



# Before the hammer falls: an empirical analysis of the market reaction to art thefts

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## Abstract

This study investigates the effects of art theft on art auction sales. In particular, it focuses on the impact on the auction sales when an artist's artwork has been stolen and reported in a public list of stolen art. By using criminal data from Interpol's International Stolen Works of Art Database (SWoA) from 2002 to 2016 all over the world, and auction data concerning all lots put at auction by Christie's, Sotheby's, and Phillips in New York and London between 2012 and 2016, we build a hand-collected data on top-tier international auction sales of modern and contemporary artists whose artwork have previously been stolen. The empirical analysis is based on an economic framework of the art auction and on hedonic regression models to test the effect of theft on auction prices. The results hint at a negative effect of theft on the prices of the artworks at market level, which gets stronger as the number of reported stolen artworks from the same artist increases. Overall, the paper provides a nuanced understanding of the complex incentives and disincentives surrounding the reporting of stolen artworks, emphasising the need to balance private interests with broader goals of art theft prevention and recovery. It invites further exploration of potential solutions and their practicality in addressing these conflicts of interest in the art world.

**Keywords** Art market · Art theft · Crime data analysis · Public list of stolen art

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## 1 Introduction

The thefts of Leonardo da Vinci's *The Mona Lisa* and Edvard Munch's *The Scream* represent two of the most well-known art thefts in European art history, each with its own unique circumstances and significance. The theft of *The Mona Lisa* from the Louvre in 1911 by its employee Vincenzo Peruggia is arguably one of the most well-known thefts from a museum in modern history. The theft of Munch's *The Scream*, in 1994, became notable for another reason: namely the ease in which it was stolen, and the slander given by the criminal who left a written note reading "thanks for the poor security" (New York Times, 1996, para3). These high-profile thefts garnered significant international media attention giving the paintings cultural significance and universal recognition.

In addition to cultural, social, and emotional value, there is economic value attained to stolen artworks. For example, the stolen works of art from the Isabella Stewart Gardner Museum in 1990, including works by Vermeer, Rembrandt, and Degas, are currently valued at a staggering \$500 million. The theft of five valuable paintings, including artworks by Picasso, Matisse, Braque, Modigliani, and Léger, from the Musée d'Art Moderne de la Ville de Paris, was estimated to be worth €100 million. Although it can be difficult to estimate the 'true' value of stolen works of art, due to a myriad of prices that surround a given work of art (e.g., hammer price, insurance value, potential reward money), it is evident that these famous art theft cases underscore the ongoing risks of art crimes on the art world.

The cultural significance of these works of art make their thefts not only financially damaging, but also detrimental to our shared cultural heritage. The recovery of some stolen artworks provides a glimmer of hope, but the unresolved cases serve as a reminder of the enduring mystery surrounding art thefts and the ongoing efforts needed to combat this criminal activity. The motives behind these thefts vary, ranging from financial gain to making bold statements, or seeking recognition. Despite efforts to recover stolen art, many valuable pieces remain missing, emphasising the ongoing challenges faced by law enforcement and the art community in combating art crime.

Art thefts have gained increased attention from lawmakers and international organisations in recent years. Efforts have been made to combat art crimes and protect cultural heritage through various means on local and international level. These include local administrative laws, the creation of international conventions such as the Convention on the Means of Prohibiting and Preventing the Illicit Import, Export, and Transfer of Ownership of Cultural Property (UNESCO 1970 Convention), the Council of Europe Convention on Offences relating to Cultural Property (Council of Europe, 2017), and the involvement of organisations like the International Institute for the Unification of Private Law (UNIDROIT). Additionally, databases of stolen artworks, such as Interpol's Stolen Works of Art database (SWoA) and ID-ART app, the Federal Bureau of Investigation's (FBI) National Stolen Art File (NSAF), and other national registers, play a part in raising awareness and in

aiding in the intelligence-led policing and recovery of stolen pieces. In fact, these lists provide centralised databases of stolen artworks, making the information accessible to law enforcement agencies worldwide, and in the case of Interpol also the wider public. They serve as valuable resources for art buyers, sellers, and institutions to verify the provenance and authenticity of artworks, thereby reducing the risk of unknowingly dealing with stolen pieces. By publicly exposing stolen artworks, these lists increase the chances of recovery and act as deterrents for potential buyers of illicitly obtained art. However, the public nature of these lists can also have indirect effects on the art market.

These databases are in no way exhaustive. Art crime suffers from a high ‘dark figure’: the vast majority of thefts of art and heritage go unreported, or even unnoticed (Oosterman, 2019). Reliance only on these databases for provenance research is therefore highly discouraged by experts. Additionally, the inclusion of artworks on these lists can generate media attention and public awareness, turning them into news stories. Such exposure can have significant impacts on the market value and desirability of stolen artworks. Potential buyers may hesitate to acquire works that are known to be stolen or listed as missing, fearing legal repercussions or damage to their reputation. This increased scrutiny and public awareness indirectly influence the market dynamics surrounding stolen art, because of an increased perceived risk linked to art purchase.<sup>1</sup> So far, however, impacts of such information on art market prices have not been empirically studied in the economic literature. This is most likely due to the scarcity of available data on this phenomenon.

Leaving aside studies on art market thefts, the existing literature is thorough. It outlines both theoretical and empirical research that has examined the correlation between theft and prices, focusing particularly on the elasticity of thefts with respect to price (Quinn et al., 2023).<sup>2</sup> While many researchers have studied how changes in prices affect theft rates (d’Este, 2020; Draca et al., 2019), the reverse causality—how theft rates impact prices—remains largely unexplored theoretically, with empirical studies being limited to the real estate market (Ceccato and Wilhelmsson, 2020; Cigdem-Bayram and Prentice, 2019; de La Paz et al., 2022; Margaretic and Sosa, 2023). Therefore, considering art, akin to real estate, as an investment, an investigation into this matter may also be of interest various art market agents, as well as inform those responsible for policing crime in this market.<sup>3</sup>

In this paper, we test the existence of a relationship between reported art thefts and auction sales performance in the art market. By analysing the available, yet

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<sup>1</sup> Furthermore, the disclosure of private information through these lists can lead to information friction. While some lists aim to make information about stolen artworks readily available, there may be cases where some details are not disclosed or held back due to ongoing investigations or sensitive considerations. The selective release of information can create asymmetries and uncertainties in the market, affecting buyers, sellers, and the overall trading environment.

<sup>2</sup> The empirical evidence shows a significant and positive effect of prices on thefts. However, this effect only indicates the channel through which prices and thefts are related. In particular, prices primarily affect thefts by influencing thieves’ incentives. Other potential channels may also exist, but they tend to negatively bias the price elasticity of theft (Shoukry, 2016).

<sup>3</sup> The art market is characterised by specific risks not commonly found in other markets, reflected in the large differences in art investment returns between countries (Frey, 2019a).

rarely used, data, and applying multivariate analyses inspired by previous sociological and economic theories, we aim to bring to the attention the impact art theft has on art auctions in particular, and the art market in general. As far as we know, this is the first time such a methodology is used to analyse this issue, making use of a unique dataset of market data and police data. However, in no way do we, as authors, argue that in the case of market effects, public databases should be closed or restricted. In general, we argue for more transparency as opposed to less.

In particular, we therefore discuss the behaviour of collectors buying artworks at auction in the case of the theft of a piece of modern or contemporary visual art in recent years. The market reaction to these thefts is analysed to assess its impact on the price of an artist's artwork when another of his/her artworks has been stolen and reported, with possible repercussions at market level. To do so, we use both criminal data and auction sales data: the former comes from Interpol's International Stolen Works of Art Database (SWoA) and covers the thefts all over the world from 2002 to 2016; the latter consists of hand-collected data on top-tier international auction sales of modern and contemporary artists from 2012 to 2016. The resulting unique dataset covers both the artists whose artworks are part of the SWoA, with sales after the theft date, and those whose artworks are not part of the SWoA.

Employing these data, the empirical analysis tests a set of hypotheses conceptually based on agents' perception of risk associated with thefts, which may have a negative effect on the reserve prices and possibly on the auction price of an artwork.

Our results suggest that the theft of an artist's artwork has a significant impact on certain aspects of the auction market. In particular, thefts negatively affect auction prices, indicating that the occurrence of a theft can lower the prices of artworks at auction. This effect is at work when the thefts date back to several years before the auction, and is increasing in the number of stolen pieces. Overall, these results highlight the complex relationship between thefts and the art market, with a role of indirect effects of this type of crime. The findings suggest that thefts can have significant implications for market outcomes, both for academics and practitioners of the art world.

While studies on art thefts are not few in the social sciences literature, the economics literature has not empirically investigated the way such phenomena can impact the art market outcomes. Lack of data and of thefts declaration, as we will further explain in this paper, are only part of the reasons that justify such under-exploration. Another important reason is related to how theft reports are processed by the police offices and how such information is then reported in lists such as the SWoA. This piece is the first paper trying to make use of available information—which is available to art buyers and sellers too—to understand whether recorded thefts modify art market agents' risk perception and whether this potential change impacts on art market prices. In this way, we are able to identify whether art thefts lists can have a role in influencing the art market and, if so, whether such information has a negative or positive on selling prices.

The remainder of this article is structured as follows. In Sect. 2 we present a literature review on art crime and art thefts, together with our empirical hypotheses. In Sect. 3, we present our data, the empirical model, and the results. Section 4

discusses our results and Sect. 5 provides a wider disciplinary significance of these, together with limitations of our study and possible future paths of research.

## 2 Art crime and art thefts

### 2.1 Art crime definition and legal issues

Discussions about the nature of art crime and its cultural, social, and economic consequences prove a lively debate within the fields of criminology and law. Both in practice and academia, however, it has proven difficult to establish a clear definition of what exactly ‘art crime’ entails. Conklin (1994) initially presented art crime as an umbrella term encompassing five primary criminal activities: forgery, fraud, vandalism, smuggling, and theft. Although nowadays we still consider art crime an umbrella term, the concept has since then been extended to “art and heritage crime” (e.g., Grove 2013, Thomas 2014, Oosterman & Yates 2020). Heritage here encompasses any physical or immaterial manifestation of community and individual identity. Although the definition is by no means all-encompassing, heritage crime can be considered as “(...) any offense which harms the value of [a country’s] heritage assets and their settings to this and future generations” (Historic England, 2023).<sup>4</sup> In terms of criminal activity, however, we can consider all types of criminal activities associated with art and/or cultural heritage to be a form of art and heritage crime. Despite the plethora of criminal activities associated with art and heritage, often art theft is treated as a ‘regular’ property crime, which makes sense as art and heritage crime is not a delineated term within criminal law as such. Therefore, art and heritage thefts might be reported to the designated enforcement agencies, however, not implemented in a dedicated database on stolen art and heritage, leading to a considerable dark figure of this particular crime (James, 2000; Oosterman, 2019). This means that many artworks and/or cultural heritage objects that are stolen are not reported to, for example, the police or insurers, therefore never being included in specialised databases. Although it is difficult to establish a recovery rate for this type of crime - due to the large dark figure - it is suspected to be very low. At the same time, recurring international police operations (usually a collaboration between Interpol, Europol, and local law enforcement agencies, e.g., ‘Operation Pandora’), yearly see tens of thousands of cultural objects seized in global networks that span over 100 countries. It is safe to say therefore that the illicit trade in these materials is large (Brodie et al., 2022). This global network furthermore poses significant challenges, not only for policing, but also for the return of cultural objects which has to do with the concept of ‘ownership’. Where art markets might unproblematically discuss ownership of cultural objects, in fact, the art market sells cultural objects and is therefore in the business of title transfer; the abstract idea of ‘ownership’ is not a universally understood concept. For example, in many countries in Latin America, national heritage laws dictate that all objects ‘from the ground’ are part of the nation and can therefore not be traded, sold, or taken without confirmation from a public body,

<sup>4</sup> Historic England was more commonly known as “English Heritage” until 1 April 2015.

usually a Ministry (Oosterman and Yates, 2020). In many jurisdictions in this region, it is therefore not possible to privately own these types of objects. Issues arise when these objects leave their jurisdictions illegally (e.g., without an export license) and are then sold on an art market, because whenever there is a dispute (e.g., request for return) the legislation of the country in which the object is located at that time prevails (Campfens, 2020). This of course poses an issue in relation to art crimes that involve trafficking, because this can mean that when an object is bought in good faith (the buyer did not have any reason to believe that the object had illicit origins) or if enough time has passed (statute of limitations), the object not only becomes implemented in a licit market, the title—and therefore ownership—is now also transferred. This can, and has, led to the vast circulation of illicit materials in the art and antiquities market (Mackenzie and Yates, 2017), with potential impacts on the risk perception of possible thefts of licitly owned artworks.

In this article, we focus specifically on art thefts, as an operational definition encompassing all artworks that are registered stolen and implemented in (in this case) Interpol's Stolen Works of Art Database (SWoA). We focus therefore on one particular criminal activity, and do not take into account instances of, for example, vandalism, trafficking, or looting. We do this because we have no way to infer or develop hypothesis for these types of criminal activities as the data is either unavailable or too dispersed.

## 2.2 Data on art thefts

Various institutions gather and organise data on art thefts. By far the most extensive and well-known, publicly accessible database is Interpol's Stolen Works of Art Database (SWoA), which is currently the largest public police database with more than 52,000 registered objects from all over the world. As Interpol is the largest international policing organisation, comprising of 196 member countries, the SWoA in turn is the largest database on stolen works of art entirely comprised of data of public policing authorities. Member states, through National Coordinating Bureaus (NCB's), provide Interpol with information about national art thefts. Interpol uses that data to fill the database and inform relevant member states about missing works of art. Of course, there remain issues with the dark figure (as previously mentioned). Not all member states register or document stolen works of art in a specialised national database, or register works of art as being works of art. At the same time, not all art thefts are registered or reported to the police. Therefore, the Interpol database should not be considered as a truly representative database. Nevertheless, the SWoA, and its associated ID-Art mobile application, are in fact the only public police databases in existence, and as such, participants in the art market (be it sellers, intermediaries, buyers) use the information in this database to inquire about stolen works of art. Here, the information on stolen works of art is publicly available, which is rather unique. Any civilian in any country can access the database of Interpol rather unrestrictively and entirely free of charge. In that sense, Interpol provides intelligence to all those who wish to inquire into the status of certain works of art. Despite the fact that the database might not be representative, it does give the

best (and only public) picture of stolen works of art around. As such, art market participants can inquire into possible risks associated to a sale, making this database the most relevant for our inquiry. Interpol's biggest commercial counterpart is the Art Loss Register (ALR), which holds more than 700,000 objects in its database, making it the largest private database for stolen works of art. However, the ALR charges up to €2,250 for 50 searches in a year in the database (price in December 2024) and is not publicly accessible, making it restrictive for market participants to acquire information about risk.<sup>5</sup> Several national law enforcement agencies also keep databases of stolen works of art (Oosterman, 2019; Oosterman and Yates, 2020), and several smaller commercial databases register stolen works of art (e.g., Art Recovery International). However, as previously mentioned, firm claims on scale and size of art theft are hard to make. Several statements circulating in professional and academic circles claim that "the illicit trade is the third largest criminal enterprise" or that it "grosses 3 billion annually", however this is entirely without statistical merit, and, as explained by Yates and Brodie (2023), in reality a so-called factoid.

In this article, we do not intend to debunk factoids - as Yates and Brodie have already done so adequately - or try to determine an exact scale of art thefts. Rather, we aim to provide careful economic analyses on art thefts, using the most complete data possible from trustworthy sources to measure, albeit to an extent, the effect that an art theft - and making that theft known to the public - can have on the market.

### 2.3 Economic inquiries into art theft

The study of art crime has attracted significant academic attention from various disciplines, including criminology, sociology, archaeology, and law. Researchers such as Block (2016), Fabiani (2018), Greenland (2021), Kerr (2016), Oosterman et al. (2021), and Oosterman and Yates (2021, 2022) have contributed to the understanding of art and heritage crimes from criminological and sociological perspectives. In the field of archaeology, Brodie and Sabrine (2018), Corpas (2020), and Yates (2019) have examined the issue of art and heritage crimes within the context of cultural heritage, archaeological practice, and the illicit looting and subsequent trade of cultural objects. From a legal perspective, Hufnagel and Chappell (2014), Lixinski (2019), Ulph (2015), Campfens (2020), and Vrdoljak (2015), among others, have contributed significantly to the field of art and cultural heritage law, exploring the legal dimensions and frameworks of art and heritage crimes.

Art theft remains, however, a relatively under-researched area within the field of economic inquiry; few examples are Landes and Levine (2006), who have examined various aspects of art law, including art theft and the trade of stolen artworks, and Day (2014), who explores the risks associated with purchasing stolen artwork and emphasises the significance of databases that record stolen pieces. These studies, though, were more focused on the behaviour of art market agents with respect to stolen artworks, which are likely to impact their risk perception in case of trade, however in a different way with respect to the type of impact that we are considering,

<sup>5</sup> Note that the Art Loss Register also registers missing and lost objects, meaning that theft is not always indicated.

namely the impact possibly generated by knowing that a certain artist's pieces have been stolen.

However, despite economic studies related to illegal activities in the art sector being scarce, economists have focused on analysing museums' incentives for investing in security measures and insurance against art heists (Nicita and Rizzolli, 2009; Chen and Regan, 2017) as well as the illicit trafficking of art (Fisman and Wei, 2009). Furthermore, the scarcity and inconsistency of data have hindered economists from conducting more quantitative analyses in this area. Notably, Lawrence et al. (1988) suggested a possible relationship between art theft and the art market, but they were unable to conduct a comprehensive empirical test due to the lack of reliable data. In general, only a limited number of quantitative studies have specifically addressed the topic of art theft (Burmon 2017, Ho 1992, the former focuses on stolen arts recovery, the latter on offender motivation and decision-making).<sup>6</sup>

Given the significant role of risk in shaping art market choices, it is important to take into account how this perception of risk and art market values are related.<sup>7</sup> Therefore, we first built a economic framework to represent the relationship between risk and art market value, and then we empirically tested this relationship. To the best of our knowledge, this would be the first empirical study within economics literature analysing the impact of art theft on the art market.

## 2.4 An economic framework

Agents' risk is not only limited to evaluation issues (related to limited and asymmetric information, widely discussed in the literature), but can also come from the perception of risk related to other events besides evaluation and sales themselves, such as the discovery of the presence of fakes of the artist whose artworks are on sale (Scorcu et al., 2021), the potential application of a property-restricting regulation such as an export ban or limitation (Angelini et al., 2023), or a news item detailing that an artists' disavowed artworks were attributed to him (Coslor and Fry, 2024). According to Agnello (2002) and Ashenfelter and Graddy (2006), costs and benefits alter the return of an artist's portfolio. The costs associated with investing in

<sup>6</sup> In economic models of crime, economic incentives affect individuals' participation in criminal activities operating through legal wages in the formal labor market and the economic returns to illegal activities. Especially for car thieves, evidence consistently shows that economic incentives play a crucial role in influencing criminal behavior (Van Ours and Vollaard, 2016; Draca and Machin, 2015). Several commodity markets have exhibited a positive relationship between commodity prices and theft rates. Notable examples include copper, metal, and fuel, as documented in studies by Sidebottom et al. (2011), Brabenc and Montag (2018), and Sidebottom et al. (2023). These studies suggest that as the prices of these commodities rise, the incentive for theft increases, leading to higher theft rates. In this respect, durability as a feature of the quality of goods affects the incentives of prospective criminals to steal durable goods (Galiani et al., 2020). No studies on this strand, though, empirically analyse art theft.

<sup>7</sup> A key actor in evaluating the risk in the art market are art insurers, and art thefts are one of the main three types of event that influence risk perception in the art market, together with art deterioration and art fraud (Pavia et al., 2021). Their involvement in insuring cultural objects gives them significant power in determining prices within the art market. Through risk assessments, security measures, and financial guarantees, they help prevent crime and shape the art market (Kerr, 2016; Baker and Simon, 2002). Art insurers emphasise insuring the financial value of artworks, influencing market governance (Kerr, 2016).

art include special and diversifiable risks such as fire, theft, fakes, forgeries, and false attribution.<sup>8</sup> These costs are inherent to specific risks of investment in fine art, and collectors should diversify their artists' portfolios to reduce these risks. Furthermore, among the benefits of art investment is the psychic return (Anderson et al., 2016).<sup>9</sup> In other words, it is possible to observe that different agents will have different reserve prices for the same artwork even if they use the same information set. In the auctioning process, indeed, items are traded by making a bid and selling the item to the highest bidder.<sup>10</sup>

Since the perception of risk is influenced by several events, including bad and good news, we expect that the theft of an artist's artwork will affect the auction prices of his/her other artworks. If the perceived risk associated with art theft may imply lower reserve prices, this effect could potentially be transferred to auction prices, which are observable. Therefore, we need to focus on the full price, which includes the selling price along with the transaction costs (e.g., insurance costs, needed to protect buyers from potential risks associated with the transaction itself, see Velthuis 2011). Bad news might also have an opposite effect through two different channels: (i) the theft of an artist's artwork reduces the number of available artworks by that artist, thereby increasing their scarcity; thanks to existing lists of stolen artworks such as Interpol's SWoA, the public may become aware of such a scarcity, triggering an increase on price due to a supply change; and (ii) media coverage of the theft could raise the artist's profile and stimulate market interest towards his/her works, leading to a potential increase in the demand.

In fact, the hypothesis that stolen artworks will experience a negative effect on their market value may overlook some forces of the art market, where scarcity, attention, and perception play critical roles. Several theoretical underpinnings suggest that a theft event could paradoxically increase an artwork's market value under certain conditions. While the risk associated with stolen artworks often deters some buyers, it is essential to recognise that the art market cannot operate purely on conventional risk-return principles. Scarcity, notoriety, cultural capital, and status signaling can offset the risk associated with theft, transforming it into an alternative asset under certain circumstances. These arguments suggest that theft can sometimes have positive price effects, elevating an artwork's profile, enriching its narrative, and appealing to collectors who value exclusivity and uniqueness more than security. However, despite these arguments for a

<sup>8</sup> For example, Frey and Pommehne (1988) estimated fire and theft insurance costs to range from 0.2 to 1.0 percent of an artwork's value. See Chapter 3.4 in Frey (2019) for a brief discussion of various types of art market risks, among which the one we are investigating is missing.

<sup>9</sup> For example, Candela et al. (2013), using an opportunity cost framework and the analytical tools of portfolio theory, estimated a consistently positive measure of psychic return for five artistic periods and five art forms.

<sup>10</sup> The seller's reserve price is a predetermined price agreed upon between the seller and the auction house, below which the artwork will not be sold. While the exact reserve price is typically kept confidential, several rules of thumb exist regarding its relationship to the minimum estimate (Castellani et al., 2018) On the other side, within an independent private value auction, the bidder's reserve price is revealed during the auction, but the private value component of art induces buyers to overpay for paintings (the winner's curse) depending on the potential number of bidders (Goetzmann and Spiegel, 1995).

potential positive effect, the negative impact is likely to prevail in the art markets when buyers emphasise security, provenance, and confidence. Although notoriety and attention can sometimes boost an artwork's visibility, when the art market demand is particularly risk adverse, buyers prefer security, provenance integrity, and marketability. Legal, financial, and reputational risks compound to make stolen artworks less attractive investments, reducing demand and thus lowering prices. It follows naturally that collectors (in particular speculators, as defined by Coslor et al., 2020) buying art as an investment asset will be particularly exposed to the risk of a theft, since their aim is to resell the piece. Having more stolen pieces of a certain artist circulating in the market may increase the perceived risk of buying a stolen artwork in the future buyers of a speculator (or of an investor), hence reducing the net present value of such a good, meaning a lower reserve price and a possibly lower selling price. In several cases, these factors exert consistent downward pressure on the market value of stolen artworks, and the negative effects of theft can prevail over any potential gains from increased attention or notoriety.

Predicting the effects of a theft on the auction price of an artwork is challenging, but we can formulate hypotheses and test them against our data. If we expect artworks by an artist, whose other pieces have been stolen, to be linked with higher perceived risk and lower prices, this effect could be reflected at the market level when there is little to no substitution effect between artworks of different artists. This assumption holds if buyers are collectors interested in specific artists' works rather than investors speculating on these assets. Therefore, if *ceteris paribus*, the price of artworks by artist *A* decreases due to a higher perceived risk of theft, while the prices of artworks by artists *B*, *C*, etc., remain unaffected, we should observe a lower average market price. The opposite should occur if the theft of an artist's artwork positively affects the average market price.

Assuming that the risk perceived linked with the fact that an artist's artwork has been stolen and reported will have an effect on the market value of the same artist's other artworks, and that the perception of risk is likely to be linked to the intensity of the risk cause, i.e., a stronger perception of risk arises when an artist's works are particularly susceptible to theft, we present the following hypotheses:

**Hypothesis 1** The theft of an artist's artwork (negatively) affects the average market price.

**Hypothesis 2** The higher the intensity of thefts of an artist's artwork, the stronger the effect on the average market price.

To make these predictions testable in an empirical model, we will specify this economic framework by using a set of hedonic models, so we can test the effect of thefts on prices, controlling for artwork- and the trade-specific characteristics.

### 3 Empirical analysis

#### 3.1 Data

Our dataset consists of two parts: one regarding artworks auctioned at international auction houses and the other regarding the stolen artworks that have been declared as such. In what follows, we assume that all artworks at auction are not stolen objects. In other words, we expect auction houses in our dataset to perform due diligence by researching both the provenance and the property of an item. Auction houses always consult several sources such as the Art Loss Register and Interpol's SWoA to guarantee that artworks at auction are legally owned by the sellers. Following this assumption, we are implicitly removing the possible perceived risk the buyer will bear to buy a stolen object (Day, 2014; Landes and Levine, 2006; Posner and Landes, 1996), keeping only the (possible) perceived risk related to the purchase of a piece of an artist whose artworks have been stolen in the past.

Concerning the art auctions, we hand-collected a unique dataset of modern and contemporary art auctions at Christie's, Sotheby's, and Phillips between 2012 and 2016, in London and New York. Our information comes from the online catalogues of the three auction houses. Overall, we have 23,356 items and 1,872 artists. In particular, we collected for each item the following data: the name of the artist (*Artist*), the name of the auction house (*AuctionHouse* as Christie's, Sotheby's, and Phillips), the venue of auction and the currency of prices (*Currency* as Dollar for New York and Pound for London), the year of the auction (*Year*), the auction session (*Session* as day, afternoon, evening, or morning), the lot number (*Lot*), the minimum presale estimate (*Minpresale*), the maximum presale estimate (*Maxpresale*), the average presale estimate (*Meanpresale*), a standardised measure of dispersion of estimates (*Varpresale*) as  $(Maxpresale - Minpresale) / Meanpresale$ , the hammer price (*Price*) of the artwork (if sold), whether the artwork has been sold (to grasp the presence of the buy-in effect, if this is not the case) (*Sold*), the presence of guarantee to pay a consignor for a lot, regardless of whether the bidding at auction reaches the reserve price (*Guarantee*), the year the artwork was created (*Yearcreated*), and the description of the material and technique used by the artist to make the artwork (*Technique* as painting, photography, print, sculpture, mixed, or other). Furthermore, we set two further variables as the number of transactions for each artist in our sample (*Transaction*) and the number of years from the creation of an artwork to the date of the auction (*Age*). The descriptive statistics of these variables are reported in Tables 1, 2, and 3.<sup>11</sup>

Note that Christie's & Sotheby's together account for over 75% of the high-tier auction houses market, and trades are uniformly distributed among London and New

<sup>11</sup> Prices are converted into US dollars using the exchange rate applicable at the time of the trade. In this empirical analysis, we do not adjust the nominal exchange rate for inflation.

York.<sup>12</sup> Each sale year accounts for around 20% of the traded artworks, but 2016 with only 16%. Most of the artworks are paintings and the day's session is the most frequent session in our dataset. Note that less than 5% of trades are guaranteed and more than 20% of items are unsold. The oldest artwork is 109 years old (La Jambé du Paysan by Marcel Duchamp) and the most traded artist is Andy Warhol with 856 transactions. From Table 3, we can see that we are analysing the high-tier of the art market, since the prices are on average quite high, up to a maximum of almost 87 million dollars (the selling price of Orange, Red, Yellow by Mark Rothko, sold at Christie's New York in 2012). For this reason, in what follows we will take the logarithm of prices and estimates in our empirical models, to reduce the variability of these variables.<sup>13</sup>

Concerning stolen artworks, we used Interpol's Stolen Works of Art Database (SWoA), which consists entirely of reported artworks that are stolen from all over the world.<sup>14</sup> The data used for this analysis were extracted from Interpol's database in February 2023, containing 19,404 entries of stolen objects between 2002 and 2016.<sup>15</sup> In particular, we searched for artists both in the contemporary period at the auction (2012–16, 5 years) and in the period before (2002–11, 10 years), limiting our analysis to consider only the latter set to avoid endogeneity issues due to the link between price and theft, that we discussed in the previous sections. For each of the entries, we gathered the following data: the name of the artist, the country in which it was stolen, and the date of theft. Matching the variable *Artist* from the art auctions dataset with the name of the artist in SWoA, we added the new data (country and the date of theft) to our dataset of auction prices. Of 1,872 artists present at single unit auctions, 49 are those whose artworks were stolen between 2002 and 2011. Based on this information, we set a dummy variable to check if the theft or thefts happened before the auction trade: *Theft* is a dummy variable equal to 1 if the artist who made the artwork at auction had at least one of his/her artworks stolen from 2002 to the auction date. Also, we set a discrete variable to measure the number of an artist's stolen artworks between 2002 and 2011 (*Pieces*).<sup>16</sup>

We merged the two datasets by making use of the variable *Artist*, after checking for consistency between the way the name was written in the two datasets. The dataset resulting from the merge is made up of a total of 23,356 sold artworks, made

<sup>12</sup> We limited the analysis to these 3 auction houses only, which constitute the most important auction houses in the market. Our analysis is limited to two cities only, which however can be considered the main cities in the analysed period for the Western art market. This clearly limits the analysis to the high tier of the art market in Western regions, as we will discuss in the limitations section.

<sup>13</sup> This transformation, typical in studies of art market prices, is also used to reduce possible issues linked to the skewed distribution of prices.

<sup>14</sup> Objects are entered into the Interpol database by the national police force of the member countries of Interpol.

<sup>15</sup> All stolen objects are recorded with both theft and upload dates, and for each item the following information is reported: object type, media, materials, description, country, city, and place where it was stolen, title, status as stolen and unclaimed, shape and dimension, name of artist and signature with position. Furthermore, entries show the picture of the objects.

<sup>16</sup> To reduce the variability of this variable, we apply a logarithmic transformation (after adding 1) in our empirical models. This adjustment is necessary because the variable contains numerous observations with a nil value.

**Table 1** Descriptive statistics of categorical variables

Variable	Freq	Percent
<i>AuctionHouse</i> = Christie's	8,886	38.05
<i>AuctionHouse</i> = Phillips	5,292	22.66
<i>AuctionHouse</i> = Sotheby's	9,178	39.30
<i>Session</i> = Morning	2,050	8.78
<i>Session</i> = Day	15,578	66.70
<i>Session</i> = Afternoon	1,766	7.56
<i>Session</i> = Evening	3,962	16.96
<i>Technique</i> = Mixed	541	2.32
<i>Technique</i> = Other	4,529	19.39
<i>Technique</i> = Painting	13,759	58.91
<i>Technique</i> = Photography	364	1.56
<i>Technique</i> = Printing	2,173	9.30
<i>Technique</i> = Sculpture	1,990	8.52
<i>Year</i> = 2012	4,836	20.71
<i>Year</i> = 2013	4,872	20.86
<i>Year</i> = 2014	4,975	21.30
<i>Year</i> = 2015	4,834	20.70
<i>Year</i> = 2016	3,839	16.44
Total	23,356	100

**Table 2** Descriptive statistics of dummy variables

Variable	Freq	Percent
<i>Currency</i> = USD	11,824	50.63
<i>Currency</i> = GBP	11,532	49.37
<i>Guarantee</i> = Yes	1,079	4.62
<i>Guarantee</i> = No	22,277	95.38
<i>Sold</i> = No	4,999	21.40
<i>Sold</i> = Yes	18,357	78.60
Total	23,356	100

**Table 3** Descriptive statistics of discrete and continuous variables

Variable	Obs	Mean	Std. dev	Min	Max
<i>Price</i>	18,357	705,450.50	2,843,248	375	86,882,500
<i>Age</i>	23,356	24.29	18.73	0	109
<i>Transaction</i>	23,356	106.84	171.30	1	856
<i>Lot</i>	23,356	239.13	157.05	1	667
<i>Minpresale</i>	23,356	445,853.60	1,800,425	389.98	40,000,000
<i>Maxpresale</i>	23,356	635,162.00	2,562,112	545.97	60,000,000
<i>Meanpre-sale</i>	23,356	540,507.80	2,179,868	467.97	50,000,000
<i>Varpresale</i>	23,356	0.35	0.07	0.06	1.77

by 1,872 artists, those that were already part of the dataset of modern and contemporary art auctions.<sup>17</sup>

Table 4 gives a hint of the importance of thefts in the art market we are considering; for example, 2,710 over 23,356 items in our dataset (i.e., 11.60%) are made by an artist whose artworks have been stolen before the auction at least once. These available data contain information that signal a possible risk of art thefts (as well as the police effort to recover stolen artworks); therefore, the information that a piece of art is part of the SWoA could signal the risk of art theft, and this is what we are going to test on our data. In other words, we wonder if thefts affect the auction price of artworks made by an artist whose pieces have been stolen before the auction.

### 3.2 Empirical models and results

In this section, we specify the models required to test hypotheses 1 and 2, as introduced in the economic framework. The first model we employ is the selection model (Heckman model), which follows:

$$\begin{cases} S_i = \alpha_s + T_i\gamma_s + P_i\delta_s + W_i'\theta + F_i\tau_s + u_i \\ \log(\text{Price}_i) = \alpha_y + T_i\gamma_y + P_i\delta_y + X_i'\beta + F_i\tau_y + \epsilon_i \text{ iff } S_i > 0 \end{cases} \quad (1)$$

where  $X_i$  is a vector of variables identifying the artwork- and the trade-specific characteristics,  $F_i$  is the vector of fixed effects which contains both year- and technique-specific fixed effect, and  $u_i$  and  $\epsilon_i$  are the error terms.  $T_i$  is the theft-related variables vector; this vector is a  $1 \times 1$  vector for model 1, consisting in the dummy variable  $Theft_i$ , to test for hypothesis 1, as well as in model 2, consisting in the counting variable  $Pieces_i$ , to measure the effect intensity of the theft, as for hypothesis 2; in model 3,  $T_i$  is a  $2 \times 1$  vector, containing both variables. The vector  $W_i$  contains the variables included in  $X_i$  and the additional dummy variable  $Guarantee_i$ .  $\alpha_j$ ,  $\gamma_j$ ,  $\delta_j$ ,  $\tau_j$ , together with those contained in the vectors  $\theta$  and  $\beta$ , are the parameters to be estimated, where  $j = s, y$ .

To capture the complex nature of the dependent variable, we control for other effects such as the market fame of frequently stolen artists and the importance of the historical relevance of an artwork. We use the number of transactions for each artist in our sample (*Transaction*) as a proxy for artist's market fame and the number of years from the creation of an artwork to the date of the auction (*Age*) as a proxy for its historical significance.<sup>18</sup> In particular, the vector  $X_i$  contains both measures of these latent variables.

<sup>17</sup> Clearly, the SWoA also contains records of some artists that were not present in our auction sales data.

<sup>18</sup> While the *Transactions* variable serves as a proxy for fame, it may not fully account for all dimensions of an artwork's notoriety. If more famous artworks are inherently more attractive to thieves - beyond just being frequently transacted - then fame could still exert an independent influence on theft risk. A potential way to address this concern would be to include additional controls, such as media coverage, exhibition history, or inclusion in high-profile collections, to better isolate the fame effect from transactional activity. Further analysis, perhaps through interaction terms or alternative fame proxies, could help determine where fame continues to play a significant role beyond what is captured by the *Transactions* variable.

The first equation of the system (1) is the selection equation while the second equation is the price equation: the former equation models the propensity of an artwork  $i$  to be sold,  $S_i$ , as a linear combination between the vector of parameters  $\theta$ ,  $\gamma_s$ ,  $\delta_s$ ,  $\tau_s$  and several characteristics included in the vector  $W_i$ ,  $T_i$ , and  $F_i$  given the constant  $\alpha_s$ . The variable  $S_i$  is latent but we can observe the dummy variable  $\sigma_i$ , which indicates if the artwork is sold (i.e.  $\sigma_i = 1$  if and only if  $S_i > 0$ ) so we do not observe the price when  $\sigma_i = 0$  (i.e. when  $S_i \leq 0$ ). If the two error terms  $u_i$  and  $\epsilon_i$  are correlated, a sample selection bias can exist and Ordinary Least Squares (OLS) estimates of the prices are inconsistent. To take into account this potential bias and obtain a consistent estimate of the coefficients, we can simultaneously estimate the selection and price equations by Maximum Likelihood (ML) estimation (Castellani et al., 2018).

Finally, as the effects of our independent variables in the lower part of the price distribution may differ from their effects in the upper part, we model both the conditional mean and median of  $\log(\text{Price})$  using, respectively, a regression and a quantile regression for robustness check. Specifically, we perform by OLS estimation a simple regression model

$$\log(\text{Price}_i) = \alpha_y + T_i\gamma_y + P_i\delta_y + X_i'\beta + F_i\tau_y + \epsilon_i \quad (2)$$

where the variables have the same meaning as before. Furthermore, we estimate a quantile regression model by minimizing the sums of the absolute residuals, where  $Q_y(q|\dots)$  is the conditional quantile function and  $q$  represents the  $q$ -quantile ( $q = 0.5$  for the median) of artwork prices, conditional on all dependent variables (Candela et al., 2016).

From the results reported in Table 5, we fail to reject Hypothesis 1, that is the theft of an artist's artwork negatively affects the auction prices. We can also see, from the second column of the table, that a theft of an artist's artwork does not affect the probability of an artwork being sold at auction. Furthermore, we find empirical support to Hypothesis 2, that is the higher the intensity of thefts of an artist's artwork, the stronger the negative effect on the average market price.<sup>19</sup> This confirms that a relationship between thefts and the economic evaluation of artworks exists and it is negative, a result possibly explained by the risk argument we discussed in Sect. 2.4.

In particular, in the price equation of the Heckman model all independent variables have a significant effect on price, except for the variable *Age*, while in the selection equation, only the variable *Theft* and *Age* do not affect the probability of an artwork being sold. Additionally, there is a significative correlation between the error terms of the two equations.<sup>20</sup>

<sup>19</sup> According to informal rules of thumb applied to the Variance Inflation Factor (VIF), we do not find evidence of multicollinearity since the mean of all the VIFs is not considerably larger than 1 and the largest VIF is slightly greater than 10.

<sup>20</sup> This suggests that the Heckman selection model is preferable to regression and quantile regression model for estimating the effect of thefts and its intensity on the art market prices, as sample selection bias is present and would affect any estimation of regression models to test Hypotheses 1 and 2.

**Table 4** Descriptive statistics of SWoA-related variables

Variable	Obs	Mean	Std. dev	Min	Max
<i>Theft</i>	23,356	0.16	0.36	0	1
<i>Pieces</i>	23,356	0.87	3.78	0	79

The two regression models for conditional mean and median show similar results in terms of significance, sign and magnitude of the coefficients. Both models indicate that the effect of theft and its intensity on artwork price is negative and statistically significant, consistent with the results in the price equation of the Heckman model. All other coefficients display a fairly similar pattern across the two specifications of the regression models, indicating that the independent variables do not have significantly different effects across the various parts of the artwork price distribution. After controlling for year- and technique-specific effects, the age of the artwork has a positive but almost nil impact on the final price, suggesting that the historical importance of an artwork has a minimal role in the modern and contemporary art market. Similarly, the artist's market fame has a positive but negligible effect on price, since the price increases as the number of transactions per artist increases. Furthermore, the measures of expected return and variance,  $\log(\text{Meanpresale})$  and  $\text{Varpresale}$ , have a positive effect on price. Christie's achieves statistically higher hammer prices compared to Sotheby's and Phillips in our sample. Day and morning sessions yield lower hammer prices than afternoon sessions, while evening sessions do not significantly influence auction prices. Finally, prices are generally higher in New York than in London, and price tends to decrease as the lot number rises.

## 4 Discussion

Looking at our findings from an economics perspective, we can analyse the existence of different types of incentives for reporting a stolen piece. This may create a negative one for the criminals to steal artworks, since an artwork that ends up in a database such as the SWoA, ALR, or NSAF, if coupled with due diligence,<sup>21</sup> could see its illicit market price reduced. This is likely the reason why databases and lists are suggested in international law tools such as in the afore-mentioned UNIDROIT and Nicosia Convention. In addition to that, this effect is at work in the licit market for the pieces made by an artist whose artworks have been stolen and reported, and it is increasing in the number of stolen pieces by such artist, suggesting that the perceived risk of theft is generally already attached to the artist name by both buyers and auction houses, but, when this risk happen to be higher (because of a high number of stolen artworks made by the subject), this triggers some type of negative risk premium. A possible explanation of the increase in the impact as the number of stolen pieces (*Pieces*) increases is that a higher number of stolen pieces by the same

<sup>21</sup> Notice that applying due diligence is not always known to be the case, even for reputable auction houses (see for example Brodie 2014, Brodie 2019, Tsirogiannis2015).

**Table 5** Estimation results

Model	Heckman model		Reg.	Quant. reg.
Response variable	$\log(\text{Price})$	<i>Sold</i>	$\log(\text{Price})$	$\log(\text{Price})$
<i>Theft</i>	-0.09***	-0.11	-0.08***	-0.08***
$\log(\text{Pieces})$	-0.11***	-0.17**	-0.09***	-0.08***
<i>Age</i>	0.00	-0.00	0.00***	0.00***
<i>Transaction</i>	0.00***	0.00**	0.00***	0.00***
<i>Lot</i>	-0.00***	-0.00***	-0.00***	-0.00***
$\log(\text{Meanpresale})$	0.88***	-0.24***	0.90***	0.90***
<i>Varpresale</i>	0.12***	-0.06	0.11***	0.13***
<i>AuctionHouse</i>				
Phillips	-0.29***	-0.57***	-0.22***	-0.23***
Sotheby's	-0.03***	-0.12***	-0.02	-0.03***
<i>Session</i>				
Day	-0.05**	-0.13***	-0.04**	-0.04**
Morning	-0.15***	-0.20***	-0.12***	-0.10***
Evening	0.04	0.20***	0.01	0.01
Guarantee		0.44***	0.03	0.04***
<i>Currency</i>				
USD	0.13***	0.32***	0.09***	0.10***
Constant	1.57***	4.09***	1.47***	1.37***
Year fixed effect	Yes	Yes	Yes	Yes
Technique-specific fixed effect	Yes	Yes	Yes	Yes
Std. err. adjusted for 1,872 artist clusters	Yes	Yes	Yes	
Std. err. robust				Yes
Number of obs	23,356	23,356	18,357	18,357
Err. Corr. ( $\log(\text{Price})$ , <i>Sold</i> )	0.88***	0.88***		
Adj. $R^2$ (Pseudo- $R^2$ )			0.93	(0.75)

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Quantile regression has been estimated for  $q = 0.5$ . All coefficients are rounded to the second digit

artists may suggest that a resell market for his/her stolen pieces exist, making the possession of one of his/her piece riskier as the number of stolen pieces rises.

But why should a victim of theft not report a piece? A victim of an art theft who reports a stolen piece is indirectly declaring that he/she possessed the aforementioned artwork, which may not be desirable for tax return reasons. On the other hand, he/she may want to report the theft since, in case of recovery of the piece, it could be returned. Alongside these direct effects, our analysis highlights the existence of possible indirect effects, which should be taken into account. In particular, having reported pieces in the databases reduces the selling price of the artworks of the artists whose pieces have been stolen in the long time, and this effect is stronger the higher the number of reported stolen pieces and the more recent the date of

the theft. If the victim of the theft owned only a piece by a certain artist and this piece was stolen, there should not be any impact on his/her other artworks' economic value, in case he/she wants to resell them in the future. However, if he/she owned more than one piece by the same artist and more than one of these artworks was stolen, our results suggest that the economic value of the other pieces should decrease. This constitutes a disincentive to report the artworks. Given that, private incentives are actually in conflict with the goal of the stolen artworks' databases and lists. While obliging to report a theft would potentially solve this issue, it would not be easily enforceable. An alternative, but still not easy to pursue, way to cope with these conflicting incentives would be to have a formal declaration of the owned artworks, so that, should one of the pieces be stolen and recovered, the owner could be tracked down easily, without actually requiring a report of the theft. This is actually in line with what the Interpol's app ID-art permits the users to do, that is, listing their owned artworks. Notice that, however, the tax return-related disincentive would apply to this type of solution as well.

Furthermore, two aspects have to be highlighted in implementing our discussion into the empirical model to test our hypotheses. The first one concerns the type of impact we are expecting: we are implicitly assuming that the different perceived risk will impact only on the intercept and will not interact with the effect on the price of each of the artwork's characteristics; this is reflected in our empirical model, where we treat the variable concerning the theft information as additive. The second one is that the our economic framework can be seen as an analysis of a causality effect due to the theft on art market prices and probability; we could not develop an experiment to test our hypotheses given the impossibility of having a real counterfactual. However, once artworks' observed prices are analysed in a hedonic model, we could empirically grasp the direction of the theft information impact.<sup>22</sup>

## 5 Conclusions

Although we cannot determine the exact scale and impact of art crimes, in economic and cultural contexts, the structural reality argues that it has a significant impact on individuals, communities, and the art market (Oosterman et al., 2021; Oosterman and Yates, 2020). The significant economic value and cultural significance of stolen pieces make their thefts not only financially damaging, but also detrimental to shared cultural heritage and identity.

This study investigated the effects of art theft on art auction sales focusing, in particular, on the impact on the auction prices of an artist's artwork when another of his/her artworks had been stolen and reported on Interpol's International Stolen Works of Art Database.

The assumption that theft negatively affects auction prices is supported by our data, indicating that the presence of theft risk can lower the prices of artworks at

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<sup>22</sup> Notice that this setting can also be applied to other types of information shocks such as the discovery of a fake or the death of an artist. See for example Bocart and Oosterlinck (2011) and Scorcu et al. (2021) for fakes, and Ekelund et al. (2000) and Ursprung and Wiermann (2011) for analyses of the death effect.

auction. Such an impact is stronger as the number of pieces stolen by the same artist increases. This finding aligns with the expectation that potential buyers may be hesitant to bid on the artwork of an artist whose pieces have been stolen, leading to lower prices.

In conclusion, while this study provides valuable insights into the relationship between art theft and market dynamics, there are several avenues for further research. Investigating microeconomic and macroeconomic incentives, along with embracing technological solutions, can contribute to more effective strategies for combating art theft and protecting cultural heritage, further discussed in the next subsection. Both academics and practitioners should work together to develop and implement these strategies. This can include enhancing security measures, promoting transparency and cooperation among market participants, and supporting initiatives that facilitate the reporting and recovery of stolen artworks.

### 5.1 Limitations and future research

Our work presents some limitations, mostly due to the availability of data. In fact, art thefts that are not reported to Interpol, for any reason, are excluded from our dataset. At the same time, we are focusing only on the very high tier of the art market, as represented by the main international auction houses, located in New York and London.<sup>23</sup> We here discuss these limitations and suggest possible further analyses that may be carried on with more refined data.

We consider the number of transactions for each artist and the number of years from the creation of an artwork to the date of the auction as the artistic production levels of artists. However, exploring whether the reduction in supply due to theft has a stronger effect on artists with limited artistic production (e.g., artists with fewer total artworks created) compared to prolific artists could enhance our understanding of how theft impacts market dynamics and pricing. Notice, however, that this is in part taken into account by the artist fixed effects we use in our estimations. A further analysis could also take into account other segments of the market, different from the high tier, where information is more scarce (Angelini et al., 2022) and where different responses to such information diffusion can be observed.

Since a theft could involve a reduction of the number of artworks of that artist in the art market ('scarcity effect') or an increase in the interest the market pays to this artist ('brand effect'), we focus only on the effects of this type of information. Examining the impact of undervalued artworks that are later discovered to be of significant worth ('sleepers') and the certification status of artworks by art foundations would provide a more nuanced understanding of market dynamics. Investigating how the supply of sleepers and certified pieces is affected by thefts and their subsequent impact on market outcomes could shed light on the role of rarity and authentication in pricing and demand.

We set a series of empirical models to test how the theft perceived risk influences the art market value only considering the agents acting in art auctions. Assessing

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<sup>23</sup> We thank an anonymous referee for suggesting to highlight this.

the microeconomic incentives for reporting stolen pieces by different market agents, including buyers, sellers, and law enforcement, would provide insights into the factors that drive information sharing and cooperation. Understanding the motivations and barriers to reporting stolen artworks can contribute to the development of effective strategies for improving recovery rates and reducing illicit art market activities.

A model that also considered sellers would have been more complete, but we preferred to limit our analysis to an exchange of goods with observable data, such as the one between the buyer and the auction house. In particular, investigating the sellers' strategies in response to theft news would be interesting due to two possible opposing forces: on one hand, they may not want to sell an artwork by an artist who has had their work stolen because this could reduce the price; on the other hand, they may be afraid to keep the artwork because it could be stolen.

Our data on thefts comes from Interpol's International Stolen Works of Art Database covering 13 European countries. Exploring the macroeconomic incentives for maintaining registers/lists and the broader economic benefits they offer is important. Investigating the impact of registers/lists on market integrity, cultural heritage preservation, and fostering trust among market participants would provide a comprehensive understanding of their value and support informed policy decisions. Hence, our analysis could be extended by considering other databases maintained by police groups, such as the NSAF by the FBI, or by private entities, such as the Art Loss Register.

We test with our empirical models several assumptions on the effect of a change in agents' information set. Embracing technological advancements, such as Interpol's app for smartphones, can enhance the effectiveness of registers and streamline the reporting and identification of stolen artworks. Further research could explore the adoption and impact of such technologies in improving information flow, facilitating recovery efforts, and enhancing the efficiency of anti-theft measures.

While it is likely that thieves will try to steal artworks considered more valuable, even though it may be hard for them to sell these pieces on the licit market, hence triggering an endogeneity problem in an analysis such the one we present here, there exist other variables that impact the thieves choice. A tentative list may contain the ease of access to the location containing the artworks (presence of alarm, presence of guards, etc.), the condition of having an opportune spatial and temporal alignment, the knowledge of what is hosted in the location chosen for the theft (which is surely greater for public museums than for private houses). The theft of artworks is influenced by several factors that significantly deter potential thieves. The difficulty of trading stolen artworks, coupled with the high risk of punishment, often outweighs the value of most artworks, with few exceptions (Lasso de la Vega et al., 2021, 2023). Additionally, collections containing significant artworks are typically protected by extensive security systems and insurance coverage, rendering the impact of a marginal addition to the collection negligible. Understanding these deterrents is crucial for developing effective strategies to prevent artwork theft and protect valuable collections. All these variables are only partially correlated with economic value of the artworks, and surely constraint the thieves in their choice of what to steal, which is then not always the most valuable piece. Furthermore, thieves may not be able to catch the market expected value of an artwork and then choose

(if the conditions linked to the variables we named before being favourable) which artwork to steal, unless they have some knowledgeable theft commissioner. These points highlight that the endogeneity issue in our sample is weak.

Finally, this study highlights the importance of registers/lists in transforming private information into public knowledge, particularly in the high-tier art market. While the impact on marketability and auction prices may be limited in this segment, further research is needed to explore the potential benefits of registers/lists in the low-tier market and understand the incentives for reporting stolen pieces. Embracing technological solutions and considering the macroeconomic and microeconomic factors at play can contribute to the development of effective strategies to combat art theft and protect cultural heritage.

**Author contributions** All authors wrote and reviewed the manuscript and took part in the empirical analysis of the model. F.A. and M.C. developed the conceptual and empirical model and provided the auction data. N.O. developed and provided the data of art thefts.

**Data availability** No datasets were generated during the current study.

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