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Fractional Equity, Blockchain, and the Future of Creative Work

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Abstract. A core challenge in studying the real return on artist' work is the extreme difficulty accessing private records from when an artwork was first sold and thus relying on public auction data. In addition, artists do not typically receive proceeds after the initial sale. This paper, for the first time, uses archivally sourced primary market records to model returns on art and introduces a novel fractional equity structure for artists. We first model what would happen if the American artists Jasper Johns and Robert Rauschenberg had retained 10% equity in their work when it was first sold. Second, we model a portfolio return using data from the Betty Parsons Gallery and the Green Gallery. To add a portfolio analysis to the performance of "star" artists, we model the galleries as a fund invested in all of artworks sold, using auction sales as the realization event. We find that the individual Johns and Rauschenberg works would have vastly outperformed equities markets. The gallery portfolio still substantially outperforms the S&P, even including 20% transaction costs. Beyond the art market, our larger conceptual framework for retained fractional equity has broad implications for compensation of early-stage creative work in any field and for potential applications of blockchain technology.

History: Accepted by Karl Diether, finance.

Keywords: asset pricing • investment • labor • innovation • technology

1. Introduction

In 2017, Leonardo da Vinci's *Salvator Mundi* sold for $450.3 million at Christie's New York. The chain of newsworthy, marquee art prices perhaps began in 1980 when Burton and Emily Hall Tremaine sold Jasper Johns' *Three Flags* to the Whitney Museum of American Art for $1 million (an astonishing sum back then), or in 1973 when the Robert Rauschenberg painting, *Thaw,* that had sold for $900 in 1959 was resold at auction for $85,000. Artists do not commonly receive any of the gains when their works sell at auction.

Artists and regulators have tried to effect participation in the upside when their work is resold, whether through private contract or resale royalty (Banternghansa and Graddy 2011, Petty 2014, Shipley 2017, van Haaften-Schick 2018). This attempt to include artists masks a larger problem in art markets: how little we understand about the value of art. Experts appraise single objects, and scholars study overall market returns. However, to fully analyze returns on a collector's investment in art, one must at least know what the collector initially paid at the point of primary sale from a gallery. Analogous to a cost basis, this figure is not included in standard methods for studying art markets.

Typically, studies of the investment returns on art are based on an index of artworks that have sold in the secondary market, that is, at auction. Methods of assembling art price indices include repeat sales (Anderson 1974; Baumol 1986; Frey and Pommerehne 1989; Goetzmann 1993; Mei and Moses 2002, 2005), hedonic regression (Renneboog and Spaenjers 2013), and hybrid methods (Korteweg et al. 2016). These indices bear a significant survivorship bias based on the selection of what works go to auction (Burton and Jacobsen 1999) and variability in return across individual works (Spaenjers et al. 2015). They also only track intermediary points in an artwork's pricing history, that is, only once the artwork is already introduced into the secondary market. In contrast, a fractional ownership model, as we propose, would track the financial trajectory of an artwork from its first point of sale.

Although some fields such as book publishing, film, and music lend themselves to royalties because the creative work exists in multiple equal copies, our suggested model of fractional equity in works of art offers a new way of thinking about pay for creative work that could apply in those fields as well. We suggest recognizing creative workers as coinvestors alongside the patrons, collectors, clients, and employers who purchase their work. Such a scheme transforms and democratizes not only access to art markets but also much broader and less industry-specific forms of shared ownership in the future value one's work helps to create.

This approach opens up a new field of research by framing art market analyses as part of the study of creative labor. We expand from the traditional view of

art markets as a trade in the relics of genius to include the artists' studios as effectively the factories of genius. Our work generalizes to solve numerous practical and challenging theoretical problems in management science more broadly by offering ways of modeling hybrid rent/investment or wage/property-right pay in the gig economy. We may come to see the payment of salary as anachronistic and want to give all workers in value-creating jobs some fractional equity in the upside they create. Beyond the art market, our findings show the inability of a static price to capture the risks taken in making early-stage creative work in many other fields.

2. Approach

Using historical primary market sales prices and corresponding secondary market auction results, we study investment returns for both individual artists and whole galleries. First, we model what would have happened if the American artists Robert Rauschenberg (1925–2008) and Jasper Johns (b. 1930) had retained 10% equity in their work when it was first sold via the eponymous Leo Castelli Gallery between 1958 and 1963. This time period covers the startup phase of the artists' careers and of the gallery that Leo Castelli founded in 1957 (Cohen-Solal 2010).[1] We combine publicly available auction data with private sales information culled from the Leo Castelli papers at the *Archives of American Art*, in Washington, DC (see Appendix). We corroborate those archival materials using other sources, including the Jasper Johns' catalogue raisonné,[2] and the Robert Rauschenberg Foundation's online archive (Rauschenberg Foundation).

We hypothesize that the artists would be better off foregoing some payment when their work is first sold in exchange for this retained equity, even considering the opportunity cost to the artist of having retained equity in artworks that did not resell at public auction.[3] The specific model proposed in this paper is for artists to forego a percentage of the proceeds when their work is first sold so that they pay to retain that percentage of equity. In the basic case, instead of a 50-50 dealer-artist split, the split instead becomes 50-40-10, with the artist taking 40% cash and keeping 10% equity. For instance, in the case of Rauschenberg's $900 artwork *Thaw* (1958), the work would have sold for $810 instead of $900. The dealer would have still taken $450, but the artist would have taken $360 and retained the other $90 as equity in the piece. Had Rauschenberg held that equity, he would have received $8,500 from the 1973 sale.[4]

We have the artist pay in foregone income to retain the equity to avoid the criticism that resale royalties are a form of exceptional welfare paid to artists (Rub, 2014). In addition, by having the artist pay to retain the equity, we mitigate arguments related to the price elasticity of demand for art, such as are made by Banternghansa and Graddy (2011) and Ginsburgh (2007), who argue that resale royalties increase the effective price of art and therefore decrease demand. By having the artist pay an opportunity cost to retain the equity, there may be a contractual effect on the collector's willingness to accept the complexity of the retained equity going forward, but the price itself is proportionate, raising fewer concerns with regard to price elasticity of demand.[5]

To test our hypothesis that artists would be better off retaining 10% equity in their work, we add to our study of individual artworks a portfolio analysis that accounts for works the artists sold that did not later have realization events at auction. In our sample, many artworks did not resell at auction because they resold privately or in many cases were donated to art museums. Our inclusion only of auction sales is thus conservative.

Although some works in our sample were sold at auction a second time, we limit our study of retained equity in the individual artworks to the first auction resale. We reason that a simplified contract in which an artist retains equity would have the artist automatically cash in equity at the first public resale. We separately consider those repeat sales across all our artist and gallery records to consider the common repeat sales method of art investment analysis methodologically. We hypothesize that rates of return using primary sales will be markedly different from those using first and second (repeat) auction records.

Second, to move beyond what Rosen (1981) terms a *star* artist analysis implied by the study of Jasper Johns and Robert Rauschenberg, even though they would not have had the benefit of hindsight at the point of first sale, we introduce two further data sets containing larger selections of artworks. We use archivally sourced sales invoices from the Betty Parsons Gallery and the Green Gallery.[6] These mid- to-late 20th-century New York dealers' files show a compelling portfolio nature. For example, Betty Parsons, whose New York gallery ran from 1946 until 1983, sold paintings by Mark Rothko (1903–1970) for $300 in 1950 that are now worth $100 million. However, Parsons also sold, at comparable prices, works by artists such as Paul Feeley (1910–1966) and Lyman Kipp (1929–2014), for whom there is no discernable auction market. Our second gallerist, Richard Bellamy, ran the Green Gallery from 1960 to 1965 and was criticized in his time for having a *cacophonous mix* of artists based on his tireless visits to artists' studios (Rachleff-Burtt 2017). This criticism of cacophony indicates substantial portfolio diversity.

We acknowledge the limitation of this study that neither Green nor Betty Parsons is a *representative gallery* in a large sample-set sense. In fact, we would argue that there is no such thing as a representative gallery. To designate a gallery as such is only possible ex post and is really only a retroactive designation of

an average gallery. Within this limitation, Green and Parsons are among a cohort of respected New York galleries of their time. They were among only a handful of prominent galleries dealing contemporary art in New York in the 1950s and 1960s, and they were both located on Fifty-Seventh Street, the key gallery neighborhood of the time.[7] One might imagine by analogy that they are colleges or universities within the upper tier of a ranking system. In the same way that Cameron et al. (2019) are able to extract insights on gender and inclusion in the art market by focusing only on alumni of the Yale School of Art, we focus on these two galleries for which we have detailed data. The insights gained and pathways opened by this structure of research significantly outweigh the limitations.

3. Analysis

We first analyze the individual artworks, then the portfolios of Jasper Johns' and Robert Rauschenberg's works, and then the portfolios of the overall galleries. Throughout our analysis, we use value-weighted portfolios, as an equal weighting would misrepresent the significant range of initial gallery sales price, which in the case of Jasper Johns and Robert Rauschenberg ranges from $150 to $15,000. We find that each of these approaches dramatically outperforms the stock market.

3.1. The Individual Artist Analysis of Fractional Equity

Of approximately 130 works by Jasper Johns and Robert Rauschenberg listed in the Leo Castelli papers from 1958 to 1963, we match 9 works by Johns and 12 by Rauschenberg to later auction results in the secondary market. Tables 1 and 2 present the annualized financial returns on the individual works of art.

For the 21 individual artworks, their implied individual annual rates of return from primary sale to first auction range from +20.92% to +40.90% for Johns (Table 1) and from 12.04% to +37.41% for Rauschenberg (Table 2). We note that, for both artists, the returns are relatively evenly distributed.

The tables show the enormous difference between the original sales prices, which start as low as $150, and the auction prices in millions of U.S. dollars. We see percentage gains on individual works of well more than 1,000,000%, leading to some annualized returns on investment (ROIs) of 30%–40% over decades. For instance, Table 1 shows that Jasper Johns' *Small Green Target* (1956) rose meteorically from an original purchase price of $300 in 1958 to an auction hammer price of $3,000,000 in 2004. The percentage gain in nominal price for *Small Green Target* is 1,999,900%, for an annualized rate of return of 23.80%, for each and every year from 1958 to 2004.

In Tables 1 and 2, we offer a ratio of 10% of the auction hammer price to the return on the opportunity cost of retained equity if invested in the stock market, as represented by an investment in the S&P 500 index. For example, if Robert Rauschenberg had retained 10% equity in his work *State* (1958) when the Leo Castelli Gallery first sold the work in 1959 for $300, the artist's $30 would have become $44,000 in the art market. By comparison, had Robert Rauschenberg taken the $30 in cash in 1959 and invested it in the stock market index S&P 500, he would have received only $2,417.10 over the same time period. The results in Table 2 show that the works by Rauschenberg outperform the S&P 500 by between 2.75 and 156.36 times. Table 1 indicates that the works by Jasper Johns outperform the S&P 500 by between 20.64 and 1,086.67 times. We note that we still observe similar outperformance even with an assumption of 20% transaction costs.

We then consider the portfolio of the individual artworks made by each of Jasper Johns and Robert Rauschenberg from first sale through auctions by including all the artworks found in archival records but not matched to auction results. For each artist, we analyze the returns as represented by 10% of the first auction sale for the 9 works of Jasper Johns and for the 12 works of Robert Rauschenberg compared with the opportunity cost of having retained equity in all the works sold (51 works for Johns and 80 works for Rauschenberg, respectively). We model this opportunity cost as invested in the S&P 500 at the time it was paid and compare that with the 10% equity as realized in the first-sale auction. For the auction proceeds, some received as early as 1970, we reinvest those proceeds in the S&P 500 to represent a measure of the time value of money.

For Jasper Johns, we find that the retained equity portfolio, as reinvested in the S&P 500, would have by 2018 generated $17.16 million compared with $3.49 million if the 10% equity had been invested in the S&P 500 all along (Figure 1). For Robert Rauschenberg, the opportunity cost of retaining the 10% equity (as measured by the S&P 500 returns of that retained amount, over time) would have been $949,000. The comparable auction proceeds on retained equity, with the S&P 500 reinvestment, would have been $51.72 million, or 50 times higher (Figure 2). We additionally model what would have happened if the auctions had entailed large transaction costs. At 20% transaction cost, Johns would still have had $13.73 million, almost four times the S&P 500 return over the same period. With 20% transaction fees, that figure for Rauschenberg would have been $41.38 million, or 40 times the U.S. equities result.

3.2. The Gallery Art-Fund Analysis of Fractional Equity

To move beyond the individual artist approach, we consider a broader portfolio analysis of a mixed artwork grouping based on the sales invoices of the

Table 1. Annualized Return on Investment: Jasper Johns

No.	Artwork	Sold at Castelli Gallery	Price (USD)	Sold at auction	Hammer price (USD)	Gain (USD)	Percentage gain	Annualized ROI	10% of gallery price	Invested in S&P 500	10% of AHP	Ratio AHP/S&P 500 investment	Ratio AHP (–20%)/S&P 500 investment
1	*Small Green Target* (1956)	1958	150	Sotheby's NY, November 9, 2004	3,000,000	2,999,850	1,999,900%	23.80%	15	1,503.30	300,000.00	199.56	159.65
2	*Grey Numbers* (1957)	1958	350	Christie's NY, November 9, 1988	260,000	259,650	74,186%	24.31%	35	561.57	26,000.00	46.30	37.04
3	*White Flag* (1955)	1958	2,000	Christie's NY, November 9, 1988	6,400,000	6,398,000	319,900%	30.43%	200	3,208.95	640,000.00	199.44	159.55
4	*Tennyson* (1958)	1958	1,000	Sotheby's NY, November 18, 1970	70,000	69,000	6,900%	40.90%	100	246.96	7,000.00	28.34	22.68
5	*Target* (1958)	1959	200	Sotheby's NY, November 10, 1986	280,000	279,800	139,900%	30.29%	20	233.53	28,000.00	119.90	95.92
6	*Newspaper* (1957)	1959	450	Christie's NY, May 7, 1997	600,000	599,550	133,233%	20.92%	45	2,907.44	60,000.00	20.64	16.51
7	*Colored Alphabet* (1959)	1959	175	Christie's NY, May 3, 1989	3,200,000	3,199,825	1,828,471%	38.91%	17.50	330.26	320,000.00	968.93	775.15
8	*False Start* (1959)	1960	1,000	Sotheby's NY, November 10, 1988	15,500,000	15,499,000	1,549,900%	40.50%	100	1,426.38	1,550,000.00	1,086.67	869.33
9	*Gray Rectangles* (1957)	1963	12,000	Sotheby's NY, November 10, 1988	3,900,000	3,888,000	32,400%	25.59%	1,200	12,035.42	390,000.00	32.40	25.92

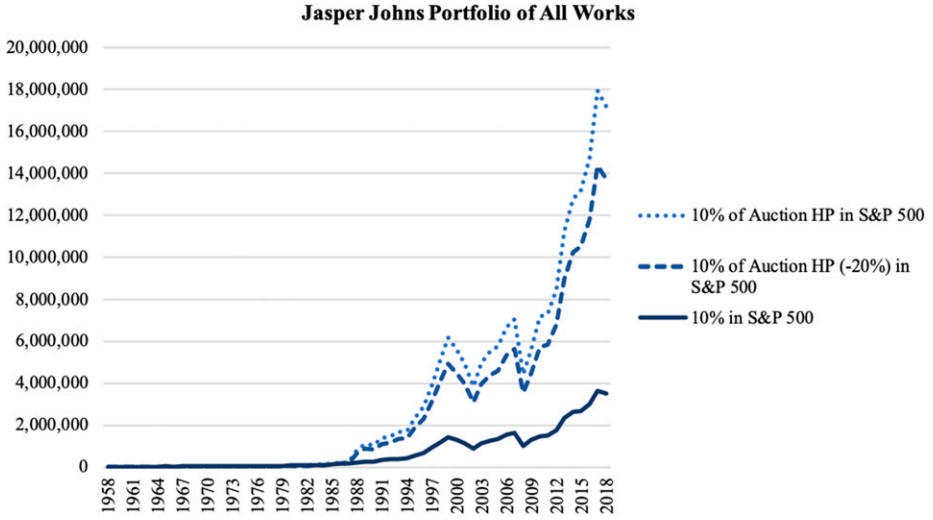
Notes. This table shows the original sales data for Jasper Johns' artworks sold by the Leo Castelli Gallery over the period from 1959 to 1963, combined with their respective first-auction hammer prices and given gain, loss, and annualized ROI. The price USD is the gallery price in the primary market. The hammer price USD is the auction price in the secondary market. We take 10% of the primary market price as retained by the artist. Thus, the artist holds a claim on 10% of the auction hammer price. We then show the opportunity cost of the artist's decision to retain equity by comparing the gains that would have occurred had the originally retained equity (10% of gallery price) been invested in the S&P 500. The ratio AHP/S&P 500 investment shows the ratio of outperformance of the retained equity to the comparable general equities investment. The last column, ratio AHP (–20%)/S&P 500 investment, compares the ratio of gains from retained equity in art to the S&P 500, assuming 20% transaction cost on the auction sale. AHP, auction hammer price; ROI, return on investment; USD, US dollars.

Table 2. Annualized Return on Investment: Robert Rauschenberg

No.	Artwork	Sold at Castelli Gallery	Price (USD)	Sold at auction	Hammer price (USD)	Gain (USD)	Percentage gain	Annualized ROI	10% of gallery price	Invested in S&P 500	10% of AHP	Ratio AHP/S&P 500 investment	Ratio AHP (–20%)/S&P 500 investment
1	*State* (1958)	1959	300	Sotheby's NY, May 14, 1998	440,000	439,700	146,566%	20.62%	30	429.92	44,000.00	102.34	81.88
2	*Thaw* (1958)	1959	900	Sotheby's NY, October 18, 1973	85,000	84,100	9,344%	37.41%	90	230.42	8,500.00	36.89	29.51
3	*Forge* (1959)	1959	1,000	Pierre-Marie Rogeon Paris, June 27, 1973	60,563 (255,000 FF)	59,563	5,956%	34.06%	100	256.02	6,056.30	23.66	18.92
4	*The Red Painting* (1954)	1959	1,200	Christie's NY, November 8, 1983	420,000	418,800	34,900%	27.17%	120	843.45	42,000.00	49.80	39.84
5	*Forecast* (1960)	1960	1,400	Sotheby's NY, November 18, 1970	19,000	17,600	1,257%	28.53%	140	307.36	1,900.00	6.18	4.95
6	*Nettle* (1960)	1960	3,200	Christie's NY, May 4, 1993	650,000	646,800	20,213%	17.55%	320	9,002.70	65,000.00	7.22	5.78
7	*Rebus* (1955)	1961	2,800	Sotheby's NY, November 10, 1988	5,750,000	5,747,200	205,257%	32.12%	280	3,677.31	575,000.00	156.36	125.10
8	*Glider* (1962)	1963	7,500	Christie's NY, November 14, 1995	750,000	742,500	9,900%	15.28%	750	20,681.43	75,000.00	3.63	2.90
9	*Calendar* (1962)	1963	7,500	Christie's NY, May 13, 2015	2,741,000	2,733,500	36,447%	12.04%	750	99,755.42	274,100.00	2.75	2.20
10	*Dry Run* (1963)	1963	4,000	Sotheby's NY, November 17, 1998	900,000	896,000	22,400%	16.53%	400	19,663.08	90,000.00	4.58	3.66
11	*Exile* (1962)	1963	3,500	Sotheby's NY, November 9, 2010	7,100,000	7,096,000	202,757%	17.43%	350	25,756.53	710,000.00	27.57	22.05
12	*Overcast II* (1962)	1964	7,500	Christie's NY, November 9, 1979	170,000	162,500	2,167%	22.52%	750	1,688.51	17,000.00	10.07	8.05

Notes. This table shows the original sales data for Robert Rauschenberg's artworks sold by the Leo Castelli Gallery over the period from 1959 to 1963, combined with their respective first-auction hammer prices and given gain, loss, and annualized ROI. The price USD is the gallery price in the primary market. The hammer price USD is the auction price in the secondary market. We take 10% of the primary market price as retained by the artist. Thus, the artist holds a claim on 10% of the auction hammer price. We then show the opportunity cost of the artist's decision to retain equity by comparing the gains that would have occurred had the originally retained equity (10% of gallery price) been invested in the S&P 500. The ratio AHP/S&P 500 investment shows the ratio of outperformance of the retained equity to the comparable general equities investment. The last column, ratio AHP (–20%)/S&P 500 investment, compares the ratio of gains from retained equity in art to the S&P 500, assuming 20% transaction cost on the auction sale. AHP, auction hammer price; ROI, return on investment; USD, US dollars.

Figure 1. (Color online) Comparison of Jasper Johns Portfolio to S&P 500



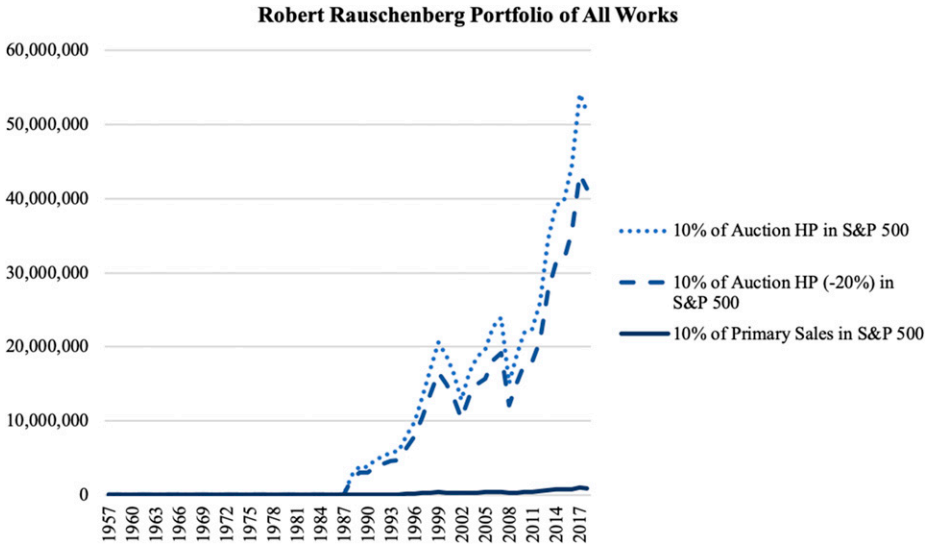
Notes. This figure combines all the Jasper Johns' artworks that sold at auction into a portfolio of all works. We then consider the 10% retained equity that Johns would have had in all the works. We compare the retained equity portfolio to its opportunity cost, as represented by an investment of the foregone income (to retain equity) as invested in the S&P 500. We use 10% of the first sales price as the cost basis and 10% of the hammer price as return on investment. We also compare 10% of the hammer price to the S&P 500 index, assuming 20% transaction cost on the art sale.

Betty Parsons Gallery and the Green Gallery (Betty Parsons Gallery, Richard Bellamy Papers).[8] We model the combination of the two art galleries as an art fund invested in the retained equity shares.

Table 3 presents summary statistics. For our final sample of 1,002 total sales records across both galleries (433 for Green and 569 for Betty Parsons), we find 108 matching auction sales (48 for Green and 60 for Betty Parsons). These sales span the period from 1946 through 1981.

The 1,002 works within our Green and Parsons analysis represent 121 different artists. Of those artists, only 27 had works sell at auction. We thus note that, although public auction results have the strong advantage of a larger database, in our sample, only 23% of the artists who sold their works via the gallery had a work go to auction in a span of decades. We further observe, albeit in too small a sample size to generalize, that a disproportionate number of women artists and artists of color, who were already

Figure 2. (Color online) Comparison of Robert Rauschenberg Portfolio to S&P 500



Notes. This figure combines all the Robert Rauschenberg's artworks that sold at auction into a portfolio of all works. We then consider the 10% retained equity that Johns would have had in all the works. We compare the retained equity portfolio to its opportunity cost, as represented by an investment of the foregone income (to retain equity) as invested in the S&P 500. We use 10% of the first sales price as the cost basis and 10% of the hammer price as return on investment. We also compare 10% of the hammer price to the S&P 500 index, assuming 20% transaction cost on the art sale.

Table 3. Summary Statistics

Panel A: By artist and artwork

Artworks			Artists		
Category	Number of artworks	Breakdown by gallery	Category	Number of artists	Breakdown by gallery
Primary market	1,002		Primary market	121	
Green	433	43%	Green	20	17%
Parsons	569	57%	Parsons	101	83%
To auction[a]	108		To auction[a]	27	
Green	48	44%	Green	11	41%
Parsons	60	56%	Parsons	16	59%

Panel B: By gender

Artists in overall sample			Artists going to auction		
Category	Number of artworks	Breakdown by gallery	Category	Number of artists	Breakdown by gallery
Total	121		Total	27	
Green	20		Green	11	
Male	18	90%	Male	10	91%
Female	2	10%	Female	1	9%
Parsons	101		Parsons	16	
Male	77	76%	Male	11	69%
Female	24	24%	Female	5	31%

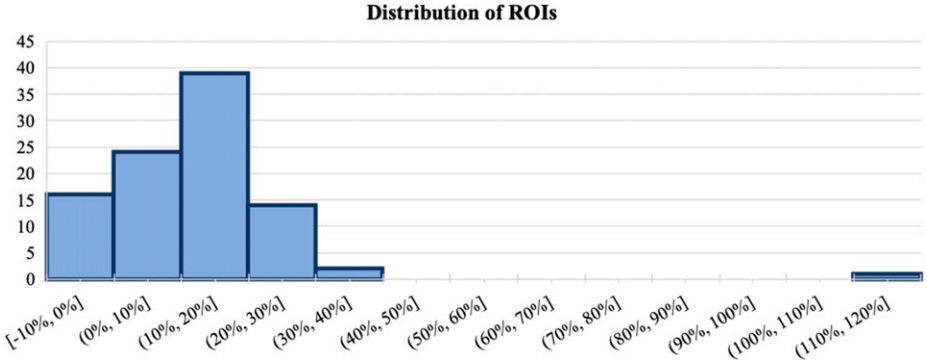
Notes. This table shows the breakdown of artists and artworks contained within the Green Gallery and Betty Parsons Gallery sample sets. Panel A distinguishes by number of artworks and by number of individual artists. Panel B differentiates by gender of the artist.
[a]Excludes buy-ins.

underrepresented in primary market sales, fell out of the sample before works went to auction.[9] Of the 20 artists represented by Green Gallery, 11 had works go to auction. Two of the gallery's original 20 artists were women, one of whom, Lee Lozano (1930–1999), had works go to auction. For Betty Parsons, who represented 101 different artists, there were 24 female and 77 male artists. Of the 16 Parsons gallery artists with works that sold at auction, 5 were women.

Although it is difficult to exhaustively research the ethnic background of all the artists, Parsons represented a handful of artists of color including some of both Japanese and Haitian nationalities. Although there was auction activity for the Japanese artists Kenzo Okada (1902–1982) and Minoru Kawabata (1911–2001), in our analysis, none of the black Haitian artists saw works go to auction.[10] Especially given recent studies on racial and gender inclusion in art markets (Adams et al. 2017), we note that if other pathways from primary markets to public auction results look even remotely like this one, then the inclusion of primary market data has even more to teach us about the field.

We first model the opportunity cost to retain 10% equity in all 1,002 artworks, relative to the gains from 10% of proceeds from the 108 auction sales. We then model the galleries as one collective venture capital (VC) fund. We hypothesize that, like a VC fund, an art gallery takes risks on a wider array of works and then makes some home-run returns, some midlevel returns, and some write-offs.

Figure 3. (Color online) Distribution of Returns by Artwork and Annualized Average ROI



Notes. This histogram shows the distribution of returns by artwork within the combined Green Gallery and Betty Parsons Gallery fund. We compute an annualized ROI for each artwork.

Instead of a standard public market equivalent (PME) approach (Kaplan and Schoar 2005), we use a rolling method of comparison with the S&P 500 index so as not to overemphasize a starting point. Although a closed-end VC fund would have such a finite starting reference point, in this case, each gallery was a going concern. To avoid the time-horizon distortion of a PME over a continuous, multidecade period, we instead show the return from the start of the gallery to the last sale with reinvestment of auction proceeds in the S&P 500.

The PME method is used very well by Chambers et al. (2020). The authors consider the returns on the collection of John Maynard Keynes. Their data and approach lend themselves to a PME analysis because they have measured returns at intervals. Keynes happens to have collected artworks in fairly concentrated time frames, for instance, around a specific 1918 auction and also had his work appraised at fixed intervals. In contrast, if we were to suppose that the fund began in 1946 but did not have a first realization event until a 1970 auction, we would introduce substantial distortion.

In addition, it is also important that the artists' equity is reinvested in the S&P 500 index to correctly reflect the opportunity cost from the artist's point of view. Figure 3 presents the distribution of returns by artwork within the combined gallery portfolio. We compute the annualized ROI for each artwork and observe a relatively strong distribution of returns as opposed to a pure superstar effect (Rosen 1981).

Figure 4 shows the distribution of holding period (in years) from first sale to first auction for the combined gallery portfolio. Excluding repeat sales, we observe a relatively strong distribution of holding periods, focused in a longer (i.e., 20–50 years) range.

We further isolate the annualized ROI and holding period by artist as well as by artwork. Table 4 shows the annualized ROI by artist, the average holding period in years, and the number of artworks each artist had in the larger 1,002 sample and in the 108 works that went to auction. We also show the percentage yield to auction.

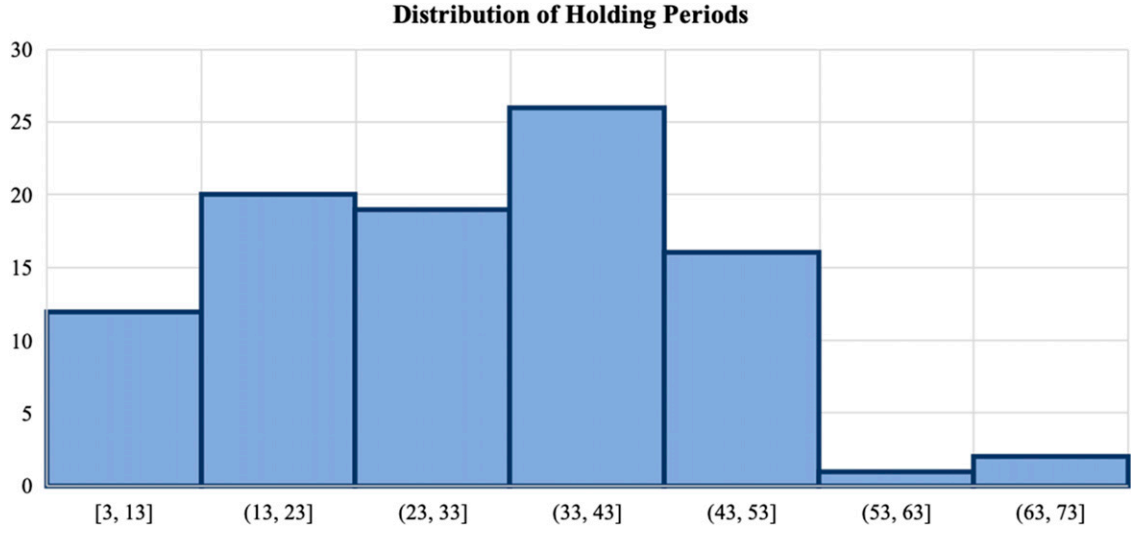
These annualized ROIs by artist range from 24.45% to −9.62%.[11] We note that the superstar artist Jackson Pollock is outperformed in ROI by two other artists who are much less known, especially outside the art world. We also find that the ROIs are relatively equally distributed, with many annualized average returns in the low double digits.

3.3. Building a Hedonic Art Index

Because our analysis has allowed us to see substantial differences between primary market and repeat sales returns, we built a new hedonic art index rather than use an existing repeat-sales index to compare and contextualize our results. Our gallery portfolio is modeled with a reinvestment in the S&P 500 to represent the artist's opportunity cost of capital more accurately. Thus, we expect that our constructed gallery art fund will be higher than the hedonic art index but that they will still offer a means of comparison.

We use the Blouin Art Sales Index (BASI), an online database representing sales from 350 auction houses worldwide. Considered to be the most comprehensive database for art auction sales, BASI contains more than 5.3 million artworks by more than 240,000 separate artists, covering the period 1922 to 2016. We limit our focus to the 1.9 million paintings in the BASI data.

Figure 4. (Color online) Distribution of Holding Period for Artworks Going to Auction



Notes. In this figure, we isolate the artworks within the Green Gallery and Betty Parsons Gallery primary-market sales data and display the holding period for artworks that went to auction. We exclude repeat sales and show only holding period from first sale to first auction.

Table 4. Artists Ranked by Annual ROI with Holding Period and Auction Yield

Rank by ROI	Artist	Average annual ROI	Average holding period (years)	Gallery works sold	Auction sales	Auction yield
1	John D Graham (1886–1961)	24.45%	14.89	1	1	100%
2	Richard Tuttle (1941–)	23.32%	24.34	41	4	10%
3	Jackson Pollock (1912–1956)	21.24%	44.22	58	9	16%
4	Ellsworth Kelly (1923–2015)	20.42%	10.73	8	2	25%
5	James Rosenquist (1933–2017)	19.90%	13.42	28	2	7%
6	Agnes Martin (1912–2004)	19.60%	17.78	4	3	75%
7	Tom Wesselmann (1931–2004)	18.17%	32.53	84	13	15%
8	Larry Poons (1937–)	16.81%	22.21	28	4	14%
9	Claes Oldenburg (1929–)	14.36%	41.68	40	8	20%
10	George Segal (1924–2000)	13.89%	31.21	60	5	8%
11	Robert Morris (1931–2018)	13.33%	35.27	54	4	7%
12	Lucas Samaras (1936–)	10.78%	50.62	45	1	2%
13	Richard Pousette-Dart (1916–1992)	8.86%	39.00	11	1	9%
14	Saul Steinberg (1914–1999)	6.99%	28.22	21	4	19%
15	Lee Lozano (1930–1999)	5.72%	50.12	14	1	7%
16	Toko Shinoda (1913–)	5.45%	23.02	3	1	33%
17	Theora Hamblett (1895–1977)	3.99%	19.27	4	1	25%
18	Ruth Vollmer (1903–1982)	3.42%	28.42	4	1	25%
19	Neil Williams (1934–1988)	2.90%	41.68	24	2	8%
20	Cleve Gray (1918–2004)	2.62%	35.38	25	1	4%
21	Walter Tandy Murch (1907–1967)	2.23%	25.35	19	10	53%
22	Leo Valledor (1936–1989)	1.57%	40.38	3	1	33%
23	Robert Beauchamp (1923–1995)	1.22%	51.98	29	1	3%
24	Kenzo Okada (1902–1982)	1.09%	24.78	22	13	59%
25	William Taggart (1936–2007)	–0.72%	34.33	9	1	11%
26	Lee Hall (1934–2017)	–7.70%	3.59	2	1	50%
27	Mino Argento (1927–)	–9.62%	24.56	3	1	33%

Notes. This table presents on the artist level the average annualized ROI, the average holding period, and the auction yield. For each artist, we calculate the ROI for all their works that sold at auction. We list the artists in rank order by their average annual ROI. We exclude repeat sales. We also list the average holding period from first sale to auction, the total number of works originally sold by the gallery, and the number of those works that went to auction. The auction yield shows the percentage of works in the gallery sample set that were resold at in a first auction sale.

For each BASI auction record, we have specific information about the artist, the artwork, and the transaction. For the artist, we know their name, nationality, and dates of birth and death (if applicable). To describe each artwork, we know the title (or Untitled), the date of creation, the medium (e.g., oil on canvas), the dimensions, the style or artistic movement, and whether the work is signed or otherwise given an identifying mark by the artist. For the transaction, we know the auction house, date of sale, lot number, U.S. dollar hammer price (i.e., the price registered in the auction room, excluding any buyer's premium paid to the auction house, converted on the date of auction from local currency into U.S. dollars), and whether an artwork failed to meet the reserve price and thus was bought in.

We construct a multivariate hedonic index to acknowledge that paintings are heterogenous assets whose value is determined by a set of physical and general characteristics. We construct an art price index of the *Top 100 Post-War and Contemporary Artists* by ranking all Post-War and Contemporary artists by turnover in U.S. dollars and then taking the 100 artists with the highest turnover. We construct the index around a dependent variable of the natural logarithm of the auction sales price expressed in U.S. dollars. We define as the independent variables the surface size, medium, and presence of a signature, the artist's status as living or deceased, the name of the auction house, the location of the sale, and the auction date. Given the high degree of correlation across these variables, we avoid the problem of multicollinearity and related inflation of the number of standard errors of the regression coefficient by assigning each dummy variable a reference variable, which we then delete from the sample.

The variables are defined in more detail as follows:

Surface is defined as each painting's size, taken as width multiplied by height, then converted to the log of the surface area. We expect a positive size coefficient estimate.

Auction house includes separate dummy variables to isolate factors of reputation (e.g., Christie's and Sotheby's) and location (e.g., New York and London). These four dummy variables allow us to reflect the findings of de la Barre et al. (1994) that auction house

renown has a significant positive effect on price of an individual painting, as well as the result of Renneboog and Spaenjers (2013) that less familiar works by major artists are often sold by smaller auction houses. We thus expect significant positive coefficient estimates.

Medium is defined with oil on canvas as the reference variable, with six other painting mediums given separate dummy variables, defining each dummy D_{it} as having a value of one when one of the dummies has the appointed medium. We expect the highest prices for oil on canvas and thus anticipate negative coefficient estimates.

Signature is a binary marker of whether the work of art is signed with signed works given a dummy variable of one. Signed paintings are typically more expensive, given that the signature strengthens the certainty of attribution (Anderson 1974). We expect a positive coefficient estimate.

Living status is defined as a dummy variable of one to indicate that an artist is still living at the time of auction. Because the death of the artist inherently limits future production and creates scarcity, we anticipate that where artists were already successful during their lifetimes, their deaths will increase the prices of their works, as also found by Kräussl (2013) and Penasse et al. (2020).

Sales date is a dummy variable defined as the year of sale, between 1970 and 2016. A value of 1 indicates the painting is sold in period t using the respective art index.

We use these variables to perform an ordinary least squares (OLS) regression on the BASI auction price data, constructing the following hedonic regression model:

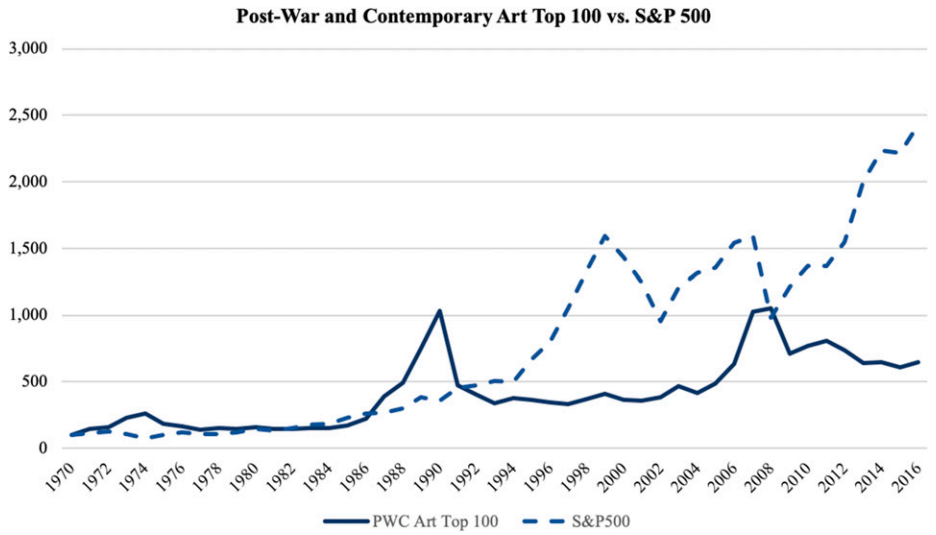
$$\ln P_{it} = \alpha + \sum_{j=1}^{z} \beta_j X_{ij} + \sum_{t=0}^{\tau} \gamma_t D_{it} + \varepsilon_{it} \qquad \varepsilon \sim N(0, \sigma^2),$$

where P_{it} represents the price of painting i at time t, α is the regression intercept, β_j is the coefficient for the quality characteristic X_j, and X_{ij} is the quality characteristic representing the value of the painting i. The antilog of γ_t is the coefficient that reflects the time dummy, and D_{it} is the dummy variable, where a value of one is assigned when the painting was sold in the time period t.

Figure 5 presents the resulting art price index and compares our *Top 100 Post-War and Contemporary Artists* index to the S&P 500 over the period 1970 to 2016. Ideally, we would be able to compare the hedonic art index to the full gallery fund trajectory from 1946 to the present. However, there is no Postwar and Contemporary category robustly represented in the data until 1970. Prior to 1970, only the London auction results by Christie's and Sotheby's are reported, and the artworks fall into other genres such as Old Masters works.

The comparison in Figure 5 of the hedonic art index and the S&P 500 index tracks various broadly agreed trendlines in art markets and equity markets. The art market outperforms the S&P 500 index in the late 1980s, reflecting the 1980s booming art market.

Figure 5. (Color online) Historical Performance of Post-War and Contemporary Art Index and S&P 500



Notes. This figure shows our hedonic index of the Top 100 Post-War and Contemporary Artists over the period 1970 to 2016, with 1970 as the base year with an index value of 100. We compare the art market performance with the U.S. equity market development, as exemplified by the S&P 500 index.

The S&P 500 index outperforms in the late 1990s, reflecting the tech boom in equity prices. Both markets fall shortly after 2008, with the art market decline lagging that of the stock market.

We note that our approach makes direct comparison difficult because the reinvestment in the S&P 500 index is important to the fact that fractional equity takes the vantage point of the artist as creator of value. Figure 5 shows the comparison of the art fund and the S&P 500 as of 2016, which allows the reader to see that the art fund reinvested in the S&P 500 is roughly double the equity value in that time frame. Logically, that gives us a PME of the art fund, even without considering the S&P 500 reinvestment, of greater than 1. Because so many art market studies have rates of return that are strongly determined by the chosen holding period (Baumol 1986, Ashenfelter and Graddy 2003), we find the more dynamic approach used here offers the important focus on aligning value creation and value capture while allowing more accurate reflection of holding period and reinvestment. The S&P 500 reinvestment is crucial to the artist's opportunity cost because the artist has foregone investible income in order to retain the equity but then receives the payment for the equity at many intervals.

3.4. Gallery Portfolio Performance

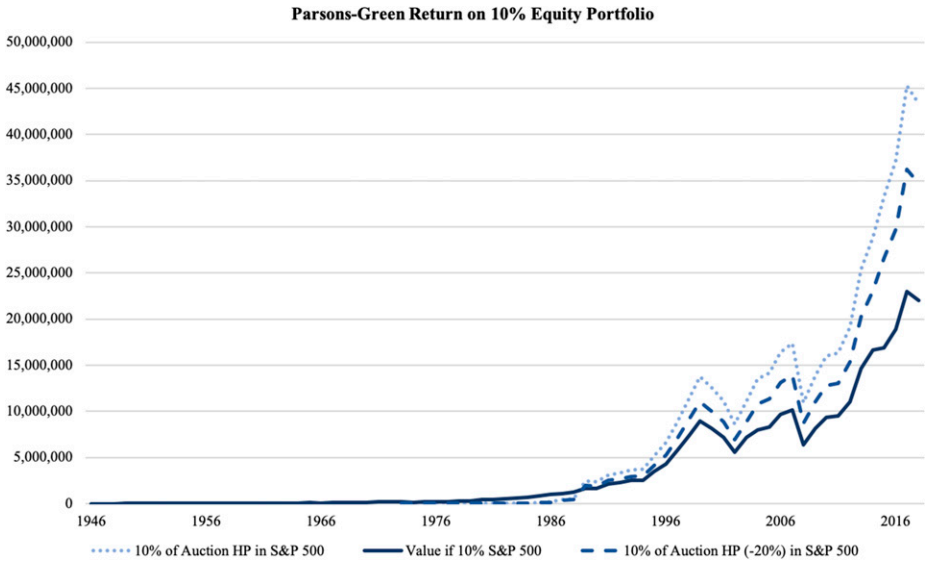
We find that the 10% equity investment in the artworks sold by the combined gallery art fund would have generated $43.32 million by 2018. The same original amounts invested directly in the S&P would have grown to $22.00 million (Figure 6). We find that even with 20% transaction costs, the retained equity portfolio, reinvested in the S&P 500, would still have grown to $34.66 million.

When we model the Parsons-Green Gallery works as if an open-end VC fund that bought as investments all of the artworks that were sold by the two galleries, we find that from 1946 to 2018, the fund grew to $448.81 million, relative to a comparable S&P 500 growth to $246.69 million. With 20% transaction costs as point of the auction sale, the overall fund grew to $359.05 million (Figure 7). Although this analysis duplicates the pattern of the combined-gallery retained-equity portfolio, it enables us to consider the overall balance sheet of the combined firm. The balance sheet starts at −$350, hits its low point at −$7.70 million in 1988, and then reverses in 1989 to +$6.78 million. The balance sheet grows to $202.12 million by 2018, below the value of the S&P 500 investment comparison of $246.69 million.

Even with a portfolio in which only 10.8% of works resold, the returns to an artist or any other early-stage risktaker notably outperform a substantial period of growth in U.S. equities. These returns are not predictive markers but still offer a clear indication of the opportunity cost of mispriced early-stage creative work. The artists and dealers in our study took risk and generated value, but the structure of the art market did not let them capture it.

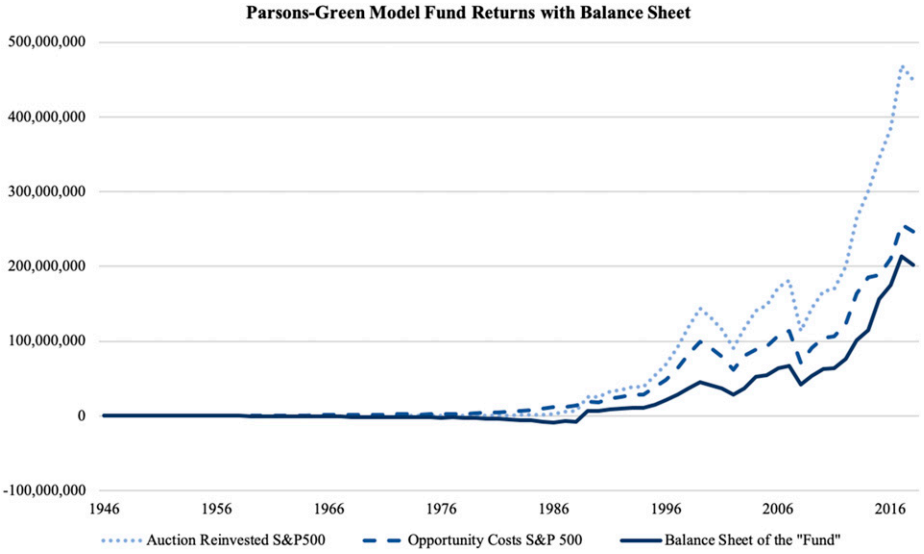
Although the primary purpose of our analysis has been to test our hypotheses regarding returns on fractional equity for art, we see that our own data allow an empirical comparison with other methods of

Figure 6. (Color online) Parsons-Green Returns of 10% Retained Equity Portfolio



Notes. This figure shows the total retained equity for all the sales of the Green Gallery and Betty Parsons Gallery as if the retained equity shares together were the holdings of an investment fund. The cost to invest is the acquisition of the 10% equity. The return on the investment is 10% of the hammer price (HP) at auction. The fund returns the hammer price on the 108 works that sold at auction and has the acquisition cost of retaining equity all 1,002 of the works in the sample. We then compare that retained equity portfolio to the acquisition cost as invested in the S&P 500 index at the time of each sale. We offer the return on the art portfolio both with and without a 20% transaction cost on the auction sale.

Figure 7. (Color online) Parsons-Green Model Fund Returns with Balance Sheet



Notes. This figure presents the combined fund of all of the artworks sold by Green Gallery and Betty Parsons Gallery. We consider the auction results as the realization event for all of the artworks. We show the overall balance sheet of the combined firm. We replicate this approach assuming 20% auction transaction costs as well.

art market return. We find that, in addition to indicating strong returns on fractional equity, our introduction of primary sales data allows us to compare the repeat sales within our data set to the corresponding returns from primary sales.

To measure the difference in returns from repeat sales and from primary sale to first or second auction, we isolate all of the repeat sales from Jasper Johns and Robert Rauschenberg and from the Betty Parsons Gallery and Green Gallery data. Across approximately 1,133 records (131 across Johns and Rauschenberg and 1,002 across Green and Parsons), we are able to isolate 19 artworks with repeat sales, representing 10 different artists. For these 19 works, we find three different rates of return: (1) from primary sale to first auction, that is, the rate used in our study of individual artists; (2) from first auction to second auction, that is, the repeat sale; and (3) from primary sale to second auction, for completeness of information. Figure 8 shows these three different returns by individual artwork.

We observe that these rates of return vary dramatically. For example, the Robert Rauschenberg artwork *Forge* (1959) was sold though Leo Castelli in 1959 for $1,000. This artwork was then sold at auction for $60,563 in June 1973 and in May 2007 for $6.2 million. The returns vary substantially (1) from initial sale to first auction (34.06%), (2) between the repeat sales (14.63%), and (3) from initial sale to second auction (19.99%).

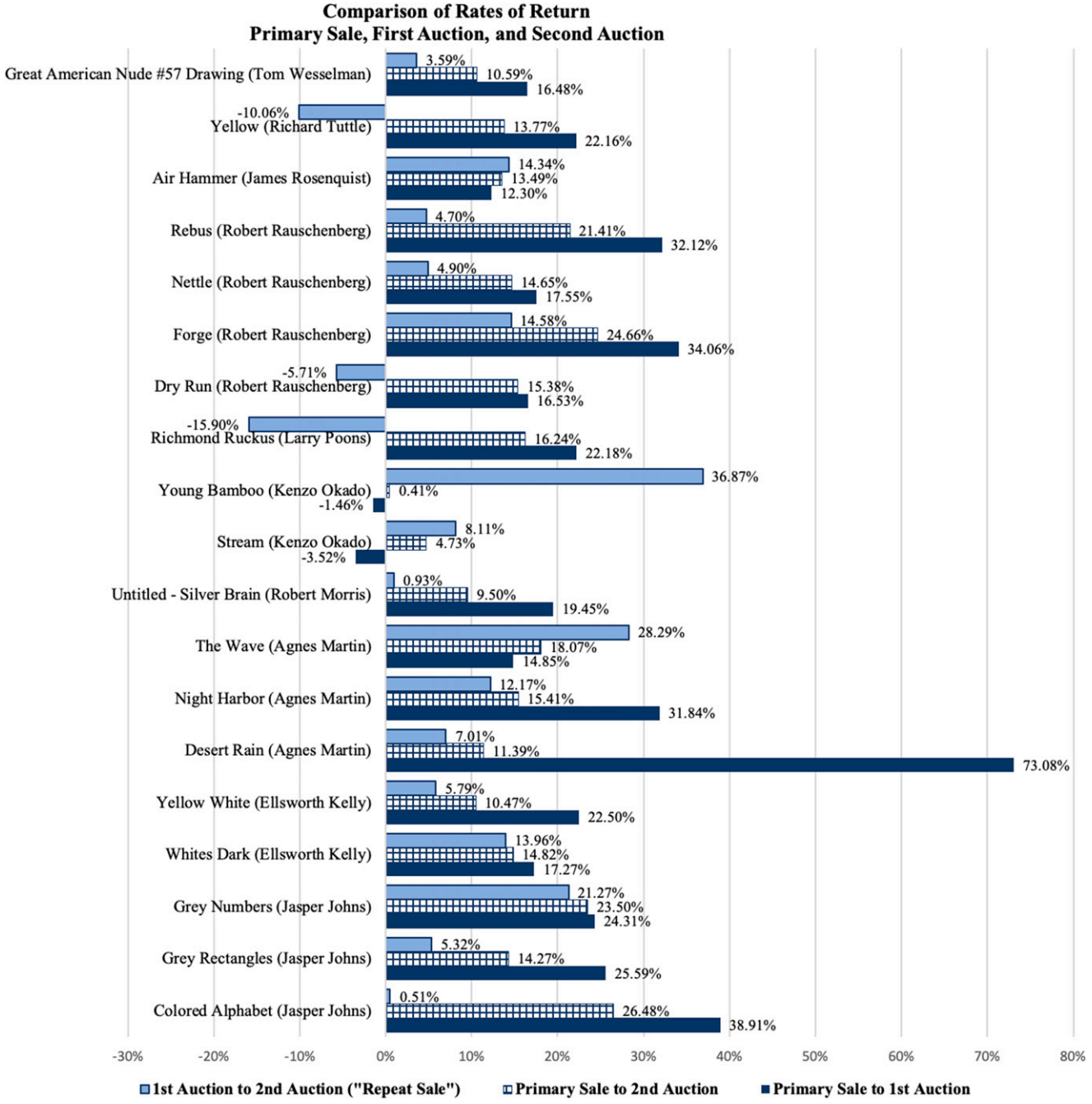
However, many other comparisons in our sample are much more dramatic. For the Agnes Martin (1912–2004) work *Desert Rain*, the repeat sales return is 7%, but the artwork has already increased in value by 73% from primary sale to first auction. For all 19 repeat sales when considered together, the mean of primary market price to first auction is +22.96%, whereas the mean of repeat sales is +7.93%. This difference is striking.

We also note that in our sample, only 1.7% of all artworks experienced a repeat sale. That small percentage going to repeat sale and the substantial variation across returns demonstrate the empirical importance of introducing primary market data into art market analysis as much as is feasible. Although repeat sales analysis has been foundational essentially to all art market analysis, this small experiment within our data set produces a clear initial signal that repeat sales do not generalize across the life of an artwork and that they represent, in this case, only a small fraction of works that were sold by artists through galleries. We acknowledge the significant limitation of data set size in our analysis relative to repeat sales. Although the repeat sales method has advantages in large data sets, the discrepancy in returns from first transaction to first auction and from first to second (repeat) sale also underscores the larger hypothesis in this paper: Creative work demands a different vantage point on early-stage value.

4. Managerial Implications

Although both Jasper Johns and Robert Rauschenberg became among the most successful artists of their time, the works in our sample were sold very early on, as the larger value of their artistic output was only just becoming known. Similarly, Betty Parsons and Richard Bellamy, the founder of the Green Gallery,

Figure 8. (Color online) Comparison of Repeat Sale to Primary Sale Rates of Return



Note. This figure compares for our 19 repeat sales three rates of return: (1) from primary sale to first auction, (2) from first to second auction, that is, the repeat sale, and (3) from primary sale to second auction.

were risk-taking—some would say, visionary—art dealers. Parsons herself was a practicing artist and the early dealer of Jackson Pollock and Mark Rothko. Although art market analyses generally consider past sales, the assignment of equity is future oriented. It is a structural correction of a misalignment of price and value in cases where value is only known over time. We do not argue that artists are incentivized by equity so much as that the assignment of equity more accurately aligns price and value. Our analysis shows that, as in many other fields, the outsize returns go to entrepreneurs and their earliest investors. As Betty Parsons once told an interviewer, "A new work by a new artist is not history, it's the present" (de Coppet and Jones 1984, p. 26). The same could be said of any successful startup.

Particularly in the case of Johns and Rauschenberg, it would be easy to dismiss these artists as cherry-picked examples, owing to the artists' subsequent fame and success. Yet the largest returns on their

work are accounted for by the earliest investments made. The artists were their own first investors, having made artworks years before the works were sold. In addition, all the dealers in this study—Betty Parsons and Richard Bellamy of Green Gallery and Leo Castelli—were early investors in the financial and more general risk-taking senses. Bellamy paid advances and sometimes covered artists' bills.[12] Leo Castelli paid his artists monthly retainers. In the archival correspondence, numerous collectors seemed to buy work as much as a form of patronage as investment, and the art investor Robert Scull, whose had the advantageous sale of a Rauschenberg work for $85,000 in 1973, actually was the personal financial backer of the Green Gallery itself. If not for these acts of early-stage investment by artists, dealers, and collectors, many of these artworks might never have come into being. We see no reason why artists and their early collaborators should not have access to equity structures so common in other venture industries yet specific to the singular and collectible nature of artworks.

Importantly, these equity shares are different from resale royalties that typically follow from a legal framework of moral rights rather than economic incentives to copyright and are thus not legally transferrable in numerous jurisdictions, including the European Union (EU) [13] Fractional equity functions as a property right under the Coase Theorem, meaning that, unlike a bonus payment, it can be traded in a marketplace in which the market itself can set the price provided the cost of transacting is not onerously high (Coase 1960; Stigler 1989; Whitaker 2014, 2018). For art and other early creative work, this equity share structurally aligns price and value more dynamically and accurately by allowing creators of value to participate in the upside. Such a system would require a secondary marketplace in which fractional equity shares in art, other collectibles, and other creative projects to be traded. As such, blockchain technology has structural attributes that would support such a system, including tokenization, clarity around provenance and registration of shares and title, and avenues for design of complex yet transparent contracts, whether self-executing smart contracts or otherwise.[14]

Although an artist holding fractional equity would still be highly concentrated in that artist's own work, a system of fractional equity issued out of artists' studios, in collaboration with dealers and other backers and in tandem with a blockchain-based secondary market, gives the artist a strong advantage. The artist's current best option is generally to hold back physical artworks from different phases of the artist's career and then pay to store them. With retained equity, artists could avoid these storage costs and also more fully diversify across all of their own works and not only a few representative artworks from each phase.

In addition, artists could further diversify by collectively creating pooled investment funds with other artists. Artists in the fund might, for example, hold 80% exposure to their own fractional equity shares and a 20% exposure to the overall body of artworks by a larger group of artists. Via such a structure, both artists and collectors have new avenues for diversification by purchasing portfolios of fractional shares. In addition, fractional equity systems make it theoretically possible for a larger number of investor-collectors to participate in art markets. Perhaps in time, that broader participation could also support greater diversity and inclusion in art markets and democratization of access to investing in art. More broadly, the retained-equity approach shifts pay for creative work from consumption to investment and creates a secondary market for diversifiable investment in creative work via purchase of shares.

Although retaining equity may not benefit all artists or other creative workers financially at a given point in time, owning the shares creates vital optionality on the occasions in which early stage work does lead to significant, or even modest, market gains. Furthermore, it remains the decision of artists to forego cash to retain equity, thus allowing the artist the degree of choice in how to invest. It is always possible the retained equity will be worth little. However, the structural possibility of fractional shares of artworks solves for the two pernicious problems of liquidity (Ang et al. 2014) and severability in art investment, given the original nature of some artworks and the infrequent interval and transaction cost of much art trade.

The retained equity approach structurally allows artists and other early risk takers to use the economic nature of property rights to own shares that include them in potential upside and, at the least, solve for the difficulty of pricing artworks in the primary market when the artist's continued work after sale can strongly affect the future resale price.[15] Workers invest resources early on, pay a price before value could possibly be known; fractional shares and not U.S. dollar amounts can most accurately represent that risk. A next phase of the overall labor economy may see a shift from wage to a hybrid salary/retained equity pay. Rather than considering redistribution through tax and a universal basic income, we might see fractional equity models of shared ownership. As such, the art world provides a test case in an industry with more discretely definable creative contribution and, in a field whose entire global size is less than Apple's 2019 quarterly revenues, thus some safer exploratory distance from larger levers of the economy.

This potential for restructuring compensation and reward around creative work aligns with the broadening adoption of blockchain technology. In addition to its applications to tracking the authenticity and

provenance of artworks (Whitaker 2019), the blockchain has broad structural advantages for the management of fractional shares and theoretically low-transaction-cost trading. The distributed ledger (Nakamoto 2008) and time stamp on transactions (Haber and Stornetta 1991) will likely lead to new methods of value creation and capture (Cohen 2017) and decentralized clearing of transactions in financial networks (Csóka and Herings 2018), in this particular case the clearing of trade in fractional shares.

Although fractional ownership using blockchain has received some attention in the arts (with companies such as Maecenas and Masterworks), these ventures purchase whole artworks on the secondary market and then selling off shares. In contrast, retained fractional equity shifts art from a collectibles market in which one can own all or part of an artwork, to a creativity economy, in which the original designation of shares corresponds to the risks taken. Using blockchain techniques, fractional equity can be assigned at the point of origination, that is, the artist's studio, both aiding authentication and reorienting market structures from point-to-point price increases at intervals to the more flexible representation of the value of art and other creative work over time.

Such a system also has the potential to reorient art markets from trade in collectable objects to recognition of artists and their studios as the creators of that value. Artists may gain market power if their studios, and not intermediaries, become the origination points for blockchain-enabled listing of works. At the least, this form of art market analysis using primary sales data better includes artists while also indicating empirically the limitations of repeat sales to generalize. By using data from earlier in the life cycle of the artwork, this method brings art market analysis closer, in a valuation sense, to the operating companies (i.e., artists' studios) of the art market. As more data becomes available, from heirs or from galleries themselves, the field will be able to tell increasingly robust stories about the history of the value of art and also to build more robust tools for valuing art as accurately and flexibly as possible over time.

5. Conclusions

We undertook the analysis of whether fractional equity would outperform the art market because we observed the structural misalignment of price and value for early-stage creative work. We did not know at the outset that we would see such outsize performance. To outperform the market by a factor of 5 is handy; to do so by a factor of more than 1,000 is suspicious. We acknowledge that we were working with the earliest work of two of the most well-known American artists of the 20th and 21st centuries. Even drawing in the Betty Parsons Gallery and Green Gallery files, we are by definition limited to the records already deemed worth keeping. Fortunately, those files have been kept somewhat intact. However, more systematic, long-term collection of data from artists, as well as gallerists, would provide fertile testing ground for these innovative financial structures that may generalize well outside the arts.

Particularly in fields such as cryptocurrency, in which initial coin offerings (ICOs) have become important capital-raising tools (Howell et al. 2020), we note that ICOs bear uncanny structural similarity to markets for art. As those systems develop and as the business models of freelancer work continue to evolve, fractional equity has substantial application to jobs with intensive research and development (R&D) undertaken at long-term risk or shifting of risk to individual workers such as rideshare drivers through the use of individuals' own vehicles and other resources. Although some of these issues can be addressed with regular employee ownership or stock options, long-term creative work, as encapsulated by art, particularly benefits from fractional equity and the secondary trading that creates better pricing in an illiquid market and continues to create returns and option value for those actors with the largest added value in the sheer existence of the work.

Although systems of bonus, equity, and royalty exist in finance, startups, and publishing, the approach of retained equity bears a more purist long-term focus on value creation and provides useful additional structures for compensating R&D and innovation (Howell 2017), including fractional equity held by grant-making institutions and even government agencies that support basic science. Fractional equity, as managed by a distributed ledger, allows for this structural realignment of price and value across many areas of early-stage research, across public and private sectors, and across national jurisdictions.

We did not intend this work, by any means, to extend to the prediction of the success of artists. Despite pattern recognition of past artistic success (Fraiberger et al, 2018), the largest gains tend to transcend templates of the past. Our work, however, does seriously demonstrate what is possible. Given that large possibility, this structural intervention in markets of assigning retained equity for creative work deserves serious consideration, with larger data sets, more complex tax assumptions, and inclusion of costs of production.

We conclude by returning to the starting point of the data in this study, which was a handwritten notebook. In cursive handwriting in a small personal notebook, Leo Castelli recorded $300 sales that would go on to become multimillion-dollar auction results. Before that, in poorly heated studios, the artists developed the work itself. The moment of value creation

is, in its idiosyncrasy, markedly different from the moment of value capture as the artwork is later resold. The fractional equity model bridges the idiosyncratic starting point and possible stratospheric returns while offering tools for diversified investment and democratized access to markets for art.

The sheer act of assigning equity is a structural alignment of price and value that generalizes beyond fine art to represent ways of making the risks of any R&D conform to the market's ability to assign value. Ultimately, our model solves for the central difficulty of pricing—that is, accurately reflecting the value of—early-stage creative work. Value can be more flexibly, and in the long run more accurately, assigned as a fraction than a U.S. dollar amount. Thus, these now famous artworks have something crucial to tell us about labor and about the central tension between market efficiency and market reliance on innovation. These artists underscore the necessity of seeing early-stage creative work as an act of investment. The blockchain enables a future of work in which anyone can have fractional ownership of the upside they help to create.

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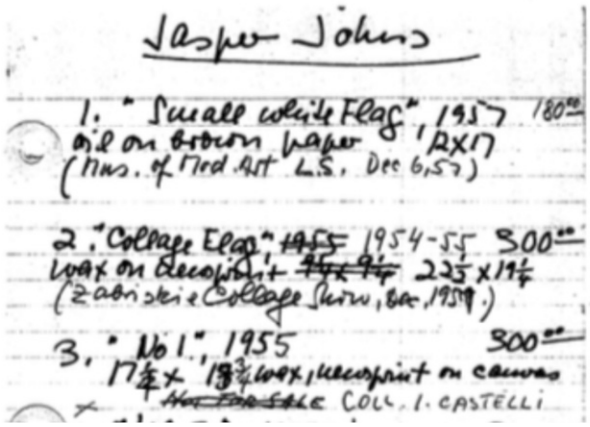
Appendix. Samples of Data Sources

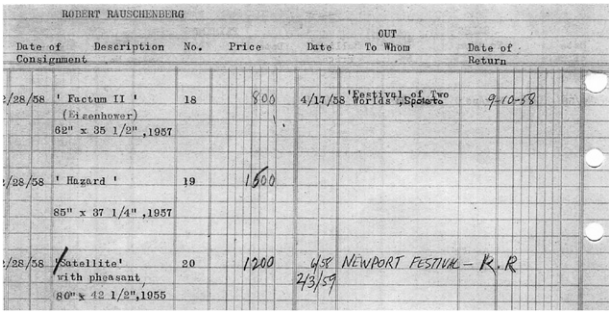
A.1. Leo Castelli Notebook, 1957–1959 (excerpt)

Sample pages from a personal notebook of Castelli, containing handwritten records of early Jasper Johns sales. Leo Castelli Papers, Archives of American Art, Washington, DC.



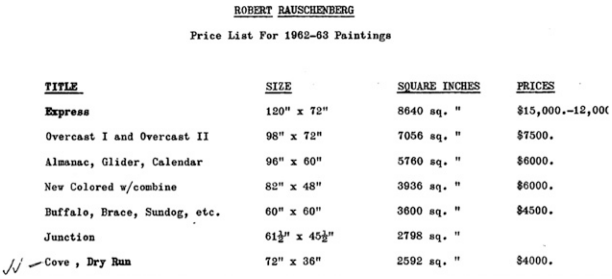
A.2. Registry for the Artist Robert Rauschenberg

The Castelli Gallery's internal ledger for loans and sales of Rauschenberg's work. Leo Castelli Papers, Archives of American Art, Washington, DC.



A.3. 1962–1963 Price List for the Artist Robert Rauschenberg

A Castelli Gallery price list for works by Rauschenberg, including handwritten annotation of a discount. Leo Castelli Papers, Archives of American Art, Washington, DC.

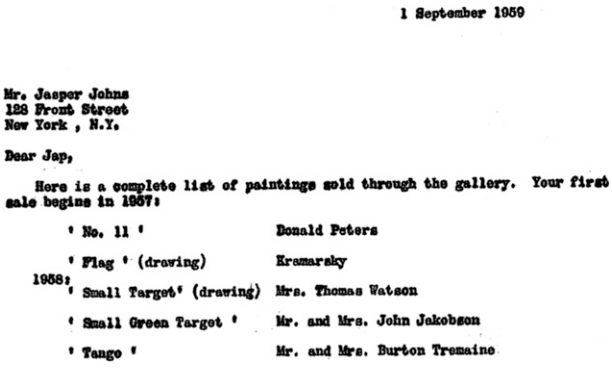

ROBERT RAUSCHENBERG

Price List For 1962-63 Paintings

TITLE	SIZE	SQUARE INCHES	PRICES
Express	120" x 72"	8640 sq. "	$15,000.-12,000
Overcast I and Overcast II	98" x 72"	7056 sq. "	$7500.
Almanac, Glider, Calendar	96" x 60"	5760 sq. "	$6000.
New Colored w/combine	82" x 48"	3936 sq. "	$6000.
Buffalo, Brace, Sundog, etc.	60" x 60"	3600 sq. "	$4500.
Junction	61½" x 45½"	2798 sq. "	
Cove, Dry Run	72" x 36"	2592 sq. "	$4000.

A.4. Letter from the Castelli Gallery to Jasper Johns with List of Sales

A full list of Jasper Johns works sold by the gallery from 1957 to 1959, with collector name. Leo Castelli Papers, Archives of American Art, Washington, DC.


1 September 1959

Mr. Jasper Johns
128 Front Street
New York, N.Y.

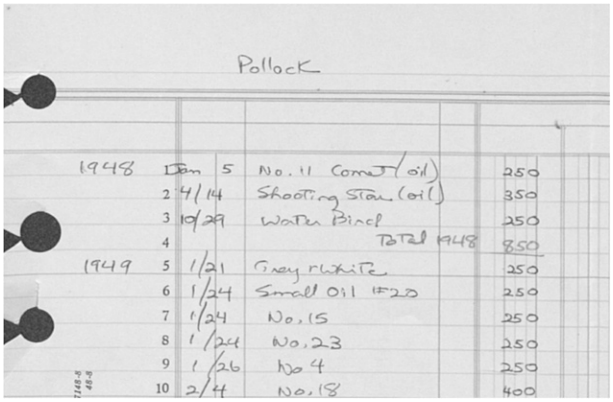
Dear Jap,

Here is a complete list of paintings sold through the gallery. Your first sale begins in 1957:

	'No. 11'	Donald Peters
	'Flag' (drawing)	Kramarsky
1958:	'Small Target' (drawing)	Mrs. Thomas Watson
	'Small Green Target'	Mr. and Mrs. John Jakobson
	'Tango'	Mr. and Mrs. Burton Tremaine

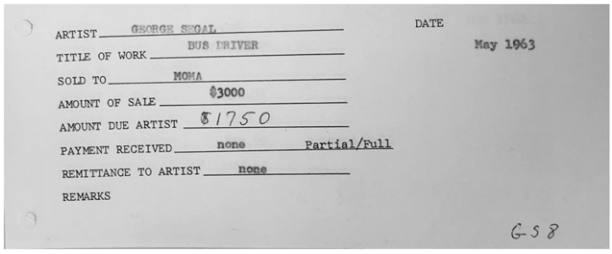
A.5. Betty Parsons Sales Summaries: Pollock, Reinhardt, and Rothko, 1946–1955

Betty Parsons Papers, Archives of American Art, Washington, DC.



A.6. Sample Invoice, Green Gallery

Richard Bellamy Papers, Archives of the Museum of Modern Art, New York, NY.



Endnotes

[1] The choice of Jasper Johns and Robert Rauschenberg specifically derives from data availability. The Castelli Gallery sales invoices are closely held by the family and are not yet included in the archives. Both artists were included in a group show in 1957 and had their first solo shows at the gallery in 1958.

[2] Catalogues raisonnés (Bernstein et al. 2016) are the definitive and complete listing of an artist's body of work. They serve a purpose in art markets somewhat analogous to an equity being listed on an exchange or a debt being rated; inclusion in the catalog attests to the work's authenticity. Trading an unlisted work is much more complicated and risky.

[3] We note that our analysis ignores both carrying costs of owning art, that is, insurance, climate control, and storage, as well as any *aesthetic dividends* or other personal enjoyment of living with art. However, our fund-model analysis includes conservative estimates of transaction costs.

[4] The work was sold by collectors Robert and Ethel Scull, whose fortune came from taxi cabs and whose art was sold because of divorce. Robert Rauschenberg famously appeared at the auction and told Mr. Scull, in colorful language with a playful shove, that the artist's work had led to Scull's gain (Petty 2014).

[5] We note that in practice in art markets, prices are typically fungible at 10%, the rate paid to art advisors and commonly absorbed by galleries. Additionally, in the empirical study of Banternghansa and Graddy (2011) on the introduction of resale royalties in England, they in fact found no discernable effect.

[6] The Betty Parsons papers are held in the Archives of American Art, Smithsonian Institution, in Washington, DC. The Richard Bellamy Papers are held in the Archives of the Museum of Modern Art in New York. For the Parsons files, we use the chronological files of invoices. For the Bellamy papers, we use the general sales invoice files of the Green Gallery, which are organized by artist.

[7] In books summarizing the New York art world of the 1950s and 1960s (Perl 2007), the core galleries dealing contemporary art at the time were Marlboro, Leo Castelli, Green, Betty Parsons, Sidney Janis, and Knoedler.

[8] We use sales invoices and an internal gallery accounting file of the works sold by Betty Parsons for the artists Jackson Pollock (1912–1956), Mark Rothko (1903–1970), and Ad Reinhardt (1913–1967) over the period from 1946 to 1955. We note the difficulty of matching titles from invoices to auction results given the naming conventions of some artists, for example, No. 1, 1950 but also No. 1, 1951, and innumerable artworks called Untitled (see the appendix for sample invoices from both galleries).

[9] According to a 1970 census of artists in the United States, at that time, 56% of painters and sculptors were male and 44% of them were women. The total labor force was 85% white, whereas the artist labor force was 91% white. Of artists, 3.6% were black, 3.8% were *Spanish* (sic; Hispanic or Latinx not recorded at the time), and 1.8% were classified as *Other*. The census defined *established* artists as those who worked 40 hours per week and who listed artist as their occupation in both 1965 and 1970. The study found that 33% of nonminority artists, 23% of minority artists, 38% of men, and 19% of women artists met this threshold of established (National Endowment for the Arts 1978).

[10] We exclude from our analysis Kawabata, whose work went to auction twice but was bought in both times.

[11] The unusually low returns at the lower end are based on artists with only one resale, at a loss.

[12] The Green Gallery received invoices from the lightbulb manufacturer with stern cover letters threatening to stop supplying light bulbs to Dan Flavin if the then still emergent artist or his gallery failed to pay (Richard Bellamy Papers, Museum of Modern Art, Series II.D.).

[13] Resale royalties are also capped at €12,500 in the EU and structured without a cost basis, thus functioning as a surcharge more than an equity instrument.

[14] Although numerous contractual complications arise, including requirements of appraisal and insurance of the physical artworks, Hansmann and Kraakman (2002) show that fractional equity can function as a property right that is divisible and that can remain intact through a chain of subsequent transactions. Those contracts would also need to clarify that minority owners were cashed out prior to museum donation to avoid a problem of asset truncation either to zero or to the tax rate in jurisdictions with a credit for donation.

[15] As argued earlier, the artist's death (Kräussl 2013, Penasse et al. 2020) can also affect the future price. In that case, the artist's estate or heirs would benefit from this realignment of price and value.

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