

# When a Master Dies: Speculation and Asset Float<sup>\*</sup>

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September 25, 2020

## Abstract

The death of an artist constitutes a negative shock to his future production; it permanently decreases the artist's float. We use this shock to test predictions of speculative trading models with short-selling constraints. Symmetrically to [Hong et al. \(2006\)](#), where an increase in float decreases turnover and price, an artist's premature death leads to an increase in prices and turnover. We document that, as predicted by our model, premature death increases prices (54.7%) and secondary market volume (63.2%) permanently, and this effect is larger if an artist dies young or is more famous.

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<sup>\*</sup>We would like to thank Marcelo Fernandes, Slava Fos, Ed Glaeser, Florian Heider, Harrison Hong, and seminar participants at Columbia University, at 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, 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.

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*Pour moi les tableaux de grand prix  
Sont ceux que plus cher on m'achète.  
Après tout, que m'importe le talent?*<sup>1</sup>

## I. Introduction

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.<sup>2</sup>

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, it is also less probable that a current owner's valuation will stay among the highest in the future,

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<sup>1</sup>"For me, highly priced paintings are those that I can sell ever more expensively. After all, why should I care about talent?" Quote from Forbeck, the art-dealer in the play "Rembrandt ou la Vente après décès" (by Charles-Guillaume Etienne, 1777-1845) (see Spieth 2017).

<sup>2</sup>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.

leading to a higher average turnover in the future.<sup>3</sup>

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 ten-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 earlier (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 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

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<sup>3</sup>[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.

when the artist dies at a younger age, when she presumably leaves a larger un-produced body of work. Fourth, for death to have an impact on prices and sales, the artist needs to have gained a reputation, otherwise 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 dataset 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 have not been studied often.<sup>4</sup> 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.<sup>5</sup> 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 art-works 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

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<sup>4</sup>The impact of supply-elasticity in speculative episodes in housing markets is modeled and documented in Glaeser et al. (2008).

<sup>5</sup>Our approach differs from these studies by its focus on premature and sudden deaths. In addition, our research design relies on the set up of a matched control group. A control group effectively pins down the counterfactual price and volume trajectories in the absence of premature and sudden death. In the absence of a matched sample, the control group consists of all non-treated artists. It is likely these artists exhibit different price and volume trajectories as they age, which would contaminate the estimate of the death effect. Our research design minimizes this risk by constructing a matched sample.

stand even after we add a control for yearly-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.

The remainder of the paper is structured as follows: In Section II we present a model of speculation where the premature death of an artist leads to a permanent increase in prices and turnover of her art-works and the effects on prices and turnover decline with the age of death.<sup>6</sup> In Section III, we detail our datasets and develop the empirical strategy and econometric considerations while in Section IV, we present the results and present robustness and placebo tests. Possible alternative explanations are discussed in Section V. Section VI concludes. An appendix contains some proofs.

## II. 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 lock-up expirations on the implosion of the internet bubble. In their model, pre-lock up holders of the stock are over-optimistic about insiders' valuation of future dividends. When lock-up 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 3-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

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<sup>6</sup>In independent work, [Bernales et al. \(2019\)](#) also study a model featuring risk-averse agents with heterogeneous beliefs, in which a reduction in supply leads to an increase in volume. [Lovo and Spaenjers \(2018\)](#) propose a model where trading also arises endogenously, but do not study the effect of a change in supply.

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.<sup>7</sup> A minor difference is that because there are no dividends associated with art works, art-buyers derive utility from holding art-works.

There are an infinite number of time periods  $t = 1, 2, \dots$ , and two goods: art and a numeraire non-art 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  $\pi$ , and if  $d_t = 1$  then  $d_{t+1} = 1$ . Thus if an artist is alive in period  $t$ , the probability that she 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  $\alpha_t$  is a positive random variable independent of the past realizations of  $N_s$ ,*

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<sup>7</sup>Although [Hong et al. \(2006\)](#) considers an infinite horizon model all the action in the model occurs before period 2 when all supply uncertainty disappears.

$$s \leq t - 1.$$

[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  $\alpha_t$  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 (non-art) good and access to a “risk-free” technology on the non-art 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. The coefficient  $\theta_t^i$  at time  $t$  reflects a public signal that each group of buyers interprets differently. More precisely, we use a third independent process,  $\theta$ , 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.<sup>8</sup> Before trading at  $t$  occurs, all art buyers observe  $\theta_t$ . However the two groups disagree on the interpretation of  $\theta_t$ . The forecast of buyers in group  $i = 1, 2$ , conditional on  $\theta_t$ ,  $\theta_t^i$ , satisfies: (i)  $E^1[\theta_t^1|\theta_t] = \theta_t$  and (ii)  $E^1[\theta_t^1|\theta_t] + E^2[\theta_t^2|\theta_t] = \theta^\ell + \theta^h$ . We will refer to the group that forecasts  $\theta^h$  ( $\theta^\ell$ ) as optimists (pessimists).

Notice that exactly 1/2 of the art buyers have  $E[\theta_t|\theta_t] = \theta^\ell$ , 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  $\theta^i$  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.<sup>9</sup> A buyer of a group who has conditional expectation  $\theta^i$  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:

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

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

<sup>8</sup> $\theta_t$  i.i.d. is particularly convenient, since it eliminates one extra state-variable.

<sup>9</sup>As we argue in Remark 1 below, we could instead have assumed that agents agree on the utility associated with holding art-works but disagree about temporary shocks to prices next period.



holds with equality for the group with  $\theta_i^i = \theta^h$ . We will call an equilibrium in which (3) holds with inequality for  $\theta^\ell$  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  $\gamma$  and the current supply fully determines whether an equilibrium is interior or in a corner.

[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

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

the first time in which an artist produces enough art-work so that an interior equilibrium obtains. Since the process  $N_t$  is non-decreasing, an interior equilibrium holds for each  $t \geq v$ .

**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:

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

Inequality (7) ensures that the stopping time  $v > 1$ . The first inequality in (8) guarantees that  $v$  is always finite, that is, if an artist survives long enough, she will produce sufficient art-works so that an interior equilibrium obtains. The second inequality in (8) will insure that in a candidate equilibrium, the marginal utility of art-works is always positive.<sup>10</sup>

Since the realization of  $\theta_t$  does not affect aggregate demand, it is natural to assume that the price of art-works 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 consider equilibria after death. We let  $\tau = \max\{t : d_t = 0\} \geq 1$ . For convenience we refer to the stopping time  $\tau$  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

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

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

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

We can now prove:

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

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

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<sup>10</sup>The need for this assumption is a result of our use of quadratic utility to obtain explicit formulae.

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

[c] The price of art-works 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  $m > (1 + r)$

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

Assumption 3 states that the rate of growth of the price of art-work 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  $\tau$  then for any  $t \leq \tau$ ,

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

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

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  $s > 0$ ,  $E[p^e(N_t) - p_t^a(N_t)] \geq E[p^e(N_{t+s}) - p_{t+s}^a(N_{t+s})]$  that is, an artist that 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).

We next 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, *i.e.* where new works of art sell, or 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 art-works 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.<sup>11</sup>

**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*

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<sup>11</sup>Artists almost never use auctions as a primary market, as living artists usually have an agreement with galleries to sell through them. The only exception of a directly auctioned artist that we know of is Damien 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, 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 (14 Sept. 2008) 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'.

*expected amount of turnover change declines with the age of death.*

Thus, the turnover of an artist that dies always increases permanently after death<sup>12</sup> 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  $\varphi$  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  $\varphi_t$  ( $-\varphi_t$ ) 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  $v_1 < v_2$ , since  $v$  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  $\tau < v$ . 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 that 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]).

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<sup>12</sup>Lemma 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.

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.)

### III. Data and empirical strategy

#### A. *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 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 is both reliable and publicly available, and has 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 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 pre-sale 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 non-negligible.

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. 76 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.<sup>13</sup>

## *B. 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 compiled 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 dataset 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 one year before and one 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.

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<sup>13</sup>Buying art as an investment is not a recent phenomenon. The noted 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 \(1997\)](#), page 78.



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, and had at least 200 sales in auctions from 1957 to 2016.<sup>14</sup> 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 that 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 economic 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 encyclopaedia (including Grove Dictionary of Art/Oxford Art Online and Wikipedia). We report statistics on causes of death in Table I.

Each auction record contains information on the artist, artwork, and sale. We observe the name of the artist, his 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 dataset thus does not contain this information. The information on the art object includes title, year of creation (for about a 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 2015 US dollar equivalent hammer prices using the US

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

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.<sup>15</sup> 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.

### *C. 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 irrespective of whether the artist is alive or not 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

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<sup>15</sup>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.

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 that 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 that 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 that best satisfy these criteria. This procedure is similar to the identification strategy used by, e.g., 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 ten years before the death of the treated artist. We distinguish cases where the artist’s work has been auctioned prior to his death, to 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.<sup>16</sup>

Third, we require that a matched artist be born no more than ten 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 ten 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.<sup>17</sup> As an example, the algorithm matches Eva Hesse, one of the pioneers of post-minimalism, who died in 1970 at age 34, with the Japanese artist Yoko Ono (1933-), a key member of the *Fluxus* group. In an online appendix, we show the list of artists and their matches.<sup>18</sup>

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 allow 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 V.C.

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 II 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

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<sup>16</sup>Google nGram data is unavailable after 2008; for artists that died after that, we take Fame in 2008.

<sup>17</sup>We also considered a simpler procedure where we minimize the Euclidean distance for the vector of standardized matching variables and obtained similar regression results.

<sup>18</sup>Of course, only the overall composition of the control group matters for the regression results.

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 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, 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 ten 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.<sup>19</sup>

#### *D. 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

$$\log P_{i,t,k} = \beta_0 + \beta_1 \text{PostDeath}_{i,t} + \alpha_i + \delta_t + \gamma'_1 \text{Age}_{i,t} + \gamma'_2 \text{Artwork}_{i,t,k} + \gamma'_3 \text{Artist}_{i,t} + \epsilon_{itk}, \quad (11)$$

where  $P_{itk}$  denotes the auction price of artwork  $k$  for artist  $i$  in year  $t$ ,  $\text{PostDeath}$  is an indicator variable that switches to one from the artist's death year if the artist dies before 65,  $\alpha_i$  and  $\delta_t$  are artist and year fixed effects,  $\text{Age}_{i,t}$  corresponds to age brackets dummies in five-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

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<sup>19</sup>Although our sample contains both superstars and lesser known artists, Table II does not suggest that outliers may be present. We nevertheless verified that our results do not change when we winsorize prices and volume or drop the most traded artists.

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  $\beta_1$  indicates that artists command higher prices or volume on average after their death. We estimate the effect of death on prices in (11) by OLS. 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.

## IV. Results

### A. Main effect of premature death

Table III gives the resulting  $\beta_1$ -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 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 III, 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 IV. 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 \(2011\)](#).

## *B. Robustness*

We check the robustness of our main findings in Tables V to VIII. Our results stay the same when using the full sample of artists alive in 1957 (Table V): premature decease leads to both higher prices and volume, which respectively increase by 51.4% and 61.4%. The death of an artist can have an impact on his visibility and thus, on 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 each artist name in the English-language books digitized by Google Books.<sup>20</sup> The coefficients remain highly significant and effects are of similar magnitude (Table VI). In Table VII, 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.<sup>21</sup> Reassuringly, Table VII indicates that the death effect in this pseudo dataset on prices and volume is small and insignificant.

In Table VIII, 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 reported heart disease), accident, murder, suicide,<sup>22</sup> overdose, sudden disease, and complications from surgery. Deaths are classified as anticipated whenever

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<sup>20</sup>The results in Table VI are based on the shorter sample of artists for which Fame is available in the year of death, but same results hold if we use 2008 Fame for artists that died after 2008.

<sup>21</sup>We match the large majority of artists, yielding a sample only slightly smaller of 69 (235) treated artists in the price (volume) specification.

<sup>22</sup>One exception is Keith Vaughan's suicide, which was preceded by a diagnosed cancer two years before his death.



our source mentions that an artist was ill or in fragile condition. Table VIII 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.

### *C. Sensitivity to age at death*

We next explore the sensitivity of our result to the 65 year age cutoff. Death constitutes a negative shock to the future production of the artist. This shock is larger when the artist leaves a larger un-produced 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. In Figure 2, we report the coefficients for the 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 V. 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.

### *D. 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 IX shows results for artists whose Fame is within the top/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.

### *E. 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 (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 fifteen year period starting five years prior to the artist's death and ending ten years after her death. More concretely, the  $\beta_1$  coefficient is replaced by a  $15 \times 1$  vector and the PostDeath indicator is decomposed into 15 dummy variables. The first dummy is equal to one for observations up to five years prior to a treated artist death; the second dummy equals one in the fourth year prior to a treated artist death, etc. The 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.<sup>23</sup> 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 columns 1 in Panels A and B in Table III). We observe a sharp increase in both prices and volume on the year following death. The point estimates are all insignificant in the pre-treatment years and are all positive (mostly significant) for all years after the death of the artist.<sup>24</sup>

### *F. 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

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<sup>23</sup>Table II 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.

<sup>24</sup>We also find no evidence of extrapolative behavior, *e.g.* Barberis et al. (2018), as a result of death of an artist although extrapolation is most probably present in art markets (see Penasse and Renneboog 2017).

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  $t + j$ . Taking the difference of Equation (11) yields

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

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:

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

where  $r_{t,t+j} = \log P_{i,t+j,k} - \log P_{i,t,k}$  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 non-zero  $\beta_2$  tests whether treated artists earn different returns *after* their death—whether there is a drift in prices. Our theory predicts that the effect of death is permanent. We therefore expect an estimate of  $\beta_1$  that is close to the estimates presented in the top panel of Table III, and a  $\beta_2$  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” for instance), 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 dataset, each pair of transactions for the same item is a unique observation. We find 792 repeat sales for 50 treated artists that 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, because it consists of artists for whom we could find matching pairs, i.e., artists that are relatively more active on the secondary market than our baseline sample. Moreover, because the resale pairs are not randomly drawn, our  $\beta_1$ -estimates may be affected by selection bias, if collectors are more likely to resell an artwork whose price has increased.

We report the estimated  $\beta_1$ - and  $\beta_2$ -coefficients in Table X. 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,  $\beta_2$ -coefficients are small and indistinguishable from zero, indicating returns are not different after death. This confirms that the effect on prices is permanent.

We can also use the repeat-sale dataset to indirectly test if 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 if 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 resale year and age fixed effects:

$$h_{i,t,t+j} = \beta_0 + \beta_1 \text{Deceased}_{i,t} + \delta_{t+j} + \gamma'_1 \text{Age}_{i,t} + \gamma'_2 \text{Artist}_{i,t} + \epsilon_{i,t,t+j}. \quad (14)$$

Given that volume increases after death, we expect holding periods to decrease, i.e., the regression (14) can be interpreted similarly to our baseline specification (12) with an opposite sign. In this setting, however, the  $\beta_1$ -coefficient only captures resales initiated after the premature death of the treated artist. Table XI 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.

## V. Alternative explanations

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

### A. 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. It is natural to 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 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:

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

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 Eq. (11)). We then run Equation (12) while controlling for our (log) artist price indices. Note that, as

in Eq. (11), we can only work with the smaller sample of artists that 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 XII shows the impact of death on volume, once we control for average prices. The coefficient associated with average-prices is significantly positive, implying that there is indeed a positive partial price-volume correlation. Nevertheless, the  $\beta_1$  coefficient retains statistical significance and is about the same as our baseline estimate.<sup>25</sup> This result indicates that the volume death-effect is not a consequence of the price increase after death.

### *B. 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 unpalatable. In addition, this channel would predict a temporary effect on volume, unlike our model which predicts a permanent increase. Although transaction costs and inattentive collectors may slow down the process of portfolio adjustment, it is unlikely that rebalancing would last for more than ten 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.<sup>26</sup> However, out of 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 IV.F, we presented evidence that turnover increases after death, as predicted by our model. The regression design (Eq. (14)) in fact allowed us to verify that

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<sup>25</sup>If we use the smaller sample but exclude the price index controls, the  $\beta_1$  estimates are slightly higher, as expected (0.544 with the control group and 0.467 without).

<sup>26</sup>We are grateful to a referee for suggesting this prediction.

this increased turnover (a decrease in holding periods) is not caused mostly by sellers who owned the artwork prior to the death. Concretely, the portfolio rebalancing explanation would have predicted  $\beta_1 = 0$ , in contrast to what we find in the data (Table XI).

### *C. 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. It is reasonable to expect that death increases notoriety—Vincent van Gogh being a well-known example. Recall that, in Table IX, 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.<sup>27</sup> 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 price effects, the change in notoriety should decrease with age of death. While this seems plausible—artists that are older are probability 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 XII). This means that an artist's added notoriety following death has to affect volume in a way that is not only orthogonal 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: (i) we compare the number of exhibitions (including retrospectives) of the treated and control artists in relevant time-spans, and (ii) 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/month after decease.

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<sup>27</sup>It should be noted that this popular example is, in fact, inaccurate. According to the Van Gogh Museum, Van Gogh (1853-1890) began receiving attention in the final two years of his life.

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 5510 solo-exhibitions for treated artists and 6237 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 artist for several time windows—the two (three) years prior to the death of the treated artist, the two (three) 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).<sup>28</sup> Since we use Factiva data starting in 1990, we have only 55 treated artists. On average, there were 32.7 articles written around the world in the year before their deaths. In the subsequent year (including the date of decease), the average number of articles by 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 two years at the usual confidence levels (t-value is 1.36).

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.

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<sup>28</sup>We screened all articles in English, French, German, Dutch, Italian and Spanish, and used Google translate for other languages.



#### *D. 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’ estate/foundations appoint one or more galleries to handle sales instead of auction houses—making 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 IX shows, is largely responsible for our results, we were able to identify the galleries appointed by estates. In the Blouin dataset, we did not find references to artists’ estates in the provenance included in auction catalogues. We next 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.<sup>29</sup>

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

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<sup>29</sup>In the Blouin database in 2007-2016 we found less than 38 art-works by artists that died in the previous year in which family ownership is mentioned. This represents less than 0.5% of the sales of works by artists of died in the prior year in which provenance information is provided. The equivalent numbers are less than 0.25% in the subsequent years.

White Cube, told the *New York Times* “The last thing I want messing around with my career is an auction house.”<sup>30</sup>

### *E. 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, 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 why this would be the case. First, it is possible that more expensive artworks are more likely to be auctioned. A death-induced increase in price would then increase the share of auctioned work in the secondary market. We have shown in Table XII that there is indeed a positive partial correlation between artist prices and volume, but this effect does not offset the effect of death on volume. Second, it could be that galleries representing an artist offer their unsold inventory for sale, after an artist’s death, through auctions rather than directly to their private clients. In Section V.D 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 if the share of auctioned

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<sup>30</sup>*New York Times*, December 1 2017.

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.<sup>31</sup> 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 III.C). 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.<sup>32</sup> 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 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

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<sup>31</sup>We are thankful to one referee for making this suggestion.

<sup>32</sup>For the living artist, this ratio amounts to  $AM/(PM+SDM+AM)$  for living against  $AM/(SDM+AM)$  for the dead artists.

significant difference, what gives indirect evidence of no large shift in gallery sales.

## VI. 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 outweigh optimists' beliefs and have a speculative component that reflects the resale option. If collectors have limited capacity to bear risk, a decrease in float may increase the value and the frequency of 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 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 dataset 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 that 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 resulting 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.<sup>33</sup>

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<sup>33</sup>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.

## Appendix: Proofs

**Proof of Proposition 1:** In a corner equilibrium only the optimists hold art-works and hence

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

In turn in an interior equilibrium, where both types hold art-works

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

Hence we obtain claim [a]. In addition, the first equality in equation (A-2) and market clearing imply claim [b]. □

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

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

$$p^e(N_t) - p_t^a(N_t) = \frac{1 - \pi}{1 + r} (p^e(N_t) - E_t p_{t+1}^a(N_{t+1})). \quad (\text{A-3})$$

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

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

Differencing these last two expressions we again obtain (A-3) 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:

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

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  $p^e(N_{t+1}) < p^e(N_t)$ ,

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

Thus  $p_t^a(N_t) < p^e(N_t)$ . Furthermore, equation (A-3) implies  $p^e(N_t) - p_t^a(N_t) < (p^e(N_t) - E_t p_{t+1}^a(N_{t+1}))$  what completes the proof of item [a].

Also, from (A-3) and the law of iterated expectations we obtain:

$$E[p^e(N_{t+1}) - p_{t+1}^a(N_{t+1})] = \left(1 + \frac{r+\pi}{1-\pi}\right) E[p^e(N_t) - p_t^a(N_t)] - E[p^e(N_t) - p^e(N_{t+1})]. \quad (\text{A-4})$$

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  $\frac{r+\pi}{1-\pi} E[p^e(N_{t+1}) - E p_{t+1}^a(N_{t+1})] > E[p^e(N_t) - p^e(N_{t+1})]$ . Furthermore, Proposition 2 implies that since  $E[N_{t+1} - N_t]$  decreases with  $t$  then,

$$E[p^e(N_{t+s}) - p^e(N_{t+s+1})] \text{ strictly decreases with } s. \quad (\text{A-5})$$

To verify (A-5) 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 (A-5). 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 (A-4) 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 (A-4)

$$E[p^e(N_{t+s+1}) - p_{t+s+1}^a(N_{t+s+1})] \geq \left(1 + \frac{r}{1 - \pi}\right) E[p^e(N_{t+s}) - p_{t+s}^a(N_{t+s})], \quad (\text{A-6})$$

Hence for any  $s' > s$

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

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

[i] If  $\tau < v$

$$\frac{1}{2} - \frac{N_{\tau-1}}{2N_\tau}. \quad (\text{A-7})$$



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

$$\min \left\{ \frac{1}{4} - \frac{N_{\tau-1}}{2N_\tau} + \frac{\theta^h - \theta^\ell}{8\gamma N_\tau}; \frac{\theta^h - \theta^\ell}{4\gamma N_\tau} \right\} \quad (\text{A-8})$$

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

$$\min \left\{ \frac{1}{4} - \frac{N_{\tau-1}}{4N_\tau}; \frac{\theta^h - \theta^\ell}{4\gamma N_\tau} \right\} \quad (\text{A-9})$$

Proof: If  $\tau < v$  equilibrium at any period  $t < \tau$  is a corner equilibrium. In period  $\tau$ , with probability 1/2, secondary market trading volume is 0 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  $\tau$ , the average volume in the secondary market in period  $\tau$  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 0 and with probability 1/2, trading volume is  $N_\tau$ . 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 that dies young, conditional on the history  $\{N_t\}_{t=0}^\tau$  is:

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

what establishes item [i].

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

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

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

$$\frac{\theta^h - \theta^\ell}{4\gamma N_\tau}. \quad (\text{A-10})$$

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

$$\frac{1}{2} \max \left\{ 2N_{\tau-1} - N_\tau + \frac{\theta^h - \theta^\ell}{2\gamma}; 0 \right\} \quad (\text{A-11})$$

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

$$\frac{1}{4} \max \left\{ \frac{2N_{\tau-1}}{N_\tau} - 1 + \frac{\theta^h - \theta^\ell}{2\gamma N_\tau}; 0 \right\} \quad (\text{A-12})$$

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

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

establishing item [ii].

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

$$\max \left\{ \frac{N_{\tau-1}}{2N_\tau} - \frac{1}{2} + \frac{\theta^h - \theta^\ell}{2\gamma N_\tau}; 0 \right\} \quad (\text{A-13})$$

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 [iii]. □

**Proof of Proposition 4:** It is easy to check that Assumption 1 guarantees that each of the expressions (A-7)-(A-9) is positive, what establishes item [a].

In addition,  $v$  is a deterministic function of  $\omega$ , and Assumption 1 guarantees that the expressions (A-7)-(A-9) decline with the age of death  $\tau$ . For each  $t \geq 1$  let  $\Omega_t^1 = \{\omega : t < v\}$ ,  $\Omega_t^2 = \{\omega : t - 1 < v \leq t\}$ , and  $\Omega_t^3 = \{\omega : t - 1 \geq v\}$ . Thus the change in turnover at  $t$  in history  $\omega$ ,  $g(t, \omega)$ , equals expression (A-7) if  $\omega \in \Omega_t^1$ , expression (A-8) if  $\omega \in \Omega_t^2$ , and expression (A-9) if  $\omega \in \Omega_t^3$ .

For any  $t$ , if  $\omega \in \Omega_t^2$ , since  $\frac{\theta^h - \theta^\ell}{2\gamma N_t} < 1$ ,

$$\min \left\{ \frac{1}{4} - \frac{N_{t-1}}{2N_t} + \frac{\theta^h - \theta^\ell}{8\gamma N_t}; \frac{\theta^h - \theta^\ell}{4\gamma N_t} \right\} \leq \frac{1}{4} - \frac{N_{t-1}}{2N_t} + \frac{\theta^h - \theta^\ell}{8\gamma N_t} < \frac{1}{2} - \frac{N_{t-1}}{2N_t} \quad (\text{A-14})$$

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

$$\begin{aligned} \min \left\{ \frac{1}{4} - \frac{N_t}{4N_{t+1}}; \frac{\theta^h - \theta^\ell}{4\gamma N_{t+1}} \right\} &< \min \left\{ \frac{1}{4} - \frac{N_t}{2N_{t+1}} + \frac{\theta^h - \theta^\ell}{8\gamma N_{t+1}}; \frac{\theta^h - \theta^\ell}{4\gamma N_{t+1}} \right\} \\ &< \frac{1}{2} - \frac{N_t}{2N_{t+1}} \end{aligned} \quad (\text{A-15})$$

If  $\omega \in \Omega_t^1$  and  $t' > t$  then Equations (A-14) and (A-15) and the monotonicity of the expressions (A-7)-(A-9) 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 (A-15) and the monotonicity of the expressions (A-8) and (A-9) 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 (A-9). This establishes that item [b] holds. □

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**Table I: Cause of death**

	<i>N</i>	Share of total (%)
<i>Panel A: All deaths</i>		
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*	1	0.4
Sudden death	67	27.2
Total	246	100.0
<i>Panel B: Sudden deaths</i>		
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 deaths into Cancer; AIDS; Heart disease; Tuberculosis; Alcohol and drug-related disease; Other disease; Unspecified illness (for cases in which the precise disease is not reported); Unknown; Sudden death. \* This observation corresponds to Keith Vaughan. Vaughan died of suicide, but we classify his death as predictable since he had been diagnosed cancer two years prior to his death. Panel B reports the cause of death for the subsample of sudden deaths from Panel A.

**Table II: Matched sample**

Variable	Sample	Mean	SD	Min	Max
Year of birth	Deceased $\leq$ 65 years	1924.4	16.2	1894.0	1966.0
	Control group	1924.7	16.3	1892.0	1966.0
Year of death	Deceased $\leq$ 65 years	1978.7	14.1	1958.0	2013.0
	Control group <sup>a</sup>	1993.8	12.9	1970.0	2018.0
Age at death	Deceased $\leq$ 65 years	54.3	9.3	23.0	65.0
	Control group <sup>a</sup>	77.0	7.8	66.0	101.0
Av. price at treatment (thousands) <sup>b</sup>	Deceased $\leq$ 65 years	9.8	11.8	1.0	82.9
	Control group	10.4	11.6	1.1	80.2
Av. yearly volume at treatment	Deceased $\leq$ 65 years	0.9	3.4	0.0	36.7
	Control group	0.8	3.0	0.0	25.7
Fame at treatment <sup>c</sup>	Deceased $\leq$ 65 years	-0.0	0.9	-0.5	3.6
	Control group	-0.1	0.9	-0.5	3.6
No. of artists	Deceased $\leq$ 65 years	242.0			
	Control group	242.0			

This table reports summary statistics for the group of treated and control artists defined in Section III.C. The statistics are computed using data prior to the year of death of the treated artist. Prices are reported in 2015 dollars. 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. <sup>a</sup> For the 165 control artists who die in our sample. <sup>b</sup> For the 73 treated and control artists who are ‘active’ with at least one transaction prior to the treated artist’s death. <sup>c</sup> For the 242 artists (and their controls) who pass away before 2009 (when Google nGram data is available).



**Table III: Impact of artist death on prices and volume – Matched sample**

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

This table shows the  $\beta_1$ -coefficients in Equations (11)-(12). The sample consists of artists who passed away at the age of 65 or earlier 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 price requires that artists are active on the auction market before their death, hence the smaller sample. Standard errors are clustered at the artist level.

**Table IV: Turnover elasticity of price**

Elasticity			Source
<i>Panel A: Art Sample</i>			
Average float change of early death	$\Delta f$	-0.50	Authors' calculation
Average log price change	$\Delta p$	0.46	Table III
Average log volume change	$\Delta v$	0.49	Table III
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	
<i>Panel B: Related Studies</i>			
Turnover elasticity of price	$\varepsilon_{tp}$	0.38	Cochrane (2003) (Table 3)
Turnover elasticity of price	$\varepsilon_{tp}$	0.24	Xiong and Yu (2011) and authors' calculation.

**Table V: Impact of artist death on prices and volume – Full sample**

	Unmatched control group	Without control group
<i>Panel A: Death and auction prices</i>		
Deceased $\leq 65$ years	0.415	0.246
<i>t</i> -stat	(3.98)	(1.86)
Year and age fixed effects and hed. controls	Y	Y
Artist fixed effects	Y	Y
No. of observations	694,071	41,576
No. of artists (treated + all controls)	76+2160	76
<i>Panel B: Death and volume</i>		
Deceased $\leq 65$ years	0.479	0.460
<i>t</i> -stat	(3.05)	(3.20)
Year and age fixed effects	Y	Y
Artist fixed effects	Y	Y
No. of observations	124,273	13,657
No. of artists (treated + all controls)	246+1990	246

This table shows the  $\beta_1$ -coefficients in Equations (11)-(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, 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.

**Table VI: Impact of artist death on prices and volume – Alternative control for notoriety (1957-2008)**

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

This table shows the  $\beta_1$ -coefficients in Equations (11)-(12). Similarly to Table III, the sample consists of artists who passed away at the age of 65 or earlier 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 III, 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.

**Table VII: Impact of artist death on prices and volume – Placebo sample**

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

This table shows the  $\beta_1$ -coefficients in Equations (11)-(12). The sample consists of a placebo sample consisting of the matched artists in the baseline regression (Table III). We drop artists who passed away at 65 or earlier and use this placebo group as 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, 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.

**Table VIII: Impact of artist death on prices and volume – Sudden deaths**

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

This table shows the  $\beta_1$ -coefficients in Equations (11)-(12). The sample consists of artists who suddenly passed away at the age of 65 or earlier together with their matched controls (left column). We report characteristics of the sudden death sample in Table I. 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). Standard errors are clustered at the artist level.

**Table IX: Impact of artist death on prices and volume – Conditioning on Fame at Death (1957-2008)**

	High Fame	Low Fame
<i>Panel A: Death and auction prices</i>		
Deceased $\leq 65$ years	0.599	-0.224
<i>t</i> -stat	(4.57)	(-1.42)
Year and age fixed effects and hed. controls	Y	Y
Artist fixed effects	Y	Y
No. of observations	45,385	2,480
No. of artists (treated + matched controls)	24+24	24+24
<i>Panel B: Death and volume</i>		
Deceased $\leq 65$ years	0.586	0.029
<i>t</i> -stat	(2.87)	(0.12)
Year and age fixed effects	Y	Y
Artist fixed effects	Y	Y
No. of observations	8,815	7,629
No. of artists (treated + matched controls)	81+81	81+81

This table shows the  $\beta_1$ -coefficients in Equations (11)-(12). Similarly to Table III, the sample consists of artists who passed away at the age of 65 or earlier together with their matched controls. The left/right column shows results for artist which 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/bottom tercile at the year of their death. The sample stops in 2008 because our Fame data is 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 III. 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.

**Table X: Impact of artist death on round-trip returns**

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

This table shows the  $\beta_1$ - and  $\beta_2$ - coefficients in Equation (13). The first coefficient measures the death effect, similarly to our hedonic specification (11). The  $\beta_2$  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 earlier, 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.

**Table XI: Impact of artist death on holding periods**

	With control group	Without control group
Deceased $\leq 65$ at purchase	-1.398	-1.506
<i>t</i> -stat	(-6.19)	(-6.88)
Year and age fixed effects	Y	Y
Artist fixed effects	Y	Y
No. of observations	792	457
No. of artists (treated + controls)	50+49	50

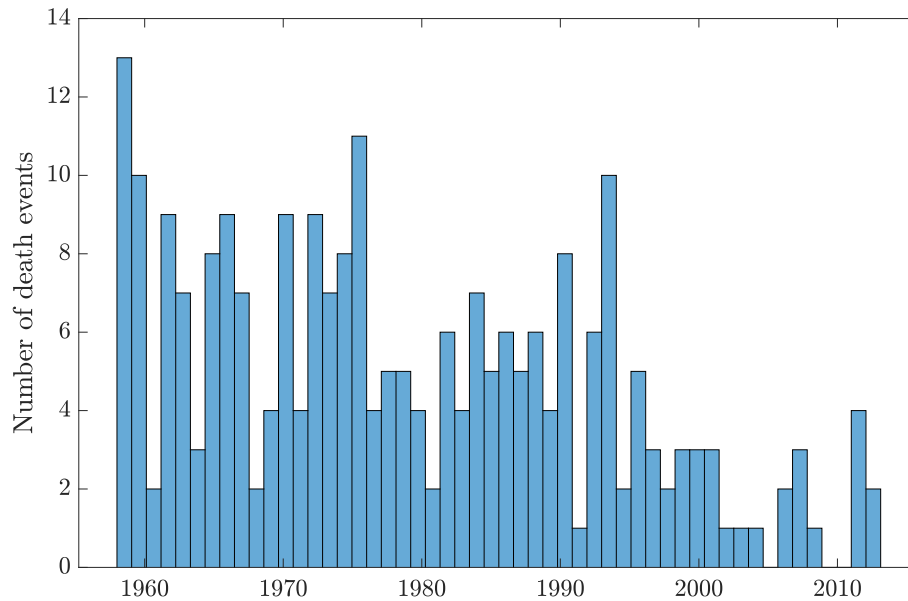
This table shows the  $\beta_1$ -coefficient in Equation (14), which captures the change in the log annual holding period for treated artists who are deceased at purchase. The sample consists of repeat-sales for artists who passed away at the age of 65 or earlier, as well as their matched controls (left column). We also report estimates with treated artists only in the right column. Standard errors are clustered at the artist level.



**Table XII: Impact of artist death on volume – Controlling for artist prices**

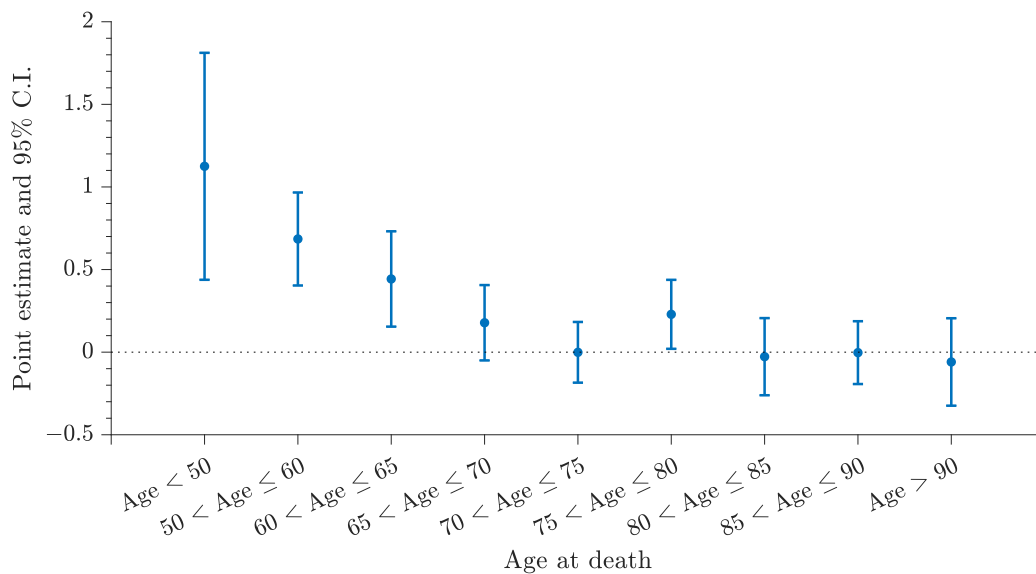
	With control group	Without control group
$\delta_{i,t}$	0.168	0.138
$t$ -stat	(3.59)	(1.99)
Deceased $\leq 65$ years	0.458	0.420
$t$ -stat	(3.48)	(3.14)
Year and age fixed effects	Y	Y
Artist fixed effects	Y	Y
No. of observations	4,993	2,467
No. of artists (treated + matched controls)	72+72	72

This table shows the  $\beta_1$ -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 earlier 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 Eq. (15) and is linearly interpolated in the absence of trading volume for a given artist-year. Standard errors are clustered at the artist level.

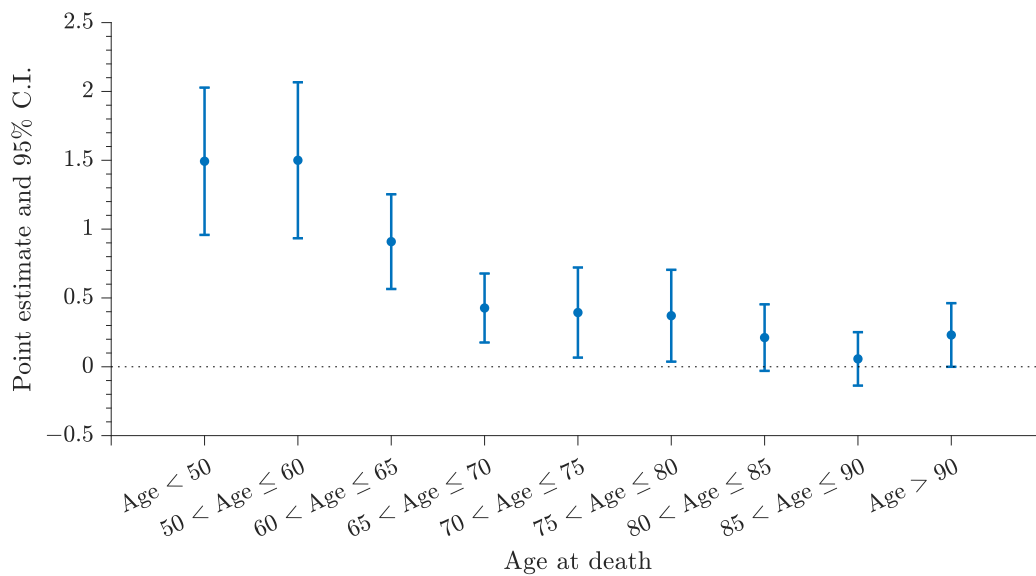


**Figure 1: Distribution of premature death events**

This figure depicts the number of artists who died at the age of 65 or earlier 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. In order to analyze the impact of death on prices and returns, we require at least one year of price data before and after the death in our sample window.



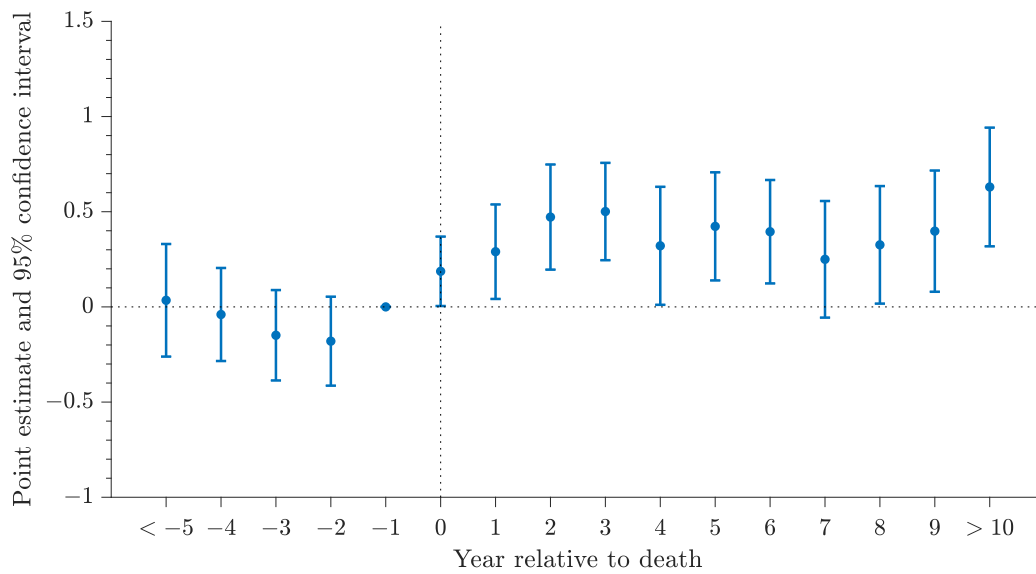
(a) Prices



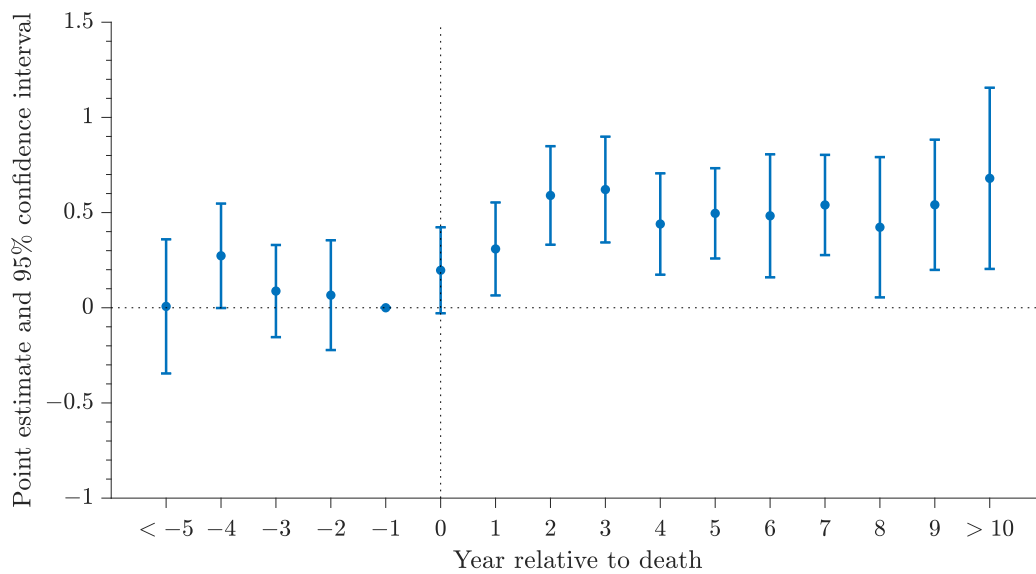
(b) Volume

**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.



(a) Prices



(b) Volume

**Figure 3: Prices and trading volume around 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 III. Observations more than 5 (10) years before (after) the death are grouped together. Standard errors are clustered at the artist level.

## Appendix – For Online Publication

This table lists all (246) treated artists in our sample together with their matches, when appropriate. Treated artists are sorted alphabetically except for the four unmatched artists that are listed in the bottom of the table.

Treated artists				Controls			
Artist	Birth	Death	Active	Artist	Birth	Death	
Aagaard Andersen, Gunnar	1919	1982		Lassnig, Maria	1919	2014	
Abedin, Zainul	1914	1976		Hogan, Joao	1914	1988	
Afro	1912	1976	Y	Soulages, Pierre	1919	–	
Ali, Shakir	1916	1975		Heyboer, Anton	1924	2005	
Altenbourg, Gerhard	1926	1989	Y	Trujillo, Guillermo	1927	–	
Angus, Rita	1908	1970		Korniss, Dezso	1908	1984	
Apap, William	1918	1970		Quiros, Antonio	1918	1984	
Arbus, Diane	1923	1971		Bury, Pol	1922	2005	
Arkley, Howard	1951	1999	Y	Oulton, Therese	1953	–	
Atlan, Jean-Michel	1913	1960		Butler, Reg	1913	1981	
Ayrton, Michael	1921	1975	Y	Johnson, Ray	1927	1995	
Baldessin, George	1939	1978	Y	Attersee, Christian Ludwig	1940	–	
Bandeira, Antonio	1922	1967		Cruz-Diez, Carlos	1923	–	
Batlle Planas, Juan	1911	1966		Paniker, K. C. S.	1911	1977	
Bazile, Castera	1923	1966		Palacios, Luisa	1923	1990	
Baziotes, William	1912	1963		Burri, Alberto	1915	1995	
Bela	1917	1968		Hare, David	1917	1992	
Belkin, Arnold	1930	1992	Y	Felguerez, Manuel	1928	–	
Beuys, Joseph	1921	1986	Y	Pearlstein, Philip	1924	–	
Binyinyiwuy	1928	1982		Imai, Toshimitsu	1928	2002	
Birulli, Renato	1905	1959		Porter, Fairfield	1907	1975	
Boetti, Alighiero	1940	1994		Onobrakpeya, Bruce	1932	–	
Bogusz, Marian	1920	1980		Castro, Amilcar de	1920	2002	
Bonevardi, Marcelo	1929	1994	Y	Saul, Peter	1934	–	
Borduas, Paul-Emile	1905	1960		Cremer, Fritz	1906	1993	
Brauner, Victor	1903	1966		Krasner, Lee	1908	1984	
Bredow, Rudolf	1909	1973		Bergman, Anna-Eva	1909	1987	
Brittain, Miller	1912	1968		Spyropoulos, Yannis	1912	1990	
Broodthaers, Marcel	1924	1976		Neri, Manuel	1930	–	
Brown, Joan	1938	1990		Weiner, Lawrence	1942	–	
Brown, Mike	1938	1997	Y	Jaray, Tess	1937	–	
Bruning, Peter	1929	1970		Larter, Richard	1929	2014	
Buthe, Michael	1944	1994	Y	McLean, Bruce	1944	–	
Caballero, Luis	1943	1995	Y	Mosset, Olivier	1944	–	
Campbell, George	1917	1979	Y	Rodhe, Lennart	1916	2005	
Carrillo, Lilia	1930	1974		Claus, Carlfriedrich	1930	1998	
Castagnino, Juan Carlos	1908	1972		Stematsky, Avigdor	1908	1989	
Chaissac, Gaston	1910	1964		Lamba, Jacqueline	1910	1993	
Chambers, Jack	1931	1978		Comtois, Ulysse	1931	1999	
Cherkaoui, Ahmed	1934	1967		Gaucher, Yves	1934	2000	
Chighine, Alfredo	1914	1974	Y	Messagier, Jean	1920	1999	
Christensen, Dan	1942	2007	Y	Self, Colin	1941	–	
Chukwuogo-Roy, Chinwe	1952	2012		Von Hausswolff, C. M.	1956	–	

Colquhoun, Robert	1914	1962		Schumacher, Emil	1912	1999
Corbett, Edward	1919	1971		Abreu, Mario	1919	1993
Coronel, Pedro	1923	1985	Y	Colville, Alex	1920	2013
Corzas, Francisco	1936	1983	Y	Chavez, Gerardo	1937	-
Crippa, Roberto	1921	1972	Y	Sugai, Kumi	1919	1996
Curnoe, Greg	1936	1992		Gershuni, Moshe	1936	2017
Cutrone, Ronnie	1948	2013	Y	Cahn, Miriam	1949	-
Dallaire, Jean	1916	1965		Badii, Libero	1916	2001
Daraniyagala, Justin Pieris	1903	1967		Wang Xuetao	1903	1982
Davies, John	1936	1999	Y	Goode, Joe	1937	-
Davis, Gene	1920	1985	Y	Carrington, Leonora	1917	2011
Defeo, Jay	1929	1989		Beksinski, Zdzislaw	1929	2005
Deira, Ernesto	1928	1986	Y	Makowski, Zbigniew	1930	-
Dekkers, Ad	1938	1974		Lancaster, Mark	1938	-
Deyrolle, Jean	1911	1967		Orlando, Felipe	1911	2001
Diller, Burgoyne	1906	1965		Aeschbacher, Hans	1906	1980
Disney, Walt	1901	1966		Turner, Helen Monro	1901	1977
Djanira	1914	1979		Guerrero, Jose	1914	1991
Dotremont, Christian	1922	1979		Day, Melvin	1923	2016
Downey, Juan	1940	1993		Attersee, Christian Ludwig	1940	-
Dumouchel, Albert	1916	1971		Gysin, Brion	1916	1986
Duwe, Harald	1926	1984		Johnson, George Henry	1926	2007
Eardley, Joan	1921	1963		Raza, Sayed Haider	1922	-
Echeverria, Enrique	1923	1972		Hlito, Alfredo	1923	1994
Endara Crow, Gonzalo	1936	1996	Y	Amaral, Antonio Henrique	1935	2015
Engilberts, Jon	1908	1972		Marczynski, Adam	1908	1985
Espaliu, Pepe	1955	1993		Nel, Karel Anthony	1955	-
Evans, Merlyn	1910	1973	Y	Lancaster, Osbert	1908	1986
Eyuboglu, Bedri Rahmi	1911	1975		Lardera, Berto	1911	1989
Fahlstrom, Oyvind	1928	1976		Scott, Patrick	1921	2014
Fairhurst, Angus	1966	2008	Y	Paine, Roxy	1966	-
Farrell, Micheal	1940	2000	Y	Wilson, Robert	1941	-
Feeley, Paul	1910	1966		Mortensen, Richard	1910	1993
Feni, Dumile	1942	1991		Bruggen, Coosje van	1942	2009
Fernhout, Edgar	1912	1974		Cage, John	1912	1992
Ferren, John	1905	1970		Cadmus, Paul	1904	1999
Fisher, Sandra	1947	1994	Y	Lavier, Bertrand	1949	-
Flavin, Dan	1933	1996	Y	Buren, Daniel	1938	-
Fomison, Tony	1939	1990	Y	Polesello, Rogelio	1939	2014
Forg, Gunther	1952	2013	Y	Scharf, Kenny	1958	-
Fraile, Alfonso	1930	1988	Y	Brizzi, Ary	1930	2014
Freedman, Barnett	1901	1958		Johnson, William H.	1901	1970
Frink, Elisabeth	1930	1993	Y	Cuevas, Jose Luis	1934	-
Fruhtrunk, Gunter	1923	1982	Y	Kupferman, Moshe	1926	2003
Fu Baoshi	1904	1965		Messel, Oliver	1904	1978
Gadanyi, Jenó	1896	1960		Adalid, Agustin Lazo	1896	1971
Galan, Julio	1958	2006	Y	Currie, Ken	1960	-
Garcia Ponce, Fernando	1933	1987		Molinari, Guido	1933	2004
Gnoli, Domenico (ii)	1933	1970		Ferrer, Rafael	1933	-
Goldstein, Jack	1945	2003	Y	Nerdrum, Odd	1944	-
Gonzales-Torres, Felix	1957	1996		Sitthiket, Vasan	1957	-
Gonzalez, Juan	1945	1993		Piper, Adrian	1948	-

Graves, Nancy	1939	1995		Hiller, Susan	1940	–
Greco, Alberto	1931	1965		Baya	1931	1998
Grundig, Hans	1901	1958		Evergood, Philip	1901	1973
Grunwald, Henryk	1904	1958		Mason, Alice Trumbull	1904	1971
Guerrero Galvan, Jesus	1910	1973		Sterne, Hedda	1910	2011
Gundersen, Gunnar S.	1921	1983		Garcia Guerrero, Luis	1921	1996
Hardin, Helen	1943	1984		Rosler, Martha	1943	–
Haring, Keith	1958	1990	Y	Paladino, Mimmo	1948	–
Hennessy, Patrick	1915	1980		Dzubas, Friedel	1915	1994
Hesse, Eva	1936	1970		Ono, Yoko	1933	–
Hester, Joy	1920	1960		Gonzalez Bogen, Carlos	1920	1992
Hilton, Roger	1911	1975	Y	Schultze, Bernard	1915	2005
Hockelmann, Antonius	1937	2000	Y	Max, Peter	1937	–
Hung, Francisco	1937	2001	Y	Senbergs, Jan	1939	–
Immendorff, Jorg	1945	2007	Y	Fetting, Rainer	1949	–
Jacoulet, Paul	1896	1960		Rodriguez Lozano, Manuel	1896	1971
Jarema, Maria	1908	1958		Aroch, Arie	1908	1974
Jarman, Derek	1942	1994	Y	Petrick, Wolfgang	1939	–
John, Jiri	1923	1972		Kemble, Kenneth	1923	1998
Jones, Joe	1909	1963		Stromme, Olav	1909	1978
Jorn, Asger	1914	1973	Y	Friend, Donald	1914	1989
Kazuki, Yasuo	1911	1974		Benoit, Rigaud	1911	1986
Kelley, Mike	1954	2012	Y	Sherman, Cindy	1954	–
Kemeny, Zoltan	1907	1965		Kotin, Albert	1907	1980
Kenny, Michael	1941	1999	Y	Pacheco, Ana-Maria	1943	–
Kim Hwan-gi	1913	1974		Oppenheim, Meret	1913	1985
King, Cecil	1921	1986		Espinola Gomez, Manuel	1921	2003
Kinley, Peter	1926	1988	Y	Skotnes, Cecil	1926	2009
Kippenberger, Martin	1953	1997	Y	Schutte, Thomas	1954	–
Klein, Yves	1928	1962		Leslie, Alfred	1927	–
Kline, Franz	1910	1962		Graves, Morris	1910	2001
Kobzdej, Aleksander	1920	1972		Barcala, Washington	1920	1993
Kondor, Bela	1931	1972		Coughtry, Graham	1931	1999
Kudo, Tetsumi	1935	1990	Y	Rodriguez, Alirio	1934	2018
Kurelek, William	1927	1977	Y	Rainer, Arnulf	1929	–
Lanyon, Peter	1918	1964		Johnson, Lester	1919	2010
Lasekan, Akinola	1916	1972		Thieler, Fred	1916	1999
Lavonen, Ahti	1928	1970		Swaminathan, Jagdish	1928	1994
Ledy, Cheik	1962	1997		Yuskavage, Lisa	1962	–
Leura Tjapaltjarri, Tim	1929	1984		Metzkes, Harald	1929	–
Licini, Osvaldo	1894	1958		Reggiani, Mauro	1897	1980
Lo Savio, Francesco	1935	1963		Sihlali, Durant	1935	2004
Louis, Morris	1912	1962		Guttuso, Renato	1911	1987
Lueg, Konrad	1939	1996	Y	Donaldson, Anthony	1939	–
Lui Shou-kwan	1919	1975		Walters, Gordon	1919	1995
Lunar, Emerio	1940	1990		Coen, Arnaldo	1940	–
MacBryde, Robert	1913	1966		Gopas, Rudolf	1913	1983
Macdonald, Jock	1897	1960		Yirawala	1897	1976
Mafai, Mario	1902	1965		Sternberg, Harry	1904	2001
Magani, Mick	1920	1984		Muller, Robert	1920	2003
Malaval, Robert	1937	1980		Suarez, Pablo	1937	2006
Manzoni, Piero	1933	1963		Katz, Alex	1927	–

Mapplethorpe, Robert	1946	1989		Anderson, Laurie	1947	-
Marika, Mawalan	1908	1967		Camarena, Jorge Gonzalez	1908	1980
Marika, Wandjuk	1927	1987		Malangi, David	1927	1999
Martin, Mary	1907	1969		Bill, Max	1908	1994
Matta-Clark, Gordon	1943	1978		Turrell, James	1943	-
Maymuru, Narritjin	1916	1981		Palazuelo, Pablo	1916	2007
McHale, John	1922	1978		Niro, Robert de, Sr.	1922	1993
Medek, Mikulas	1926	1974		Capdevila, F. M.	1926	1995
Mendieta, Ana	1948	1985		Abramovic, Marina	1946	-
Messil, Gabriel	1934	1986		Khakhar, Bhupen	1934	2003
Millares, Manolo	1926	1972		Aitchison, Craigie	1926	2009
Milpururru, George	1934	1998	Y	Cohen, Bernard	1933	-
Minaux, Andre	1923	1986	Y	Renqvist, Torsten	1924	2007
Mithinari	1929	1976		Gironella, Alberto	1929	1999
Moke	1950	2001	Y	Coe, Sue	1951	-
Molvig, Jon	1923	1970		Alonso, Raul	1923	1993
Morton, Ree	1936	1977		Wakabayashi, Isamu	1936	2003
Mualla, Fikret	1903	1967		Rimsa, Juan	1903	1978
Munoz, Juan	1953	2001	Y	Leirner, Jac	1961	-
Namatjira, Albert	1902	1959		Carter, Clarence Holbrook	1904	2000
Nanninga, Jaap	1904	1962		Burra, Edward	1905	1976
Newman, Barnett	1905	1970		Motherwell, Robert	1915	1991
Nickolls, Trevor	1949	2012	Y	Koningsbruggen, Rob van	1948	-
Oiticica, Helio	1937	1980		Brawley, Robert J	1937	2006
Ojeda, Gustavo	1958	1989	Y	Favier, Phillipe	1957	-
Onus, Lin	1948	1996		Woodrow, Bill	1948	-
Orszag, Lili	1926	1978		Thomas, Rover	1926	1998
Paalen, Wolfgang	1905	1959		Tworkov, Jack	1900	1982
Pacheco, Maria Luisa	1919	1982	Y	Lataster, Ger	1920	2012
Palermo, Blinky	1943	1977		Marioni, Joseph	1943	2009
Pancetti, Jose Gianini	1902	1958		Stokes, Adrian	1902	1972
Pane, Gina	1939	1990		Alviani, Getulio	1939	2018
Park, David	1911	1960		Mariano	1912	1980
Parvez, Ahmed	1926	1979		Ronald, William	1926	1998
Paschke, Ed	1939	2004	Y	Knoebel, Imi	1940	-
Pedro, Antonio	1909	1966		Lewis, Norman	1909	1979
Peeters, Jozef	1895	1960		Maxy, Max Herman	1895	1971
Pike, Jimmy	1940	2002	Y	Revilla, Carlos	1940	-
Poliakoff, Serge	1906	1969	Y	Manessier, Alfred	1911	1993
Ponc, Joan	1927	1984		Rivera, Manuel	1927	1995
Popkov, Viktor	1932	1974		Uglow, Euan	1932	2000
Portinari, Candido	1903	1962		Clifton, Marshall	1903	1975
Potworowski, Piotr	1898	1962	Y	Zack, Leon	1892	1980
Preller, Alexis	1911	1975	Y	Meistermann, Georg	1911	1990
Reinhardt, Ad	1913	1967		Smith, Tony	1912	1980
Requichot, Bernard	1929	1961		Munoz, Lucio	1929	1998
Rhoades, Jason	1965	2006		Bulloch, Angela	1966	-
Richier, Germaine	1902	1959		Herrera, Velino	1902	1973
Sadequain	1930	1987		Pomodoro, Gio	1930	2002
Sage, Kay	1898	1963		Feng Zikai	1898	1975
Schwalbe, Ole	1929	1990	Y	Hrdlicka, Alfred	1928	2009
Seitz, Gustav	1906	1969		Baij, Ramkinker	1906	1980



Seligmann, Kurt	1900	1962		Woodruff, Hale	1900	1980
Sempere, Eusebio	1923	1985		Cesariny, Mario	1923	2006
Serpa, Ivan	1923	1973		Jess (Collins, Burgess)	1923	2004
Shi Lu	1919	1982		Yamamoto, Taro	1919	1994
Silva, Carlos	1930	1987		Eggenschwiler, Franz	1930	2000
Skold, Otte	1894	1958		Bernath, Aurel	1895	1982
Smith, David	1906	1965		Brooks, James	1906	1992
Smithson, Robert	1938	1973		Bell, Larry	1939	–
Sokolov-Skalya, Pavel	1899	1961		Glarner, Fritz	1899	1972
Stajuda, Jerzy	1936	1992		Golden, Daan van	1936	2017
Stankiewicz, Richard	1922	1983		Velarde, Pablita	1918	2006
Stepanova, Varvara	1894	1958		Centurion, Emilio	1894	1970
Stohrer, Walter	1937	2000	Y	Iseli, Rolf	1934	–
Swift, Patrick	1927	1983		Daws, Lawrence	1927	–
Takamatsu, Jiro	1936	1998	Y	Schonebeck, Eugen	1936	–
Taylor, E. Mervyn	1906	1964		Grundig, Lea	1906	1977
Thek, Paul	1933	1988		Tousignant, Claude	1932	–
Thomkins, Andre	1930	1985	Y	Tubke, Werner	1929	2004
Thompson, Bob	1937	1966		Scholder, Fritz	1937	2005
Tschusiya, Tilsa	1928	1984		Fernandez, Agustin	1928	2006
Tsingos, Thanos	1914	1965		Balint, Endre	1914	1986
Tuckson, Tony	1921	1973		Iskowitz, Gershon	1921	1988
Valcin, Gerard	1927	1988	Y	Guinovart, Josep	1927	2007
Varo, Remedios	1908	1963		Lewers, Margo	1908	1978
Vassilieff, Danila	1897	1958		Pan Tianshou	1897	1971
Vaughan, Keith	1912	1977	Y	Turcato, Giulio	1912	1995
Vega, Jorge de la	1930	1971		DArcangelo, Allan	1930	1998
Vordemberge-Gildewart, F.	1899	1962		Carvalho, Flavio de	1899	1973
Warhol, Andy	1928	1987	Y	Riopelle, Jean-Paul	1923	2002
West, Franz	1947	2012	Y	Neshat, Shirin	1957	–
White, Charles Wilbert	1918	1979		Solari, Luis	1918	1993
Whiteley, Brett	1939	1992	Y	Kirkeby, Per	1938	–
Wiedemann, Guillermo	1905	1969		Narvaez, Francisco	1905	1982
Wilke, Hannah	1940	1993		Armajani, Siah	1939	–
Wilkerson, Jerry	1943	2007	Y	Buraimoh, Jimoh	1943	–
Williams, Fred	1927	1982	Y	Fuchs, Ernst	1930	–
Wlodarski, Marek	1903	1960		Bodmer, Walter	1903	1973
Wojnarowicz, David	1954	1992	Y	Frize, Bernard	1954	–
Woodman, Francesca	1958	1981		Wiszniewski, Adrian	1958	–
Wunuwun, Jack	1930	1990		Jaimes Sanchez, Humberto	1930	2003
Zabaleta, Rafael	1907	1960		Yunapingu, Munggurawuy	1907	1979
Zobel, Fernando	1924	1984		Morellet, Francois	1926	2016
Zverev, Anatoly	1931	1986		Opalka, Roman	1931	2011
Basquiat, Jean-Michel	1960	1988	Y	–		
Bratby, John	1928	1992	Y	–		
Giacometti, Alberto	1901	1966	Y	–		
Willing, Victor	1928	1988	Y	–		