes. Columns (1) and (2) report the estimated coefficients; columns (3) and (4) reports the odds ratios. Standard errors are presented in parentheses. We note that 371,616 groups (3,385,041 observations) were omitted because of all-positive or all-negative outcomes. FE, fixed effect.

***$p < 0.01$.

resale royalties on market liquidity using the sale listing records. A sale listing is recorded when an NFT owner sets a price and lists the NFT up for sale. If a buyer agrees to the listed price, an exchange of money (cryptocurrency) occurs for the corresponding NFT. In such a case, we classify the sale listing as a successful listing. Alternatively, a listing may be canceled by the NFT owner or remain active during our observation window. We consider the listings that have yet to be sold by the end of our observation period as unsuccessful.

First, we estimate the likelihood of a successful sale when NFTs are listed on the market using sale listing observations as the unit of analysis. We do not differentiate between the primary and secondary market listings as the platform's commission revenue is unaffected by the source of the sale. We include the seller fixed effects and control for the price of the sale listing and whether the NFT is an animated image. Table 6 presents the estimates from the logistic regression.[17] We find that an increase in the royalty rate decreases the probability of a successful sale. Specifically, the logistic regression results show that a 1% increase in the royalty rate is associated with a 0.276%–0.291% reduction in the odds of a successful sale.

Next, we use survival analysis to estimate the time that it takes for an NFT to be sold. In this analysis, we exclude sale listing observations in which the owner deliberately cancels the listing without waiting for a potential sale as well as listings created less than one month before the end of the data collection period. This ensures that all sale listings have at least one month to potentially be sold. A successful sale is defined as a failure event in survival analysis terms. We control for the price of the sale listing and relevant NFT characteristics as previously described. The results of this analysis are presented in Table 7. Our findings reveal that an NFT with a higher resale royalty takes significantly longer to sell as evidenced by the estimated coefficients being negative in columns (1) and (2) in Table 7 and the hazard ratios being less than one in columns (3) and (4) in Table 7. This implies that for each 1% increase in royalties, the rate at which sale listings end (because of

Table 7. Survival Analysis of the NFT Sale Listings

Dependent variable: *Time to Sale*	Sale listings: Survival analysis			
	(1)	(2)	(3)	(4)
ln(*Royalty*)	−0.217***	−0.051***	0.805***	0.951***
	(0.013)	(0.014)	(0.011)	(0.013)
ln(*Price*)	−0.469***	−0.473***	0.626***	0.623***
	(0.011)	(0.011)	(0.007)	(0.007)
GIF and lazy minted		✓		✓
N	4,203,639	4,203,639	4,203,639	4,203,639
Loglikelihood	−40,019	−39,235	−40,019	−39,235

Notes. This table presents the results of a survival analysis examining the effect of resale royalties on the duration of NFT sale listings. In survival analysis, negative coefficients indicate a shorter time to sale, whereas positive coefficients suggest longer listing durations. Hazard ratios below one imply that NFTs with higher royalties may remain listed for longer periods before selling. Columns (1) and (2) reports estimated coefficients; columns (3) and (4) reports hazard ratios. The estimations suggest that increased royalties may reduce market liquidity. Robust standard errors are clustered at creator level and presented in parentheses. FE, fixed effect.

***$p < 0.01$.

successful sales) decreases by about 4.9%. In other words, higher royalties increase survivability of sale listings, meaning that these listings remain active and unsold for longer durations.

Taken together, our findings provide empirical evidence for the negative impact of resale royalties on market liquidity. We estimate the likelihood of NFT sellers converting a sale listing into a successful sale and the speed at which this occurs. We discover that resale royalties have a detrimental effect on the success rate of a sale listing; an increase in the resale royalty is associated with a decrease in the odds of success for a sale listing. Furthermore, NFTs with higher resale royalties take significantly longer to sell as evidenced by a decrease in the hazard rate with an increase in the resale royalty. Specifically, the time to a defined failure event (i.e., successful sale) is prolonged when resale royalties are higher. These results suggest that platform managers receive fewer and less frequent commissions for NFTs with higher resale royalties, harming the market liquidity. These findings imply that allowing NFT creators to set higher levels of resale royalties may not be in the best interests of the platform.[18]

6. Identification and Robustness Checks

In Sections 6.1–6.3, we conduct various analyses to strengthen identification, and in Sections 6.4–6.6, we perform additional robustness checks.

6.1. Difference in Differences and Doubly Robust Difference in Differences for Lazy Minting

To establish a causal relationship, we employ a difference-in-differences (DiD) approach. This method allows us to isolate the effect of the policy change by comparing changes in behavior between treatment and control groups over time. By doing so, we can more confidently attribute any observed changes to the policy change rather than to other confounding factors. For the first hypothesis (Hypothesis 1a), we identify two groups of creators: those who transitioned from conventional minting to lazy minting after the policy intervention (i.e., the treatment group) and those who continued with conventional minting even after the policy change (i.e., the control group).[19] The treatment group consists of 2,446 creators, whereas the control group comprises 953 creators. We test Hypothesis 1a using mints from both groups by including creator, time, and collection fixed effects. We present the coefficient estimates in columns (1) and (2) in Table 8. Our results are consistent with those of the full sample based on a 12-month window surrounding the policy change.

To further bolster our analyses, we conduct a robustness test using a two-period panel data set consisting of the periods immediately before and after the introduction of the lazy minting policy. In this test, we calculate the average resale royalty for each creator in both periods and apply a difference-in-difference test, utilizing the treatment group (consisting of creators who switched from traditional minting to lazy minting) and the control group (those who did not make the switch). We employ a doubly robust difference-in-differences estimation method proposed by Sant'Anna and Zhao (2020) to strengthen identification. This method only requires either the treatment equation or the outcome equation to be correctly specified, and thus, it is doubly robust. The results of this analysis are presented in Table 8.

Moreover, we implemented a coarsened exact matching method to ensure that treatment and control groups are comparable in other characteristics. We matched creators based on four key variables: the number of NFTs sold, purchased, listed for sale, and minted. Balance tests (shown in Table 1 in Online Appendix B) and the balance plot (depicted in Figure 1 in Online Appendix B) confirm that the treatment and control groups are highly similar in the matched sample. Using the matched sample, we replicated our DiD analyses and report the estimations in column (4) in Table 8.

Table 8. Impact of Lazy Minting on Resale Royalty

	Treatment vs. control group			
	DiD		Two-period doubly robust DiD	Matched DiD
Dependent variable: ln(*Royalty*)	(1)	(2)	(3)	(4)
Lazy Minted	−0.16***	−0.248**	−0.103***	−0.093**
	(0.04)	(0.116)	(0.019)	(0.045)
Creator FE	✓	✓	✓	✓
Created date FE	✓	✓	✓	✓
GIF	✓	✓	✓	✓
Collection FE		✓		
N	43,984	43,984	6,798	10,799

Notes. Robust standard errors are clustered at the creator level and presented in parentheses. FE, fixed effect.
**$p < 0.05$; ***$p < 0.01$.

In consonance with our expectation and our primary estimations, the result shows that NFTs minted via the lazy method exhibit significantly lower royalty rates. This further strengthens our hypothesis that the introduction of lazy minting leads to lower royalty rates for NFTs.

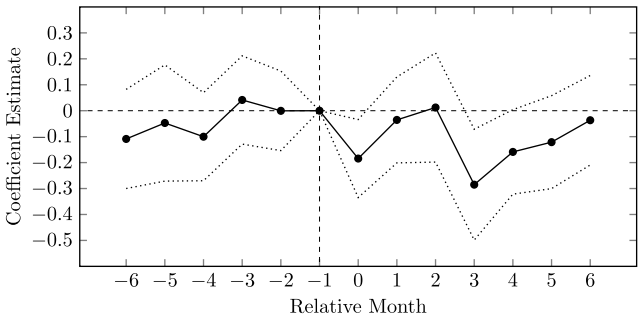
6.2. Parallel Trends Test

The discretionary nature of lazy minting introduces potential selection bias, where creators who opt for lazy minting may systematically differ from those who continue with traditional minting. This self-selection could influence the results if not carefully addressed. Although random assignment into treatment and control groups would be the gold standard for establishing causal identification, such an approach is not feasible in the context of NFT marketplaces because of the inherently optional nature of the lazy minting choice.[20] To address this challenge, we employ a difference-in-differences estimation strategy. The credibility of the DiD approach hinges on the assumption of parallel trends, which posits that in the absence of treatment, the treatment and control groups would have followed similar trajectories in their royalty rate choices over time. We test the parallel trends assumption using a leads and lags model and find no statistically significant differences in the royalty rates chosen by the treatment and control groups prior to the introduction of the lazy minting. This finding supports the validity of our DiD design.[21] The leads and lags coefficient estimates are depicted in Figure 2, which illustrates that the difference in royalty rates between the two groups emerges only after the policy change. The confirmation of the parallel trends assumption provides a robust framework for our causal interpretation, indicating that any observed differences postintervention can be attributed to the lazy minting policy rather than preexisting differences between these two groups.

6.3. Instrumental Variables (IV) Estimation for Primary Sales Prices

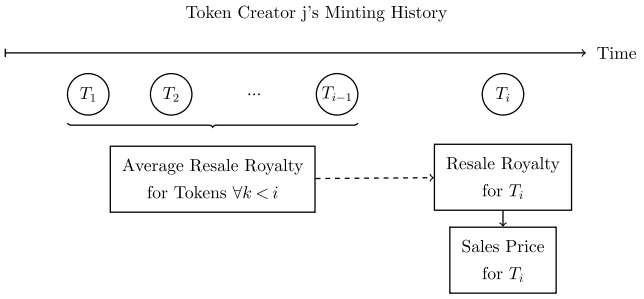
To further validate our results, we conduct an additional analysis using instrumental variables, which are constructed based on the historical resale royalty setting behavior of NFT creators as illustrated in Figure 3. Specifically, we use the average resale royalty rate that each NFT creator sets before minting the focal NFT as the instrumental variable. We assume that the royalty rates setting behavior of an NFT creator is consistent, meaning that the royalty rate of the focal NFT should closely resemble those set for previous NFTs. On the other hand, the royalty rate of past NFTs should not directly influence the sales price of the focal NFT. First, we estimate an instrumental variable model to analyze the relationship between resale royalty and sales price in ETH. Although the original sales prices are in ETH, market participants may consider their fiat currency equivalents. Therefore, we also replicate the analysis using sales prices in USD. In all specifications, we control for minting cost using the minting cost in ETH (USD) in the specifications where the dependent variable is in ETH (USD), respectively. The estimations of second-stage models are presented in Table 9.

Figure 2. The Leads and Lags Coefficients for Resale Royalty



Note. The dotted lines represent the 95% confidence intervals (standard error band) around the point estimates.

Figure 3. An Illustration of the Constructed Instrumental Variable



Note. The term T_i represents the NFT i minted by a token creator, where T_k is minted before T_i (i.e., the token of interest), $\forall k < i$.

Across all models, we consistently find that resale royalty is significantly associated with a decrease in primary market sales prices for NFTs. Additionally, we conduct several analyses to test for the validity of our IV. These include an underidentification test, a weak identification test, and a falsification test for the exogeneity of our IV (Barron et al. 2021). The falsification test is designed to detect whether our IV is confounded by spurious time trends correlating with both resale royalty rates and ETH prices. By randomizing our royalty rate regressor, we preserve the overall time trends while eliminating the direct influence of our IV on the royalty rates. Our findings from this falsification test, presented in Online Appendix D, indeed yield an insignificant estimate, supporting the exogeneity of our IV. Moreover, both underidentification and weak identification tests also lend additional support for the strength and exogeneity of our IV. These estimations are presented in Online Appendix E.

To further alleviate the concerns about the exogeneity of the instrument, we relax the exclusion restriction

Table 9. Two-Stage Least Squares (2SLS) Regression Estimations of the Relationship Between Resale Royalty and Sales Price on the Primary Market

	Primary sales: 2SLS regression			
	ln(*Sales price ETH*)		ln(*Sales price USD*)	
Dependent variable	(1)	(2)	(3)	(4)
ln(*Royalty*)	−0.085***	−0.085***	−0.217***	−0.217***
	(0.008)	(0.008)	(0.03)	(0.03)
Lazy Minted		−0.323***		−1.56***
		(0.042)		(0.169)
Collection FE	✓	✓	✓	✓
Mint date FE	✓	✓	✓	✓
Sale date FE	✓	✓	✓	✓
GIF		✓		✓
N	20,972	20,972	20,972	20,972
First-stage *F* statistic	21,962	21,871	21,962	21,871

Notes. Robust standard errors are clustered at the NFT level and presented in parentheses. FE, fixed effect.
***$p < 0.01$.

assumption with the plausible exogeneity test (Conley et al. 2012, Van Kippersluis and Rietveld 2018, Lal et al. 2024). The procedure for this test is as follows. First, we conduct a zero-first-stage (ZFS) test as a placebo test on a subsample of sales initiated by buyers where the instrument is not expected to influence the treatment.[22] The intuition behind this ZFS test is that if the instrument is valid, it should have no significant effect on the treatment variable in this specific subsample where no relationship is expected. A result close to zero in the ZFS test would provide supportive evidence for the validity of our instrument. Then, we combine the estimations from the ZFS test to relax the exclusion restriction assumption. Conley et al. (2012) suggest that the strict exclusion restriction assumption for instrumental variables can be relaxed and replaced with a user-specified plausible distribution for gamma instead of assuming that it is zero. They propose a local-to-zero (LTZ) approximation, which accounts for local violations of the exclusion restriction. This method replaces the standard assumption that gamma is zero with an estimate derived from the ZFS test. Figure 4 depicts the estimation results, which show consistent estimations for the LTZ approximation and lend further support for the IV estimations, even when the strict exogeneity assumption is relaxed.

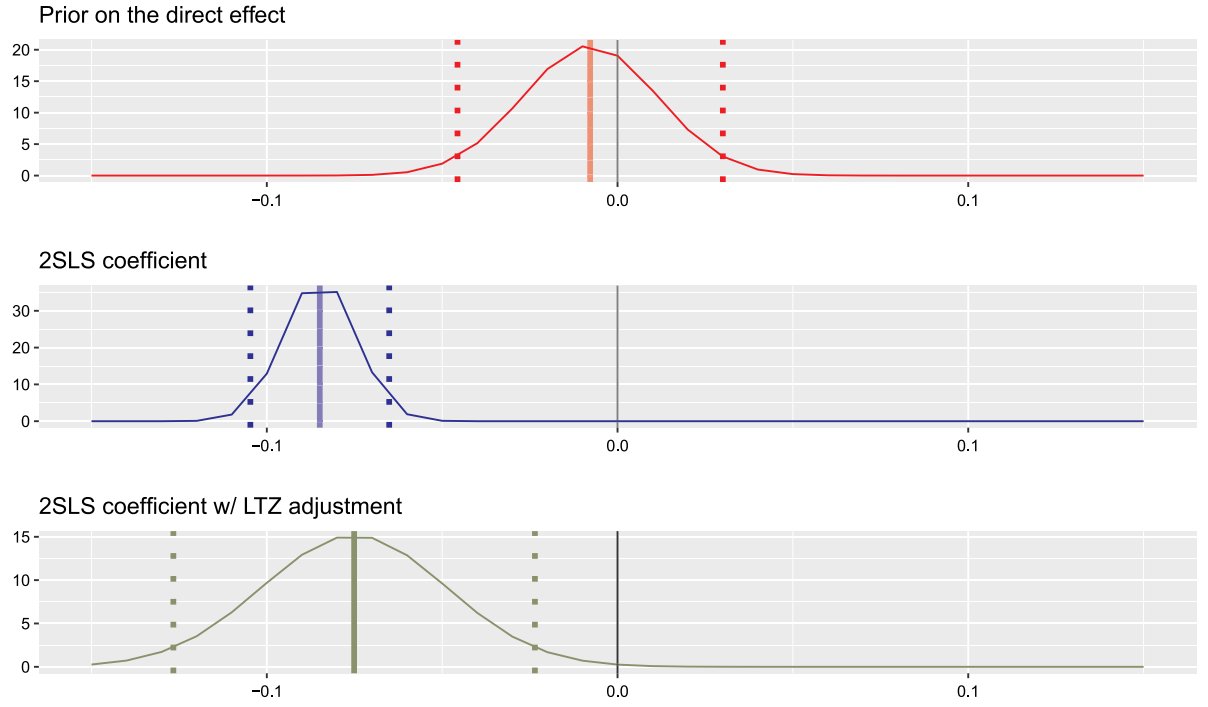
6.3.1. Alternative Instrumental Variable. To further alleviate concerns related to the exogeneity of the IV, we construct an alternative instrumental variable using the royalty rates of NFT creators who the focal creator follows. Rarible allows NFT creators to follow each other and form a social network. We gather follower information for each NFT creator in our sample and calculate the average royalty rate of those who the focal NFT creator follows. We argue that NFT creators may observe and be influenced by the royalty setting behavior of those who they follow, potentially leading them to set similar royalty rates. However, it is unlikely that the sale prices of a creator's NFTs are directly influenced by the NFTs of other creators who they follow. A causal mediation test for the new instrument variable lends empirical support for the relevance of the new IV.[23] We replicate our IV analyses using this alternative instrument and find qualitatively similar results, further strengthening the robustness of our IV estimations. In addition, we take several steps to ensure the validity of our identification strategy, including conducting underidentification, weak identification, and falsification tests for this new IV. These estimations are reported in Online Appendix F.

6.4. Other Factors Influencing NFT Sales

We acknowledge the presence of other factors that may influence the relationship between royalty rates and sale prices. These factors include the other related platforms in which the sales occurred and NFT-specific characteristics, such as aesthetic appeal to the community, pixel dimensions (the number of pixels in width and height), the presence of unlockable content, and whether the NFT is a GIF (a moving/animated image). Moreover, we incorporate an additional control variable that helps identify whether the sale is initiated by the creator or the buyer—specifically, whether the sales are solely initiated by creators or are influenced by both the demand and supply sides.

6.4.1. Other Marketplaces Where the Sales Occurred. NFTs may be listed on multiple platforms concurrently, and their sales performance could be affected by the specific platform on which they are listed. To address this concern, we gather additional data to

Figure 4. (Color online) Plausibly Exogenous Test for IV Estimation Including Zero-First-Stage Test (the Top Panel Titled "Prior on the Direct Effect") and Local-to-Zero Adjustment for 2SLS Coefficient



determine whether NFTs are listed and sold on major platforms, such as Looksrare, OpenSea, Blur, SudoSwap, and X2Y2. We introduce dummy variables into our analysis to account for the platform on which the NFT was listed and sold. Even after controlling for the platform fixed effects (column (1) in Table 10), the impact of resale royalties on sale prices remains consistently significant. This additional analysis shows that our findings are not limited to a particular platform and are robust to the presence of multiple platforms. Hence, it mitigates concerns related to the platform-specific influence on sale performance.

6.4.2. NFT-Specific Characteristics. The uniqueness and distinct qualities of each NFT, including artistic value, significantly influence pricing. The intrinsic value of an NFT, to a large extent, reflects the skill of its creator, which we partially control for in our model through creator fixed effects. However, we acknowledge that even for the same creator, there can be considerable variability in the quality and artistic value of NFTs over time. To address this, we include control variables, such as the number of "likes" that each NFT received, as this can serve as an indicator of its aesthetic appeal to the community. Additionally, we account for various NFT characteristics, including pixel dimensions (the number of pixels in width and height), the presence of unlockable content, and whether the NFT is a GIF (a moving/animated image). With the addition of these controls, we find that the impact of resale royalties on sale prices remains consistent. These additional analyses provide further robustness to our findings, demonstrating that the observed effects of resale royalty are not merely driven by the variability in the intrinsic value of the NFTs.

6.4.3. Sales Initiation. Sales of an NFT can be initiated in two ways: (1) by the creator listing the NFT for sale at a set price or (2) by a prospective buyer placing a bid on the NFT. Bids can be placed on any NFT regardless of its sale list status. In other words, potential buyers can bid on an NFT even if it is not listed for sale, and they may also bid below the asking price on a listed NFT. Upon receiving a bid, the seller has the option to accept or reject the offer. In our new analysis, we introduce "Accept Bid?" to differentiate between sales initiated by buyers through bidding and those initiated by sellers through listing at a prespecified sale price. The coefficient estimates are shown in columns (3) and (4) in Table 10. Even when controlling for the type of sales initiator—whether demand side (buyers) or supply side (sellers)—the impact of royalties on NFT sale prices remains consistent and significant. These additional analyses effectively alleviate concerns that sales initiated by either sellers or buyers might confound the impact of resale royalties on sale prices, demonstrating the robustness of our findings.

6.5. Granularity of the Minting Fee

The granularity of the independent variable, namely the minting fee, is not the primary focus of our study.

Table 10. Fixed Effects Regression Estimation Results of the NFT Sales in the Primary Market with Other Factors Influencing NFT Sales

	Sales on the primary market			
Dependent variable: ln(*Sales price ETH*)	(1)	(2)	(3)	(4)
ln(*Royalty*)	−0.035**	−0.035**	−0.041**	−0.04**
	(0.016)	(0.016)	(0.017)	(0.017)
Lazy Minted	−0.05*	−0.076**	−0.033	−0.004
	(0.027)	(0.037)	(0.043)	(0.034)
OpenSea	−0.009			0.033
	(0.014)			(0.031)
LooksRare	0.067***			0.057***
	(0.000)			(0.016)
X2Y2	3.05***			3.14***
	(0.027)			(0.034)
ln(*Pixel Width*)		0.003		0.003
		(0.011)		(0.011)
ln(*Pixel Height*)		−0.001		−0.001
		(0.011)		(0.011)
ln(*Likes*)		−0.002		−0.002
		(0.004)		(0.004)
Unlockable		0.066***		0.066***
		(0.018)		(0.019)
Accept Bid?			−0.023**	−0.01
			(0.012)	(0.016)
Creator FE	✓	✓	✓	✓
Mint day FE	✓	✓	✓	✓
Sale day FE	✓	✓	✓	✓
GIF	✓	✓	✓	✓
Collection FE				✓
N	21,953	21,953	21,953	21,832
Adjusted R^2	0.783	0.782	0.722	0.724

Notes. The dependent variable is the log of sales price in ETH. Robust standard errors are clustered at the creator level and presented in parentheses. FE, fixed effect.
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Instead, we have used the binary variable resulting from a policy change of minting fee in our identification strategy. The main rationale for this approach is as follows; the granular minting fee is highly influenced by fluctuations in blockchain traffic and is inherently endogenous. For instance, minting fees can surge during periods of high blockchain traffic, particularly as NFT popularity increases. This could, in turn, influence the sales prices of NFTs because of their increased appeal. On the other hand, the introduction of the lazy minting policy serves as an exogenous shock that was unforeseen. Thus, the impact of the presence of minting fees (or the lack thereof) on royalty rates and sales performance is less likely to be endogenous compared with a granular measurement. Nonetheless, to address potential concerns and for thoroughness, we conduct an additional robustness check on the relationship between the granular minting fees and royalty rates. The results, presented in Table 11, consistently show that an increase in minting fees is associated with higher royalty rates set by creators.

6.6. Royalty Commissions for Four Years

Our analysis of primary sales prices reveals that an increase in resale royalties results in a significant decrease in primary sales prices. However, this reduction in sales revenue may not necessarily be detrimental to the longer-term financial stability of NFT creators. The initial decrease may be offset by supplementary income from royalty commissions earned through subsequent resale of the NFT. In order to assess the longer-term consequences of resale royalties for NFT creators' financial well-beings, we investigate whether the initial decrease in primary sales prices is eventually compensated for by royalty commissions over a four-year period.

To evaluate the extent to which NFT creators benefit from resale royalties, we assess the royalty revenue generated from secondary sales within four years of the primary sale.[24] Because of the relatively recent launch of Rarible in May 2020, empirical evidence beyond four years is yet infeasible.[25] We construct a dependent variable, total revenue, defined as the sum of the primary sales price and the royalty commissions

Table 11. Impact of Granularity of the Minting Fee on Resale Royalty

	ln(*Royalty*)	
Dependent variable	(1)	(2)
ln(*Minting Fee ETH*)	0.07***	
	(0.01)	
ln(*Minting Fee USD*)		0.063***
		(0.01)
Creator FE	✓	✓
Mint day FE	✓	✓
Collection FE	✓	✓
GIF	✓	✓
N	114,929	114,929
Adjusted R^2	0.715	0.715

Notes. Robust standard errors are clustered at the creator level and presented in parentheses. FE, fixed effect.
***$p < 0.01$.

received from secondary sales within a four-year period.[26] We examine whether NFTs with higher royalty rates yield higher total revenue for NFT creators. The results are presented in Table 12.

Interestingly, our analysis suggests that resale royalties do not necessarily benefit creators within the four-year period following the initial sale. Creators set lower primary sales prices for NFTs with higher royalty rates, expecting that the royalty commissions from secondary sales will compensate for the reduced revenue on the primary market. However, our estimates challenge these expectations. Although creators forgo immediate financial gains by setting lower initial sales prices, they do not receive enough compensation through royalty commissions within the first four years to offset their initial losses on the primary market. This counterintuitive finding challenges the conventional understanding that resale royalties are advantageous for NFT creators. However, given that the time period under examination is four years, it is possible that NFT creators may eventually recoup this initial loss over a longer time horizon.

7. Underlying Mechanism and Alternative Explanations

7.1. Underlying Mechanism: Overconfidence Effect

To analyze the underlying mechanisms and conditions under which our results hold, we explore the overconfidence effect among NFT creators and its role in our findings. Specifically, we investigate whether the delayed gratification effect—where creators lower primary market sale prices in the hope of future royalty payments—is related to the confidence of the NFT creators about the future secondary market sales and royalty commissions. We use two proxy variables to measure the creator's confidence: (1) the number of sales the focal NFT creator has made (the higher the sales, the higher the confidence) and (2) the number of followers the focal NFT creator has (the higher the followers, the higher the confidence).[27] The rationale behind this analysis is that a higher number of successful sales increases the NFT creator's confidence in the potential for future secondary market sales and royalty commissions. Similarly, when there are many followers, it is likely to boost the NFT creator's perception of their popularity, increasing their confidence regarding future secondary sales and royalty payments.

We perform analyses using these two proxy variables and investigate whether the delayed gratification effect persists across different confidence levels. We split the sample based on the median number of sales and followers to categorize creators into high-confidence and low-confidence groups.[28] Our results, presented in Table 13, show that only the more confident NFT creators reduce their primary sale prices as the royalty rates increase. This finding sheds light on the underlying mechanism regarding the delayed gratification effect and its relationship with NFT creators' confidence in future secondary market sales. It also reveals an overconfidence effect because highly confident NFT creators reduce their primary sale prices but are unlikely to

Table 12. Sales Prices and the Royalty Commission up to Four Years Following the First Sale

	Sales price + royalty commission					
Dependent variable: ln(*Total Revenue*)	1 month (1)	6 months (2)	1 year (3)	2 years (4)	3 years (5)	4 years (6)
ln(*Royalty*)	−0.036**	−0.034**	−0.033**	−0.033**	−0.033**	−0.033**
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Creator FE	✓	✓	✓	✓	✓	✓
Mint date FE	✓	✓	✓	✓	✓	✓
First sale date FE	✓	✓	✓	✓	✓	✓
Collection FE	✓	✓	✓	✓	✓	✓
GIF and lazy minted	✓	✓	✓	✓	✓	✓
N	21,538	21,538	21,538	21,538	21,538	21,538
Adjusted R^2	0.742	0.743	0.743	0.744	0.743	0.743

Notes. Robust standard errors are clustered at the creator level and presented in parentheses. FE, fixed effect.
**$p < 0.05$.

Table 13. Underlying Mechanism: Overconfidence Effect on the Relationship Between the Royalty Rate and NFT Sales Price in the Primary Market

	Overconfidence effect			
	Number of followers		Number of sales	
Dependent variable: ln(*Sales Price ETH*)	Low (1)	High (2)	Low (3)	High (3)
ln(*Royalty*)	−0.008	−0.07**	−0.017	−0.065**
	(0.013)	(0.032)	(0.012)	(0.03)
Creator FE	✓	✓	✓	✓
Mint day FE	✓	✓	✓	✓
Sale day FE	✓	✓	✓	✓
Collection FE	✓	✓	✓	✓
Lazy minted and GIF	✓	✓	✓	✓
N	10,228	10,896	10,614	10,930
Adjusted R^2	0.873	0.729	0.833	0.799

Notes. The dependent variable is the log of sales price in ETH. Robust standard errors are clustered at the creator level and presented in parentheses. FE, fixed effect.
**$p < 0.05$.

recoup that reduction through royalty payments within four years.

7.2. Ruling Out the Alternative Explanation: High-Tax Effect

It may be argued that the results are driven by the "high-tax effect" rather than the "partial ownership effect." The "high-tax effect" refers to the perception of higher resale royalties as an excise tax, causing a demand shift away from the art subject to this "tax" toward art that is not (Filer 1984). To test the presence of (or to rule out) the high-tax effect separately from the partial ownership effect, we use a proxy variable that captures the buyer's intention when purchasing an NFT. We argue that the high-tax effect is only present when there is an intention for a secondary sale. This is because the tax effect of resale royalty only applies to buyers when they need to pay the royalty commission from the subsequent sale. On the other hand, when buyers intend to keep the NFT in their portfolio without selling it, the high-tax effect is less relevant for them at the time of purchase of the NFT in the primary market. To construct this proxy variable, we collected data on resale listings for all buyers in our sample. Specifically, we tracked whether each NFT was listed for sale with a price tag after its initial purchase. This approach allows us to identify buyers who demonstrated an intention to resell their NFTs.

We test the effect of the high-tax effect using moderation analyses with the proxy variable as a moderator for the royalty rate. The results, presented in Table 14, show that the tax effect did not play a significant role, whereas the impact of royalty on sale prices remained significant, even for buyers without an intention to resell. This empirical evidence supports that the presence of the tax effect does not seem to be strong and prevalent, whereas the partial ownership effect appears to be the likely explanation.

8. Discussion

This study investigates both the antecedents of royalty-setting behavior and the consequences of royalty rates in NFT marketplaces. We find that a higher minting cost for the focal NFT and higher (sunk) minting costs for other NFTs lead creators to set higher royalty rates for the focal NFT. Our analysis also reveals that NFTs with higher royalty rates are traded at significantly lower prices on the primary market than their counterparts with lower royalty rates. Although resale royalties are intended to financially support NFT creators in

Table 14. Ruling Out Alternative Explanation: High-Tax Effect on the NFT Sales Prices in the Primary Market

Dependent variable: ln(*Sales Price ETH*)	NFT sales in primary market (1)
ln(*Royalty*)	−0.025**
	(0.012)
High Tax Effect	0.047
	(0.058)
ln(*Royalty*) × *High Tax Effect*	−0.018
	(0.026)
Creator FE	✓
Mint day FE	✓
Sale day FE	✓
Collection FE	✓
Lazy minted and GIF	✓
N	21,953
Adjusted R^2	0.793

Notes. The dependent variable is the log of sales price in ETH. Robust standard errors are clustered at the creator level and presented in parentheses. FE, fixed effect.
**$p < 0.05$.

the long run, our findings indicate that they do not consistently benefit NFT creators. Specifically, our estimates show that NFT creators do not accrue financial benefits from resale royalty within the four years following the initial sale of their NFTs. Additionally, we provide evidence that NFTs with higher royalty rates are less likely to be sold and take longer to sell than NFTs with lower royalty rates. Conventional wisdom suggests that resale royalties benefit NFT creators and in turn, increase platform revenue. However, our findings suggest that the opposite may be true for NFTs with higher royalty rates as the market becomes less liquid and the average commission decreases because of significantly lower primary sales prices. These findings indicate that resale royalties may lead to unintended consequences for both NFT creators and platforms.

8.1. Theoretical Contributions

To the best of our knowledge, this study represents the first empirical investigation into the long-debated question of the impact of resale royalties on NFT marketplaces. Although prior literature has investigated royalty rates in other physical artworks, no study has empirically studied royalty rates in the NFT context, likely because NFTs are a relatively new phenomenon in the realm of digital artworks. Moreover, the underlying blockchain technology and the traceability of secondary sales offer a novel setting for exploring royalty rates. Our findings contribute to existing theories in IS and other related disciplines in several ways.

First, we provide empirical evidence and enrich relevant theories in IS. NFT marketplaces are considered as novel digital goods markets, although they bear similarities to markets for physical goods. For instance, the costs associated with content creation in NFT marketplaces resemble those in other markets where the production is costly. However, it is unclear whether theories associated with costs, such as the sunk-cost fallacy, apply to the novel context of NFT marketplaces. We found evidence that NFT minting fees can indeed trigger a sunk-cost fallacy, albeit a short-lived one. NFTs minted within a three-day window influence the royalty-setting behaviors for the focal NFT, even though the minting costs for the other NFTs are sunk. This suggests that the sunk-cost fallacy plays a role even in digital goods markets, specifically in NFT marketplaces.

Second, we contribute to settling the long-standing debate about resale royalties, a topic of interest among academics and policymakers since the 1920s. Our findings suggest that resale royalties can lead to a delayed gratification effect. In other words, NFT creators forego immediate rewards in the primary market in the hope of greater future monetary benefits.

Lastly, we find evidence for a partial ownership effect for NFT buyers because of resale royalties. We observed that the partial ownership effect influences buyer behaviors, resulting in fewer sales or prolonged time to sale for NFTs with higher royalty rates. These findings not only provide empirical support for existing theories but also pave the way for future research to expand these theories in the context of NFT marketplaces, which differ fundamentally from the market for physical goods. We believe that our study offers an empirically grounded contribution to the understanding of NFT marketplaces, providing a solid foundation for future scholarly work in this rapidly evolving field. We anticipate more studies on NFT marketplaces, and our study pioneers this research direction, calling for further evidence to support or refine existing theories as well as develop new ones in the context of NFT marketplaces.

8.2. Managerial Implications

Our findings have significant implications for NFT marketplace managers and creators. Contrary to the widespread belief that economic incentives through resale royalties benefit NFT creators, our research suggests that creators may be financially harmed by minting NFTs with high royalty rates. Although creators have received substantial royalty payments (over $1.8 billion worth of royalties were paid out to creators of Ethereum-based NFT collections as of October 2022 (Qadir and Parker 2022)), our findings indicate that these royalty payments do not compensate for the reduced prices in the primary market for at least four years.

Moreover, our research suggests that platform managers may not always profit from implementing resale royalties. The average sales price in the primary market decreases significantly, and commission revenue from sales becomes less frequent for NFTs with higher royalty rates. These findings may shed light on recent developments in the NFT ecosystem regarding royalty enforcement. In August 2023, OpenSea, the leading NFT marketplace, announced that it would no longer enforce royalty fees for buyers of new NFTs, and for existing NFTs, royalty enforcement would cease after February 2024.[29] This decision shocked many NFT creators who had come to rely on royalties for their economic well-being. In response, other NFT marketplaces took opposing stances. For instance, Rarible announced that it would continue to enforce royalties permanently.[30] Our findings contribute to this ongoing debate about whether marketplaces should enforce royalties, offering empirical evidence to better inform platform managers and policymakers.

Platform managers must carefully craft their information policies and design incentive mechanisms to survive and thrive in the long run. Maintaining a balance between the number of NFT creators and resellers in NFT marketplaces is vital for the economic viability

of such two-sided markets. NFT platforms compete to attract creators as their primary source of income is commission revenue from NFT sales. On the other hand, NFT creators financially rely on buyers that ultimately become resellers in the secondary market. One could not survive without the other. Hence, platform managers must ensure the economic sustainability of both NFT creators and resellers. Many NFT platforms adopted the resale royalties as a potential solution to offset the high minting costs, which undermine the financial stability of creators and stifle the emergence of new NFTs. The adoption of resale royalties, however, might have unintended consequences for primary sales prices and market liquidity beyond the probable benefits for NFT production. Our findings call for a more comprehensive assessment of the value of resale royalties, considering their effects on market dynamics beyond simply stimulating the NFT production. Sustaining the long-term economic viability of NFT marketplaces requires other important factors, such as engaging and rewarding active users, attracting new creators and buyers, and generating loyalty mechanisms to encourage buyer retention. Moreover, platform managers should strive to balance strategies between amateur and professional creators with respect to royalty rate setting.

8.3. Limitations and Future Research Directions

Our study is not without its limitations. First, our analysis relies on observational secondary data from an NFT marketplace. Although the difference-in-differences approach with parallel trends tests—which shows that the treatment group and the control group exhibited similar behavior prior to the policy change—is the most appropriate identification strategy for causal inference in observational data, we acknowledge that the gold standard for causality is using primary data with treatment manipulations in a randomized setting to completely eliminate concerns about self-selection. Although observational secondary data allow us to examine real-world market dynamics, future research could complement our findings with primary data obtained through controlled experiments. For instance, a randomized experiment could assigned one group of participants to high-royalty-rate NFTs and another group of participants to low-royalty-rate NFTs. Researchers could then examine outcomes, such as participants' willingness to pay and willingness to resell on the secondary market. Such an experimental design could provide additional causal evidence on the impact of resale royalties. We note that such experiments would require collaboration with NFT platforms to implement randomized assignment of minting options, which was not feasible in our study.

Second, our study focuses primarily on the economic aspects of resale royalties. However, there may be additional nonmonetary motivations and psychological factors influencing the behaviors of NFT creators and buyers. Qualitative research methods, such as surveys and interviews with stakeholders on NFT marketplaces, could provide deeper insights into additional mechanisms and motivations.

Third, although the analyses of proxy variables for the overconfidence effect are informative and provide suggestive evidence, we acknowledge that they may not capture all aspects of creator confidence. There could be alternative measures of confidence. Future research could explore alternative measures of confidence, such as surveys of creator attitudes or pricing trends of NFTs by the creator.

There are several avenues for future research to extend this study. One potential direction is to explore the impact of resale royalties on NFT production. In our hypothesis development, we posited that resale royalties may stimulate NFT creation by providing ongoing income through secondary sales. It remains an open question whether the adoption of resale royalties increases the quantity and quality of NFTs produced. Future studies should investigate the effect of resale royalties on the supply side of the NFT market.

Another interesting direction would be to examine whether the adoption of resale royalties attracts fewer or more NFT creators to a platform. Our findings suggest that NFT creators do not benefit from trading NFTs with resale royalties, and it is possible that some creators may avoid platforms that impose high resale royalties (e.g., KnownOrigin imposes a fixed rate of 12.5%). Additionally, although our study shows that NFT creators do not benefit from resale royalties within the first four years, it is unclear whether they might recoup the up-front losses through resale royalties over a longer time frame. As the NFT market grows and more data become available, further research can empirically investigate the duration required to offset the initial reduction in primary sales price.

Moreover, exploring the heterogeneity of NFT categories and examining how our findings vary across categories, such as digital art, collectibles, gaming, or virtual real estate, could be fruitful avenues for further investigation. For instance, the impact of creator confidence on pricing might be more pronounced in digital art, where individual artistic reputation plays a crucial role. On the other hand, in gaming or collectibles, the in-game utility of NFTs or the rarity of collectibles might be more influential. Another interesting avenue for future research would be to investigate the impact of fraudulent practices, like wash trading. We invite future researchers to extend our work in these interesting directions.

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Endnotes

[1] Miners secure and verify the transactions of creating NFTs and record them on the blockchain chosen by the platform. They receive a transaction fee in return for their computational work to legitimize the transaction.

[2] See https://rarible.com/how-it-works/getting-started/what-are-Raribles-fees.

[3] In this paper, we focus on minting by creators. The rationale behind this choice is that NFT creators decide on the royalty rate when they mint NFTs. In contrast, other forms of minting, such as minting for collectors, may limit creators' choice of royalty rates because of rules set by the collectors and their collections.

[4] As of 2023, the average cost of minting an ERC-721 token is approximately 0.05 Ether (~50 U.S. dollars (USD)).

[5] The phrase "everything else being equal" is used to signify the isolation of treatment effects, much like in a natural experiment. For instance, the introduction of lazy minting —a policy allowing cost-free minting of NFTs—serves as an exogenous shock. This enables us analyze its effects on royalty rates following this policy change while other factors remain unchanged.

[6] Creators set the maximum gas fee that they are willing to pay but may end up paying less because the actual gas fee paid is algorithmically determined yet bounded by the maximum set by the creator.

[7] In our sample, 61.5% of creators minted their entire NFT portfolio within a week.

[8] To test our hypotheses on the sales price, we leverage the sales data from before the introduction of the lazy minting feature. During this period, NFTs had to be minted first and the associated cost paid before they could be sold. Therefore, all NFTs in our data set from before the policy change have an associated gas fee paid by the creators.

[9] There are several reasons why we chose Rarible for our research instead of the most popular NFT marketplace, OpenSea. First, answering our research questions requires variation on royalty rates. OpenSea imposes a cap on resale royalties at 10%, whereas Rarible leaves it as a discretionary decision for creators to set their own royalty rates. Additionally, many collections within OpenSea do not allow NFT creators to set their own royalty rates, whereas most Rarible collections do.

[10] We first started off with 227,449 ERC-721 collections available on the Rarible and OpenSea platforms. Among these, we identified 15,914 collections—with 3,527 from Rarible and 12,387 from OpenSea—that have recorded at least one NFT sale. Among them, 88 collections allow discretionary royalties, meaning that creators can set their desired royalty rates.

[11] The data also include zero-sale NFTs given that at least one other NFT in that collection recorded a sale.

[12] We employ time fixed effects to control for unobservable time-specific factors, such as popularity spikes or fluctuations in cryptocurrency value during the observation period. For example, creation date fixed effects account for variances in NFT creation dates affecting royalty-setting behavior, and sale date fixed effects account for variations in sale prices on the date of sale. As previously noted, royalty rates are set at the time of minting and remain fixed thereafter, which explains why the time variable does not appear on the left-hand side of the equations of Hypotheses 1a and 1b.

[13] See https://rarible.com/blog/create-nfts-for-free-on-rarible-com-via-a-new-lazy-minting-feature/.

[14] We selected the DID_M (De Chaisemartin and d'Haultfoeuille 2020) model for several reasons. First, the DID_M model accommodates heterogeneous treatment effects within two-way fixed effects. In our analyses, we incorporate both creator fixed effects and time fixed effects. Moreover, the DID_M model allows for staggered adoption within the treatment group. In our data, NFT creators adopt the lazy minting option in a staggered manner.

[15] Ideally, a randomized experiment regarding the choice of lazy minting would yield a causal relationship between the antecedents and consequences of royalty rates. However, implementing such randomization is not feasible on NFT platforms as creators independently choose their minting mode.

[16] It is important to note that the relationship between the minting cost of production and royalty rates is not straightforward because of temporal factors. The minting cost is immediate and certain for creators, whereas the costs to buyers—through higher royalty rates and future royalty commissions on the secondary market—are uncertain and are not immediate.

[17] Online Appendix G provides the Ordinary Least Squares estimations for the success rate of sale listings with qualitatively similar findings.

[18] It is important to note that a platform's overall financial performance is influenced by many other factors, including the potential influx of new NFT creators attracted by higher resale royalties. Providing a comprehensive analysis of the overall financial performance of platforms with respect to resale royalties is beyond the scope of this paper.

[19] Our DiD analysis specifically focuses on creators who were actively minting before the lazy minting policy change. We excluded new creators who joined after the policy implementation to avoid the potential bias that could arise from compositional changes (Sant'Anna and Xu 2023) because of the influx of new creators after the introduction of lazy minting. This approach ensures that our treatment and control groups consist of the same set of creators before and after the policy change, allowing us to isolate the impact of the lazy minting on existing creators.

[20] Unfortunately, Rarible does not mandate a specific minting method (regular or lazy minting), nor does it randomly assign creators to lazy or regular minting options. To establish the causal effect of lazy minting on royalty rates, we would ideally randomize creators into lazy or regular minting options and compare the royalty rates of NFTs that they minted. However, such randomization is infeasible because of the optional nature of minting methods, and the concern over self-selection is not avoidable.

[21] The leads and lags coefficients estimates are reported in Online Appendix C.

[22] Because buyers initiate the bid for sale and sellers accept the bid without price adjustments, we argue that the creator's pricing decisions would not play a significant role in this subsample.

[23] See Figure 3 in Online Appendix F for the causal mediation test estimations.

[24] Our analysis aggregates both the royalty commissions from the secondary market and the sales revenue from the primary market.

[25] We acknowledge that employing a structural model might provide additional insights; however, capturing the intricate trade-offs between all of the decisions would require a full-fledged model,

which is beyond the scope of this empirical study. We encourage future research to explore this avenue.

[26] We give an illustrative example. An NFT with a resale royalty of 10% was sold in the primary market for 0.8 ETH. Six months after the initial sale, it was resold in the secondary market for 1 ETH, with 0.1 ETH going to the creator. Twenty-four months after the initial sale, it was resold in the secondary market for 0.5 ETH, with 0.05 ETH going to the creator. The creator's total revenue was 0.9 ETH 6 months after the initial sale and increased to 0.95 ETH 24 months after the initial sale.

[27] Our proxy measures using past sales and followers are similar to those used in the literature on chief executive officer (CEO) overconfidence. For instance, Malmendier and Tate (2005), Galasso and Simcoe (2011), and Hirshleifer et al. (2012) use proxies for CEO overconfidence based on how CEOs hold or exercise company stock options, which is directly related to their financial well-being. This is analogous to our use of past sales as an indicator of financial success and by extension, a creator's confidence in the NFT market. Moreover, Malmendier and Tate (2008) proxy CEO overconfidence based on how frequently CEOs were referred to in news articles, which is conceptually similar to our use of follower count as an indicator of how much attention NFT creators receive. These parallels demonstrate that our proxy variables are grounded in the literature for measuring overconfidence.

[28] Considering the number of past sales and the number of followers at the time of the sale, the median number of past sales is five, and the median number of followers is 50.

[29] See https://x.com/opensea/status/1626682043655507969.

[30] See https://nftnow.com/news/opensea-changes-royalty-policy-to-optional-rarible-responds/.

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