When a master dies

Penasse, J.N.G.; Renneboog, Luc; Scheinkman, Jose

Published in:
Review of Financial Studies

DOI:
10.1093/rfs/hhab006

Publication date:
2021

Document Version
Publisher's PDF, also known as Version of record

The Review of Financial Studies

When a Master Dies: Speculation and Asset Float

Julien Pénasse
University of Luxembourg

Luc Renneboog
Tilburg University

José A. Scheinkman
Columbia University, Princeton University, and NBER

An artist's death constitutes a negative shock to his future production; death permanently decreases the artist's float. We use this shock to test predictions of speculative trading models with short-selling constraints. As predicted in our model, we find that an artist's premature death leads to a permanent increase in prices and turnover; this effect being larger for more famous artists. We document that premature death increases prices (by 54.7%) and secondary market volume (by 63.2%). (*JEL* G12, P34, Z11, D44)

Received February 28, 2020; editorial decision September 21, 2020 by Editor Stijn Van Nieuwerburgh. Authors have furnished an Internet Appendix, which is available on the Oxford University Press Web site next to the link to the final published paper online.

Pour moi les tableaux de grand prix
Sont ceux que plus cher on m'achète.

Après tout, que m'importe le talent?[1]

We thank Stijn Van Nieuwerburgh (the editor), two anonymous referees, Marcelo Fernandes, Slava Fos, Ed Glaeser, Florian Heider, and Harrison Hong and seminar participants at EHESS (Paris), the inaugural lecture of the Charles and Lynn Zhang Professorship at Columbia University, the Arrow Lecture at the Hebrew University of Jerusalem, SBFIN (Brazil), Tokyo University, University of Luxembourg, the European Winter Finance Conference, the Yale-RFS Real and Private-Value Assets Conference, and the Northeastern Finance Conference for comments. We thank Jialin Yu for providing the original data of Xiong and Yu (2011) and John Silberman for an insightful conversation on artists' estates. We also thank Raghav Bansal, Zoey Chopra, Kristine Fu, Emilio Garcia, Yuexin Li, and Haaris Mateen for excellent research assistance. Supplementary data can be found on *The Review of Financial Studies* web site. Send correspondence to Julien Pénasse, julien.penasse@uni.lu.

[1] "For me, highly priced paintings are those that I can sell ever more expensively. After all, why should I care about talent?" This is a translation of the words spoken by Forbeck, the art dealer in the play *Rembrandt ou la Vente après décès* by Charles-Guillaume Etienne, 1777–1845 (see Spieth 2017).

The Review of Financial Studies 34 (2021) 3840–3879

doi:10.1093/rfs/hhab006 Advance Access publication January 30, 2021

Around 1660, an Italian art dealer brought bad news to Rembrandt: his style of painting was no longer in vogue and sold at lower prices. Rembrandt did not yield to the art dealer's suggestion to start painting in the idealizing style of the classic painters, but thought up a cunning plan. He disappeared and had the rumor spread that he had died (De Wilt, 2006). As a consequence, works by a "dead" Rembrandt were sold for up to three times the normal price.[2] This anecdote illustrates that the unexpected death of an artist leads to higher prices, a natural consequence of the lower future supply relative to expectations. Intuition might suggest that the lower supply would also lead to a smaller volume of trade in the future but theories of speculation based on fluctuating differences in beliefs and short-selling restrictions (Harrison and Kreps 1978; Scheinkman and Xiong 2003) suggest that the lower outstanding supply may actually lead to an increase in both prices and secondary market turnover (Hong et al. 2006). A smaller float means that the marginal future buyer is likely to have a more optimistic view, which makes the option to sell more valuable for the current owner. When the marginal future buyer is more optimistic, the current owner's valuation is less likely to stay among the highest in the future. The scenario leads to higher average turnover in the future.[3] In this paper, we use a database of auction-sales of modern and contemporary art to evaluate the impact of an unexpected death of an artist. Since we do not observe the counterfactual evolution of an artists' *oeuvre* had she not died, we match an artist who died prematurely with an artist who lived for at least 10 years after the death of the treated artist and who is otherwise similar or close in birth-year, and number of auctioned paintings, price level, and reputation over a 10-year look-back period prior to the death of the treated artist. We define death as premature if it takes place at an age of 65 or younger (we perform sensitivity analyses on this age cutoff). Many artists keep producing as they age. We estimate that in our sample premature death cut an artist's lifetime output by about half (compared to the production of artists who did not die prematurely). Our database of treated artists counts 246 cases of premature and sudden deaths out of 2,236 artists who were alive at the beginning of our sample period. We identify 57,997 auction transactions for the combined subsamples of treated and matched artists. Following Penasse and Renneboog (2017), we use the number of transactions observed each year (trading volume) to proxy for secondary-market turnover. Our empirical results lead to four conclusions. First, premature death increases

[2] Several versions of this anecdote circulate. The aforementioned play has been performed in France since 1800. According to the play, Rembrandt and his first wife Saskia van Uylenburgh conspired: Rembrandt left Amsterdam for a while, Saskia spread the rumor that her husband had died and dressed in traditional mourning clothing. As a consequence, the demand for Rembrandt's paintings and etchings surged and the "widow" sold many, while remarking that there would be no new supply of Rembrandts (De Wilt, 2006). After a while, Rembrandt reappeared. In a different context, a similar anecdote was told: As a consequence of his bankruptcy, all his work was auctioned to pay off creditors. Prior to the auction, Rembrandt faked his death to increase the proceeds from the sales.

[3] Mei et al. (2009) and Xiong and Yu (2011) document the negative cross-sectional correlation between turnover and float during two speculative episodes in Chinese markets.

prices by 54.7% and sales by 63.2%. Second, death has a permanent impact for 10 years and beyond on prices and volume in our diff-in-diff setup, which we confirm using event study designs and a repeat-sales analysis. Since an artist's unexpected death necessarily diminishes supply, the increase in trading volume we document implies an even larger increase in turnover relative to the counterfactual. We use our estimates for a back-of-the-envelope calculation of the elasticity of price with respect to turnover. We find an elasticity of .46, which is quantitatively comparable to prior estimates obtained by Cochrane (2003) for Nasdaq stocks during the internet bubble or the elasticity of the price of warrants with respect to float for the data in Xiong and Yu (2011). Third, the death effect is more pronounced when the artist dies at a younger age, when she presumably leaves a larger unproduced body of work. Fourth, for death to affect prices and sales, the artist needs to have gained a reputation, without which there is no effect. All these findings are confirmed by robustness tests on the definition of premature death and of an artist's notoriety, and with different samples (matched artists' sample, all artists' in the global database, sudden deaths). A placebo test reassuringly shows that the death effect in a pseudo-data-set is insignificant.
While popular wisdom claims that a dead artist is worth more than one alive, the impact of death on art transactions and prices has not been studied often.[4] In the traditional hedonic regressions that aim at constructing art indexes, some papers include a dummy variable indicating that an artist is dead at the time of the transaction (see, e.g., Ekelund et al. 2000; Matheson and Baade 2004; Maddison and Pedersen 2008; Ursprung and Wiermann 2011; Renneboog and Spaenjers 2013). These studies all conclude that death is accompanied by higher average prices. [5] While not controlling for age at death, Korteweg et al. (2016) document that paintings do not sell more frequently subsequent to an artist's demise, "despite popular belief that the passing away of an artist temporarily raises visibility of his or her artwork." The authors speculate that this is because "most artists' deaths do not come as a surprise to the market." The price increase following unexpected death is compatible with any theory in which supply affects prices, and a *temporary* increase in trading-activity in the secondary market could be a consequence of the price increase, since the current holders of the artworks of the deceased artist may decide to consume some of the capital gains or simply to rebalance their portfolios. If auctions of individual works are subject to fixed costs, an increase in price could affect observed sales volume. However, our results on volume stand even after we add a control for the yearly

[4] Glaeser et al. (2008) model and document the impact of supply elasticity in speculative episodes in housing markets.

[5] Our approach differs from those of other studies in its focus on premature deaths. In addition, our research design relies on the setup of a matched control group. A control group effectively pins down the counterfactual price and volume trajectories in the absence of premature death. In the absence of a matched sample, the control group consists of all nontreated artists. These artists likely exhibit different price and volume trajectories as they age, and differences would contaminate the estimate of the death effect. Our research design minimizes this risk by constructing a matched sample.

average sale price of an artist's works. The observed *permanent* increase in volume is more difficult to explain by alternative theories and gives support to the hypothesis that theories of speculation based on fluctuating differences in beliefs and short-selling restrictions apply to the art market.

1. Model

In this section, we exposit a model of speculation that motivates the regressions in this paper. The model combines differences in beliefs and short-sale constraints with limited capacity for bearing risk. Hong et al. (2006) were the first to combine these elements by assuming risk-averse agents. Their goal was to model the effect of lockup expirations on the implosion of the internet bubble. In their model, pre-lock-up holders of the stock are overoptimistic about insiders' valuation of future dividends. When lockup expires, insiders sell more shares than these shareholders predicted. Risk aversion implies that this unexpected larger float could implode the bubble. Hong et al. (2006) also showed, in a model with a single trading period, that an increase in float would decrease turnover. Scheinkman (2014) wrote a simpler three-period model in which agents have limited capital that may result in cash-in-the-market pricing (Allen and Gale, 1998). Agents face uncertainty with respect to future supply and dividends. For simplicity, agents agree on the distribution of future supply but disagree on the distribution of future dividends. Short-sale constraints ensure that if the initial supply is small enough to be held by the most optimistic agents, prices are high even if there is a risk of future supply increase. Later, if the supply realization is large enough, optimists' limited capital implies that, in equilibrium, the marginal buyer is a pessimist and prices and turnover decrease. The main difference between our model and the previous literature is motivated by our desire to examine the impact of the premature death of an artist on prices and turnover. The asset suppliers in our model—the artists—add a random amount to the existing supply until a random date when they die. To model the random death rate, it is natural to consider an infinite horizon model.[6] A minor difference is that because no dividends are associated with the artwork, art buyers derive utility from holding the artwork.

There are an infinite number of time periods $t=1,2,\ldots$, and two goods: art and a numeraire nonart good. There are two sources of aggregate uncertainty, random increases in supply and the death of an artist, and one source of idiosyncratic shocks to individual demand. More precisely we consider three independent processes in a probability space. The first process, d, models the death of an artist. $d_t \in \{0,1\}$, with $d_t=0$ if and only if the artist is alive at t. We assume $d_1=0$ and if $d_t=0$ then the probability that $d_{t+1}=1$ equals π, and if $d_t=1$ then $d_{t+1}=1$. Thus, if an artist is alive in period t, the probability that she

[6] Although Hong et al. (2006) consider an infinite horizon model, all the action in the model occurs before period 2, when all supply uncertainty disappears.

dies before period $t+1$ is a constant $\pi > 0$. An artist produces as long as she is alive, increasing supply. The second stochastic process N defines the supply of an artist's work, measured as the supply per potential buyer. We assume

Assumption 1.

[a] $N_1 > 0$ and for $t \geq 2$,

$$N_t = N_{t-1} + \alpha_t$$

where α_t is a positive random variable independent of the past realizations of N_s, $s \leq t-1$.

[b] $E[\alpha_t]$ is strictly decreasing in t and there exist positive constants k_0, k_1, $b_0 < b_1 < 1$ such that

$$k_0 b_0^t \leq \alpha_t \leq k_1 b_1^t \tag{1}$$

Assumption 1 guarantees that, on average, artists' new output decreases with age. This is not unreasonable, since in our empirical work artists are "born" when their work is sold in auctions, at age 23 or above. The inequalities in (1) will be used to establish lower and upper bounds to accumulated output as an artist ages. Since the process N_t is Markovian, from now on we will write E_t for $E[\cdot|N_t] = E[\cdot|\{N_s\}_{1 \leq s \leq t}]$, the expected value of a random variable conditional on the realization of the histories of supply up to time t.

One particular case that is sufficient for understanding the intuition of our results is when α_t is deterministic. In this case, the only uncertainty concerning supply that is left in the model concerns the date of death of an artist.

We assume that all agents have time-separable utility functions and a common discount rate $\frac{1}{1+r}$ per period. Each art buyer receives in each period an endowment of e units of the numeraire (nonart) good and access to a "risk-free" technology on the nonart good with a gross rate of return per period of $1+r$. There are two equally sized groups of art buyers denoted by $i \in 1, 2$. Art buyers cannot short art, and if an art buyer in group $i = 1, 2$ holds $x \geq 0$ units of art and consumes c units of other goods between periods t and $t+1$, he has period t utility flow:

$$u^i(x, c, \theta_t^i) = \theta_t^i x - \frac{1}{2}\gamma x^2 + c \tag{2}$$

The utility function is quasi-linear and quadratic on the art good.[7] The coefficient θ_t^i at time t reflects a public signal that each group of buyers interprets differently. More precisely, we use a third independent process, θ, that has values in $\{\theta^\ell, \theta^h\}$ with $0 < \theta^\ell < \theta^h$. We assume that $\{\theta_t\}_{t \geq 1}$ are i.i.d. random variables and the probability that $\theta_t = \theta^\ell = 1/2$.[8] Before trading at t occurs, all

[7] The quadratic term plays in the model a similar role as the "cost-of-carry" in Nutz and Scheinkman (2020).

[8] θ_t i.i.d. is particularly convenient, since it eliminates one extra state variable.

art buyers observe θ_t. However, the two groups disagree on the interpretation of θ_t. The forecast of buyers in group $i=1,2$, conditional on θ_t, θ_t^i, satisfies (a) $E^1[\theta_t^1|\theta_t]=\theta_t$ and (b) $E^1[\theta_t^1|\theta_t]+E^2[\theta_t^2|\theta_t]=\theta^\ell+\theta^h$. We will refer to the group that forecasts $\theta^h\,(\theta^\ell)$ as optimists (pessimists). Notice that exactly one half of the art buyers have $E^\cdot[\theta_t^\cdot|\theta_t]=\theta^\ell$, that is, there is no aggregate uncertainty concerning average beliefs on the expected value of holding an artist's work, although aggregate uncertainty could be easily introduced. Nevertheless, as in Harrison and Kreps (1978), the combination of *volatile* differences in opinions and short-sale constraints creates speculative behavior. When buying a piece of art, agents bid higher than if they were forced to hold the art forever. They bid higher because they also acquire the option to resell the art later to a more optimistic agent, a resale option that has value because differences in opinions are volatile. We write p_t for the price of a unit of art in period t. To determine the optimal amount of art to hold, a buyer in group i has to consider today's price, the expected price tomorrow and the expected value of his θ^i coefficient, conditional on the current signal. Given the structure of uncertainty we assumed, $E_t p_{t+1}$ is the same for both groups and only $E^i[\theta_t^i|\theta_t]$ differs across groups.[9] A buyer of a group who has conditional expectation $\theta^\cdot$ would equate the marginal gain in expected utility obtained from buying an extra unit today and selling it tomorrow to 0, that is, demand would satisfy the Euler equation:

$$\theta^\cdot-\gamma x(\theta^\cdot,p_t,E_t p_{t+1})-p_t+\frac{E_t p_{t+1}}{1+r}\leq 0\,(=\text{ if } x(\theta^\cdot,p_t,E_t p_{t+1})>0). \qquad (3)$$

In addition, in equilibrium we must have

$$.5x(\theta^h,p_t,E_t p_{t+1})+.5x(\theta^\ell,p_t,E_t p_{t+1})=N_t,$$

where N_t is the per (potential) buyer supply of art at t. This implies that (3) always holds with equality for the group with $\theta_t^i=\theta^h$. We will call an equilibrium in which (3) holds with inequality for θ^ℓ a *corner equilibrium* and otherwise an *interior equilibrium*.

The next proposition summarizes properties of corner and interior equilibria. All proofs are in the appendix.

Proposition 1.

[a] For each t, p_t is a corner equilibrium if and only if

$$\theta^h-\theta^\ell\geq 2\gamma N_t.$$

Thus, in every period, the relationship between difference in beliefs and the product of γ and the current supply fully determines whether an equilibrium is interior or in a corner.

[9] As we argue in Remark 1 below, we could instead have assumed that agents agree on the utility associated with holding artworks but disagree about temporary shocks to prices in the next period.

[b] If an interior equilibrium holds at t

$$x(\theta^h, p_t, E_t p_{t+1}) = N_t + \frac{\theta^h - \theta^\ell}{2\gamma}, \tag{4}$$

$$x(\theta^\ell, p_t, E_t p_{t+1}) = N_t - \frac{\theta^h - \theta^\ell}{2\gamma}. \tag{5}$$

Since in a corner equilibrium optimist buyers hold the full supply, $x(\theta^h, p_t, E_t p_{t+1}) = 2N_t$, we have a full characterization of art holdings by optimists and pessimists in equilibrium as a function of the current supply N_t.

We define the stopping time

$$\upsilon := \inf\left\{t : N_t \geq \frac{\theta^h - \theta^\ell}{2\gamma}\right\}, \tag{6}$$

the first time in which an artist produces enough artwork so that an interior equilibrium obtains. Since the process N_t is nondecreasing, an interior equilibrium holds for each $t \geq \upsilon$.

Assumption 2.

[a] In the first period a corner equilibrium obtains, that is,

$$\frac{\theta^h - \theta^\ell}{2\gamma} > N_1. \tag{7}$$

[b] The constants k_0, k_1, $b_0 < b_1 < 1$, satisfy

$$\frac{\theta^h - \theta^\ell}{2\gamma} < N_1 + k_0 \frac{\alpha_0}{1-\alpha_0} < N_1 + k_1 \frac{\alpha_1}{1-\alpha_1} < \frac{\theta^h + \theta^\ell}{2\gamma}. \tag{8}$$

Inequality (7) ensures that the stopping time $\upsilon > 1$. The first inequality in (8) guarantees that υ is always finite, that is, if an artist survives long enough, she will produce sufficient artworks so that an interior equilibrium obtains. The second inequality in (8) will insure that in a candidate equilibrium, the marginal utility of artworks is always positive.[10] Since the realization of θ_t does not affect aggregate demand, it is natural to assume that the price of artworks of an artist who is dead at a period t (i.e., $d_t = 1$) only depends on the available supply at t. To facilitate reading, we will write this price as $p^e(N_t)$, where e stands for expired. On the other hand, since the process N_t is time dependent, the price while an artist is alive will depend on t and we write this price as $p_t^a(N_t)$. We first

[10] The need for this assumption is a result of our use of quadratic utility to obtain explicit formulae.

consider equilibria after death. We let $\tau = \max\{t : d_t = 0\} \geq 1$. For convenience we refer to the stopping time τ as the date of death of the artist, though it is really the last date in which the artist is alive and produces. For $t \geq \tau$, $N_t = N_\tau$, and thus $p_t = p^e(N_\tau)$ is constant, so that

$$\theta^{\cdot} - \gamma x(\theta^{\cdot}, p_t, p_t) - \delta p_t \leq 0 (= \text{ if } x(\theta^{\cdot}, p_t, p_t) > 0). \tag{9}$$

where $\delta = \frac{r}{1+r}$. Let

$$\bar{\theta} = \frac{\theta^h + \theta^\ell}{2}.$$

We can now prove

Proposition 2. Let τ be the date of an artist's death. Then for each $t > \tau$, $p_t = p^e(N_\tau)$ where

[a] If $\tau < \upsilon$, then $p^e(N_\tau) = \frac{\theta^h - 2\gamma N_\tau}{\delta} > \frac{\bar{\theta} - \gamma N_\tau}{\delta}$.

[b] If $\tau \geq \upsilon$, then $p^e(N_\tau) = \frac{\bar{\theta} - \gamma N_\tau}{\delta}$.

[c] The price of artworks of an artist after death declines with the length of the life of the artist.

We turn now to the price of art before death. As it is the case for most infinite-horizon models we will need a transversality condition at infinity. Since we established in Proposition 2 that $p^e(N_t)$ is a positive decreasing sequence, the transversality condition is only needed for prices of living artists, for which we assume

Assumption 3. For any constant $m > (1+r)$

$$\lim_{t \to \infty} m^{-t} E p_t^a(N_t) = 0.$$

Assumption 3 states that the rate of growth of the price of artwork by a live artist cannot dominate the gross return on the risk-free asset, a natural assumption since holding art provides positive utility and utility is linear on income. If an artist dies at τ, then for any $t \leq \tau$,

$$\theta^{\cdot} - \gamma x(\theta^{\cdot}, p_t^a(N_t), (1-\pi) E_t p_{t+1}^a(N_{t+1}) + \pi p^e(N_t)) - p_t^a(N_t) + \frac{(1-\pi) E_t p_{t+1}^a(N_{t+1}) + \pi p^e(N_t)}{1+r} \leq 0 \tag{10}$$

with equality if $x(\theta^{\cdot}, p_t, (1-\pi) E_t p_{t+1}^a(N_{t+1}) + \pi p^e(N_t)) > 0$. We can now prove

Proposition 3.

[a] $E_t[p_{t+1}^a(N_{t+1})] < p_t^a(N_t) < p^e(N_t)$. In particular, when an artist dies, prices for her work go up permanently.

[b] In addition, for each $s>0$, $E[p^e(N_t)-p^a_t(N_t)]\geq E[p^e(N_{t+s})-p^a_{t+s}(N_{t+s})]$ that is, an artist who dies older experiences, on average, a smaller price increase.

Proposition 3 predicts that prices increase permanently at death, this increase being less pronounced the older an artist dies. It also implies that prices decline on average over time as the artist produces more work. This decline may not be observed in the data: over time, an artist is likely to become more famous, to produce better art, or simply to become more fashionable. In the model, we focus on the effect of changes in supply and ignore these possibilities, which are absorbed by time and age fixed effects and proxies for notoriety in our empirical design. A similar remark applies to the model's prediction regarding secondary market turnover (see below).

Next, we turn to secondary trading turnover and start by introducing assumptions on the trading process. We assume that all new and old art sells at the same price, so buyers would be indifferent between buying in the primary market, that is, where new works of art sell, or in the secondary market. We will also assume that art is sold in a way that minimizes total transactions. This is a natural assumption that would be an equilibrium outcome if we assumed transaction costs, even as these transaction costs converged to zero. Demand $x_t(\cdot)$ by a collector is first satisfied by work she brought from the previous period y_{t-1}. If $x_t(\cdot)<y_{t-1}$ the collector would sell $y_{t-1}-x_t(\cdot)$. Otherwise the collector would first bid for new art works. If the supply of new work is less than $x_t(\cdot)-y_{t-1}$, the collector would buy from other collectors in the secondary market. Our measure of turnover is transactions between collectors, normalized by the total amount of artworks in existence. We do so, because transactions in the secondary market reflect the exercise of the resale option that characterizes speculative behavior. In addition, the empirical part of this paper uses auction data, which we argue below is a good proxy for secondary trading activity.[11]

Proposition 4.

[a] Average turnover goes up permanently after the death of an artist.

[b] If the single source of supply uncertainty is the date of death of an artist, then the expected amount of turnover change declines with the age of death.

[11] Artists almost never use auctions as a primary market, as living artists usually have agreements with galleries to sell through them. The only exception of a directly auctioned artist who we know of is Damian Hirst, who wanted to "change the face of art dealing" and to bypass the galleries by organizing an auction of his work (upsetting the galleries he worked with, namely, the Gagosian Gallery in New York and the White Cube Gallery in London). Hirst offered 223 art objects for sale via Sotheby's London. The auction failed and Hirst blamed the galleries: "The galleries have convinced everyone not to bid." The *New York Times* reported: "Damien Hirst has a recurring nightmare. His big auction here is about to begin and the Sotheby's salesroom is overflowing with collectors and dealers. […] Suddenly the place goes quiet. Not a paddle is raised" (Vogel 2008).

Thus, the turnover of an artist who dies always increases permanently after death[12] and if the only source of supply uncertainty concerns the date of death of an artist, this increase is largest the earlier the artist dies.

Remark 1. An examination of the Euler Equation (3) shows that instead of differences in utility functions, we could instead have assumed that the groups differ on their forecasts of temporary demand shocks. More precisely, consider a process φ independent of the processes d and N with i.i.d realizations $\varphi_t \in \{-\phi; \phi\}$ and with $P(\varphi_t = \phi) = \frac{1}{2}$, and that each group of buyers forecast that temporary demand shocks in period $t+1$ would increase (decrease) prices on average by φ_t $(-\varphi_t)$ relative to the equilibrium rational expectations price. The utility function for both groups would be

$$u^i(x,c) = \bar{\theta}x - \frac{1}{2}\gamma(x)^2 + c.$$

Remark 2. Suppose one consider two artists $j=1,2$ with $\frac{\theta_1^h}{\theta_2^h} = \frac{\theta_1^\ell}{\theta_2^\ell} > 1$, that is, pessimistic and optimistic investors forecast that artist 1, that we will call reputable, would give higher utility than artist 2. It is clear from Equation (6) that $\upsilon_1 < \upsilon_2$, since υ was defined as the first time such that $N_t \geq \frac{\theta^h - \theta^\ell}{2\gamma}$ and $\theta_1^h - \theta_1^\ell > \theta_2^h - \theta_2^\ell$. Recall that our definition of young requires that the time of death $\tau < \upsilon$. Thus, for a given age of death, the reputable artist is more likely to have died "young," and thus her work would experience a larger increase in prices and turnover than the work of a less-reputable artist who died at the same chronological age.

To summarize, our model yields the following predictions. First, price and average turnover of the work of artists who die increase upon death (Propositions 3[a] and 4[a])). Second, these propositions also imply that the changes in supply and turnover are permanent. Third, Propositions 3[b] and 4[b] imply that the effect of death on price and turnover is more pronounced when the supply shock is larger, that is when an artist dies at a younger age. This is because older artists are expected to add less to the outstanding stock than younger artists. Fourth, prices and turnover increase more for a reputable artist than for a comparatively less-reputable artist (Remark 2.)

2. Data and Empirical Strategy

2.1 The art market

The setting for our empirical work is the auction market for modern and contemporary art. Works of art are usually sold through two types of

12 Lemma A.1 in the appendix gives formulae for the change in turnover. The formulae show how differences in beliefs interact with the extinction of new production at death to determine the expected change in turnover.

intermediaries, dealers (galleries) and auction houses. (We use the terms "dealers" and "galleries" interchangeably throughout the paper.) Auction houses effectively act as brokers and operate most of the secondary market for art and other luxury goods. According to the Tefaf Art Market Report 2017, the art market is worth about USD 45 billion worldwide, typically split equally between dealers and auction houses (Pownall, 2017).

Dealers are often small businesses, lightly regulated, so that this market is largely opaque. As a result, dealer prices tend not to be reliable or easily obtainable. We therefore work with auction data, which aligns well with our interest in the secondary market. Auction data are both reliable and publicly available and have been used to study a broad number of finance and economics questions (e.g., Beggs and Graddy 2009; Galenson and Weinberg 2000; Mei and Moses 2005). A drawback of the data is that fewer artists are active on the auction market at the time of their death. This means that we can only measure the effect of death on prices conditional on the death of artists for whom there is a secondary auction market.

The way the auction market operates has changed little over the centuries. Sellers consign works of art to an auction house and works are grouped to create an auction. Every auction comes with a catalog listing all of the lots in the sale with information about each piece and often features a public presale exhibition. At the auction itself, each item is bid on, one at a time. When an item does not attract any bids or the bids do not exceed the reserve price, it is bought-in. If it is sold, the winner is required to pay the hammer price along with the buyer's commission and any taxes. The auction house also takes a seller's commission, which is deducted from the hammer price, and passes on the remainder of the proceeds to the consignor.

Transaction costs are substantial in the art market. Auction houses typically charge commissions of around 10% from each party, and transaction costs may also include mandatory insurance and shipping charges (see Pesando 1993; Ashenfelter and Graddy 2003). If a lot does not sell, consignors often face "buy-back" fees, reimbursing the auction house for its various costs, such as photographing, researching, and cataloging the item. Sellers also incur some charges, such as shipping and handling costs, even when a work of art goes unsold (i.e., it is "bought-in"). Art buyers also have to take into account the various costs incurred to maintain, store, restore and insure works of art, which can be nonnegligible.

Despite these large transaction costs, art-as-investment is increasingly popular. The first formal art fund was one launched by the British Rail Pension Fund in 1974, investing $70 million worth of art and luxury furniture (Trucco, 1989). The Art & Finance Report 2014, a joint report by Deloitte Luxembourg and ArtTactic, identifies 72 art funds in operation in 2014. Art funds are only the tip of the art investment iceberg. Seventy-six percent of art buyers still view their acquisitions as investments, intending to at least avoid negative returns (Picinati di Torcello and Petterson, 2014).

There are about 300,000 art advisors in the world today (Reyburn, 2014). Equally interesting is the practice of flipping art. Art flippers purchase art with the intent of offering the piece at a profit shortly after purchase. Flipping is facilitated by specialized firms offering high-security warehouses, in tax-free jurisdictions, specially designed for the purpose of quickly reselling art. For example, a 2015 *New York Times Magazine* article covers a new storage company, Uovo (Alden, 2015): "Everything about the facility seems designed to remove friction from the art market—to turn physical objects into liquid assets. Apart from its private viewing rooms for deal making, which are now common in the storage business, what really sets Uovo apart is its vast database. [...] [G]iving clients and prospective buyers remote access to so much data, while making the business more efficient, also helps make the art more like a tradable unit, able to change hands without even leaving a warehouse.[13]

2.2 Auction data

Our primary data sources are the Blouin Art Sales database and Auction Club, online databases commonly used in research on art markets. In the Blouin database, we retain a million auction records from 1957 until 2016, for 8,199 artists, covering art periods from Medieval art to Modern and Contemporary art. The selected artists also appear in the Oxford Grove online Dictionary and/or in Artcyclopedia. Only London sales are included until 1969, but from the 1970s, the coverage consists of almost all major, medium-sized, and even smaller auction houses around the world. We restrict our attention to 2,051 artists who were alive in 1957, the beginning of our sample period. We expand the universe of contemporary artists using various sources (mostly from lists complied by Wikipedia), and obtain additional transactions from the data provider Auction Club. This additional search yields transactions for 866 artists including 185 that were not in our initial data set and were alive at the start of our sample window. Our final sample thus comprise 2,236 artists.

This paper focuses on 246 artists who passed away prematurely and no later than 2015. This enables us to observe transactions at least 1 year before and 1 year after the death of the artist. We consider a death as premature if it occurs prior to an artist's 66th birthday (we later explore the sensitivity of our results to this cutoff). On average, these artists died at age 54. The relatively young average age of decease suggests that premature death may have suppressed a substantial body of work. To provide a rough estimate of the size of the anticipated oeuvre which was not produced as a result of premature death, we again use Blouin Art Sales data and select the sample of painters who were born after 1880 (and hence active in the 20th century), lived to at least age 70,

[13] Buying art as an investment is not a recent phenomenon. The noted art collector Peggy Guggenheim wrote after a visit to New York in 1959 that "[T]he entire art movement had become an enormous business venture . . . Some buy merely for investment, placing pictures in storage without even seeing them, phoning their gallery every day for the latest quotation, as though they were waiting to sell stock at the most advantageous moment" (Guggenheim, 1997), p. 78.

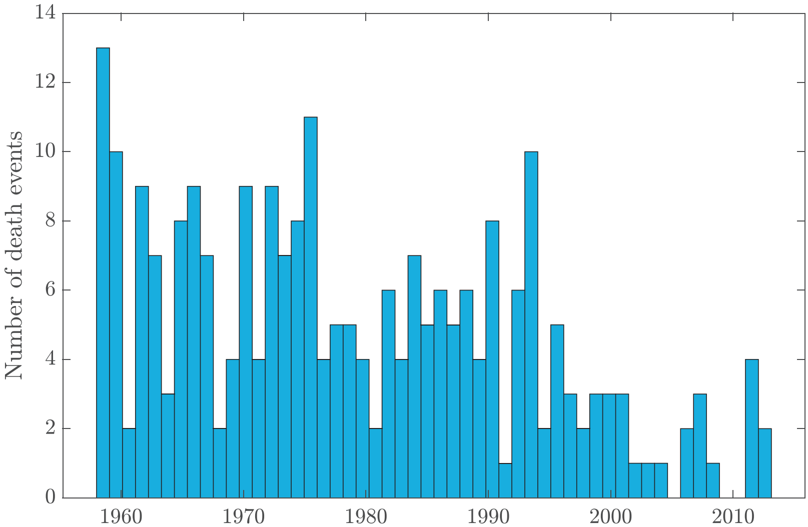

Figure 1
Distribution of premature death events
This figure graphs the number of artists who died at the age of 65 or younger in a specific year over our time span 1958–2014. The total sample of artists who died prematurely over our sample window (1957–2016) amounts to 258. To analyze the impact of death on prices and returns, we require at least 1 year of price data before and after the death in our sample window.

and had at least 200 sales in auctions from 1957 to 2016.[14] On average, each painter had 605 sales but Blouin provides year-of-production for only 255 of these. The painters in this sample created, on average, 129 paintings before and including the age of 54 and 126 paintings subsequently. Hence, we can reasonably argue that the average prematurely deceased artist who we focus on in this paper produced only half of her potential oeuvre.

The "death events" are spread over the sample period. A group of nine artists passed away in 1958, while the last two artists died in 2013. This is convenient from an econometric point of view, because it reduces the risk that our results may be driven by the state of the market at a narrow point in time (Figure 1). Whenever possible, we collect the cause of death of artists who passed away at the age of 65 or younger. We gather this biographical information from a combination of obituaries, biographical memoirs, newspaper articles, magazine articles, and encyclopedia (including Grove Dictionary of Art/Oxford Art Online and Wikipedia). Table 1 reports statistics on causes of death.

Each auction record contains information on the artist, artwork, and sale. We observe the artist's name, nationality, and years of birth and death. Even in public sales, the identity of the buyer and the seller are typically kept secret by the auction house, and our data set thus does not contain this information. The

14 Although catalogue raisonnés would provide more complete data, they only exist for a small number of artists.

Table 1
Cause of death

	N	Share of total (%)
A. All deaths		
Unknown	87	35.4
Cancer	39	15.9
Unspecified illness	20	8.1
AIDS	10	4.1
Other disease	8	3.3
Heart disease	5	2.0
Tuberculosis	5	2.0
Alcohol and drug-related disease	4	1.6
Suicide[a]	1	0.4
Sudden death	67	27.2
Total	246	100.0
B. Sudden deaths		
Heart attack	24	35.8
Suicide	11	16.4
Accident or murder	11	16.4
Sudden unspecified cause	6	9.0
Overdose	5	7.5
Sudden disease	4	6.0
Stroke	4	6.0
Complications from surgery	2	3.0
Total	67	100.0

This table reports the composition of our sample of artists who died between 1958 and 2014. Based on the cited cause of death in obituaries, biographical memoirs, newspaper articles, magazine articles, and Google searches (including Wikipedia articles), panel A classifies the cause of death as cancer; acquired immunodeficiency syndrome (AIDS); heart disease; tuberculosis; alcohol and drug-related disease; other disease; unspecified illness (for cases in which the precise disease is not reported); unknown; and sudden death. Panel B reports the cause of death for the subsample of sudden deaths from panel A. [a]This observation corresponds to Keith Vaughan. Vaughan died of suicide, but we classify his death as predictable since he had been diagnosed cancer 2 years prior to his death.

information on the art object includes title, year of creation (for about one-third of observations), medium, size, and whether the piece is signed. The transaction information includes the auction house, date of the auction, lot number, and hammer price. Our sample includes periods of large inflation, and we calculate the US$(2015) equivalent hammer prices using the U.S. consumer price index.

Our main variables of interest are auction prices and trading volume around death events. Few artists sell at auction every year, and many artists only sell when they reach a certain level of notoriety. Each year-artist for which we do not observe a transaction is recorded as a zero, provided the artist is aged 23 or older.[15] Our volume panel consists of 124,273 artist-year volume observations, of which 13,657 correspond to the 246 treated artists. Estimating the death effect on art prices imposes an additional condition, since we need to observe at least one transaction before and after the death of the artist. To measure the impact on prices, we thus rely on a subset of 76 artists who were active on the auction market before their death.

15 We set the beginning of an artist's career at the age of 23, which corresponds to the earliest sale in an artist's career (Jean-Michel Basquiat) in our sample.

2.3 Empirical strategy

Our model implies that the death of a young artist raises prices and turnover *permanently*, relative to a counterfactual where the artists would have survived to produce a much larger body of work. A natural starting point is to examine whether the price and traded volume of a deceased artist change after the artist passes away. Our hypothesis is that, everything else equal, prices and volume should increase. That is, we are interested in the counterfactual price and volume trajectory of the same artist if she would not have passed away prematurely. Since both prices and volume may correlate with age, as well as the passage of time, our specifications must include not only artist fixed effects but also age and time fixed effects. In particular, age fixed effects are set, regardless of whether or not the artist is alive at the time of the transaction, because they serve the purpose of separately identifying the effect of death from the effect of age. Even with such a rich set of fixed effects, it is important to reflect on what control group will serve to pin down the counterfactual prices and volume in the absence of premature death. When the sample only includes the works of artists who passed away prematurely, we cannot separately identify the effect of death from the effect of old age. In our baseline specification, since the age cutoff of premature death is 65 years, the age fixed effects for ages exceeding 65 capture both the effect of age and the effect of death. Separating the effect of death from the effect of age therefore requires the presence of a control group of artists who did not die prematurely. Because artists may experience different career paths—the effect of age may be different across artists—it is a priori important to construct a control group that is as close as possible to the group of treated artists.

Our preferred empirical strategy therefore relies on constructing a synthetic control group of artists who is very similar to the group of treated artists. We implement a matching procedure to construct a control group of artists who are most comparable to the group of 246 artists who died prematurely. We delineate a set of covariates along which matched artists must resemble each other. The control group must consist of artists of approximately the same age as the "treated" group, selling art in the auction market in the same quantity and price range. We also need comparable notoriety for treated and matched artists. We then implement a variation on the coarsened exact matching procedure (Iacus et al., 2012) to identify the artists who best satisfy these criteria. This procedure is similar to the identification strategy used, for example, by Azoulay et al. (2010), to estimate the effect of "superstar" scientists on the productivity of their collaborators.

To construct our synthetic control group, we first match artists based on the average real USD price commanded by the artist's work and the average number of artworks sold per year. Both variables are measured over a lookback period of at most 10 years before the death of the treated artist. We distinguish between cases in which the artist's work has been auctioned prior to his death and cases in which no work of the artist has been sold prior to his death. For artists with prior sales, we search for other artists for which both past sales and prices fall within a 50% range of the treated artist. We match the remaining individuals without prior sales to other artists without prior sales. In the absence of price information, we check that the reputation of the treated artists and those in the control sample are similar at the time of death of the treated artist. To do so, following Penasse and Renneboog (2017), we measure the yearly "Fame" of the artist as the percentage of mentions of each artist name in the English-language books digitized by Google Books. We require that the control artist's Fame in the year of the death of the treated artist, winsorized at the 5% level, falls within a 50% range of the treated artist's Fame.[16] In addition, we require that a matched artist be born no more than 10 years before or after the treated artist and that the matched artist be presently alive or passed away at age 66 or older and at least 10 years after the treated artist. This ensures that matched artists belong approximately to the same age cohort, while at the same time they do not die prematurely, so that we can identify the effect of the treated artist's death. We match without replacement so that each artist is assigned exactly one match. Whenever more than one match is found, we pick the matches that minimize the (normalized) Euclidean distance in the year of births of the two artists, sales, and price at death or fame. If several matches satisfy this last distance criterion, we pick one at random.[17] As an example, the algorithm matches Eva Hesse, one of the pioneers of postminimalism, who died in 1970 at age 34, with the Japanese artist Yoko Ono (1933–), a key member of the *Fluxus* group. In the Internet Appendix, we list artists and their matches.[18]

Finally, we note that while our design aims at capturing the causal effect of death, we are interested in capturing the effect of the realized supply. This requires two additional assumptions. First, premature death must affect treated artists, but not their controls. We later construct a placebo test that allows us to check that assumption. Second, death must not boost the artist's (unobserved) notoriety. We consider a series of proxies for notoriety and return to this question in Section 4.3.

Our control selection procedure matches 242 of the 246 treated artists (98.37%). We have a total of 57,997 transactions for these artists and the control group. Table 2 provides summary statistics for the variables of interest for the sample of artists who died prematurely and their matched counterparts. Statistics on average real USD prices, average yearly volume and fame are computed for both samples of artists, based on the years before the death event of the treated artists. Fame is standardized so that the cross section of all artists in a given year has a zero mean and unit standard deviation. Both treated and control artists are, by construction, well balanced on all covariates relating to

[16] Google nGram data are unavailable after 2008; for artists who died after that, we take Fame in 2008.

[17] We also consider a simpler procedure in which we minimize the Euclidean distance for the vector of standardized matching variables and obtain similar regression results.

[18] Of course, only the overall composition of the control group matters for the regression results.

Table 2
Matched sample

Variable	Sample	Mean	SD	Min	Max
Year of birth	Deceased ≤ 65 years	1924.4	16.2	1894	1966
	Control group	1924.7	16.3	1892	1966
Year of death	Deceased ≤ 65 years	1978.7	14.1	1958	2013
	Control group[a]	1993.8	12.9	1970	2018
Age at death	Deceased ≤ 65 years	54.3	9.3	23.0	65.0
	Control group[a]	77.0	7.8	66.0	101.0
Avg. price at treatment (thousands)[b]	Deceased ≤ 65 years	9.8	11.8	1.0	82.9
	Control group	10.4	11.6	1.1	80.2
Avg. yearly volume at treatment	Deceased ≤ 65 years	0.9	3.4	0.0	36.7
	Control group	0.8	3.0	0.0	25.7
Fame at treatment[c]	Deceased ≤ 65 years	−0.0	0.9	−0.5	3.6
	Control group	−0.1	0.9	−0.5	3.6
No. of artists	Deceased ≤ 65 years	242.0			
	Control group	242.0			

This table reports summary statistics for the group of treated and control artists defined in Section 2.3. The statistics are computed using data prior to the year of death of the treated artist. Prices are reported in US$(2015). Volume is defined as the total number of transactions per year. Fame is the standardized percentage of mentions of each artist name in the English-language books digitized by Google Books. [a] For the 165 control artists who die in our sample. [b] For the 73 treated and control artists who are "active" with at least one transaction prior to the treated artist's death. [c] For the 242 artists (and their controls) who pass away before 2009 (when Google nGram data are available).

age, past prices, and volume. The typical artist in our sample is born in the mid-1920s. Treated artists pass away at the age of 54.3 on average; 22.7 years younger than the typical control (conditional on the later artist dying before 2016). There is considerable variation in the age of and time of death. For instance, the youngest artist in our sample, Francesca Woodman, died in 1981 at the age of 23; 17 passed away at the age of 65. On average, treated and matched artists sold one work through auction per year in the 10 years that preceded their death. 170 artists had not sold a single work of art at the time of their death; also, in this respect, matched artists are very similar.[19]

2.4 Econometric considerations

We use a difference-in-differences framework to estimate the impact of death on prices and volume. Our econometric specification differs slightly depending on whether the outcome variable is price or trading volume. For the former, our specification is

$$\begin{aligned}\log P_{i,t,k} &= \beta_0+\beta_1 \text{PostDeath}_{i,t}+\alpha_i+\delta_t+\gamma_1' \text{Age}_{i,t} \\ &\quad +\gamma_2' \text{Artwork}_{i,t,k}+\gamma_3' \text{Artist}_{i,t}+\epsilon_{itk},\end{aligned} \tag{11}$$

[19] Although our sample contains both superstars and lesser-known artists, Table 2 does not suggest that outliers may be present. We nevertheless verify that our results do not change when we winsorize prices and volume or drop the most-traded artists.

where $P_{i,t,k}$ denotes the auction price of artwork k for artist i in year t, PostDeath is an indicator variable that switches to one from the artist's death year if the artist dies before 65, α_i and δ_t are artist and year fixed effects, $\text{Age}_{i,t}$ corresponds to age brackets dummies in 5-year intervals, and $\text{Artwork}_{i,t,k}$ is a vector of artwork-specific controls that affect the price of art. This vector includes observed characteristics, such as whether a given work is signed, whether it is dated, the medium (oil, watercolor, etc.), size, and auction house dummy variables. The vector $\text{Artist}_{i,t}$ includes artist characteristics reflecting the fact that artist notoriety may change over time. To proxy for notoriety, we create a dummy variable equal to one when the artist has exhibited at the Documenta exhibition in Kassel, and another equal to one when the artist's work has been sold at Sotheby's or Christie's main venues, in London or New York. We also report regression results controlling for "Fame," as defined above, since the variable is only available on a shorter sample (up to 2008). Equations of the form of (11) are often referred to as "hedonic regressions" in the literature on the determinants of real estate and art prices (e.g., Renneboog and Spaenjers, 2013). To estimate the impact of death on the number of artworks sold $V_{i,t}$ for artist i in year t, we use the following specification, which is commonly used for count data with many zeros:

$$E[V_{i,t}|Z_{i,t}]=\exp[\beta_0+\beta_1\text{PostDeath}_{i,t}+\alpha_i+\delta_t+\gamma_1'\text{Age}_{i,t}+\gamma_3'\text{Artist}_{i,t}], \quad (12)$$

where all variables are defined as above ($Z_{i,t}$ includes all right-hand-side variables in Equation (12)). In both instances, a positive β_1 indicates that artists command higher prices or volume on average after their death. We estimate the effect of death on prices in (11) by an ordinary least squares (OLS) regression. In Equation (12), where the dependent variable is volume with a large number of zeros, we present conditional quasi-maximum likelihood (QML) estimates of the fixed effects Poisson model (Hausman et al., 1984). In both cases, we compute standard errors using the generalized Huber-White formula clustered at the artist level. QML standard errors are consistent even if the underlying data generating process is not Poisson, as long as Equation (12) is the correct specification of the conditional mean (Cameron and Trivedi, 1998). Bertrand et al. (2004) show that these "cluster-robust" standard errors perform well in the context of differences-in-differences estimation similar to our setting.

3. Results

3.1 Main effect of premature death

Table 3 gives the resultant β_1 estimates. The top panel reports the impact of death on auction prices, and the bottom panel reports the effect on trading volume. The first column of each panel gives the results including the control group of matched artists, whereas the second column of each panel shows the results for the treated artists only. The table reports the number of observations as well as the number of treated artists and the number of control artists, if

Table 3
Impact of artist death on prices and volume: Matched sample

	With control group	Without control group
A. Death and auction prices		
Deceased ≤65 years	0.436	0.277
t-stat	(3.88)	(2.11)
Year and age fixed effects and hed. controls	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	57,997	37,178
No. of artists (treated + matched controls)	72+72	72
B. Death and volume		
Deceased ≤65 years	0.490	0.437
t-stat	(3.34)	(2.99)
Year and age fixed effects	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	26,865	13,449
No. of artists (treated + matched controls)	242+242	242

This table shows the β_1 coefficients in Equations (11) and (12). The sample consists of artists who passed away at the age of 65 or younger, together with their matched controls (left column). We also report estimates with treated artists only in the right column. Panel A gives OLS estimates of a regression of log real auction prices on the treatment dummy, while controlling for year, age, and individual fixed effects, two dummies proxying for notoriety (a dummy equal to one when the artist had exhibited at the Documenta, and another one when the artist has sold at least once at Sotheby's or Christie's in London or New York), and the full set of controls to address artwork heterogeneity (medium, auction house, a dummy equal to one if the artwork is signed, a dummy equal to one if the artwork is dated, artwork height and width). Panel B gives conditional quasi-maximum likelihood Poisson estimates of a regression of annual trading volume on the same set of controls (minus artwork-specific controls). The unit of observation is at the artist-year level. Note the smaller number of artists in panel A than in panel B; measuring the death effect on art prices requires that artists are active on the auction market before their death and hence the smaller sample. Standard errors are clustered at the artist level.

any. Observe that the number of artists is smaller in the top panel. We measure the impact of death on prices for the 72 artists who were active on the auction market before their death. In the bottom panel, we can work with the full sample of 242 artists.

Overall, we find that both prices and volume surge when an artist passes away prematurely. In our baseline specification that includes the control group (column 1), we find that prices increase by $\exp(0.436)-1=54.7\%$. Likewise, volume increases by 63.2%. All estimates are highly significant. The effect is practically the same for volume and are smaller but in the same magnitude for prices when we exclude artists of the control group.

The price and volume elasticities implicit in Table 3, together with our estimate that the premature death of our treated artists caused a halving of their float (compared to the output of artists who did not die prematurely), allows us to calculate the elasticities with respect to float of price and volume that are displayed in Table 4. In turn, these imply an elasticity of price with respect to turnover of .46. This back-of-the-envelope calculation yields a result that is not far from the point estimate of .38 obtained by Cochrane (2003) for the elasticity of price-to-book with respect to float for Nasdaq stocks during the internet-bubble month of December 1999 or the elasticity of the price of warrants with respect to float (.24) for the data in Xiong and Yu (2011).

Table 4
Turnover elasticity of price

Elasticity			Source
A: Art sample			
Avg. float chg. of early death	Δf	−0.50	Authors' calculation
Avg. log price change	Δp	0.46	Table 3
Avg. log volume change	Δv	0.49	Table 3
Float elasticity of price	$\varepsilon_{fp} = \frac{\Delta p}{\Delta f}$	−0.92	
Float elasticity of volume	$\varepsilon_{fv} = \frac{\Delta v}{\Delta f}$	−0.98	
Float elasticity of turnover	$\varepsilon_{ft} = \varepsilon_{fv} - 1$	−1.98	
Turnover elasticity of price	$\varepsilon_{tp} = \frac{\Delta p}{\Delta t} = \frac{\varepsilon_{fp}}{\varepsilon_{ft}}$	0.46	
B: Related studies			
Turnover elasticity of price	ε_{tp}	0.38	Cochrane (2003) (Table 3)
Turnover elasticity of price	ε_{tp}	0.24	Xiong and Yu (2011) and authors' calculation

Table 5
Impact of artist death on prices and volume: Full sample

	Unmatched control group	Without control group
A. Death and auction prices		
Deceased ≤65 years	0.415	0.246
t-stat	(3.98)	(1.86)
Year and age fixed effects and hed. controls	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	694,071	41,576
No. of artists (treated + all controls)	76+2,160	76
B. Death and volume		
Deceased ≤65 years	0.479	0.460
t-stat	(3.05)	(3.20)
Year and age fixed effects	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	124,273	13,657
No. of artists (treated + all controls)	246+1,990	246

This table shows the β_1 coefficients in Equations (11) and (12). The sample consists of all artists alive at the beginning of the sample period (1957) or later. We also report estimates with treated artists only in the right column. Panel A gives OLS estimates of a regression of log real auction prices on the treatment dummy, while controlling for year, age, and individual fixed effects, two dummies proxying for notoriety (a dummy equal to one when the artist had exhibited at the Documenta, and another one when the artist has sold at least once at Sotheby's or Christie's in London or New York), and the full set of controls to address artwork heterogeneity (medium, auction house, a dummy equal to one if the artwork is signed, a dummy equal to one if the artwork is dated, and artwork height and width). Panel B gives conditional quasi-maximum likelihood Poisson estimates of a regression of annual trading volume on the same set of controls (minus artwork-specific controls). Standard errors are clustered at the artist level.

3.2 Robustness

We check the robustness of our main findings in Tables 5 to 8. Our results stay the same when using the full sample of artists alive in 1957 (Table 5): premature decease leads to both higher prices and volume, which respectively increase by 51.4% and 61.4%. The death of an artist can affect his visibility and thus, collectors' willingness to pay, which is why we repeat the above analyses, while controlling for an alternative definition of notoriety based on the Fame variable. The Fame variable, as defined earlier, is the percentage of mentions of

Table 6
Impact of artist death on prices and volume: Alternative control for notoriety, 1957–2008

	With control group	Without control group
A. Death and auction prices		
Deceased ≤65 years	0.360	0.248
t-stat	(3.16)	(2.11)
Year and age fixed effects and hed. controls	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	31,653	18,643
No. of artists (treated + matched controls)	72+72	72
B. Death and volume		
Deceased ≤65 years	0.406	0.409
t-stat	(2.98)	(3.33)
Year and age fixed effects	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	22,651	11,329
No. of artists (treated + matched controls)	242+242	242

This table shows the β_1 coefficients in Equations (11) and (12). Similarly to Table 3, the sample consists of artists who passed away at the age of 65 or younger, together with their matched controls (left column). The sample stops in 2008 because our Fame control is only available through 2008. We also report estimates with treated artists only in the right column. Panel A gives OLS estimates of a regression of log real auction prices on the treatment dummy, with a similar set of controls as in Table 3, to which we add an alternative definition of notoriety (as measured by the percentage of mentions of each artist name in the English-language books digitized by Google Books). Panel B gives conditional quasi-maximum likelihood Poisson estimates of a regression of annual trading volume on the same set of controls (minus artwork-specific controls). Standard errors are clustered at the artist level.

each artist name in the English-language books digitized by Google Books.[20] The coefficients remain highly significant and effects are of a similar magnitude (Table 6). In Table 7, we perform a placebo test by dropping all treated artists and by "treating" their matched controls. To this placebo population of artists, who exhibit the same characteristics as the actually treated artists, we assign a placebo date of death that corresponds to the date of the premature death of the matched artists. We then match these artists, who are assigned a placebo premature death date, with a new group of control artists and estimate the death effect on this placebo group.[21] Reassuringly, Table 7 indicates that the death effect in this pseudo-data-set on prices and volume is small and insignificant.

In Table 8, we drop all artists for whom death could have been anticipated. We gather biographical information through a combination of the following resources: obituaries, biographical memoirs, artist biographies on auction websites, gallery descriptions, newspaper articles, magazine articles, and Google searches (including Wikipedia articles). We classify premature deaths as sudden, when the death is indicated as sudden in obituaries or news articles, or when the cause of death is given as a heart attack, stroke (for artists with no

20 The results in Table 6 are based on the shorter sample of artists for which Fame is available in the year of death, but the same results hold if we use 2008 Fame for artists who died after 2008.

21 We match the large majority of artists, and, doing so yields a sample only slightly smaller of 69 (235) treated artists in the price (volume) specification.

Table 7
Impact of artist death on prices and volume: Placebo sample

	With control group	Without control group
A. Death and auction prices		
Deceased ≤65 years	−0.058	0.106
t-stat	(−0.49)	(1.16)
Year and age fixed effects and hed. controls	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	42,212	18,876
No. of artists (treated + matched controls)	69+69	69
B. Death and volume		
Deceased ≤65 years	−0.180	−0.067
t-stat	(−1.14)	(−0.41)
Year and age fixed effects	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	25,323	12,648
No. of artists (treated + matched controls)	235+235	235

This table shows the β_1 coefficients in Equations (11) and (12). The sample consists of a placebo sample consisting of the matched artists in the baseline regression (Table 3). We drop artists who passed away at 65 or younger and use this placebo group as the treated sample. We assign a placebo date of death to each placebo-treated artist, corresponding to the date of the premature death of the matched artists who actually passed away prematurely. We then match these artists, who are assigned a placebo premature death date, with a new group of control artists. We also report estimates with placebo-treated artists only in the right column. Panel A gives OLS estimates of a regression of log real auction prices on the treatment dummy, while controlling for year, age and individual fixed effects, two dummies proxying for notoriety (a dummy equal to one when the artist had exhibited at the Documenta, and another one when the artist has sold at least once at Sotheby's or Christie's in London or New York), and the full set of controls to address artwork heterogeneity (medium, auction house, a dummy equal to one if the artwork is signed, a dummy equal to one if the artwork is dated, and artwork height and width). Panel B gives conditional quasi-maximum likelihood Poisson estimates of a regression of annual trading volume on the same set of controls (minus artwork-specific controls). Standard errors are clustered at the artist level.

reported heart disease), accident, murder, suicide,[22] overdose, sudden disease, and complications from surgery. Deaths are classified as anticipated whenever our source mentions that an artist was ill or in fragile condition. Table 8 indicates that prices and volume increase 80.0% and 84.0% upon unexpected death. These estimates are larger than our baseline estimates, but artists who died suddenly also tend to be younger than our baseline sample. The average age of treated artists with a sudden death is 50 versus 54 for the typical treated artist. We will see in the next subsection that, as the model predicts, the death effect declines with the age of death.

3.3 Sensitivity to age at death

Next, we explore the sensitivity of our result to the age cutoff of 65 years old. Death constitutes a negative shock to the future production of the artist. This shock is larger when the artist leaves a larger unproduced body of work, that is when the artist dies young. In line with this intuition, our model predicts a stronger death effect the younger the artist dies. We therefore expect the death effect to be stronger for younger artists. Figure 2 reports the coefficients for the

22 One exception is the suicide of Keith Vaughan, who received a cancer diagnosis 2 years before his death.

Table 8
Impact of artist death on prices and volume: Sudden deaths

	With control group	Without control group
A. Death and auction prices		
Deceased ≤65 years	0.588	0.307
t-stat	(3.23)	(1.77)
Year and age fixed effects and hed. controls	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	24,071	18,607
No. of artists (treated + matched controls)	19+19	19
B. Death and volume		
Deceased ≤65 years	0.610	0.690
t-stat	(2.40)	(4.16)
Year and age fixed effects	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	6,766	3,135
No. of artists (treated + matched controls)	65+65	65

This table shows the β_1 coefficients in Equations (11) and (12). The sample consists of artists who suddenly passed away at the age of 65 or younger, together with their matched controls (left column). We report characteristics of the sudden death sample in Table 1. We also report estimates with treated artists only in the right column. Panel A gives OLS estimates of a regression of log real auction prices on the treatment dummy, while controlling for year, age and individual fixed effects, two dummies proxying for notoriety (a dummy equal to one when the artist had exhibited at the Documenta, and another one when the artist has sold at least once at Sotheby's or Christie's in London or New York), and the full set of controls to address artwork heterogeneity (medium, auction house, a dummy equal to one if the artwork is signed, a dummy equal to one if the artwork is dated, and artwork height and width). Panel B gives conditional quasi-maximum likelihood Poisson estimates of a regression of annual trading volume on the same set of controls (minus artwork-specific controls). Standard errors are clustered at the artist level.

effect of death interacted by the age of the treated artist, for age cutoffs from 50 and below to ages exceeding 90. The sample includes all artists who are alive at the beginning of our sample period (1957), as in Table 5. Figure 2 confirms our prediction. The death effect declines with age as expected. The price effect is insignificant at the 95% level for ages above 65; the effect on volume turns insignificant from the age of 80.

3.4 Sensitivity to reputation

Our model also predicts that the death effect would matter mainly for artists who have already achieved a certain degree of reputation. In contrast, if the causal mechanism operates through a change in notoriety rather than disagreement, we should expect obscure artists to have a higher death effect. To analyze the impact of fame at the time of death, we split the sample of artists with higher and lower notoriety (as measured by Fame). The left/right column in Table 9 shows results for artists whose Fame is within the top or bottom tercile at the year of their death. We find that the results are driven by artists with a higher degree of notoriety, whereas there is no significant price and volume impact for less-reputable artists.

3.5 Persistence

Our model predicts that the death effect on volume and prices are permanent. To check for the duration of the death-effects, we estimate a variant of equations

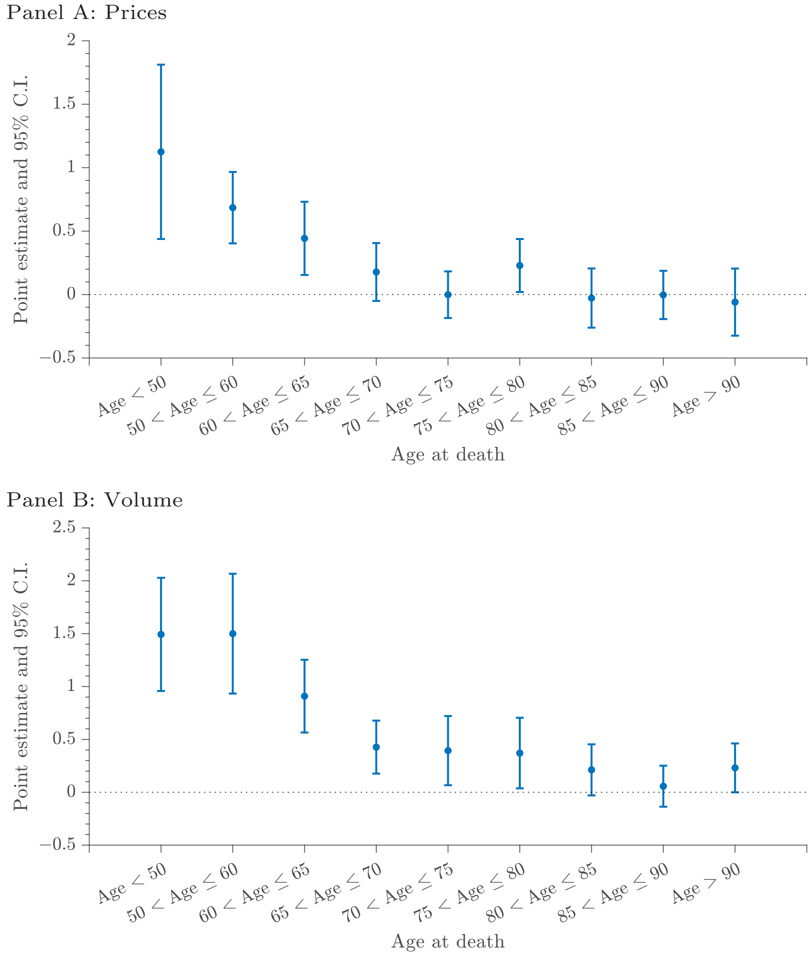

Figure 2
The death effect declines with the age at death
Panels A and B present the point estimates and 95% confidence intervals for the causal impact of death interacted with the age at death. The sample includes all artists who are alive at the beginning of our sample period (1957). Panel A gives OLS estimates (based on Equation (11)); panel B gives QML Poisson estimates (based on Equation (12)). Standard errors are clustered at the artist level.

(11)-(12), where we interact the treatment effect with indicator variables corresponding to a particular year relative to the artist's death. To reduce noise, we pool observations by year for each year within a 15-year period starting 5 years prior to the artist's death and ending 10 years after her death. More concretely, the β_1 coefficient is replaced by a 15×1 vector and the PostDeath indicator is decomposed into 15 dummy variables. The first dummy is equal to one for observations up to 5 years prior to a treated artist death; the second dummy equals one in the fourth year prior to a treated artist death, etc. The

Table 9
Impact of artist death on prices and volume: Conditioning on fame at death, 1957–2008

	High fame	Low fame
A. Death and auction prices		
Deceased ≤65 years	0.599	−0.224
t-stat	(4.57)	(−1.42)
Year and age fixed effects and hed. controls	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	45,385	2,480
No. of artists (treated + matched controls)	24+24	24+24
B. Death and volume		
Deceased ≤65 years	0.586	0.029
t-stat	(2.87)	(0.12)
Year and age fixed effects	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	8,815	7,629
No. of artists (treated + matched controls)	81+81	81+81

This table shows the β_1 coefficients in Equations (11) and (12). Similar to Table 3, the sample consists of artists who passed away at the age of 65 or younger, together with their matched controls. The left versus right columns show results for artists whose Fame (as measured by the percentage of mentions of each artist name in the English-language books digitized by Google Books) is within the top or bottom tercile at the year of their death. The sample stops in 2008, because our Fame data are only available through 2008. Panel A gives OLS estimates of a regression of log real auction prices on the treatment dummy, with a similar set of controls as in Table 3. Panel B gives conditional quasi-maximum likelihood Poisson estimates of a regression of annual trading volume on the same set of controls (minus artwork-specific controls). Standard errors are clustered at the artist level.

year prior death is left out. The final dummy is equal to one for observations 10 years or later after the passing away of the artist.[23] Figure 3 suggests that the death effect is permanent, as reflected by the point estimates and the 95% confidence interval around them (panels A and B correspond to column 1 in panels A and B in Table 3). We observe a sharp increase in both prices and volume on the year following death. The point estimates are all insignificant in the pretreatment years and are all positive (mostly significant) for all years after the death of the artist.[24]

3.6 Evidence using round-trip transaction data

So far, our estimates of the price impact have been based on different items auctioned at different periods. As is common in the literature on art and real estate, we rely on the objective "hedonic" characteristics of the auctioned items to control for unobserved heterogeneity. We can also estimate the death effect using observations for the same item, provided such item has been auctioned at least twice. This is useful, because it enables us to work directly with returns, rather than prices. Consider an item bought in time t and sold in time $t+j$.

[23] Table 2 indicates that the average year at which a treated artist passed away is 1979, which means on average we observe 37 years of post-death trading volume.

[24] We also find no evidence of extrapolative behavior, for example, Barberis et al. (2018), as a result of the death of an artist, although extrapolation is most probably present in art markets (see Penasse and Renneboog 2017).

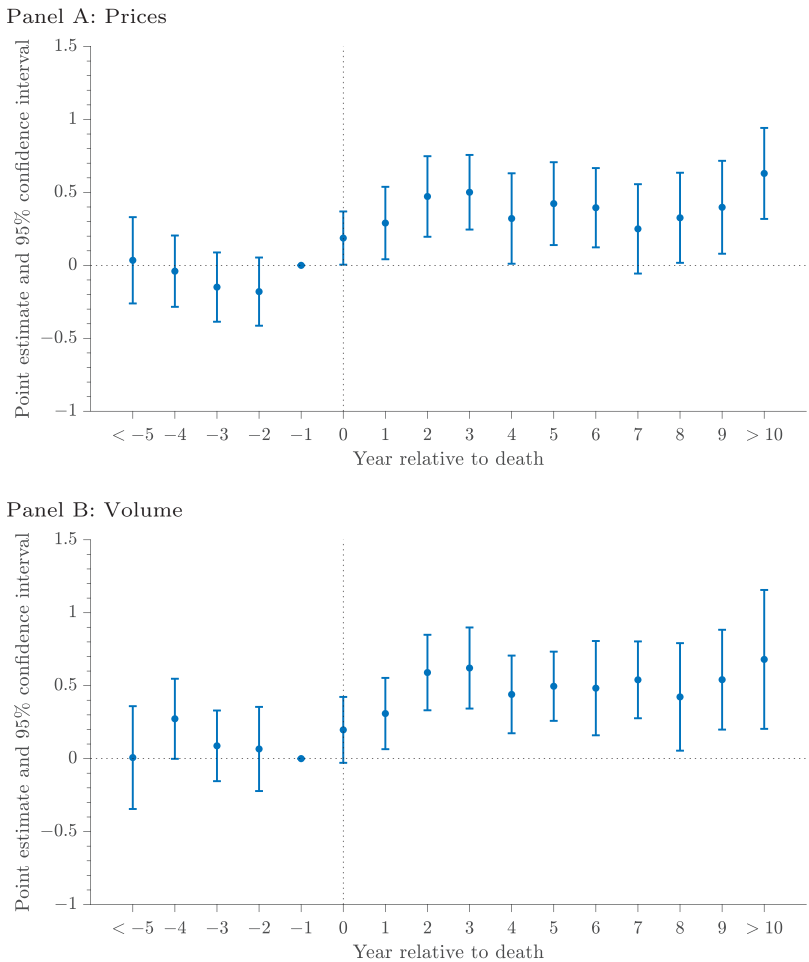

Figure 3
Prices and trading volume around the year of death
Panels A and B present the point estimates and 95% confidence intervals for the causal impact of death in a given year relative to the artist's death. The sample includes all treated artists who are active prior to their death. Panel A gives OLS estimates (based on Equation (11)); panel B gives QML Poisson estimates (based on Equation (12)), similar to column 1 of Table 3. Observations more than 5 (10) years before (after) the death are grouped together. Standard errors are clustered at the artist level.

Taking the difference of Equation (11) yields

$$\log P_{i,t+j,k} - \log P_{i,t,k} = \beta_1(\text{PostDeath}_{i,t+j} - \text{PostDeath}_{i,t}) \\ +\delta_{t+j} - \delta_t + \epsilon_{i,t,t+j}$$

The left-hand-side variable is now the round-trip log return between times t and $t+j$. The treatment variable is now the *change* in death status within the round-trip, that is, whether the artist i died between the purchase and resale of the work of art. Notice that all time invariant controls, including artwork specific variables and individual fixed effects disappear in the difference. Because individual artists may exhibit different risk characteristics, we nevertheless retain a specification with a constant and individual fixed effects:

$$r_{i,t+j,t} = \beta_0 + \beta_1 \text{Died}_{i,t,t+j} + \beta_2 \text{Deceased}_{i,t} + \delta_{t+j} - \delta_t + \alpha_i + \epsilon_{i,t,t+j}, \quad (13)$$

where $r_{i,t+j,t} = \log P_{i,t+j,k} - \log P_{i,t,k}$ and $\text{Died}_{i,t,t+j} = (\text{PostDeath}_{i,t+j} - \text{PostDeath}_{i,t})$. We also include an additional indicator variable, $\text{Deceased}_{i,t}$, that is equal to one when the artist is deceased at purchase (i.e., at time t). A nonzero β_2 tests whether treated artists earn different returns *after* their death, that is, whether price drift occurs. Our theory predicts that the effect of death is permanent. We therefore expect an estimate of β_1 that is close to the estimates presented in the top panel of Table 3, and a β_2 estimate not statistically different from zero. To construct our repeat-sale sample, we identify artworks that have been auctioned at least twice from observed characteristics, as is standard in the literature. To ensure that each pair corresponds to the actual same artwork, we exclude any object that may have been produced in multiples. We thus limit our sample to oil paintings and drop artworks with vague titles (such as "Untitled" and "Composition"), as well as any title which may have been used for artworks of different sizes by the same artist. Matching is then based on the name of the artist, size, title, and the presence of a signature. In this data set, each pair of transactions for the same item is a unique observation. We find 792 repeat sales for 50 treated artists who pass away within at least one round-trip and their 49 controls. (We keep artists in the sample even if we did not find repeat sales for their matched counterpart.) Our matching criteria leads to a small sample, as is common in the literature. We also note that this sample may be different from our baseline one. The former consists of artists for whom we could find matching pairs, that is, artists who are relatively more active on the secondary market than those in our baseline sample. Moreover, because the resale pairs are not randomly drawn, our β_1 estimates may be affected by selection bias, if collectors are more likely to resell an artwork whose price has increased. Table 10 reports the estimated β_1 and β_2 coefficients. As expected, the effect of death on returns is high: death events are associated with an "abnormal" return of $\exp(0.477) - 1 = 61.1\%$ on average, when compared to a typical matched artist who does not die. The effect is of the same magnitude when excluding the control group, so that returns are also abnormally high compared to other round-trips without death events.

We also note that the price increase is only slightly higher than our baseline estimate of 54.7%, meaning that selection bias is likely to be small in our setting. In both specifications, β_2 coefficients are small and indistinguishable from zero, indicating returns are not different after death. This confirms that

Table 10
Impact of artist death on round-trip returns

	With control group	Without control group
Died ≤65 during round-trip	0.477	0.392
t-stat	(2.00)	(1.61)
Deceased ≤65 at purchase	0.028	0.007
t-stat	(0.46)	(0.04)
Year fixed effects	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	792	457
No. of artists (treated + controls)	50+49	50

This table shows the β_1 and β_2 coefficients in Equation (13). The first coefficient measures the death effect, similarly to our hedonic specification (11). The β_2 coefficient tests whether treated artists earn different returns *after* their death. The sample consists of repeat-sales for artists who passed away at the age of 65 or younger, as well as their matched controls (left column). We also report estimates with treated artists only in the right column. Standard errors are clustered at the artist level.

the effect on prices is permanent. We can also use the repeat-sale data set to indirectly test whether turnover increases after death. While we do not observe turnover in the data, turnover is inversely related to holding periods, which are observed in our small sample of repeat-sale transactions. We can thus test whether on average holding periods decline after the premature death of an artist. Specifically, we regress the log annual holding period on a dummy that is equal to one for treated artists who are deceased at purchase (i.e., at time t), while controlling for the resale year and age fixed effects:

$$h_{i,t,t+j} = \beta_0 + \beta_1 \text{Deceased}_{i,t} + \delta_{t+j} + \gamma_1' \text{Age}_{i,t} + \gamma_2' \text{Artist}_{i,t} + \epsilon_{i,t,t+j}. \tag{14}$$

Given that volume increases after death, we expect holding periods to decrease, that is, the regression (14) can be interpreted similarly to our baseline specification (12) with an opposite sign. In this setting, however, the β_1 coefficient only captures resales initiated after the premature death of the treated artist. Table 11 shows that the coefficient is significantly negative, corresponding to a fall in holding period of about $\exp(-1.398)-1=75.3\%$. This result confirms that turnover increases after death in the small repeat-sale sample, as predicted by our model.

4. Alternative Explanations

In this section, we discuss candidate alternative mechanics which may rationalize why volume increases after death.

4.1 Volume increase as a consequence of the price increase

We first examine the possibility that the volume results are a consequence of the results on prices. One could naturally expect that more expensive artworks are more likely to be auctioned. For instance, fixed costs can lead to art pieces being present in auctions only when their prices are above a threshold. This suggests that the effect of death on volume could follow mechanically from

Table 11
Impact of artist death on holding periods

	With control group	Without control group
Deceased ≤65 at purchase	−1.398	−1.506
t-stat	(−6.19)	(−6.88)
Year and age fixed effects	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	792	457
No. of artists (treated + controls)	50+49	50

This table shows the β_1 coefficient in Equation (14), which captures the change in the log annual holding period for treated artists who are deceased at purchase. The sample consists of repeat-sales for artists who passed away at the age of 65 or younger, as well as their matched controls (left column). We also report estimates with treated artists only in the right column. Standard errors are clustered at the artist level.

its effect on prices. We can address that channel by modifying the regression (12) to directly control for the artist-level prices. To do so, we construct artist-level price indices by interacting artists and year fixed effects and include these indices in a hedonic regression:

$$\log P_{i,t,k} = \beta_0 + \delta_{i,t} + \gamma_2' \text{Artwork}_{i,t,k} + \epsilon_{i,t,k}, \tag{15}$$

for artwork k, artist i and in year t. Coefficients $\delta_{i,t}$ in this regression correspond to the average log price of same-quality works sold for each artist-year (whereby the vector $\text{Artwork}_{i,t,k}$ incorporates the artwork-specific characteristics listed at Equation (11)). We then run Equation (12), while controlling for our (log) artist price indices. Note that, as in Equation (11), we can only work with the smaller sample of artists who had an active auction market by the time of their death. Furthermore, even for this smaller subset of artists, there are some years with zero volume, for which prices are not observed. In this case, we linearly interpolate to get a continuous series (we find similar results if we do not interpolate). Table 12 shows the impact of death on volume, once we control for average prices. The coefficient associated with average prices is significantly positive, implying a positive partial price-volume correlation. Nevertheless, the β_1 coefficient retains statistical significance and is about the same as our baseline estimate.[25] This result indicates that the volume death effect is not a consequence of the price increase after death.

4.2 Portfolio rebalancing explanation

Another possibility is that the price increase leads some collectors to rebalance their collections. This reallocation would translate into higher transaction volume. This channel predicts again that the effect of death on volume follows mechanically from the death effect on prices, which the results in the previous subsection suggests is unplausible. In addition, this channel would predict a

[25] If we use the smaller sample but exclude the price index controls, the β_1 estimates are slightly higher, as expected (0.544 with the control group and 0.467 without).

Table 12
Impact of artist death on volume: Controlling for artist prices

	With control group	Without control group
$\delta_{i,t}$	0.168	0.138
t-stat	(3.59)	(1.99)
Deceased ≤65 years	0.458	0.420
t-stat	(3.48)	(3.14)
Year and age fixed effects	Yes	Yes
Artist fixed effects	Yes	Yes
No. of observations	4,993	2,467
No. of artists (treated + matched controls)	72+72	72

This table shows the β_1 coefficients in Equation (12), while controlling for the average price of items sold for each artist-year. The sample consists of active artists who passed away at the age of 65 or younger, together with their matched controls (left column). We also report estimates with treated artists only in the right column. The log artist price index $\delta_{i,t}$ is constructed according to Equation (15) and is linearly interpolated in the absence of trading volume for a given artist-year. Standard errors are clustered at the artist level.

temporary effect on volume, unlike our model which predicts a permanent increase. Although transaction costs and inattentive collectors may slow the process of portfolio adjustment, rebalancing is unlikely to last for more than 10 years with no sign of abatement, as we find in Figure 3.

Another key difference is that the portfolio rebalancing explanation predicts that most of the increased volume should come from sellers who owned the artwork prior to the death.[26] However, of the 735 transactions that we observe after the treated artists' premature death, only a tiny fraction (4.4%, or 34) were purchased prior to the death of the artist. In Section 3.6, we presented evidence that turnover increases after death, as predicted by our model. The regression design (Equation (14)), in fact, allows us to verify that this increased turnover (a decrease in holding periods) is not mostly caused by sellers who owned the artwork prior to the artist's death. Concretely, the portfolio rebalancing explanation would have predicted $\beta_1 = 0$, in contrast to what we find in the data (Table 11).

4.3 Notoriety

A possible alternative explanation for our results is that death increases an artist's notoriety, in a way that is not well-captured by our controls for notoriety, and that more famous artists trade more often. One can reasonably expect that death increases notoriety. Vincent van Gogh is a well-known example. Recall that, in Table 9, we found that the death effect is absent for artists with low fame, suggesting that van Gogh's story is, if anything, the exception rather than the rule.[27] Further, the effect on prices and volume declines with the age at death (Figure 2), which means that if increases in notoriety that are imperfectly captured by our controls were the cause of the volume and

[26] We are grateful to a referee for suggesting this prediction.

[27] This popular example is, in fact, inaccurate, as Van Gogh (1853–1890) began receiving attention in the final 2 years of his life (Naifeh and Smith 2011).

price effects, the change in notoriety should decrease with age of death. While this seems plausible—artists who are older are probably more famous—this is difficult to square with the observation that the death effect is absent for artists with low fame. In addition, we find that the effect on volume remains about the same when we control for the increases in artists' post-death prices (Table 12). This means that an artist's added notoriety following death has to affect volume in a way that is orthogonal not only to our set of controls but also to price changes. Nevertheless, it is worthwhile to explore further if media exposure or exhibitions increase durably after an artist's premature death, so that these notoriety measures can be candidates to explain the permanent changes in prices and volume that we observe. We perform two tests: (1) we compare the number of exhibitions (including retrospectives) of the treated and control artists in the relevant time spans, and (2) we compare the number of times an artist is mentioned in the media (press) in the year before and after his death, while excluding the obituaries in the week or month after his decease.

For our first test, we use data from Artfacts.net that catalogs exhibitions of a wide range of artists; the exhibition data go back to the 19th century. We identified 5,510 solo exhibitions for treated artists and 6,237 solo exhibitions for the matched artists in the Artfacts.net data. We do not find any statistical differences in the number of exhibitions between treated and matched artists for several time windows: the 2 (3) years prior to the death of the treated artist, the 2 (3) subsequent years, the life span of the treated artist, or the time span subsequent to the treated artist's death.

As a second test, we search for all mentions of our treated artists, in Factiva, a global news monitoring database in the year before and after their deaths. This media database comprises seven main search categories (Dow Jones, All, Publications, Web News, Blogs, Pictures, Multimedia). The vast majority of our hits come from the category of Publications, which includes mainly articles in newspapers and magazines in 28 languages since 1990. We would like to measure a change in artist's notoriety but need to correct for the number of articles reporting the artist's death. Therefore, we partition the articles into those that provide information about the artists and their oeuvre and those that are triggered by their decease (and hence are merely obituaries).[28] Since we use Factiva data starting in 1990, we have only 55 treated artists. On average, 32.7 articles were written around the world in the year before an artist's deaths. In the subsequent year (including the date of decease), the average number of articles written about an artist is 77.6, which is (borderline) significantly different from the number prior to death (with a t-value of 1.71). When we exclude the articles including an obituary in the week (month) after the passing of an artist, we do not find a significant difference between these 2 years at the usual confidence levels (t-value is 1.36).

[28] We screened all articles in English, French, German, Dutch, Italian, and Spanish and used Google Translate for other languages.

Overall, our tests do not indicate a significant increase in our treated artists' exposure through media (articles in newspapers and magazines) or exhibitions just after an artists' deaths.

4.4 Estate sales

One possible explanation for the increase in sales–though not for the simultaneous increase in prices—is that following decease, an artist's holdings of her own work would be sold off, increasing total sales. If these estate sales were the reason for our volume results, one would expect that the death effect on volume would increase with age because older artists should be able to accumulate a larger inventory of their own work, but our results in Figure 2 show that the volume effect declines substantially with age. In addition, the majority of artists' estates/foundations appoint one or more galleries to handle sales instead of auction houses. This setup makes it less likely that sales by estates would add to the auction sales that we use, at least for the first few years, when the volume effect is already clearly present.

For 92% of the artists in our first fame tercile, which as Table 9 shows, is largely responsible for our results, we were able to identify the galleries appointed by estates. In the Blouin data set, we did not find references to artists' estates in the provenance included in auction catalogues. Next, we searched for auction sales by an artist's family following an artist's death, in order to examine whether such sales affect volume after death. The percentage of sales by an artist's family is very small; these sales cannot be responsible for the increase in volume after the artist's death.[29] An artist's heirs or trustees of the estate/foundation are often interested in increasing the reputation of the deceased and galleries, particularly those who have had a long-term relationship with the artist, are often committed to her legacy. A representing gallery may also help underwrite the production of a "catalogue raisonné" and organize exhibits at the gallery or interested museums. In addition, auction houses do not have access to art fairs, an important venue for finding buyers. Finally, auction houses have a mixed reputation among artists. As Chuck Close, the great American painter and photographer, who has been represented since the last century by New York's Pace Gallery and London's White Cube, told the *New York Times*, "the last thing I want messing around with my career is an auction house" (Pogrebin 2017).

4.5 Shift in sales channels

Our model predicts an increase in volume in the secondary market for artworks. We noted earlier that auction houses primarily serve the secondary market,

[29] In the Blouin database in 2007–2016, we found fewer than 38 artworks by artists who died in the previous year in which family ownership is mentioned. This represents less than 0.5% of the sales of works by artists who died in the prior year in which provenance information is provided. The equivalent numbers are less than 0.25% in the subsequent years.

but dealers are also active in this market. Because we only observe auction transactions, this creates a measurement error problem. Our design implicitly assumes that death does not change the ratio of auctioned work over the total number of works sold in the secondary market. The concern is thus that our volume result is due to an increase in the share of auctioned work in the secondary market.

As artists age, the supply available in the secondary market grows relative to the supply in the primary market. Thus, even if the share of auctions in the secondary market stays constant, the fraction of total trades in auctions would grow. This mechanical effect is fully absorbed by time and age fixed effects in our diff-in-diff specifications. The threat to identification for our volume result would be that death, not age or time, has a causal effect on the likelihood that an object is sold at auction rather than through a dealer. We can think of two reasons this would be the case. First, more expensive artworks could be more likely to be auctioned. A death-induced increase in price would then increase the share of auctioned work in the secondary market. Table 12 shows a positive partial correlation between artist prices and volume, but this effect does not offset the effect of death on volume. Second, galleries representing an artist could be offering the artist's unsold inventory for sale, after the artist's death, through auctions rather than directly to the gallery's private clients. In Section 4.4 we argued that this is an unlikely explanation for the death effect on volume, notably because the effect declines markedly with age (Figure 2), which contradicts the intuition that older artists should have larger estates.

Nonetheless, we perform three additional exercises to examine whether the share of auctioned works in the secondary market shifts markedly after the premature death. First, we consulted Artsy.net, which reports works currently on sale via galleries and dealers (but not historical gallery sales) as well as recent auction records.[30] Artsy offers us a snapshot of the works sold by galleries, which combines the primary market (PM) of representing galleries (for living artists) and the secondary dealers' market (SDM) comprising sales of galleries/dealers, and, of the auctioned market (AM). We cannot perform a proper diff-in-diff analysis because of the lack of historical private sales data, but we can compare the sales volume of living and deceased artists.

We thus only compare the ratio of auctioned works, for the sample of control artists who are still alive and for the sample of treated artists who are now deceased (see Section 2.3). Another caveat is that living artists are still producing and selling through galleries meaning that the ratio of auctioned works in the secondary market must increase after death.[31] The ratio of auctioned works is indeed larger for dead artists than for living artists (0.32 vs. 0.20), but the difference is not statistically significant (t-stat of 0.33 for

[30] We are thankful to one referee for making this suggestion.

[31] For the living artist, this ratio amounts to AM/(PM+SDM+AM) for living versus AM/(SDM+AM) for dead artists.

73 pairs). We also find that the SDM remains large for artists who died long ago. The auctioned ratio for the treated artists who died long ago (0.23) is essentially the same as for the matched dead (of the control sample) who died more recently (0.21). Overall, we do not find evidence in the Artsy data of a major change in the sales channels over time.

Second, we asked 96 leading galleries/dealers around the world about how their sales would be affected by artists' deaths and how they would adjust their sales policy. From the galleries' responses, we have no evidence that an increase in volume in the auction market results from galleries dumping their inventory through auctions. Most responding galleries state that artists' deaths would not significantly affect their sales policy.

Third, we tried to identify the degree to which galleries/dealers and art fairs are mentioned in the provenance of the auction catalogues (in the Blouin database) issued between 2007 and 2016 by means of textual analysis. We compare the number of gallery sales mentioned in auction-sale catalogues before and after death. We fail to find any significant difference, what gives indirect evidence of no large shift in gallery sales.

5. Conclusions

We studied the impact of an exogenous negative supply shock to the float in the art market, namely, the impact of the premature and unexpected death of an artist on art prices and the volume of transactions. When collectors have fluctuating heterogeneous beliefs, since they cannot sell short, prices overweigh optimists' beliefs and have a speculative component that reflects the resale option. If collectors have limited capacity to bear risk, a decrease in float would increase the value and the frequency of the exercise of this resale option, increasing prices and turnover. If the production of new art diminishes on average as artists age, the effects on price and turnover should decline with the age of the artist's death. This is indeed the case according to our difference-in-differences experiment where we compare price-volume following an artists' death to price-volume of artists who survive the treated artist, but are otherwise close in terms of age, "fame," market value and transaction frequency. We document that premature death increases prices by 54.7% while volume goes up by 63.2%.

We also perform a sensitivity analysis on the definition of premature death (initially set at 65 years) and show that the death effect is more pronounced when the age at death is lower, reflecting a potentially larger un-produced body of work. In addition, we show that the death effect is only present when the artist had achieved, while alive, sufficient notoriety. Robustness tests varying the definitions of premature and notoriety, and testing different (sub)samples confirm these results. A placebo test reassuringly shows that the death effect in a pseudo-data-set is insignificant. We also exclude the possibility that our findings of price-volume increases are driven by art investors' portfolio reallocation or that the volume effect is merely a consequence of the price effect.

Using data on auctions of paintings by artists who survived to at least the age of 70, recorded by Blouin in 1957–2016, we calculate that our average prematurely deceased artist left unproduced half of her potential oeuvre. Remarkably, the resultant estimate of the price impact of this loss of float is comparable to the one produced by Cochrane (2003) for the speculative episode involving internet stocks or using the data in Xiong and Yu (2011) on speculation on Chinese warrants. Nonetheless, while the Chinese warrants had expiration dates and internet speculation imploded during the first semester of 2000, our results on price and volume over the long-term (10+ years) and a repeat-sales analysis indicate that a premature artist's death produces a permanent shock to prices and volume. The presence of these permanent effects supports the arguments in Glaeser et al. (2008) or Scheinkman (2014) on the role of supply responses on the implosion of speculative episodes.[32]

Appendix: Proofs

Proof of Proposition 1: In a corner equilibrium only the optimists hold artworks and hence

$$\theta^h - \theta^\ell \geq \gamma(x(\theta^h, p_t, E_t p_{t+1}) - x(\theta^\ell, p_t, E_t p_{t+1})) = 2\gamma N_t. \tag{A1}$$

In turn in an interior equilibrium, where both types hold artworks

$$\theta^h - \theta^\ell = \gamma(x(\theta^h, p_t, E_t p_{t+1}) - x(\theta^\ell, p_t, E_t p_{t+1})) < 2\gamma N_t. \tag{A2}$$

Hence, we obtain claim [a]. In addition, the first equality in Equation (A2) and market clearing imply claim [b]. □

Proof of Proposition 2: If $\tau < \upsilon$ then p_τ is a corner equilibrium and optimists hold $2N_\tau$ artworks per capita and thus item [a] holds. On the other hand, if $\tau \geq \upsilon$ then (9) holds with equality for both types. Adding these two equations one obtains item ([b]). The last item is then obvious. □

Proof of Proposition 3: If $p^{\cdot}(N_t)$ are corner equilibria then differencing the first-order equalities that necessarily hold for θ^h we get, using the fact that optimists must hold $2N_t$ per capita,

$$p^e(N_t) - p_t^a(N_t) = \frac{1-\pi}{1+r}\left(p^e(N_t) - E_t p_{t+1}^a(N_{t+1})\right). \tag{A3}$$

On the other hand, when $p^{\cdot}(N_t)$ are interior, we can sum the first-order conditions for both types to obtain

$$2\bar{\theta} - 2\gamma N_t + \frac{p^e(N_t)}{1+r} - p^e(N_t) = 0$$

$$2\bar{\theta} - 2\gamma N_t + \frac{(1-\pi)E_t p_{t+1}^a(N_{t+1}) + \pi p^e(N_t)}{1+r} - p_t^a(N_t) = 0$$

[32] As documented by Ofek and Richardson (2003), the dot-com price crash was linked to the increase in float that resulted from an unprecedented level of lockup expirations and insider selling.

Differencing these last two expressions we again obtain (A3) that thus hold in every equilibrium. If for some t, $p_t^a(N_t) > p^e(N_t)$ then, since $N_{t+1} > N_t$, Proposition 2 implies:

$$E_t[p_{t+1}^a(N_{t+1}) - p^e(N_{t+1})] > \frac{1+r}{1-\pi}(p_t^a(N_t) - p^e(N_t))$$

and the law of iterate expectations implies:

$$\lim_{s\to\infty} E_t p_{t+s}^a(N_{t+s}) \geq \lim_{s\to\infty} E_t[p_{t+s}^a(N_{t+s}) - p^e(N_{t+s})] > \left(\frac{1+r}{1-\pi}\right)^s (p_t^a(N_t) - p^e(N_t)),$$

what violates the transversality condition, Assumption 3. Thus, we must have $p_t^a(N_t) \leq p^e(N_t)$. In addition, for each realization of N_{t+1}, since $p^e(N_{t+1}) < p^e(N_t)$,

$$p^e(N_t) - p_t^a(N_t) = \frac{1-\pi}{1+r}\left(p^e(N_t) - E_t p_{t+1}^a(N_{t+1})\right) > \frac{1-\pi}{1+r}\left(p^e(N_{t+1}) - E_t p_{t+1}^a(N_{t+1})\right)$$

Thus $p_t^a(N_t) < p^e(N_t)$. Furthermore, equation (A3) implies $p^e(N_t) - p_t^a(N_t) < \left(p^e(N_t) - E_t p_{t+1}^a(N_{t+1})\right)$ what completes the proof of item [a]. Also, from (A3) and the law of iterated expectations we obtain:

$$E[p^e(N_{t+1}) - p_{t+1}^a(N_{t+1})] = \left(1 + \frac{r+\pi}{1-\pi}\right) E[p^e(N_t) - p_t^a(N_t)] - E[p^e(N_t) - p^e(N_{t+1})]. \quad \text{(A4)}$$

Suppose item [b] is false, that is $E[p^e(N_{t+1}) - p_{t+1}^a(N_{t+1})] > E[p^e(N_t) - p_t^a(N_t)]$ for some t. Then $\frac{r+\pi}{1-\pi} E[p^e(N_t) - p_t^a(N_t)] > E[p^e(N_t) - p^e(N_{t+1})]$ and thus $\frac{r+\pi}{1-\pi} E[p^e(N_{t+1}) - Ep_{t+1}^a(N_{t+1})] > E[p^e(N_t) - p^e(N_{t+1})]$. Furthermore, Proposition 2 implies that since $E[N_{t+1} - N_t]$ decreases with t then,

$$E[p^e(N_{t+s}) - p^e(N_{t+s+1})] \text{ strictly decreases with } s. \quad \text{(A5)}$$

To verify (A5) consider a vector of equilibria $(p^e(N_{t+s}), p^e(N_{t+s+1}), p^e(N_{t+s+1}), p^e(N_{t+s+2}))$ and associate to this equilibrium a vector of C's and I's describing whether each entry is a corner or interior equilibrium. Since the supply process is increasing, all C's must appear before any I. Using Proposition 2 and simple algebra verifies (A5). As a consequence,

$$\frac{r+\pi}{1-\pi} E[p^e(N_{t+1}) - p_{t+1}^a(N_{t+1})] > E[p^e(N_{t+1}) - p^e(N_{t+2})].$$

From Equation (A4) and item [a] established above, it follows that $E[(p^e(N_{t+2}) - p_{t+2}^a(N_{t+2})] > E[(p^e(N_{t+1}) - p_{t+1}^a(N_{t+1})]$. In turn, by our contradiction hypothesis $E[(p^e(N_{t+1}) - p_{t+1}^a(N_{t+1})] > E[p^e(N_t) - p_t^a(N_t)] > 0$. Thus for any $s > 0$, $E_t[p^e(N_{t+s}) - p_{t+s}^a(N_{t+s})]$ is a positive increasing sequence. In addition, Proposition 2 and Assumption 2 insure that there exists a $T > 0$ such that for each $t' \geq T$, $E[p^e(N_{t'}) - p^e(N_{t'+1})] < \frac{\pi}{1-\pi} E[p^e(N_t) - p_t^a(N_t)]$ and thus for $s \geq \max\{T - t, 0\}$, from (A4)

$$E[p^e(N_{t+s+1}) - p_{t+s+1}^a(N_{t+s+1})] \geq \left(1 + \frac{r}{1-\pi}\right) E[p^e(N_{t+s}) - p_{t+s}^a(N_{t+s})], \quad \text{(A6)}$$

Hence for any $s' > s$

$$\left(1 + \frac{r}{1-\pi}\right)^{s'} E[p^e(N_t) - p_t^a(N_t)] \leq E[p^e(N_{t+s'}) - p_{t+s'+1}^a(N_{t+s'+1})] \leq Ep^e(N_t),$$

a contradiction. □

To prove Proposition 4 we first establish a result on the change in turnover at death, conditional on the history of supply until death.

Lemma A.1. Suppose an artist dies at a date τ. Conditional on the history of supply $\{N_s\}_{\{s\leq\tau\}}$, the change in turnover between τ and any future period $\tau'>\tau$ is independent of τ' and equals:

[i] If $\tau<\upsilon$

$$\frac{1}{2}-\frac{N_{\tau-1}}{2N_\tau}. \tag{A7}$$

[ii] If $\tau\geq\upsilon$ and $\tau-1<\upsilon$

$$\min\left\{\frac{1}{4}-\frac{N_{\tau-1}}{2N_\tau}+\frac{\theta^h-\theta^\ell}{8\gamma N_\tau};\frac{\theta^h-\theta^\ell}{4\gamma N_\tau}\right\} \tag{A8}$$

[iii] If $\tau-1\geq\upsilon$

$$\min\left\{\frac{1}{4}-\frac{N_{\tau-1}}{4N_\tau};\frac{\theta^h-\theta^\ell}{4\gamma N_\tau}\right\} \tag{A9}$$

Proof: If $\tau<\upsilon$ equilibrium at any period $t<\tau$ is a corner equilibrium. In period τ, with probability 1/2, secondary market trading volume is zero and with probability 1/2, secondary trading volume is $N_{\tau-1}$, since the new optimists first purchase new output. Thus conditional on the history of supply until period τ, the average volume in the secondary market in period τ is $\frac{N_{\tau-1}}{2}$ and average turnover equals $\frac{N_{\tau-1}}{2N_\tau}$. From period $\tau+1$ on, all trading takes place in the secondary market and with probability 1/2 trading volume is zero and with probability 1/2, trading volume is N_τ. Thus, both average volume, which equals $\frac{N_\tau}{2}$, and turnover, which equals $\frac{N_\tau}{2N_\tau}=\frac{1}{2}$, increase following the death of an artist. Hence, the average increase in turnover of an artist who dies young, conditional on the history $\{N_t\}_{t=0}^{\tau}$ is

$$\frac{1}{2}-\frac{N_{\tau-1}}{2N_\tau}.$$

what establishes item A.1.

Consider now an artist that dies at $\tau\geq\upsilon$, that is an interior equilibrium at death. Proposition 1 states that at each $\tau+s\geq\upsilon$

$$x(\theta^h,p_{\tau+s},E_t p_{\tau+s+1})=N_{\tau+s}+\frac{\theta^h-\theta^\ell}{2\gamma}$$

$$x(\theta^\ell,p_{\tau+s},E_t p_{\tau+s+1})=N_{\tau+s}-\frac{\theta^h-\theta^\ell}{2\gamma}.$$

Thus, conditional on the history of N_s, for $s\leq\tau$, average turnover after death equals:

$$\frac{\theta^h-\theta^\ell}{4\gamma N_\tau}. \tag{A10}$$

If a corner equilibrium obtains in period $\tau-1$, then with probability $1/2$, we get no trading and with probability $1/2$ trading equals

$$\frac{1}{2}\max\left\{2N_{\tau-1}-N_\tau+\frac{\theta^h-\theta^\ell}{2\gamma};0\right\} \tag{A11}$$

Thus conditional on the history of N_s, for $s\leq\tau$, average turnover in the period when the artists dies equals

$$\frac{1}{4}\max\left\{\frac{2N_{\tau-1}}{N_\tau}-1+\frac{\theta^h-\theta^\ell}{2\gamma N_\tau};0\right\} \tag{A12}$$

Thus, conditional on the history of N_s, for $s \leq \tau$, the average change in turnover at death equals:

$$\frac{\theta^h-\theta^\ell}{4\gamma N_\tau}-\max\left\{\frac{N_{\tau-1}}{2N_{\tau+\sigma}}-\frac{1}{4}+\frac{\theta^h-\theta^\ell}{8\gamma N_\tau};0\right\}=$$

$$\frac{\theta^h-\theta^\ell}{4\gamma N_\tau}+\min\left\{\frac{1}{4}-\frac{N_{\tau-1}}{2N_\tau}-\frac{\theta^h-\theta^\ell}{8\gamma N_\tau};0\right\}=$$

$$\min\left\{\frac{1}{4}-\frac{N_{\tau-1}}{2N_\tau}+\frac{\theta^h-\theta^\ell}{8\gamma N_\tau};\frac{\theta^h-\theta^\ell}{4\gamma N_\tau}\right\},$$

establishing item A.1.

If a interior equilibrium holds at $\tau-1$ then turnover in the secondary market at τ is zero with probability 1/2 and equals:

$$\max\left\{\frac{N_{\tau-1}}{2N_\tau}-\frac{1}{2}+\frac{\theta^h-\theta^\ell}{2\gamma N_\tau};0\right\} \tag{A13}$$

with probability 1/2. Thus conditional on the history of N_s for , $s \leq \tau$, the change in average turnover in the period when the artists dies equals

$$\frac{\theta^h-\theta^\ell}{4\gamma N_\tau}+\min\left\{\frac{1}{4}-\frac{N_{\tau-1}}{4N_\tau}-\frac{\theta^h-\theta^\ell}{4\gamma N_\tau};0\right\}=\min\left\{\frac{1}{4}-\frac{N_{\tau-1}}{4N_\tau};\frac{\theta^h-\theta^\ell}{4\gamma N_\tau}\right\},$$

What establishes item A.1. □

Proof of Proposition 4: It is easy to check that Assumption 1 guarantees that each of the expressions (A7)-(A9) is positive, what establishes item [a]. In addition, υ is a deterministic function of ω, and Assumption 1 guarantees that the expressions (A7)-(A9) decline with the age of death τ. For each $t \geq 1$ let $\Omega_t^1=\{\omega: t<\upsilon\}$, $\Omega_t^2=\{\omega: t-1<\upsilon \leq t\}$, and $\Omega_t^3=\{\omega: t-1 \geq \upsilon\}$. Thus the change in turnover at t in history ω , $g(t,\omega)$, equals expression (A7) if $\omega \in \Omega_t^1$, expression (A8) if $\omega \in \Omega_t^2$, and expression (A9) if $\omega \in \Omega_t^3$. For any t, if $\omega \in \Omega_t^2$, since $\frac{\theta^h-\theta^\ell}{2\gamma N_t}<1$,

$$\min\left\{\frac{1}{4}-\frac{N_{t-1}}{2N_t}+\frac{\theta^h-\theta^\ell}{8\gamma N_t};\frac{\theta^h-\theta^\ell}{4\gamma N_t}\right\}\leq\frac{1}{4}-\frac{N_{t-1}}{2N_t}+\frac{\theta^h-\theta^\ell}{8\gamma N_t}<\frac{1}{2}-\frac{N_{t-1}}{2N_t} \tag{A14}$$

In addition if $\omega \in \Omega_t^2$, $\omega \in \Omega_{t+1}^3$, and since $\frac{\theta^h-\theta^\ell}{2\gamma N_t}<1$

$$\begin{aligned}\min\left\{\frac{1}{4}-\frac{N_t}{4N_{t+1}};\frac{\theta^h-\theta^\ell}{4\gamma N_{t+1}}\right\} &< \min\left\{\frac{1}{4}-\frac{N_t}{2N_{t+1}}+\frac{\theta^h-\theta^\ell}{8\gamma N_{t+1}};\frac{\theta^h-\theta^\ell}{4\gamma N_{t+1}}\right\}\\ &< \frac{1}{2}-\frac{N_t}{2N_{t+1}}\end{aligned} \tag{A15}$$

If $\omega \in \Omega_t^1$ and $t'>t$ then Equations (A14) and (A15) and the monotonicity of the expressions (A7)-(A9) guarantee that $g(t',\omega)<g(t,\omega)$. If $\omega \in \Omega_t^2$ and $t'>t$, then $\omega \in \Omega_{t'}^3$. The first inequality in Equation (A15) and the monotonicity of the expressions (A8) and (A9) insure that $g(t',\omega)<g(t,\omega)$. Finally, if $\omega \in \Omega_t^3$ and $t'>t$, then $t' \in \Omega_t^3$, and the monotonicity of $g(t,\cdot)$ follows from the monotonicity of expression (A9). This establishes that item [b] holds. □

References

Alden, W. 2015. Art for money's sake. New York Times Magazine.

Allen, F., and D. Gale. 1998. Optimal financial crises. *Journal of Finance* 53:1245–84.

Ashenfelter, O., and K. Graddy. 2003. Auctions and the price of art. *Journal of Economic Literature* 41:763–86.

Azoulay, P., J. S. Graff Zivin, and J. Wang. 2010. Superstar extinction. *Quarterly Journal of Economics* 125:549–89.

Barberis, N., R. Greenwood, L. Jin, and A. Shleifer. 2018. Extrapolation and bubbles. *Journal of Financial Economics* 129:203–27.

Beggs, A., and K. Graddy. 2009. Anchoring effects: Evidence from art auctions, *American Economic Review* 99:1027–39.

Bernales, A., L. Reus, and V. Valdenegro. 2019. Art market bubbles, limited art supply and collectors' wealth. Technical Report, Universidad de Chile.

Bertrand, M., E. Duflo, and S. Mullainathan. 2004. How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics* 119:249–75.

Cameron, A. C., and P. K. Trivedi. 1998. *Regression analysis of count data*. Cambridge, UK: Cambridge University Press.

Cochrane, J. H. 2003. Stocks as money: Convenience yield and the tech-stock bubble. In *Asset price bubbles: The implications for monetary, regulatory, and international policies*, eds. W. C. Hunter, G. G. Kaufman, and M. Pomerleano. Cambridge: MIT Press.

De Wilt, K. 2006. *Rembrandt Inc. – marktstrategieen van een genie*. Amsterdam, the Netherlands: New Amsterdam.

Ekelund, R. B., R. W. Ressler, and J. K. Watson. 2000. The "death-effect" in art prices: A demand-side exploration. *Journal of Cultural Economics* 24:283–300.

Galenson, D. W., and B. A. Weinberg. 2000. Age and the quality of work: The case of Modern American painters. *Journal of Political Economy* 108:761–77.

Glaeser, E. L., J. Gyourko, and A. Saiz. 2008. Housing supply and housing bubbles. *Journal of Urban Economics* 64:198–217.

Guggenheim, P. 1997. *Confessions of an Art Addict* (Ecco).

Harrison, J. M., and D. M. Kreps. 1978. Speculative investor behavior in a stock market with heterogeneous expectations. *Quarterly Journal of Economics* 92:323–36.

Hausman, J., B. H. Hall, and Z. Griliches. 1984. Econometric models for count data with an application to the patents-R&D relationship. *Econometrica* 52:909–38.

Hong, H. G., J. A. Scheinkman, and W. Xiong. 2006. Asset float and speculative bubbles. *Journal of Finance* 61:1073–117.

Iacus, S. M., G. King, and G. Porro. 2012. Causal inference without balance checking: Coarsened exact matching. *Political Analysis* 20:1–24.

Korteweg, A., R. Kräussl, and P. Verwijmeren. 2016. Does it pay to invest in art? A selection-corrected returns perspective. *Review of Financial Studies* 29:1007–38.

Lovo, S., and C. Spaenjers. 2018. A model of trading and price indexes in the art market. *American Economic Review* 108:744–74.

Maddison, D., and A. J. Pedersen. 2008. The death effect in art prices: Evidence from Denmark. *Applied Economics* 40:1789–93.

Matheson, V. A., and R. A. Baade. 2004. 'Death effect' on collectible prices. *Applied Economics* 36:1151–55.

Mei, J., and M. Moses. 2005. Vested interest and biased price estimates: Evidence from an auction market. *Journal of Finance* 60:2409–35.

Mei, J., J. A. Scheinkman, and W. Xiong. 2009. Speculative trading and stock prices: Evidence from Chinese AB share premia. *Annals of Economics and Finance* 10:225–55.

Naifeh, S. W., and Smith, G. W. 2011. *Van Gogh: The Life*. Random House Incorporated.

Nutz, M., and J. A. Scheinkman. 2020. Shorting in speculative markets. *Journal of Finance* 75(2):995–1036.

Ofek, E., and M. Richardson. 2003. DotCom mania: The rise and fall of internet stock prices. *Journal of Finance* 58:1113–38.

Pénasse, J., and L. Renneboog. 2017. Speculative trading and bubbles: Evidence from the art market. Technical Report, University of Luxembourg.

Pesando, J. E. 1993. Art as an investment: The market for modern prints, *American Economic Review* 83:1075–89.

Picinati di Torcello, A., and A. Petterson. 2014. Art & Finance Report 2014. Technical Report, Deloitte Luxembourg and ArtTactic.

Pogrebin, R. 2017. As top-tier artists age, the art world hopes to cash in. *New York Times*, January 30. https://www.nytimes.com/2017/01/30/arts/design/decision-time-for-aging-artists.html

Pownall, R. A. J. 2017. Tefaf Art Market Report 2017. Technical Report, European Fine Art Foundation.

Renneboog, L., and C. Spaenjers. 2013. Buying beauty: On prices and returns in the art market. *Management Science* 59:36–53.

Reyburn, S. 2014. For Art Collectors, the Risk Behind the High Returns. International New York Times.

Scheinkman, J. A. 2014. *Speculation, trading and bubbles*. New York: Columbia University Press.

Scheinkman, J. A., and W. Xiong. 2003. Overconfidence and speculative bubbles. *Journal of Political Economy* 111:1183–220.

Spieth, D. A. 2017, *Revolutionary Paris and the market for Netherlandish Art*. Leiden, Netherlands: Brill.

Trucco, T. 1989. British pension fund sells $65.6 million in artworks. *New York Times*, April 5.

Ursprung, H. W., and C. Wiermann. 2011. Reputation, price, and death: An empirical analysis of art price formation. *Economic Inquiry* 49:697–715.

Vogel, C. 2008. Damien Hirst goes for broke at Sotheby's. *New York Times*, September 14. https://www.nytimes.com/2008/09/14/world/europe/14iht-auction.4.16140388.html

Xiong, W., and J. Yu. 2011. The Chinese warrants bubble. *American Economic Review* 101:2723–53.