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INVESTIGATING THE POTENTIAL OF INVESTING IN FINE STRINGED INSTRUMENTS AS AN ALTERNATIVE INVESTMENT ASSET

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Abstract

Often seen as a passion project or part of a philanthropic venture, rare and fine stringed instruments offer an exciting option to diversify one's investment portfolio while providing an opportunity for an exceptional long-term investment. Though, historically rare violins have not been widely recognized as assets for investment, this category is gaining interest due to its steady increase in value, a lively international market and a finite and diminishing supply. This study demonstrates that fine stringed instruments offer a steady increase of approximately 3,7-6,9% return per annum with a dramatic percentage increase since the 80's.

In this thesis, the stringed instrument public auction and private dealer markets are reviewed, the price dynamics are studied, and some fundamental intra market specific limitations are tackled in order to observe the true underlying returns of this asset. In order to build solid conclusions, the largest fine stringed instrument auction database has been developed encompassing the period from 1850 until today, although for the analysis a focus is put in the period from the 1980's until today, as it is when the demand and, consequently the market for violins boomed.

The thesis main contributions can be summarized as follows. First, I review and explain the increased attention in recent global violin auction markets and the violin segments' specific limitations. Second, I construct a price index by the use of the hedonic regression model and address major market inefficiencies such as market illiquidity and transaction costs with techniques such as the unsmoothing returns. Third, I investigate violins investment's diversification potential as well as the optimal portfolio allocation weight when including violins. From the results, violins in a portfolio can improve the risk-return characteristics; however, the amelioration depends mainly on some characteristics such as the maker. This is why I pursue the research by a first targeted study which examines the 'masterpiece effect' within the violin market by using a repeated sales database of 337 observations and concluding that Stradivari and Guarnieri del Gesù should be unquestionably the most preferred makers and therefore have the highest investment opportunity within violins, especially, when traded privately through dealers. A second study explores a completely novel topic, the 'musician effect' on the price of violins. This new idea reaches the conclusion that violins that have been played by most talented musicians reveal a higher price. By using event study to isolate the 'musician effect', it is found that musicians change in preferences over specific instruments translates as a revision in violin ratings by further pushing its price up.

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1. Introduction

1.1. Market Overview

It is estimated the global violin market for rare stringed instruments, those made over 150 years ago by the top 270 makers, to be approximately $16.2 billion[1], and it is seen form the repeated database that this market turns over every 32 years, making this market financially illiquid. Further, the market for asset-secured lending has grown over the past ten years, with the market size in 2019 estimated to be around 50 million in outstanding loans against violins[2].

If we compare these figures to the art market, we see that the global art market grew 6% in 2019 to $67.4 billion in sales[3]. In the fine stringed market, unlike the art market, there's no sense that anything contemporary is ever going to outsell an old master. This is because late 17th and early-18th instruments are unique in quality as the climate 300 years ago was cooler, which meant that trees grew more slowly, resulting in wood that was denser and more resonant.

The number of stringed instruments from the 17th century is limited. If we look into top makers, such as Stradivari and Guarnieri del Gesù, today we can only account for about 700 good quality violins, according to Tarisio auction house founder and history expert Jason Price.

In the course of the years, the supply of violins in circulation has been diminished due to various factors. Firstly, the museums and private collections buy premium violins with no intention of selling them in future. Secondly, the violins are material goods with specific risks. Indeed, the violins are prone to suffer from depreciation risks as well as the risk of being burnt, destroyed, or lost. Nevertheless, the demand has continuously grown and the competition for these items is therefore fierce, resulting in escalating prices.

Like art, wine and other passion investments, violins are targeted by those investors trying to diversify risk and, at the same time, wishing to find an artistic enjoyment from their investments. The differences in prices depend on the state of the instrument, their provenance and their historic performance. Indeed, the violins played by renown musicians are more valued than the rest. The best way to ensure the value of an instrument is to loan it to a first-class musician. The wood of the violin is "a work in progress", as it is made of living matter. The acoustic properties of the instrument change depending on the vibrations perceived. This means

1 Kenneth Research (2017), Violin Market: Advancements and Efficient Clinical Outcomes would drive the industry growth. Also see, Nobuyoshi Ozawa (2004) Orchestrated Instruments, Inc., University of Cincinnati.

2 Deloitte 2019 6th edition report, p.120.

3 McAndrew's report "The Art Market 2019" released by Art Basel and UBS.

that a violin which has not been played for various years has a more aggressive sound and it is more difficult to play than a frequently used one. The fact of lending violins to renown musicians brings a number of advantages to the investor. Firstly, this allows to guarantee the quality of the instrument, as the musician will be using it regularly. Further, the investment value will increase as the violin will be the gage of success of the musician. As mentioned above, the value of the violin increases depending on the reputation of the musicians that have played it in the past - this is, the more famous becomes the musician and its violin, the best for the investor. We will explore into this phenomenon later in this thesis.

Investing in violins has, therefore, advantages and disadvantages. Investing in violins does not give dividends, violins have high insurance costs and, are sensitive to atmospheric conditions (E.g. humidity, etc.). On the other hand, it is a functional investment that allows the musician the joy of playing a high-quality instrument (and if the investor is not a musician, it gives him/her the opportunity to listen to the instrument's music at his/her premises whenever the investor wants to). This is, in addition to its financial value, there is an aesthetic value to take account of.

In order to have an overview of the current existing numbers of violins, I have constructed a surviving units table from my own internal analysis.

Table 1 Estimated Surviving Units

Violin maker	**Estimated No of Instruments**
Antonio Stradivari	650
Ruggeri	380
G B Guadagnini	300
Joseph Guarnieris Jr.	250
Petrus Guarnieris of Venice	200
Andrea Guarnieri	200
Guarnieri del Gesu	165
Rogeri	150
Carlo Bergonzi	100
Petrus Guarnieris of Mantua	50
Omobono Stradivari	20
Tot.	**2465**

Source: Internal Analysis

1.2. Market Limitations

Simply by looking to the number of current surviving units, we can conclude that the market for fine stringed instruments is thin. There is a shortage of existence and decreasing which challenges the structures of building funds. This illiquidity limitation will need to be taken into account for a realistic result.

Another point to note is that the funding structure of this segment is based on borrowing. The schemes to purchase rare stringed instruments are borrowing from banks that specialize in loaning funds against musical instruments and assembling syndicates to raise money, and similarly to a jockey in a horse race, the musical instrument is then rented to a musician. The musician typically pays all insurance costs (0.5% - 2% of the value) as well as maintenance costs but not the rental fee.

Two investment strategies prevail amongst traders and investors - a dynamic versus a buy-and-hold strategy. Here, market is not being actively traded as we can see that the average holding period from the repeated database is 32 years, therefore it has low volume—meaning, the number of violins traded is low which translates into a large spread, as bid and ask prices fall far apart.

Another concern of this market are the high commission costs, specially, when stringed instruments are sold through auction houses, which translate into a 20-25% commission fee. Therefore, we should investigate this further by looking into differences between violins sold through auction houses and those sold via private dealers. This will be explored in the first targeted study. The dynamics are different in terms of goods traded (rarest instruments tend to be found more often within the private dealers' sector); prices reached seem to be higher within violins traded privately; commissions differ (up to 25% in auction houses versus 5% with private dealers); market dynamics differ (trade-ins are allowed in private sales); also, the transparency of pricing differs (public auctions are more reliable in reporting prices than private dealers who are more opaque due to confidentiality restrictions).
Most of these concerns have been tacked throughout this thesis.

On a more positive note, restricted supply and increasing demand from markets such as Russia, China and Korea have accelerated the gains for rare and fine instruments. Large institutional buyers have not only created more competition, but have placed pressure on the rare stringed instrument market by reducing the number of instruments on the open market, which undeniably accounts for the continued increase in prices on the international scene, and has escalated demand.

The thesis will start by exploring, with the use of the unique database constructed, the viability of violins as an investment opportunity after tackling most of the above-mentioned concerns. I will continue by building indices using the hedonic regression method and assessing, by portfolio optimization techniques, the viability of stringed instruments as an alternative asset class. Then, two targeted studies will focus on two major market specific topics: the so called 'masterpiece effect' and 'musician effect'.

2. Literature Review

Ross and Zondervan (1989) examine a repeat sales dataset of 17 Stradivarius that were bought and sold a total of 29 times between 1803 and 1982. They find an average real return over this period of approximately 2 percent, equal to the long-run real rate of interest. Unfortunately, by focusing only on one maker there is a bias.

Graddy and Margolis (2007) measure the returns to investing in violins using two different datasets. One dataset includes 75 observations on repeat sales of the same violins at auction starting in the mid-19th century and another dataset includes over 2000 observations on individual violin sales at auction since 1980. The overall real returns for the dataset on repeat sales for the period 1850-2006 that they calculate, is approximately 3.3%. And, the real returns to their overall portfolio of individual sales since 1980 is nearly 4%. They conclude that while this return is lower than other standard investments, the price path has been stable with a slight negative correlation to stocks and bonds. The new database will improve this study by raising the number of observations to 16,707 and expanding the period until the end of 2019. Further, techniques to overcome market specific limitations such as desmoothening results will be applied for more accurate results as well as studying market specific relevant topics.

Dimson and Christophe Spaenjers in their paper "The investment performance of art and other collectibles" construct a price index, by borrowing data on repeated sales of violins from Graddy and Margolis (2011). They construct a real annual price index for the period 1900 to 2009 by applying the same repeat-sales regression method as Goetzmann, Renneboog, and Spaenjers (2011). Their deflated average price appreciation since end-1899 equals 2.5% (the nominal equivalent is 6.5%.). This study does not cover the financial crisis period.

Campbell (2007) uses the Florian Leonhard Index with repeat sales in the period 1986 to 2006 and calculates an average annual real return of 9.64% with a standard deviation of 8.41%. Unfortunately, this dataset is biased as focuses mainly in reported private sales by one trader.

There have been few other attempts to measure returns to violins, but these studies have not used auction data nor have they been published in refereed journals. These studies include, "Orchestrated Investment, Inc." that in 1999 used price estimates listed in Fuchs Taxe der Streichinstrumente, a German publication that estimates prices for the violin market. It shows that from 1960-1996, Italian violins had increased on average 11.7% per year in price. And also, The Economist magazine which published in 2009 a short article including the price index from Florian Leonhard Fine Violins.

3. Database

3.1 Data on Individual Sales

The database constructed for this thesis during the past years is currently the largest reference resource for buyers, sellers and connoisseurs of fine stringed instruments and bows.

According to experts[4], the most important players in the public market now dealing with fine instruments are the following auction houses: Tarisio, Ingels&Hayday, Bromptons and Vichy. In the past, before the year 2000, major auction houses included Sotheby's, Christie's, Phillips, and Bonham's. In 2016, Tarisio provided me with their public registry of iconography, provenance and pricing information for historical stringed instruments. The raw initial database, had some missing periods due to changes in strategies of individual auction houses. I completed them by contacting auction houses individually for specific data points, with the help of The Red Book[5] and, by consulting old auction catalogues such as the Puttick and Simpson catalogues from Bonham's in British Library.

The overall database encompasses over 36,000 individual instruments and bows by over 3,500 makers and contains over 57,000 historical auction prices. For a more detailed information about database construction see note below.[6]

4 Christie's on phone call 17th of November 2014. Tarisio's email sent on the 9th of February 2017.

5 The Red Book Auction Price Guide of Authentic Stringed Instruments and Bows is a comprehensive public record of auction prices paid for violin-family instruments and bows. It features worldwide sale results from the major auction houses of Austria, England, France, Germany, Italy, and the United States from 1997 to 2012 and contains almost 24,000 auction sales representing the works of more than 4,300 instrument makers. The sales are listed alphabetically by maker, sub grouped by instruments, and arranged chronologically by sales dates. Prices are given in U.S. dollars, British pounds and Euro.

6 The initial dataset had complete data from Sotheby's London, as the fine instrument department was based in London. There is data since its creation in 1966 until 2012. In 2013, Sotheby's became Ingels&Hayday in the database when Tim and Paul decided to set up their own auction house after 18 and 15 years of experience, respectively, in Sotheby's (The Strad Magazine, 4th of January 2013: http://www.ingleshayday.com/component/content/article/33-press/general/205-tim-ingles-and-paul-hayday-leave-sothebys-to-set-up-own-auction-firm.html). From 2013, under Ingels&Hayday, there is data available until today after having contacted them directly (Samantha Rowe facilitated the data through spreadsheet.).
For Christie's London, there is data from 1972 until 2005. In 2005 Christie's stopped holding musical instrument sales in London and concentrated its musical instrument business in New York. In 2005 James Buchanan left Christie's to create Brompton's Auctioneer's (https://tarisio.com/press/tarisio-announces-european-expansion/). From Christie's New York office, there is existing data from 1979 to1986. During the dates of 1986 until 2000 there were only two musical instrument sales held in New York; one in November 1994 and one in May 2000. After contacting Mr. Keane, now the data is completed until 2012. Since

Therefore, the dataset on individual sales that spans from 1850 until 2019, is constructed by merging data on violin sales from various datasets provided mainly by Tarisio auction house and completed by other sources. Instruments included are sold by the major auction houses: Sotheby's, Christie's, Bonham's, Phillips, Tarisio, Bongartz and Skinner as well as other auction venues. In addition, as explained before, the catalogues and auction houses' websites have been checked to ensure that the database only includes full-size instruments represented in good physical condition with information on: varnish, age, authenticity, LOB, location sold and listed by individual maker. These characteristics will be included in the regressions as are recognized to have an influence on price. In the Annex, a more descriptive information on the importance of each of these variables included in the study is available.

Altogether, the general database consists of violins by more than 2,945 different makers spanning four centuries and representing virtually all of the important schools of violin making. The database consists of 25,930 violins, 2,814 cellos and 2,946 violas. We have 1,047 locations where the sales took place, where top cities are London, Paris and New York. The sample database used for this thesis encompasses 16,707 fully completed observations from 1980 until end of 2019. Tables 2- 1-4 provide summary statistics for this database.

Within the database, some records are omitted after deleting incomplete observations. We winsorized the observations with extreme low values, such as those with prices less than 50 USD. This reduced the impact of inconsistent outliers, which might come from data entry errors, cleaning blind issue, inferior maker or level conditions, etc. Therefore, we had to limit the database to a smaller sample size in order to have only fully completed observations (16,707).

1999, Mr. Kerry Keane has been the main consultant in fine instruments and since 2012 he has been on the head of Private Sales in Christie's (http://www.thestrad.com/christies-quits-instrument-auctions-for-private-sales/).
Brompton's London fine instrument department was created by James Buchanan (ex-Christies) and Peter Horner (ex-Bonham's 1991-2005) in 2005 (https://www.bromptons.co/about/team/peter-horner.html). There is original data since the first auction in 2006 until 2012, when Buchanan left to Amati. The 2013, 2014 and 2015 years have been completed by public information from online catalogues.
As for Amati, there was not original data since its opening in 2013 by James Buchanan (ex-Bonham's), the 14 auctions until today were missing. Therefore, these years were completed after contacting them directly.
For Bonham's there was data 1992 to 2015. In 2015, it closed its musical instrument department with Philip Scott (http://www.thestrad.com/bonhams-auction-house-closes-musical-instrument-department/). The data for the period 1986-1991 was completed after contacting them.
Phillips merges in 2001 with Bonham's and Philip Scott takes the role of head department until 2015. In the database, the data seems to be missing for the whole period, but it is under Bonham's auction house.
Tarisio New York was Founded in 1999 and there is complete data since then. There is data as well since the London office launched in 2007 (https://tarisio.com/press/tarisio-announces-european-expansion/).
As for Vichy, founded in 1983, the data was completed with online data available since 2005.

The most expensive violin is a Stradivari "Lady Blunt" sold for $16 M at Tarisio in 2011, previously sold in 1971 for $105,000. The oldest violin in the dataset is an Andrea Amati from 1550.

3.2. Data on Repeated Sales

The main source for private dealer data are the W. E Hill Business archives licensed from David Hill, who inherited the business and records from 1980 until 1991. The main auction house data comes from Tarisio Auction House as the maker biography's and provenance information, allowed to track specific violins. It is the belief of the author that the dealer sales data are reliable, but of course the prices are the result of self-reporting by dealers and buyers. The database has been double checked and completed with the help of the "The Red Book" (2012) price guide of authentic stringed instruments and bows, by online auction house catalogues and, by private data provided directly from auction houses.

The current repeated sales database accounts with 259 violins representing a total of 337 observations, with some violins being sold more than twice. These are typical high quality instruments by top Old Italian makers, including 168 instruments by Stradivari and 33 by del Gesù.

A distinction between violins being sold privately through dealers and those sold publicly through auction houses is made in order to explore differences in these markets. So, the database has 119 observations where both sale and buy come from auction houses; 124 observations where both sale and buy are from private dealers; 29 observations where the buy is from a dealer but the sale through an auction house; and, 65 observations where the buy is from auction house but the sale is through a dealer. Sales where the holding period was less than 5 years[7] were excluded. This was done for two main reasons: first, in order to focus on longer-run returns, and second, several instruments appeared to have been sold twice in the same year by the same auction house.

The minimum time between sales of the same violin in the dataset is 3 years and the maximum is 135 years. On average, in the overall dataset, violins were held for 32 years. It is to be noted that auction sales are overrepresented in this dataset, as they likely compromise only between 10% and 20% of the market.

7 In one of the first studies of returns to art, Baumol (1986) excludes paintings with holding periods of less than 20 yr. Goetzmann (1993), by design, excludes paintings with holding periods of less than 10 yr.

For regressions, I use prices including buyers' commissions. Other studies as the Mei Moses's (2002) study on art prices include commissions, and I would like this study to be comparable. Sellers' commissions at auction are negotiable and unknown.

4. Methodology

4.1 Hedonic Model

Each violin is a unique instrument, and the problems incurred in measuring returns to violins are similar to the problems incurred when measuring the returns to art, wine, classic cars or any other type of passion investment. The result is that there will be some ambiguity in the construction of a single index of the movement of prices over time. One concern about simply using average prices is that price rises may be exacerbated during booms as "better" instruments may come up for sale—which has generally happened with art. In general, average prices indicate variability over time in violin prices that is better described as movements in the heterogeneity of the quality of the objects offered, rather than movements in prices for the same objects.

The two primary types of indices used for heterogeneous objects are based on regressions known as 'hedonic models' and 'repeat sales models'. In hedonic models, differences in items are controlled for by including a small number of 'hedonic' characteristics. Repeat sales models, in effect, include a dummy variable for each item. A repeat sales model is better able to control for differences in items across time, but these models usually rely on only a small proportion of those items that have come to market.

Most alternative investment's auction indices are based on a model where the price of the i^{th} object sold in time period *t* is $P_{it} = P_i + P_t + \varepsilon_{it}$, where P_i is the fixed component of the price that reflects the unique and fixed character (or "quality") of the object. P_t reflects the index of aggregate movements in prices, and the remainder is an idiosyncratic error term. The key distinction in the construction of price indices is whether the fixed component is treated as determined by a small number of hedonic characteristics, X, that may be controlled by regression, or whether it is treated as a parameter that must be controlled explicitly.

'Hedonic models' control for the fixed effect P_i with the assumption that $P_i = \beta X_i + \varepsilon_i$, where ε_i is an error term independent of the P_t's, and estimate $P_{it} = \beta X_i + P_t + \varepsilon_i + \varepsilon_{it}$ Alternatively, 'repeat sale' models include a dummy variable for each specific object. The great attraction of hedonic models is that all the data may be used in the estimation, including data on objects that are only offered for sale once in the sample period. The disadvantage of these

models is the strong assumption that a (typically small) set of X variables captures much of the variability in the fixed components of price (important if the estimates of the time effects are to be precise) and that the characteristics of the objects offered do not vary systematically over time (important for unbiased estimates of the time effects). Although the repeat sale method overcomes the primary disadvantages of the hedonic model, it does so at the cost of discarding much data. There must be at least two observations on an instrument's price or it provides no information to help identify the time index. Indeed, depending on the frequency at which repeat sales occur, it may not be possible to identify all the time effects in the model.

Other studies that have calculated price indices for alternative investments include Stein (1977), Baumol (1986), Frey and Pommerehne (1989), Buelens and Ginsburgh (1993), Pesando (1993), Goetzmann (1993), Barre, Docclo, and Ginsburgh (1996), and Mei and Moses (2001).

In this first general study, the hedonic regression method tis used to construct violin price indices. This method is one of two most commonly used techniques to pricing heterogeneous assets although it has the disadvantage of being data mining consuming. It requires full predictive information from each observation in the final regression.

In 1966, the theoretical foundation of hedonic regression techniques was firstly introduced by Lancaster's (1996). He argued that it is not only a good itself that creates utility, but instead its characteristics. Hedonic regression method breaks down heterogeneous goods into price determining characteristics for which no market price stands available since they cannot be sold separately. The market conditions of heterogeneous goods implicitly result in the marginal contributions of these characteristics to the good's final price.

Considering the violin price context for instance, the characteristics may contain attributes of the maker's name, auction location, certificates of authenticity, varnish/color, year produced, and other relevant information that exists in and out of the violin. Regression techniques can be used to estimate these marginal contributions; thus, for this purpose, researchers initially employed hedonic regression in the real estate market.

Specifically, we assume that the price of violin n in period t, p_n^t, is a function of k characteristics quantified by $x_{ni}^t (i = 1, 2, \dots, k)$. During the period from 0 to T, we have

$$p_n^t = f(x_{n1}^t, x_{n2}^t, \dots x_{nk}^t, \varepsilon_n^t) \quad (1.1)$$

where ε_n^t is an error term. In order to estimate the marginal contributions of each x_{ni}^t by using OLS regression, we specify (1.1) as a log-linear model

$$lnp_n^t = \beta_0^t + \sum_{i=1}^{k} \beta_i^t \, x_{ni}^t + \varepsilon_n^t \quad (1.2)$$

where β_0^t and β_i^t are the intercept term and coefficients of parameters for each period *t*. Given the standard error assumption of zero mean and constant variance, it is further assumed that the characteristics parameters keep constant over time, at least for short term periods since violin market conditions, which determine the characteristics' marginal contributions, change gradually.

Therefore, the model (1.2) transforms to

$$lnp_n^t = \beta_0^t + \sum_{i=1}^{k} \beta_i \, x_{ni}^t + \varepsilon_n^t \quad (1.3)$$

One of the main strengths for using hedonic regression method is that all observations with complete information structure can be included compared to the repeat-sales regression method. Therefore, it covers both single and repeat sales data. Of course, this is one side of the double-edged sword. Conversely, the disadvantage of hedonic regression remains data consuming, as mentioned earlier. It requires each observation in the regression model contains full attribute information. Hence, the hedonic approach to constructing the price index for heterogeneous goods is to pool all periods data with additional time dummy variables in the specification, which generally referred to as the time dummy variable hedonic model as (1.4):

$$lnp_n^t = \beta_0 + \sum_{\tau=1}^{T} \delta^\tau \, D_n^\tau + \sum_{i=1}^{k} \beta_i \, x_{ni}^t + \varepsilon_n^t \quad (1.4)$$

where D_n^τ is the time dummy variables with value *1* if the observation falls in period τ and value *0* if it falls otherwise. The base period time dummy is left out for avoiding multi-collinearity. The time dummy parameter measures the effect of time on the logarithm price.

Taking the exponential of the time dummy coefficients yields quality-adjusted violin price change between base period *0* and period *t* after controlling for the variation in the quantities of the characteristics. Therefore, we can construct time dummy price index by sequencing price change to base period *0* for each comparison period *t*, which is

$$P^{0t} = exp\left(\hat{\delta}^{t}\right) \quad (1.5)$$

Actually, this time dummy hedonic index estimated by OLS can be written as

$$P^{0t} = \left[\frac{\Pi_{n\in S(t)}\left(p_n^t\right)^{\frac{1}{N(t)}}}{\Pi_{n\in S(0)}\left(p_n^0\right)^{\frac{1}{N(t)}}}\right] exp\left[\sum_{i=1}^{k}\widehat{\beta}_t\left(\bar{x}_i^0 - \bar{x}_i^t\right)\right] \quad (1.6)$$

where $N(s)$ is the sample size and $\overline{x_i^s} = \sum_{n\in S(s)} x_{ni}^s / N(s)$ is the sample mean of characteristic *i* in period *s (s=0, t).*

Equation (1.6) reveals that the ratio of the geometric mean of the price between period 0 and t is adjusted by the differences in the average characteristics $\bar{x}_i^0 i0$ and $\bar{x}_i^t$ This verifies time dummy hedonic method accounts for both changes in the quality mix and quality changes of the individual characteristics.

Given the assumption of constant characteristics parameters over time and the time dummy variable hedonic method for constructing violin price index in this paper, the empirical model is specified with logarithm of violin auction realized prices as the dependent variable, and with a vector of $\{x_{ni}^t\}$ indicating all relevant price-determining characteristics as independent variables.

In general, we have been following fundamental variables to control for instrument quality: instrument age when the violin was auctioned, as a proxy of scarcity; top maker dummy for Stradivari and del Gesù violins, as a proxy for maker's reputation; violin varnish dummy as a proxy for acoustic properties of wood and therefore sound quality; authenticity dummy followed by certification/label control system as a proxy of originality/non-fake. In addition, it has also been included auction related information to control for price realization, such as auction house dummy as a proxy of sales institutions' reputation and bargain power; and auction season dummy as a proxy of demand side at specific peaks of the year.

Below are the variables used for this regression explained in Table 3. In the Appendix, there is a Section explaining in detail each of them.

Table 3. Variables for regression

TARISIO	1 if the violin was sold at Auction House Tarisio; 0 otherwise
TOP_AUCTIONHOUSE	1 if the violin was sold at Auction House Sotheby's or Christie's; 0 otherwise
AUCTION_SEASON	1 if the violin is sold within the high season (feb-ma, may-jun, oct-nov); 0 otherwise
TOP_MAKER	1 if the maker is either Stradivari, del Gesù or, Guarnieri; otherwise 0
STRAD_LOB	1 if it has the standard Stradivari length (between 353-355mm); 0 otherwise
INSTRUMENT_AGE	1 if the age of the violin when sold is equal or older than 200 years; 0 otherwise
STRAD_VARNISH	1 if the violin has the special deep red colour of Strads; 0 otherwise
AUTHENTICITY	1 if we have certificates or material proof of its authenticity; 0 otherwise

Consequently, the model (1.4) becomes:

$$Lnp_n^t = \beta_0 + \sum_{\tau=1979}^{2019} \delta^\tau D_n^\tau + \beta_1 Tarisio_n^t + \beta_2 TopAuctionHouse_n^t + \beta_3 AuctionSeason_n^t + \beta_4 Top\_Maker_n^t + \beta_5 TStrad\_LOB_n^t + \beta_6 InstrumentAge_n^t + \beta_7 Varnish_n^t + \beta_8 Authenticity_n^t + \varepsilon_n^t \quad (1.7)$$

4.2 Regression Results

For the regressions, we use prices including buyers' commissions. Other studies such as the Mei and Moses (2002) study on art prices include commissions, and we would like this study to be comparable. Auction houses usually report prices including buyers' commissions. Sellers' commissions are negotiable and unknown to us. We consider buyer's commissions when interpreting regression results. We estimate the index in US dollars as all purchases, and all but a few sales, were recorded in US dollars.

In Equation (1.7) the ratio of the geometric mean of the price between period 0 and t is adjusted by the differences in the average characteristics. It accounts for both changes in the quality mix and changes of the individual characteristics. The logarithm of violin auction realized prices is the dependent variable, the vector indicating all relevant price-determining characteristics are the independent variables.

Table 4 shows the Model (1.7) variables' impact on violins value. To see the price relevance of each of the variables, the table includes a column with the "Value Impact" of each hedonic variable. "Value impact" of each variable is estimated by taking the exponent of the regression coefficient and subtracting 1 (Thornton & Innes, 1989). It is important to mention that sometimes, regression coefficients might not indicate causality but correlation. The table portrays the parameter estimates of the hedonic variables included in model (1.7), except the year dummies, after being regressed on the dependent variable LN_2019USDPRICE.

It can be observed that the variables Maker and Varnish play an important role on the price determination of violins.

Table 4. Regression Results

Table 4 displays the coefficients and p-values for the independent variables included in the model except the year dummies, after regression on the dependent variable ln Price. The price impact figure is calculated by taking the exponent of the regression coefficient and subtracting 1.

Variable	Estimate	P value	Value Impact
Tarisio	0,616	0,001	85,19%
Auction Season	-0,059	0,650	-5,71%
Instrument Age	0,513	0,000	67,04%
Varnish	0,592	0,000	80,75%
LOB	0,186	0,128	20,47%
Authenticity	0,252	0,283	28,68%
Top Auction House	0,588	0,049	45,82%
Top Maker	1,467	0,000	333,41%

5. Addressing market specific limitations

Since changes in violins' prices affect the rate of return, some factors determining prices are also common to the formation of returns on violins. However, it should be noted that the rate of return on violin investment is an outcome of the interplay between many different factors that are hard to capture and often unobservable to a layman. I will now present some general shortfalls that might lead to difficulties in the estimation of risk-adjusted returns that are specifically found in the violin market - some are also common to the general market for emotional assets; and should be taken cautiously.

5.1 Selection bias

Stein[8] and Goetzman[9] point out this matter when estimating the price return over time. The data gathered embodies a bias in selection as only includes violins sold though auction and in a smaller proportion, violins sold privately through dealers. This upward bias in prices of prominent instruments is compensated partly by forced sales such as debt, death and divorce which bring ill-timed violins for sale.

This bias is common in many other fields of heterogeneous goods markets, notably in the arts sector, and also in real-estate.

This causes an issue when constructing indices therefore returns should be adjusted downward as result of this upward bias in the volume of returns. The amount of such reduction is difficult to estimate as mainly depends on the projection of prevailing taste for a specific maker or violin. The same issue is encountered in the estimation for expected returns for fine wine, artworks, and of course in equity markets, as well.

It should be further noted too that due to market specific characteristics, the real risks are higher than the ones estimated in the index. Mainly due to the illiquidity nature of this market, results in a lowering of the risk-adjusted returns in practice, from a buy-and-hold strategy in the fine violin sector.

Also, to be mentioned, another reduction in the average returns comes from the significant transaction costs that are involved when buying and selling at auction.

8 Stein, J. P. (1977) 'The monetary appreciation of paintings', Journal of Political Economy, Vol. 85, No. 5, pp. 1021–1035.

9 Goetzman, W. (1992) 'Accounting for taste, art and the financial markets over 3 centuries', AER, Vol. 83, No. 5, pp. 1370–1376.

However, in relative terms, the underlying volatility of the violin sector seems to be below that of public equities which evolves in a superior Sharpe ratio. I will explore the concerns raised around volatility estimates later in the following sections.

5.2 Market illiquidity

A main concern is that, by observing the low volatility in prices over the years, we could easily conclude that the risk is low due to the small variation in price. Due to the index methodology, prices are smoothed over time as result of transactions occurring at longer intervals than the frequency of the index. This means that when the annual averages are computed, the data seems to have less volatility than it would, should the violins had been sold at auction more frequently. This translates in turn in a higher real risk than the one observed.

The illiquidity risk of this segment arises also because when a violin comes out to the market there are only a small number of buyers. This concern is common to other types of appraisal-based financial assets such as real estate and hedge funds.

The lower volatility in the violin market is likely the result of appraisal-induced biases, which occur during the indexation of the violin data. The smoothing of the returns is a result is this as well. This has the effect of generating volatilities that are substantially lower than the true volatility of the market.

Because the data for the violin indices are generally appraisal based, the analysis needs to account for this. There exists a difference between the appraisal based returns and the true market returns. It is the true market returns that actually represent the economic opportunity cost to investors, and the statistical properties of which are directly comparable to alternative asset classes. The illiquid nature of the violin market, with frequent valuations, and averaged price quotes, leads to a smoothing in the returns. It is therefore imperative that the indices are "unsmoothed" to eliminate, as far as possible, any underlying autocorrelation, which tends to be characteristic of these smoothed series of appraised returns.

Therefore, following the prevalent approach of the hedge fund and real state segments, used by Okunev and White[10] and which has also been chosen by Campbell[11]

10 Okunev, J. and White, D. (2003) 'Hedge fund risk factors and value at risk of credit trading strategies', Working Paper, University of New South Wales.

11 Campbell, R. (2008) 'Art as an alternative asset class', Journal of Alternative Investments.

when analyzing the fine art segment, I have used the same methodology.
Although the most widely used approaches are those of Geltner (1993), from the real-estate finance literature and now also common in the hedge fund literature (Brooks and Kat (2001) and Kat and Lu (2002)). Geltner adjusts the return series to eliminate the first-order autocorrelation.

Assuming that the observed (smoothed) return on the index, r_t^*, is a weighted average of the true underlying return at time t, r_t and the observed (smoothed) return at time $t-1$, r_{t-1}^*,

$$r_t^* = (1-\alpha)r_t + \alpha r_{t-1}^*$$

Simply rearranging enables the determination of the actual return, which, if assumed to be an AR (1) process, acts to eliminate the first-order autocorrelation.

$$r_t = \frac{r_t^* - \alpha r_{t-1}^*}{1-\alpha}$$

If the first-order autocorrelation of the smoothed series is positive, then the standard deviation of the actual return series will be greater. However, if the first-order autocorrelation of the smoothed series is negative, then the standard deviation of the actual series will be lower.

If the autocorrelation structure is more complicated, then the more rigorous process developed by Okunev and White (2003) can be adopted to remove higher levels of autocorrelation in the smoothed series:

$$\alpha = \frac{(1 + a_{0,2} - 2d_1 a_{0,1}) \pm \sqrt{(1 + a_{0,2} - 2d_1 a_{0,1})^2 - 4(a_{0,1} - d_1)^2}}{2(a_{0,1} - d_1)}$$

where the constant *a*, to unsmooth the series, is a friction of higher orders of autocorrelation.

This approach is directly applicable for violin indices, which also exhibit exceptionally high autocorrelations in reported returns. There is indeed evidence of smoothing in the returns, and for series that are positively autocorrelated, the smoothing has the effect of diminishing the risk apparent in the asset class; hence, it is necessary to

correct for the smoothing, resulting in a more volatile unsmoothed return series.

Using the more simplified approach of Geltner (1993) does not completely eliminate the first-order autocorrelation in the time series for violins. The more sophisticated approach from Okunev and White (2003), which takes into account higher orders of autocorrelation, does result in an unsmoothed series that no longer suffers from first-order autocorrelation. The high positive autocorrelative structure present in the violin series results in the unsmoothed series exhibiting significantly higher volatility. Significant positive autocorrelation means that the series suffers from appearing less volatile than the true data generating process underlying the return structure.

Unsmoothing methods have been applied to other types of illiquid funds such as private equity, venture capital, and bond mutual funds (Chen, Ferson, and Peters (2010) and Ang et al. (2018)), to highly illiquid assets such as collectible violins and art investments (Dimson and Spaenjers (2011) and Campbell (2008)), and even to unsmooth other economic series such as aggregate consumption (see Kroencke (2017)).

It is found that unsmoothing the series using the Okunev and White approach leads to a considerable increase in the price risk, with volatility rising from 8.61 per cent, which seems highly unrealistic, to 19.73 per cent; and, from 17.18 per cent to 28.03 per cent - for Violin Index and Strads Index respectively. These values are much more in line with the volatility of the other studies. Taking a universal 5% increase in the monthly standard deviation for the violin series can show how this increase affects the optimal portfolio allocation. It reduces the allocation in violins substantially, by roughly half, from over 20% to just over 10%, with the reduction roughly equally spread among the other asset classes in the portfolio. The low correlation still results in violins providing an attractive portfolio investment.

Table 5 provides summary statistics on the Violin sector using the Violins Index and Stradivari Index. The slightly higher average returns obtained by the Stradivari Violins Index is likely to be due to the focus on the high end of the market. It would appear that the average returns made in the top end of the market are slightly greater than taking the overall market as a whole. The unsmoothing procedure increases the volatility by a significant amount, and should capture the true underlying volatility in the market.

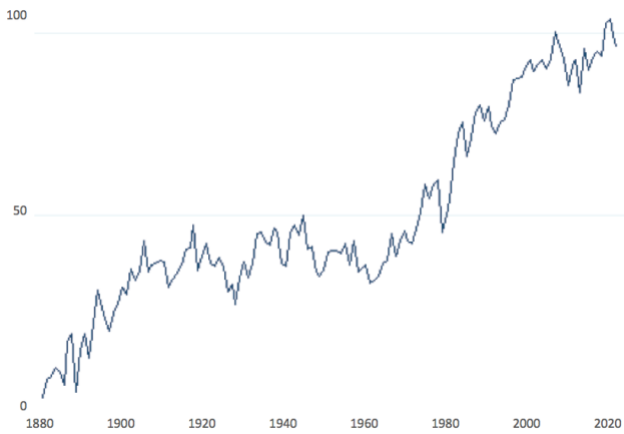
Table 5. Violin Index: Original vs. Unsmoothed method

	Strad Original	*Strad unsmoothed*	*Violins Original*	*Violins unsmoothed*
Av annual return	6.43%	4.97%	3.69%	3.57%
Av annual St. dev	17.18%	28.03%	8.61%	19.73%
Av monthly return	0.007	—	0.004	—
Av monthly St. dev	0.002	—	0.025	—
Skewness	− 0.654	− 0.271	0.215	0.417
Kurtosis	1.389	2.081	2.001	2.595

For a general view, Figure 1 plots an unsmoothed index on a log scale adjusted for inflation since 1880.

It can be observed that from 1880 to 1960 violin prices were stagnant, between about 1960 and 1980 there was a sharp rise in prices and that, prices have risen, with some ups and downs, since 1980. Therefore, there is a plateau from about 1900 through 1960, when it increases sharply until today.

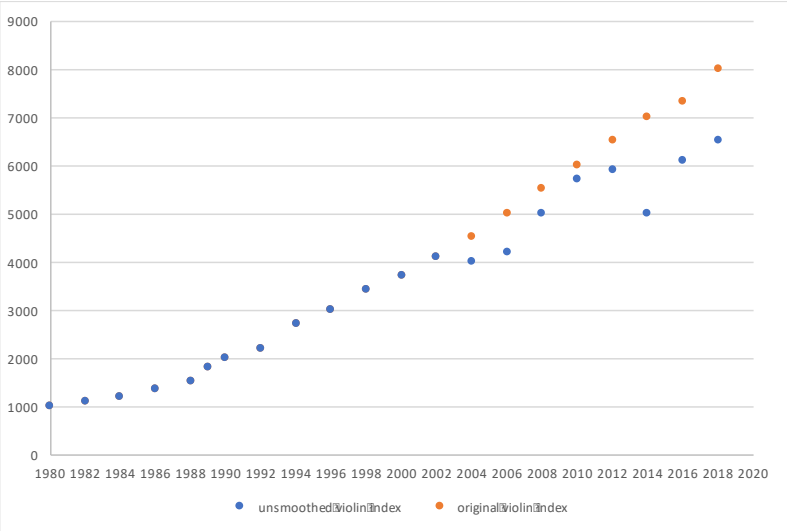
Figure 1. All period Unsmoothed Violin Index (1880-2019)



In Figure 2, I compare the data for the Violin index of both the original (smoothed) index and the unsmoothed one. For comparison reasons, I have rebased the series to 1000 in 1980.

I can conclude that the Violin index, after unsmoothing its returns, keeps nevertheless, a general upward movement in the price index over time.

Figure 2. Violin Index Smoothed vs. Unsmoothed (1980-2019)



5.3 Transaction Costs' Impact

Another point to mention is the high transaction costs of auction houses in the market of violins, where they account for a 20-25% fee, compared to a 5-10% through the private dealers. These costs have not been taken into account in any previous analysis, and for an accurate portfolio optimization model, these should be reduced from the return.

It is also important to note that the longer the time interval between investments, the transactions costs will be reduced substantially by the length of the holding period. Therefore, depending on whether a dynamic strategy is undertaken or whether a buy-and-hold strategy is chosen will make a difference in the assumptions taken as to the size of the transaction costs. The holding period averages 19 years for top makers and 32 for the rest, therefore it can be assumed that the buy-and-hold strategies predominate in this dataset.

A dilemma when comparing the returns on collectibles with those on financial securities lies in the differences in transaction costs and average holding periods. The transaction costs associated with buying and selling fine violins in auctions, as mentioned, amount to approximately 25% on a round-trip. Indeed, one can buy violins at catalogue prices through Tarisio while the company indicates a buy-back price of about 75% of catalogue value. When trading through auction, one has to take account of the buyer's

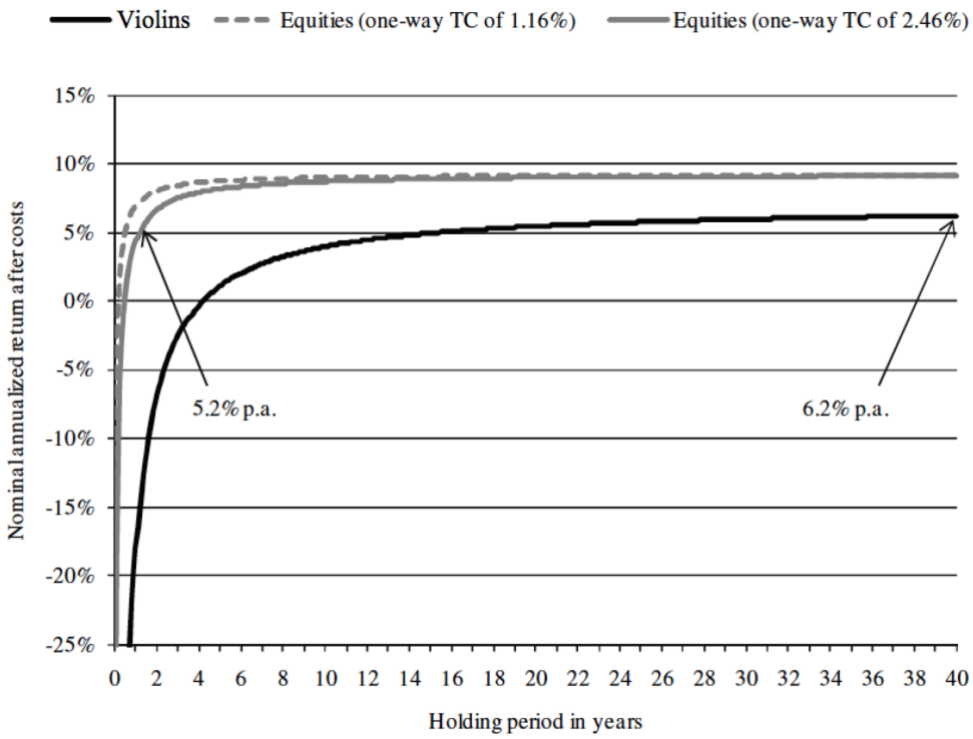
premium and seller's commission, which can add up to more than 20% of the underlying item's value.

Violins experience long holding periods though this must be partly endogenous, since high transactions costs presumably curtail trading volume. Considering the long holding periods for violins and the short holding periods for equity investment (Barber and Odean, 2000), the transaction cost drag associated with an investment-quality violin may actually be similar to that of an equity portfolio.

To develop after-cost estimates of average returns on violins and equities, I correct the baseline nominal geometric mean returns for annualized transactions costs. For violins, a transaction cost at sale of 25% is assumed. Custody costs, which are low for violins, are ignored. Commissions on buying and selling equities on the London Stock Exchange (LSE) have fluctuated over time, with an average for small transactions of 1.75% and for large transactions of 0.45%; in addition, the U.K. levies violin duty on equity purchases, and this tax averages 0.92% over the sample interval[12]. Time series of effective trading spreads are not available for Great Britain, so I proxy them with Jones' (2002) estimates of bid-ask spreads for Dow Jones Industrial Average (DJIA) index constituents, which average approximately 0.5% for a round-trip. The estimated one-way cost of equity trading is therefore the commission plus half the violin duty plus half the spread, namely between 1.16% and 2.46%, depending on the size of the transaction. I ignore management fees and custody costs. The figure below shows the resulting annual post-cost return estimates for violins and equities for holding periods ranging from one year to 40 years.

12 Green, Maggioni, and Murinde (2000) report percentage marginal commission rates for small LSE transactions of 2.50 (1900–09), 1.25 (1910–17), 2.08 (1918–51), 1.39 (1952–59), 1.25 (1960–75), 1.50 (1976–81), and 1.65 (1982–86), a rate we assume persists after the 1986 deregulation. Rates for large transactions are 0.50 (1900–51), 0.75 (1952–59), 1.25 (1960–68), 0.50 (1969–70), and 0.125 (1971–86), which I also assume persists. The percentage rates of violin duty are 0.5 (1900–46), 2.0 (1947–62), 1.0 (1963–73), 2.0 (1974–83), 1.0 (1984–85), and subsequently 0.5.

Figure 3. Annual post-cost returns on violins and equities



The figure reveals that, as an historical average, a violin investor needs to hold on to his/her violin for more than four years to expect a positive return. As mentioned, data on actual holding periods for violins are on average 32 years in the database and 19 for top violins. There are sources on holding periods for art and an analysis of all resales within Reitlinger (1961) over the period 1760–1960 which yields an average period between purchase and sale of 40 years. Despite some reservations about Reitlinger's data (Guerzoni, 1995), I regard 40 years as a reasonable estimate of the holding period for lifelong and cross-generational violin collectors. With such a holding period, the mean yearly return on top violins net of transaction costs is 6.2%. After 25 years and 10 years, the annualized after-cost returns are 5.8 % and 3.9 %, respectively. A long investment horizon is particularly necessary given that violins can also depreciate in real value over many successive years.

The average holding period for equities is much shorter. If it is assumed an annualized turnover that averages 75% of market capitalization, based on Dimson and Marsh and Jones

(2002)[13], the mean yearly post-cost return for equities equals 5.2% (or 7.3%, if transaction costs are small).

Consistent with Barber, Lee, Liu, and Odean (2009), stock market investors thus lose a meaningful proportion of their wealth through trading, and it is clear that before-cost returns do not tell the whole story. If the average violin investor retains his violin for a long interval, he/she can earn returns that are similar to those of the average equity investor (but below those of a buy-and-hold equity investor).

5.4 Other Market Inefficiencies

The presence of many market inefficiencies in the emotional assets markets, and specifically in the musical instrument market leaves room for much higher returns to be made than estimated from a sheer buy-and-hold strategy which is captured in the indices. A major source of market inefficiency is the presence of asymmetric information in the market.

This is difficult to assess but should be noted, for instance in the case of indirect investments such as violin funds and violin trusts. Here, the capacity of fund managers, who have an insight into the market inefficiencies, and who are also able to negotiate lower fees when trading fine violins means that the transaction costs incurred are less to a fine violin fund than to the direct investor with similar musical instruments.

6. Portfolio Diversification Abilities

Pursuing to the possibility of an investor diversifying his/her portfolio into the fine violin sector, the analysis depends crucially on the estimate for the correlation between fine violins prices and other asset class price returns. The lower the correlation coefficient, the greater the diversification benefits which can be gained for the investor. Assets therefore with quite moderate average returns can therefore have an attraction, and held in an optimal portfolio of financial assets, due to their ability to offset variability in the overall

13 Dimson and Marsh (1993–2009) report quarterly equally weighted (EW) and market value-weighted (VW) averages for the turnover of British equities. Over 1993–2019, the mean EW average was 74.5% (standard deviation 91.9%), while the mean VW average was 89.5% (standard deviation 74.3%). For earlier periods, Jones' (2002) estimate of DJIA turnover is, on average, close to these levels, though with considerable time series fluctuation.

portfolio and hence a reduction in risk, and thus the overall expected volatility of the overall portfolio.

In my analysis, I focus on the violin sector as a means of portfolio diversification against a number of alternative financial asset classes.

Taking into account the upward bias in the size of the returns, it could be expected a lower average return than the one generated previously in other studies.

The risks are also higher than captured in other indices, the illiquid nature of the market results in a lowering of the risk-adjusted returns in practice from a buy-and-hold strategy in the fine violin sector. The unsmoothing procedure increases the volatility by a significant amount, and should capture the true underlying volatility in the violin market. A further reduction in the average returns occurs from the significant transaction costs that are incurred when buying and selling at auction. However, in relative terms, the underlying volatility of the violin sector is lower that of public equities resulting at first glance in a superior Sharpe ratio. Violin's high transaction costs spread over 39 years equal 1.02% a year. Despite these costs, violins still remain an attractive, although small, portfolio allocation.

Table 6 below reports the distribution of nominal and real returns for violins and different asset classes over the period 1980–2019. For each asset category, it shows the geometric and arithmetic average return (p.a.) and standard deviation (S.D.). It also shows the ex post Sharpe ratios for violins, equities, bonds, art, and gold, taking the returns on bills as a proxy for risk-free returns.

It can be concluded from the SR, that the risk-adjusted return to invest in violins is similar to the one investing in art, superior to investing in gold and, inferior to equities.

Table 6 SR of Violins vs. other assets

	Mean Returns p.a.			Dispersion of annual returns S.D.		Sharpe	
	Geometric		Arithmetic				
Nominal Returns	Original	Unsmoothed		Original	Unsmoothed	Original	Unsmoothed
Violins	6.92	6.73	7.6	9.8	20,94	0.196	0.08
Strads	9.8	7.7	10.2	18.4	29,3	0.26	0.09
Art	6.4		7.3	13.4		0.173	
Gold	4.7		6.1	19.8		0.049	
Bonds	5.4		6.1	11.9		0.079	
Equities	9.2		11.2	21.8		0.281	
Bills	5		5.1	3.8		.	
Inflation	4.7		4.2	6.6		.	
Real Returns							
Violins	3.69	3.57	4.2	8.61	19.73	0.30	0.125
Strads	6.43	4.97	7.1	17.18	28.03	0.31	0.138
Art	2.4		3.2	12.5		0.152	
Gold	0.7		2	17.5		0.040	
Bonds	1.4		2.3	13.7		0.094	
Equities	5.1		7	20		0.297	
Bills	1.1		1.2	6.3		.	

In Table 7, I portray the summary statistics for a set of other financial asset classes over the period 1980–2019. I have assumed a flat rate 5 per cent point increase in the standard deviation of the series to account for the smoothed data.

Table 7 Summary Statistics of assets in the Portfolio[14]

Returns	MSCI WORLD	GSCI	REITs	UK 10 YEAR GOVT	ART	Strad original	Strad unsmooth	Violin original	Violin unsmooth
Av Annual Return	76.26	65.29	58.32	64.03	65.81	64.32	49.71	36.9	35.73
Annual St dev	216.7	302.2	198.3	79.13	85.12	171.8	280.3	86.1	190.73
Skew	− 1.234	0.024	− 1.071	− 0.120	− 0.716	− 0.654	− 0.276	0.215	0.412
Kurt	0.805	− 0.052	− 0.904	1.475	3.216	1.389	2.081	2.001	2.595
Max return	0.369	0.600	0.149	0.0245	0.171	0.982	0.116	1.017	0.172
Min return	− 0.4918	− 0.463	− 0.331	− 0.111	− 0.1067	− 0.455	− 0.074	− 0.0217	− 0.331

[14] Equity indices are from Morgan Stanley Capital Indices (MSCI World); Real estate index REITs is retrieved from Datastream. UK ten-year Government Bond Index and S&P GSCI data commodity Future data have been downloaded from Goldman Sachs. All Art Index and is from Art Market Research.

In Table 8, the correlation between these asset classes in the previous 39 years is shown. The correlation between violins and other financial asset classes is significantly low. Also, the correlation is low with the art market (although positive). It appears that these markets are independent from each other, with different factors driving demand and hence prices in these markets. It can be observed, as expected, that after unsmoothing the correlations become less drastic, as now the volatilities of violin indices have risen to more in line levels and the returns have been adjusted. After unsmoothing it can be found that violins are negatively correlated to bonds and real state and positively correlated to commodities and art. This result has hinted at the existence of a wealth effect.

Table 8. Correlations between different asset classes

	MSCI WORLD	GSCI	REITs	UK 10 YEAR GOVT	ART	Strad original	Strad unsmooth	Violin original	Violin unsmooth
MSCI WORLD	1000								
GSCI Commodity	0.004	1000							
REITs	0.580	0.256	1000						
UK 10 YEAR GOVT	0.133	− 0.056	0.306	1000					
ART	− 0.231	0.249	− 0.041	− 0.354	1000				
Strad original	0,143	− 0.306	− 0.287	− 0.386	0.011	1000			
Strad unsmooth	0.029	0.024	− 0.115	− 0.077	0.008	0.987	1000		
Violin original	0.013	− 0.017	− 0.023	− 0.057	0.004	0.2034	0.996	1000	
Violin unsmooth	− 0.019	0.016	0.001	− 0.008	0.002	0.1997	0.2033	0.998	1000

6.1. Violin's sensibility to the equity market

The lack of correlation between violin and equity returns in Table 8 may be due to the non- simultaneous nature of the two types of returns. This issue arises from three different sources. First, violin prices probably adjust slowly to changes in financial-economic conditions. Second, catalogue prices partially reflect prior periods' pricing history. Third, in order to calculate yearly violin returns, I allocate all published catalogues to the closest year-end. This gives rise to a minor disparity between the reported price trends of violins and the timing of equity returns.

To further understand the true relationship between equity market and violins, I therefore estimate the market model beta using the aggregated coefficients methodology of

Dimson (1979), which accounts for non-simultaneousity in asset returns. Dimson (1979) first runs a regression of asset returns on lagged, matching, and leading market returns:

$$R_t = \sum_{i=-a}^{b} \beta_i \, R_{t=i}^{m} + \upsilon_t$$

where *a* is the number of lagged market returns, and *b* indicates the number of leading market returns. The slope coefficients are then aggregated to get an unbiased estimate of the beta of an asset:

$$\beta = \sum_{i=-a}^{b} \beta_i$$

The results for the series of violin and equity returns are shown in the Table below.

Model 1 portrays the traditional beta which is very close to zero. In model 2, when also including one lag and one lead in the analysis a significantly positive beta of 0.223 is observed, with a β_{-1} equal to 0.142, indicating that it is mainly lagged equity market movements that matter. In model 3, this beta grows to 0.326 with two lags and one lead.

These results show that there is non-insignificant positive correlation between equity returns and violins returns, but that the systematic risk of violins is still relatively low. The low beta of violins is consistent with the finding that the financial crisis did not stop violin prices from rising.

This result has evidenced at the existence of a wealth effect: there is a positive correlation between the returns on equities and those on violins.

Table 9. Results from aggregated coefficients method[15]

	β-2	β-1		β0	β+1	β		*R*2
Model 1 (a = 0 and b = 0)				0.002		0.002		0.000
Model 2 (a=1 and b =1)		0.142	**	0.043	0.039	0.223	**	0.057
Model 3 (a = 2 and b = 1)	0.080	0.149	**	0.053	0.047	0.326	**	0.075

The table 9 reports the results of the ordinary least squares (OLS) estimation of Eq. (1), which relates violin returns to equity market returns over the period 1980–2019.

6.2. Inflation Hedging Abilities

In this section I explore the hedge that violins present against expected and unanticipated inflation.

Violins are found to have a positive correlation between nominal violin returns and inflation, but a negative correlation between real violins returns and inflation. This last result is surprising as there was a great surge in violin demand in the late 70's when inflation levels where high.

I will follow similar studies in real estate, such as Liu, Hartzell, and Hoesli (1997) that in order to initiate the analysis, they take a proxy for expected inflation that is available over the very long term. First, I will include lagged short-term interest rates in the analysis.

Fama (1975) shows that if the T-bill market is efficient, and if the expected real return on bills does not change, changes in the nominal interest rate should be due to changes in the expected rate of inflation. I will use Global Financial Data yields on one-year government notes.

[15] β aggregates the individual slope coefficients on a lagged market returns, the same-year market return, and b leading market returns into an unbiased estimate of the market model beta, using Dimson (1979). R2 is the R-squared, or the multiple correlation coefficient. ***, **, and * denote significantly different from zero at the 1%, 5%, and 10% level, respectively. All coefficients are significantly smaller than one.)

Following Fama and Schwert (1977), I will test the effectiveness of this proxy as predictors of inflation through the following model:

$$\Delta_t = \alpha + \beta E(\Delta_{t)} + \mathcal{E}_t$$

where Δ_t is the true inflation rate, measured at the end of year t.

If β is close to unity (and α is close to zero), the expected inflation will be correctly accounted for. The error term reflects the unexpected component of the observed inflation. Table 11[16] shows the result of the OLS estimation of the above Equation which compares inflation rate to ex ante prediction of inflation over the period of time. α is the intercept and β is the slope coefficient. The null hypothesis is that the proxy for expected inflation in the first column is an effective one.

Table 11 Validity of Inflation predictors

	α	t-stat H_0: α = 0	β	*t*-stat H_0: β = 1	R^2
Short-term interest rate	0.008	0.82	0.671	-1.932	0.128
Lagged inflation	0.021	3.11	0.510	-5.864	0.257

The α is statistically alike from zero, while β is only significantly different from one at the 10% level. I also use lagged inflation as a measure of expected inflation, as a robustness check. Although β is significantly smaller than unity for this proxy, a higher R-squared in the estimation of the inflation Equation is observed.

Once proven that short-term interest rates are a reasonably good proxy for inflation, the next step is to test whether violins are a hedge against expected and unexpected inflation using the methodology of Fama and Schwert (1977).

Their model is the following:

$$R_{jt} + \alpha_j + \beta_j E(\Delta_t) + \gamma_j [\Delta_t - E(\Delta_t)] + \eta_{jt}$$

16 Data on short-term interest rates comes from Global Financial Data. Inflation data comes from Dimson, Marsh, and Staunton (2009).

where R_{jt} is the nominal rate of return on asset j, $E(\Delta_t)$ is the expected inflation rate and $\Delta_t - E(\Delta_t)$ is the unanticipated inflation rate.

Violins are a hedge against anticipated inflation if β_j is equal to one, while they are a hedge against unexpected inflation if γ_j is equal to one. The estimation results from the Equation above, using short-term interest rates and past inflation as proxies for expected inflation are shown in Table 12.

Table 12 Inflation Hedging potential of violins versus other assets

	Short-term interest rate					Lagged inflation				
		t-stat		*t*-stat			*t*-stat		*t*-stat	
	β	H_0: β = 1	γ	H_0: γ = 1	R^2	β	H_0: β = 1	γ	H_0: γ = 1	R^2
Baseline results										
Violins	1.287	0.81	0.412	-2.79	0.124	0.781	-1.02	0.402	-2.61	0.102
Equities	1.598	1.02	0.162	-2.54	0.068	0.629	-0.99	0.217	-2.08	0.031
Bonds	1.598	1.12	-0.454	-8.95	0.262	0.082	-4.65	-0.317	-6.60	0.040
Bills	1.228	1.46	0.038	-64.02	0.937	0.311	-12.30	0.121	-15.02	0.242
Art	1.028	0.56	0.461	-2.73	0.124	0.534	-2.08	0.662	-1.52	0.089
Gold	1.153	0.27	0.602	-1.32	0.067	0.787	-0.96	0.721	-0.79	0.059
Aggregated coefficients methodology										
Violins	1.328	0.87	0.642	-1.38	0.148	0.963	-0.12	0.557	-0.94	0.132

Table 12 portrays the results of the OLS estimation of the Equation above that tests whether assets hedge against expected and unexpected inflation, over the dataset period. The table shows the results for two proxies of expected inflation: short-term interest rates and lagged inflation. In each case, the null hypothesis is that of a good hedge.

To further analyze the relation between unanticipated inflation and the returns in violins, the analysis performed for violins using the aggregated coefficients methodology of Dimson (1979). In second this case, γ is estimated by aggregating the slope coefficients on one lagged term, the same-year unanticipated inflation, and one leading term. The nominal violin return data are shown in Table 12[17].

17 Data on short-term interest rates come from Global Financial Data. The return data for equities, bonds, bills, and inflation come from Dimson, Marsh, and Staunton (2009). The return data for art come from Goetzmann, Renneboog, and Spaenjers (2010) and Artprice.com (2010). Gold prices are downloaded from Global Financial Data.

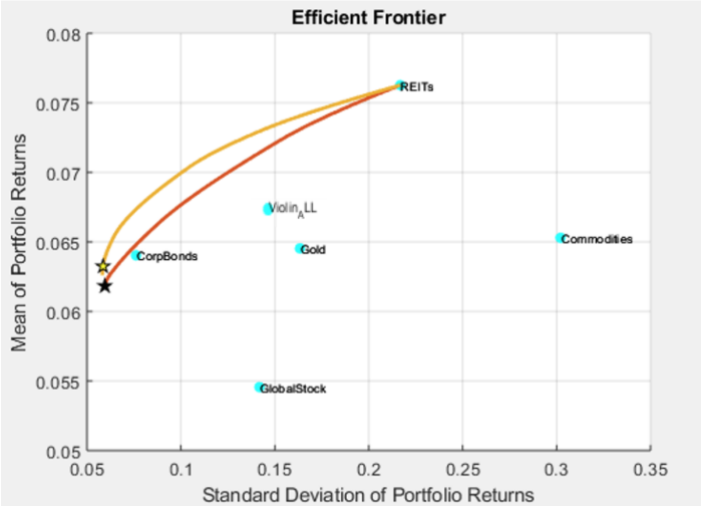
It can be seen that violins, gold and equities hedge good against expected inflation, independently of the proxy used for inflationary expectations. If dealers condition their price adjustments on realized inflation in the previous period, violins will partially hedge against expected inflation by construction, especially when past inflation is used as a proxy for inflationary expectations

When turning to unanticipated inflation, only gold seems to maintain a consistent hedging ability. Non-synchroneity is a milder problem when exploring expected inflation and returns because expected inflation rate is persistent over time, according to Fama and Schwert (1977). I repeat the Fama-Schwert tests using Dimson's aggregated coefficients methodology to find the true sensitivity of violin returns to unexpected inflation. By including one leading and one lagged term, coefficients on γ are not significantly smaller than one at the 10% level which indicates that violins only partially hedge against unanticipated inflation.

6.3. Optimal Portfolio Allocation

Markowitz (1952) pioneered the modern investment theory with his classic mean-variance efficient frontier model. He states that the better way to reduce risk is to diversify the portfolio. The Figure 4 below shows the improvements of Top Violins after unsmoothing, to base portfolio mix. It can be seen from this figure that the inclusion of Violins provides a significant diversification benefit to base portfolio mix by pushing efficient frontier upward noticeably. The yellow star stands for the optimal portfolio after violin's inclusion and the black star depicts the base portfolios.

Figure 4. Portfolio Efficient Frontiers



It is important to highlight that once again the outcome of the optimal portfolio model is specific to the input and thus to the historical returns made for the chosen asset classes over this period. If financial returns are used to estimate future returns, then the model could be used for an optimal portfolio strategy; however, future returns are by definition unknown, and thus the model only provides to the investor an idea of a diversified portfolio strategy and does not guarantee any future performance.

The outcome of the optimal portfolio strategy is given in Table 13. It can be seen that no allocation is given to equities, which given the recent poor performance and the relatively high volatility is not surprising. Corporate bonds have done well in the past years, and hence the model results in a large allocation into this asset which has achieved high annual returns.

As expected, the model allocates a 21 and a 14 per cent allocation into violins before and after unsmoothing, respectively, because the rise in volatility after the unsmoothing procedure. Interestingly, the improvement in the portfolio of 12% after including violins in the unsmoothing model surpasses the 9% improvement of the smoothing (original) model. Therefore, it can be sustained and even emphasized, that by tackling the issues posed by this niche market, violin's inclusion in a portfolio continues to show a positive addition, at least from an empirical point of view.

Table 13 Portfolio Optimization results

	Base	original	Strad uns	Violin Uns.
MSCI WORLD	0,0000	0,0000	0,0000	0,0000
ART	0,0697	0,0419	0,0805	0,0956
REITs	0,0000	0,0000	0,0000	0,0000
UK 10 YEAR GOVT	0,7018	0,6387	0,6380	0,6667
GSCI Commodity	0,2285	0,1020	0,1398	0,2379
Strad original	-	0,2174	-	-
Strad uns	-	-	0,1416	-
Violins uns	-	-	-	0,0033
Return	0,0637	0,0621	0,0632	0,0622
Risk	0,0633	0,0557	0,0556	0,0595
Sharpe Ratio	0,6434	0,7020	0,7238	0,6525
Improvement		**9%**	**12%**	**1%**

A. Study 1: Analyzing the 'work-of-art effect' in the fine stringed instrument market

Within the empirical research focusing in the returns from alternative investments, an interesting phenomenon has been observed: the 'masterpiece' or 'work-of-art' effect. Intuitively, if art works are indeed believed to be "masterpieces"— works of exceptional quality or renown—then, we might expect the returns from investing in these art works to uniformly outperform the general sample and market. However, James Pesando, Jianping Mei & Michael Moses and, Ashenfelter & Graddy - among others - have found that masterpieces tend to underperform the market and, in fact, provide lower cumulative returns than non-masterpieces.

The market of stringed instruments, like the one for art and other passion investments, is very heterogeneous. The market has a large variety of pieces, from truly outstanding works of art to regular items. This study aims to analyze the 'work-of-art effect' within the violin market – this is, to analyze whether it is more interesting to invest in one single violin rather than in a variety of lower quality violins with an equal overall value (Mei Moses, 2002). In order to do this, the repeat-sales regression method will be used to test a sample of 259 violins.

A.1. Previous Literature on the 'Work-of-Art effect'

Ashenfelter and Graddy (2003) explain the work of art in the following way "It is always better (in terms of returns realized ex-post) to buy an item at USD 10.000 than to buy 10 items at USD 1.000."

Most of the recent research on the 'masterpiece effect' was triggered by Pesando (1993), although it was John Ruskin who wrote in his 1857 book 'A Joy for Ever (And Its Price in the Market)' that "in the long run, the dearest pictures are the best bargains".

The conventional wisdom of art investing is to buy the most noted works in order to obtain the highest returns, though according to more rigorous empirical testing, masterpieces often underperform the art index. Previous studies in the literature provide mixed empirical findings in various markets on this topic. The datasets of both the Mei and Moses (2002) and Pesando (1993) suggest that buying highly prized and valuable paintings or prints is a poor investment strategy. This observation is particularly poignant in light of the fact that it is precisely these rare masterpieces that ought to yield the highest conspicuous consumption boon to utility.

Mei and Moses (2002) defined a masterpiece portfolio as the top one-third of paintings by price, and reported that masterpieces tend to have lower excess returns than non-

masterpieces, and that systematic risk does not explain the 'masterpiece effect'. Their evidence is consistent with the view that investors overpay for masterpieces under the influence of auctioneer estimates. Graddy and Ashenfelter (2002) found that "masterpieces" underperformed in the Contemporary Art sample, but have no effect in the Impressionist Art sample, consistent with Pesando (1993) and Mei and Moses (2002) in Contemporary Art. De la Barre, Docclo, and Ginsburgh (1994) find that great Impressionists return 4 percent higher than other Impressionists, though Ashenfelter and Graddy (2003) find no 'masterpiece effect' for Impressionist art and a return of 50 percent less for contemporary masterpieces. Pesando and Shum (2008) reexamined the 'masterpiece effect' in the modern print market from 1977~2004, but found mixed results. A more recent working paper by Kräussl and NasserEddine (2017) sees evidence supporting the 'masterpiece effect' – real annual returns on masterpieces, defined by the top 5% priced artworks, over different time horizons are significantly high.

An explanation for the underperformance of masterpieces is posited by Mei and Moses (2005): auction houses tend to upwardly bias price estimates for high-priced works which correlates with subsequently poor investment returns. That credulous investors systematically overpay due to the influence of auction house price estimates seems consistent with a story in which (rational) investors receive nonpecuniary benefits from high-priced art purchases. Also, note that expected returns on masterpieces should in theory be lower if agents derive utility from conspicuous consumption (Mandel, 2008)

Another explanation for the 'masterpiece effect' to be negative is due to overbidding followed by mean reversion. Thus, masterpieces outperform in one period—we could theorize the one in which their "masterpiece" status was originated or consolidated—and then underperform once they're more established and change hands less frequently (presumably, these pieces would be coveted and thus not traded as often).

Also, masterpieces are less risky because they're more liquid—they may not trade as often, but are definitely easy enough to sell in the market when they do enter it. It is elementary intuition in financial economics that lower risk involves lower returns. To that extent, non-masterpieces would provide higher returns because they're indeed riskier than established pieces. For these riskier assets, you can buy at a low price and sell at a much higher price later given changing tastes.

Given the above discussion, the 'masterpiece effect' almost becomes a market efficiency question, in that masterpieces could be considered assets that trade "efficiently", while non-masterpieces may not. Applying the concept of an efficient security to an artwork, because of

their very status as masterpieces, we can presume all possibly available information is known about these works and their artists/makers, so no new information (despite, perhaps, deterioration of the work itself or discovery as a fake, etc.) should ever come out about that item. Thus, because prices for an asset that trades efficiently should only adjust to new, material, and public information, we should expect prices for masterpieces to change very little over time and thus, these works to provide very low (if not zero) returns. Because we may lack much more information on non-masterpieces, and because there is a higher likelihood that some particular investors or participants in the market receive more or better information on them than others, non-masterpieces may thus show inaccurate prices and allow for outsized returns that deviate from their true value, as compared to masterpieces.

Ashenfelter and Graddy summarize James Pesando's discussion of the market efficiency question: when pieces trade efficiently, "the market should internalize the favorable properties of masterpieces into their prices, so that risk-adjusted returns should not exceed that of other pieces." Of course, here Pesando explains the 'masterpiece effect' without relying on the inefficiency of non-masterpieces. In fact, for Pesando, it is because the market is efficient for both masterpieces and non-masterpieces that the former do not demonstrate higher returns than the latter (for non-masterpieces, there's simply newer information about them coming to the market, so there is more positive price adjustment for newer, non-established works as opposed to masterpieces).

Of course, this entire discussion relies on some critical questions: firstly, empirical research into this topic requires us to appropriately control for survivorship bias. After all, as mentioned above, masterpieces are presumably much more liquid than non-masterpieces. As such, they are likely to sell much more often so that, when we consider all the non-masterpieces that don't "survive" in the art market, the cumulative returns of these non-masterpieces may ultimately be below that of the more reliable masterpieces, making the latter ultimately still the better investment. We should also point out that the results of any models will ultimately rely on what works are defined as masterpieces. Much of the research suffers from the fact that masterpieces are identified endogenously, based on prices, which makes a negative 'masterpiece effect' hard to discern from simple mean reversion in prices. There is thus a need for studies in which masterpieces are identified by means of another criterion than price, as also pointed out by Ashenfelter and Graddy (2006). We will further explore this issue of interest. Lastly, it is difficult to prove whether a piece or certain sectors of the market trade in an efficient way. As well as to explain why do prices change so dramatically for artworks - Other than inflation, why would a Stradivari 50 years from now sell at a much higher price

than today. The most obvious answer would simply be changing consumer preferences: perhaps 50 years from now, Stradivari violins are even more popular than today. Yet, how do we calculate when the popularity of an artist changes and how do we define that popularity to then measure and apply to the art market equivalent of an event study.

Generally speaking, masterpieces are thought to provide more liquidity and low risk in terms of price fluctuations or maybe even promise value appreciation. The aim is to explore the 'masterpiece effect' in the violin market and to see whether high net wealthy individuals should start to seek such masterpieces as a store of value.

A.2. Data and Repeated Sales Returns

The repeated sale database described under Section 3.2 has been used for this targeted study.

Given that every violin is unique, it is difficult to measure the return obtained after investing on a specific violin. This makes it difficult to construct a unique index representing the movement of prices through time. Given this singularity, the two models described previously have been developed to calculate the returns: the hedonic regression and the repeat-sales methods. As a quick reminder, through the former, some characteristics of a violin are decomposed and given separate values. Thus, it allows to compare heterogeneous assets of the same class. The key benefit of this approach is that it enables the inclusion of large datasets in the analysis, whereas the main disadvantage is its limitations to the model specifications. The repeated-sales regression, on the other hand, is superior to the hedonic price models in that it controls for all characteristics of an artwork as the prices of the same assets are tracked overtime. Its main disadvantage is that the resulting figures are based on a subset of only those assets that were repeatedly sold. That is, it omits the larger proportion of available data. Throughout various research, academics have relied on the repeat sales regression framework. This last model will be used to analyze the 'masterpiece effect' in the violin market.

The regression model used in this study is the following:

$$\ln\left(\frac{P_{IS}}{P_{IB}}\right) = \sum_{t=1}^{T} \beta_t \, \delta_t + \varepsilon_{it}$$

Where β_t is the average return of the violins included in the dataset for the period t; δ_t an indicator for each period (the coefficient of this variable is proportional to the holding period during the observed timeline); ε_{it} is the error term.

The observations consist of prices of buys and prices of sales, P_{IB} and P_{IS}, for each violin as well as the dates corresponding to these prices. *I* is the index for each instrument, *B* represents a buy and *S* a represents sale.

As the number of observations is low, we calculate the returns in periods of 10 years as Goetzmann (1993). The estimated coefficients for each period for the repeat sales model are presented in the following Table A-1.

The annual returns as well as the index for each period; $(1 + annual\ return_t)^{10} * Index_{t-1}$, are presented in Table A- 1 as well.

The average index itself equals the T^{th} root of the index in period T divided by the index in period 1, minus 1. This is, the average return for the period 1850-2009 is:

$\sqrt[158]{\frac{8809.53292}{1.21984073}}$ - 1 = 5,78%

Table A- 1 Calculation of annual return and Index for each period

	Beta	Annual return	Index
Period 1	0,2	0,02	1,22
Period 2	0,25	0,03	1,56
Period 3	0,76	0,08	3,35
Period 4	0,31	0,03	4,58
Period 5	0,64	0,07	8,72
Period 6	0,14	0,01	10,07
Period 7	0,6	0,06	18,41
Period 8	1,12	0,12	56,24
Period 9	-0,25	-0,02	43,76
Period 10	-0,08	-0,01	40,48
Period 11	0,73	0,08	84,17
Period 12	1	0,11	229,18
Period 13	1,71	0,19	1271,63
Period 14	1,33	0,14	4806,3
Period 15	0,44	0,05	7473,47
Period 16	0,16	0,02	8809,53

A.3 Methodology

Turning to our targeted study we construct two portfolios, one solely for masterpieces (defined by the 20% top prices in our sample database) and the other one, for the rest of the instruments. In order to analyze whether there exists a difference between the returns of the two portfolios, the hypothesis that the return function for the masterpieces has a coefficient β_0' greater than other violins is made.

The two following formulas for works-of-art and other items are obtained:

$$ln\left(\frac{P_{IS}}{P_{IB}}\right) = \beta_0' + \sum_{t=1}^{T} \beta_t \delta_t + \varepsilon_{it}$$

$$ln\left(\frac{P_{IS}}{P_{IB}}\right) = \beta_0 + \sum_{t=1}^{T} \beta_t \delta_t + \varepsilon_{it}$$

d is the difference between the coefficients:

$$d = \beta_0' - \beta_0.$$

From here, the two return functions can be combined by defining one variable indicator M that takes the value of 1 for the 20% top priced items and the value of 0 for the rest. The completed formula would be, therefore:

$$ln\left(\frac{P_{RS}}{P_{RB}}\right) = \beta_0 + d * M + \sum_{t=1}^{T} \beta_t \delta_t + \varepsilon_{it}$$

By doing this, it will allow us to see the significance of the coefficient of the variable M by doing a Student test. The null hypothesis is $H_0: d = 0$; this is, the 'work-of-art effect' doesn't exist. The alternative hypothesis would be $H_1: d \neq 0$; this is, there exist a 'work-of-art effect'.

A.4 Results

As we can see from Table A- 2, the coefficient of the variable M in the second model is estimated at 0.31 and is significant at the 5% limit (see Model 2, Table A- 2). The coefficient is therefore different than 0 and positive. We observe that "masterpiece" violins have a higher

return that the rest. This result is different to the one in the general literature for alternative investments.

We see here that the fact of selling a violin through an auction house versus selling it privately through a dealer could influence strongly on its price. It would be interesting then to explore this further. In the next section, we will examine the 'masterpiece effect' in either case.

Table A- 2 Regression Results

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Period 1					0,84*	
Period 2						
Period 3	0,76***	0,75***	0,66***	1,25**	0,53**	0,73***
Period 4					0,45**	
Period 5	0,64**	0,66***	0,60**		0,70***	0,70***
Period 6						
Period 7	0,60**	0,609***	0,61***	0,81**	0,52*	0,61***
Period 8	1,11***	1,12***	1,08***	0,93**	1,23***	1,11***
Period 9			-0,36*	-1,04**		
Period 10				0,88*		
Period 11	0,73***	0,69***	0,69***		0,66**	0,65***
Period 12	1,00***	1,00***	1,07***	0,87***	1,07***	0,99***
Period 13	1,71***	1,63***	1,78***	1,82***	1,03***	1,74***
Period 14	1,33***	1,25***	1,39***	1,30***	1,58***	1,36***
Period 15	0,44***	0,40***	0,50***	0,39***		0,50***
Period 16				0,35*		
Constant			-0,31***	-0,22**		-0,21***
M		**0,31*** **		0,055	1,02***	
D			**0,46*** **			
Maker						**0,29*** **
No Obsv.	337	337	337	184	153	337
Adj. R^2	0,89	0,89	0,90	0,90	0,91	0,89

Model 1: Regression for overall database
Model 2: Test of 'work-of-art effect'
Model 3: Test of dealers vs. auction houses
Model 4: Test of 'work-of-art effect' on violins sold through auction houses
Model 5: Test of 'work-of-art effect' on violins sold through dealers
Model 6: Test of 'work-of-art effect' by maker
*, **,***, significant to the level of 10%, 5%, and 1%

A.4.1. Dealers vs. Auction Houses

We are going to examine, first of all, the need of calculating the 'work-of-art effect' in each of the two sub-samples in the database. Indeed, if there is no difference in the returns of each sub-sample, the 'work-of-art effect' will not be different when differentiating public versus private sales.

We have seen in previous violin literature, that the top priced violins are sold through private dealers. We therefore make the hypothesis that the returns from violins sold via private dealers have a coefficient β_0' higher than the coefficient of those violins sold through auction houses. We use the same formulas that the ones to calculate the 'work-of-art effect' but these time, we define a variable D that takes the value 1 if the violin is sold through private dealers and, 0 if it is not the case.

$$ln\left(\frac{P_{RS}}{P_{RB}}\right) = \beta_0 + d * D + \sum_{t=1}^{T} \beta_t \delta_t + \varepsilon_{it}$$

This will allow us to verify whether the variable D is significant by doing a Student test.

The null hypothesis is $H_0: d = 0$; this is that violins sold via private dealers do not have a return significantly different to those sold via auction houses. The alternative hypothesis is $H_1: d \neq 0$; this is that the sales done through private dealers have a different return than the sales done via auction houses.

We expect the returns coming from private dealers to be higher.

We can observe from the results in Model 3 (see Model 3, Table A- 2) that the coefficient of the variable D is significantly higher that 0 and positive, as the coefficient is 0,46. Therefore, we can conclude, that there is a difference in the returns coming from violins sold via auction houses and those being sold via private dealers.

We will proceed then by calculating the 'work-of-art effect' for each sub-sample. However, we should note that the data contains only 337 observations and that by splitting the sample we will obtain two smaller sub-samples that would need to be analyzed carefully as the small sample in this database may not be a representation of the wider population.

A.4.1.1 Sub-sample of violins sold through Auction Houses

This sub-sample consists of 184 observations. The average return for the period 1850-2009 is 5,79%.

The methodology used to calculate the 'work-of-art effect' is the same we have been using above. We therefore verify whether the coefficient of the indicative variable M is significant by doing a Student test. The null hypothesis is $H_0: d = 0$ and, the alternative $H_1: d \neq 0$.

We observe this time that the coefficient of the variable M is not significantly different from 0 (see Model 4, Table A- 2) because the probability of the coefficient being higher to the statistic of Student is only 0,055. Therefore, no 'work-of-art effect' is seen in the case of violins sold through auction houses.

As noted above this result has to be taken into consideration with caution as it could have a representativeness bias.

A.4.1.2 Sub-sample of violins sold through Private Dealers

This sub-sample consists of 153 observations. The average return for the period 1850-2009 is 6,16%.

The methodology used to calculate the 'work-of-art effect' is the same that the one we used above. We therefore verify whether the coefficient of the indicative variable M is significant by doing a Student test. The null hypothesis is $H_0: d = 0$ and, the alternative $H_1: d \neq 0$.

This time, we observe the coefficient of variable M being significantly different from 0 and positive (see Model 5, Table A- 2). A positive 'work-of-art effect' for the violins sold via private dealers is observed.

We should note the same remark as above, regarding the representative bias.

A.4.2. Masterpiece Definition

Different criteria can be made when selecting how to define masterpieces. Barre (1996) does not use top prices as a way to define masterpieces as the majority of authors, he uses instead maker's reputation. Therefore, the next logical step is to test whether the 'work-of-art effect' is different when we define a masterpiece by the extent of reputation of the luthier making the item rather than by the top priced items. We will consider the makers Stradivari and del Gesù as the ones with higher reputation. We have therefore created an indicative variable Maker which takes the value of 1 if the violin has been created by either Stradivari or del Gesù and, 0 if not.

We will observe 201 violins created by Stradivari and del Gesso that represent about 60% of the dataset. We can determine whether Stradivari and del Gesù violins have a higher return thanks to a Student test. The null hypothesis is Ho: $d = 0$ and the alternative H1: $d \neq 0$.

We can see from the results in Model 6 (see Model 6, Table A- 2) that the coefficient of the variable Maker is significantly different to 0 and positive, as the coefficient is 0,29. We can therefore conclude that the violins made by Stradivari and del Gesù have higher returns than the rest.

In this study, the existence of a positive 'masterpiece effect' in the market for violins has been demonstrated, regardless whether they are defined as the 20% higher priced or by top luthier (proxy for best market quality). Further it has been proven that violins sold through private dealers experience higher returns than the ones sold through public auction houses and, through this result it has been proven the existence of a market differentiation from violins in both channels. In addition, it has been confirmed that the masterpiece effect is most prominent when violins are sold through private dealers.

B: Study 2 Analyzing the 'Musician effect' in the fine stringed instrument market

B.1 Introduction

This study, explores the price determinants of violin investment with a particular focus on the impact of the so-called musician-effect. Although natural endowments remain essential for determining the quality of an instrument, auction-wise attributes as well as musician-effect are crucial price determinants for goods that can be experienced. It is a particularity of this niche market that the final owner is most of times a different person than the musician playing the instrument. Musical instruments, specially, fine old stringed instruments need to be played in order to keep its acoustic properties and, therefore maintain its value. This triangle violin-musician-owner exists in every violin investment and translates in an important factor determining the price of these instruments. This fact motivated me to further isolate this particular musician-effect and to try to account for its real weight in this asset class.

With the previous transactional data from leading violin auction houses and historical records of musician renting the individual instruments, I analyze the impact that a re-known musician has on the prices of the violin it plays. Talented musicians are expected to be able to appreciate violin acoustic properties (which translates into higher quality), particularly for less famous instruments. This argument will be tested for the first time.

Moreover, event study methodology will be applied to further analyze the musician-effect. The evolution of a musician playing a violin towards a pared similar instrument played by various musicians or none will be treated as an event of interest. This evidence hints at an innovative approach to isolate the real musician-effect from other price determinant variables and to study the dynamics that playing a violin by a talented musician has on prices.

B.2 Data

The table below provides the descriptive statistics of the violin database over the past 39 years from 1980 to 2019. Panel A divides violins by musician reputation, past provenance and sample period. Musician reputation has been defined by using a score system which grades musician's level of expertise. Starting from base point 50, the system is divided by three scales: 50-79 talented musician, 80-95 rising talent, 96-100 established musician. Past provenance is defined by number of previous notorious owners. Table B -1 Panel A shows the descriptive statistics of the dataset. It is observed from that the distribution of violins played

by musicians is highly skewed towards top maker violins. This selection bias is not surprising since talented musicians are not usually exposed to low-quality violins.

Table B -1 Panel B demonstrates 2334 violin sales included in the event study analysis, the database is controlled for a minimum trading frequency of 2. Trading frequency ranges from 6 times to 2 times. Finally, 53 violin pairs are included in the sample set.

Among these violin pairs, some violins undergo up to 4 times re-valuations, and others encounter fewer. Re-valuation is defined as changing hands from one musician to another which translates into a change in the rating of that particular instrument. The respective distribution is also shown in Table B-1 Panel B. Re-valuations are defined as number of re-known musicians renting/playing the instrument in the 39-year span of the database.

Table B -1 Database Summary Statistics

Panel A. (451 sales)		Hammer price ($)			
		Mean	St. Dev.	Obs.	Pct.
Musician Reputation	50-79	368.77	87.09	49	1.10%
	80-95	457.42	214.52	114	19.51%
	96-100	510.16	403.55	288	44.19%
Provenance	1-3	282.61	570.34	116	23.15%
	4-6	384.98	651.68	272	60.22%
	>6	759.03	1098.59	63	10.38%
Sample Period	80-90	118.65	229.13	43	11.65%
	91-00	169.06	284.72	79	22.74%
	01-10	279.54	454.62	112	31.10%
	11-19	720.93	988.91	217	34.51%

Panel B. re-valuated violins (2334 sales)

	Mean	Min.	Max.	St. Dev.	# violins	Obs. 2334
# of Frequency	2.4	2	6	548	53	
Re-valuated times	4 times	3 times	2 times	1 times	Sum	
# of violin pairs	1	3	12	37	53	

B.3. Methodology

B.3.1. Hedonic Regression approach

In order to explore the price determinants of violins in this section, I apply the same hedonic regression method as before. The only difference is that one subjective variable is incorporated - talented musician - to the model specification. This new subjective price determinant is considered as a mixed proxy of underlying overall quality and consumer appeal. Therefore, the model becomes:

$$Lnp_n^t = \beta_0 + \sum_{\tau=1979}^{2019} \delta^\tau D_n^\tau + \beta_1 Tarisio_n^t + \beta_2 TopAuctionHouse_n^t + \beta_3 AuctionSeason_n^t + \beta_4 Top\_Maker_n^t + \beta_5 TStrad\_LOB_n^t + \beta_6 InstrumentAge_n^t + \beta_7 Varnish_n^t + \beta_8 Authenticity_n^t + \beta_9 Musician_n^t + \varepsilon_n^t$$

B.3.2 Event Study

In this study, I apply event study methodology to the violin auction market. During a musician's career, he/she rents a violin not only once but several times at different time life periods, and this fact affects the violin's interest for collectors and amateurs as indicates changes in instrument's quality and therefore acts as a rating signal. When a musician rents a new instrument, this translated to the market as a re-valuation of the violin it leaves and of the new one he/she will play. Given this niche markets' specific influence on violin buyers/collectors/investors and the general rationality in the violin market, the effect of a new musician playing an instrument impacts prices immediately when a re-valuation occurs.

The abnormal return of violin *i* at renting change date *t* is defined as the difference between the realized return and the expected return given the absence of such event:

$$AR_{i,t} = R_{i,t} - E\left[R_{i,t}\middle|\Omega_{i,t}\right]$$

where $R_{i,t}$ is the actual return based on auction hammer price, $\Omega_{i,t}$ is the information set given no revaluation change and $E\left[R_{i,t}\middle|\Omega_{i,t}\right]$ is the expected/predicted return given no change in revaluation. The cumulative abnormal return for asset *i* during time (t_1,t_2) is the addition of $AR_{i,t}$ which is:

$$CAR_{i(t_i,t_2)} = \sum_{t=t_1}^{t_2} AR_{i,t}$$

A substantial feature of an event study is the choice of an appropriate prediction model to estimate the pricing parameters. The most common models for event study in the financial

market are the constant mean return model and the market model. The hedonic regression model aforementioned as nonparametric model (local linear regression) is applied to estimate parameters of price factors as well as to solve the unbalanced transaction interval issue, which is common to all alternative assets. Because the violin auction market is not a scheduled trading market as regular as the stock market, different auction houses follow their own time schedules and categories for the transaction frequency for different violins and therefore sample periods vary.

The corresponding hedonic regression model for each violin used in the study is the following:

$$\ln p_n^t = \beta_0 + \beta_1 \ln (Age)_n^t + \beta_2 \mathrm{Loc}_n^t + \beta_3 \mathrm{LOB}_n^t + \beta_4 \ln (Qty)_n^t + \varepsilon_{it}$$

With the parameter estimations, the abnormal returns are estimated and necessary tests are implemented. Under the null hypothesis, H_0, the event fails to influence the behavior of returns, the statistical properties of the abnormal returns can be used to draw conclusions over the event window. Under, H_0, the distribution of the sample abnormal return is:

$$AR_{i,t} \sim N\left[0, \sigma^2\left(AR_{i,t}\right)\right]$$

and the respective cumulative abnormal return is:

$$CAR_{i(t_1,t_2)} \sim N\left[0, \sum_{t=t_1}^{t_2} \sigma^2 (AR_{i,t})\right]$$

Assuming no overlap in the event windows, the abnormal returns and the cumulative abnormal returns remain independent across the assets included.

Given N assets, the variance is:

$$var(\overline{R_t}) = \frac{1}{N^2} \sum_{i=1}^{N} \sigma^2 \left(AR_{i,t}\right)$$

and, the sample aggregated abnormal return for period *t* is:

$$\overline{AR_t} = \frac{1}{N}\sum_{i=1}^{N} AR_{i,t}$$

The statistical test of abnormal returns is based on the aggregated cumulative abnormal returns across assets which is:

$$\overline{CAR_{(t_1,t_2)}} = \frac{1}{N}\sum_{i=1}^{N} CAR_{i(t_1,t_2)}$$

and its variance is:

$$var(\overline{CAR_{(t_1,t_2)}}) = \frac{1}{N^2}\sum_{i=1}^{N}\left[\sum_{t=t_1}^{t_2}\sigma^2\left(AR_{i,t}\right)\right]$$

Hence, the cross-sectional t-test is defined as:

$$T_{cross} = \frac{\overline{CAR_{(t_1,t_2)}}}{\hat{\sigma}_{\overline{CAR}_{(t_1,t_2)}}}$$

Under the null hypothesis, the cumulative average abnormal return equals zero.

The variance estimator of this statistic is based on the following cross-section of abnormal returns:

$$\hat{\sigma}^2_{\overline{CAR}_{(t_1,t_2)}} = \frac{1}{N(N-1)}\sum_{i=1}^{N}\left[CAR_{i(t_1,t_2)} - \overline{CAR}_{i(t_1,t_2)}\right]^2$$

Therefore, in order to isolate the musician-effect from other price variables, I took advantage of the renting evolutions for the same violin in order to better study this effect before and after the change in hands. Event study methodology will be applied to test the significance of abnormal returns due to the changed in revaluation of this asset class.

B.4 Empirical Analysis

B.4.1 Results I

After applying OLS regression techniques on hedonic modeling including the variable 'talented musician', the regression result for all characteristics can be found in Table B-2.

The Table below shows that violins played by talented musicians exerts the same influence on violin prices after controlling for the demand side induced by relative wealth growth (variable ACWI). The coefficient of 'musician effect' almost stays constant when switching from model 1 to model 2 (which includes the demand side proxy) as well as from model 3 (same as model 1, including the variable provenance) to model 4 (same as model 3, including the demand side proxy). The premium of a violin being played by a notorious musician fluctuates in the region of 15%.

As time progresses, more talented musicians compete to play top quality violins and this further increases the scarcity, due to the fixed supply, for violins made by top makers. This fact is reflected in the variable maker which pushes the price up at the pace of 3.9% each year. It should be noted that there exists a selection bias in the data as the database used is limited to top-quality violins made mostly by top makers.

It is also observed a preference for violins with Stradivari varnish, which is a proxy for sound quality; and a descending demand and interest towards the identical by size item auctioned as seen in variable LOB.

Past provenance track provides a good proxy for guaranteed quality and therefore, it is observed in the results that it is positively influencing the price of a violin.

Table B-2
Regression result of hedonic model for logarithmic price on explanatory variables

Var.	M1	M2	M3	M4
Intercept	- 6.680***	-6.805***	-8.468***	-8.480***
	(0.13813)	(0.13764)	(0.14017)	(0.13972)
Musician Effect	**0.145*** **	**0.145*** **	**0.157*** **	**0.157*** **
	(0.00026)	(0.00026)	(0.00022)	(0.00022)
Top_Maker	0.022***	0.022***	0.039***	0.039***
	(0.00139)	(0.00139)	(0.00006)	(0.00006)
Strad_varnish	0.011***	0.011***	0.013***	0.013***
	(0.00063)	(0.00063)	(0.00062)	(0.00062)
LOB	-0.002***	-0.002***	-0.002***	-0.002***
	(0.00006)	(0.00006)	(0.00006)	(0.00006)
Provenance			**0.0106*** **	**0.0106*** **
			(0.00023)	(0.00023)
Ln(ACWI)		**0.449*** **		**0.436*** **
		(0.01003)		(0.01028)
Obs.	456	456	456	456
Root Mean SE	0.580	0.578	0.588	0.586
Adjusted R2	0.788	0.790	0.775	0.777
F-Stat vs. constant model	15200	15200	27000	25600

Previously, we have discussed the objective violin price determinants deriving from intrinsic quality characteristics and auction market mechanisms. We now turn to examine the 'musician effect' on violin price determination. Subjective elements are as crucial as objective ones for pricing experienced goods such as music instruments that are enjoyed by being played.

Probably the most important subjective element is musician's choice to play an instrument over another. Without professional music knowledge, most non-expert violin investors and collectors rely mainly on well-known musician's choices as well as on past provenance, and they are willing to pay a premium based on this. Most violins acquisitions, consider the most those violins that have "belonged" to renown musicians (through the renting scheme aforementioned) when purchasing the instrument. Moreover, the final price realized in auction houses is mainly affected by the pre-set estimate, which is also determined by subjective elements such as provenience and musician track.

The regression result confirms this argument indicating 14.5% marginal effect of 'musician effect' of violin price, which is both economically and statistically significant. Therefore, by this study we can empirically confirm a positive 'musician effect' in this niche

market. To ease the concern of collinearity between musician and other price explanatory variables, 'musician effect' is left on the left-hand side and a regression is carried on all other variables; the R2 is 0.44 and Variance Inflation Factor is 1.6, which indicates the low possibility of collinearity in the hedonic regression model.

The estimated coefficient of wealth growth is 0.5436, which is economically and statistically significant. It means that violin buyers are willing to pay half more if their wealth grows one time given other elements remain constant. However, the regression result exhibits almost the same 'musician effect' as the one without the ACWI index variable. It can be concluded from this that 'musician effect' has its own influence regardless of the investor's wealth, which determines the marginal utility of buying and consuming a top violin.

Further analysis on 'musician effect' has been carried out and results summarized in Table B- 3. Panel A shows 'musician effect' increasing with musician reputation from 8.7% (talented musician) to 10.9% (established musician). The market gives more credit to notorious musicians, and the overall reputation effect exhibits convexity.

Table B- 3
Regression results of "musician" effect

		Coefficient	SE	*t-Stat*	*p-Value*
Panel A. Musician Reputation	50-79	8.68%	0.0036	24.674	0.0000
	80-95	8.12%	0.0012	76.801	0.0000
	96-100	10.99%	0.0007	131.283	0.0000
Panel B. Provenance	1-3	11.04%	0.0003	363.201	0.0000
	4-6	10.11%	0.0004	241.950	0.0000
	>6	9.96%	0.0007	131.872	0.0000
Panel C. Sample Period	80-90	9.79%	0.0004	261.857	0.0000
	91-00	9.98%	0.0006	163.862	0.0000
	01-10	10.21%	0.0003	288.995	0.0000
	11-19	11.68%	0.0004	319.064	0.0000

The empirical result demonstrated in Panel B rejects the assumption that the 'musician effect' has a more significant impact in the violins with more important provenance. No significant difference in 'musician effect' exists between the violins with little provenance and the ones with a rich historical past. Therefore, it could be concluded from this result that the 'musician effect' has a more important role as a price determinant of a violin than past

ownership history of that same violin. Panel C reveals that 'musician effect' increasingly influences violin prices over time.

It is also found that less reputed violins are more sensitive to a musician choosing them as instrument being rented/played. Below, in Table B -4 Panel A, it is evidenced that musician choice has a higher impact on less reputed violins with lower ownership past. The results of Table B-4 Panel B show that musician's effect has a more significant influence on prices of violins made by non-top luthiers with lower provenance history.

Table B- 4
Coefficient of 'musician effect' in each quality-reputation group

Panel A		Coefficient	SE	*t-Stat*	*p-Value*
Maker	Non-Top	11.73%	0.0002	354.013	0.0000
	Top	9.73%	0.0008	93.152	0.0000
Provenance	Low	12.37%	0.0006	241.612	0.0000
	High	11.26%	0.0003	442.257	0.0000

Panel B	Estimates of Musician's effect on violin prices					
	Provenance			Non-Provenance		
Maker	High	Low	All	High	Low	All
Non-Top	14.8%***	14.8%***	12.4%***	14.2%***	**16.3%*** **	13.9%***
	(0.00094)	(0.00094)	(0.00046)	(0.00066)	(0.00082)	(0.00044)
Top	6.9%***	6.5%***	5.4%***	9.8%***	7.0%***	8.9%***
	(0.00128)	(0.00324)	(0.00121)	(0.00152)	(0.00442)	(0.00136)

In Panel B, I separate the data into subsets grouping them by top maker (Strads/del Gesu, and the rest) which is a proxy for quality, and by provenance which is a proxy for reputation (high provenance is defined as a violin having past history of 4 or more past notorious owners).

The table above portrays that the 'musician effect' is more prominent on the prices of non-top maker violins with a low provenance track record. It is seen that there is a 16.3% price premium for one extra unit of a musician playing a non-top maker violin with low provenance compared to only a 6.9% in the case of a top maker violin with a high provenance track record.

Violin collectors and investors seem to turn more their attention to violins that come from less renown makers and are rented/played by talented musicians. Therefore, the price remains sensitive to musician's choice.

B.4.2 Results II

Although price variations are controlled as much as possible when modeling, sample bias is inevitable in segmentation analysis. Therefore, the event study methodology is introduced to analyze 'musician effect' and to isolated it from other price determinants. The evolution of musician choice towards the same violin-maker pairs is chosen as the event of interest. This evidence hints at an innovative approach to isolate the real 'musician effect' from other price determinants.

In the data sample for event study, 144 violin pairs of violins with similar characteristics (maker, varnish, LOB, age) have been included, where one has been played by one or various talented musicians and the other has not; the data consists of 2334 observations in total. 53 violins out of these 144 violin pairs have been played by at least one re-known musician. Table B -1 Panel B provides summary statistics of the data used for this study.

Event window does not cover the period before the event date as the market cannot figure out beforehand which violins will be chosen to be played by notorious musicians.

Under the empirical analysis, the data sample is categorized into three groups by changes in number of talented musicians playing the same violin: downgrade from 1 to 0 (1, 0) when the violin is left; upgrade from 1 to 2, (1, 2) when the violin is taken over by a more notorious musician; and, upgrade 3 or more (>=3) when the same violin has been revaluated a third time by a talented violinist. The logic behind is that the market may react to the number of talented musicians playing the same instrument specially when 3 or more talented musicians decide to put hands on the same violin. It is expected that the effect might not be as significant when only one musician plays the instrument or even worse, if the instrument is left by the musician.

Further, abnormal returns have been calculated for several time horizons to control for this effect diminishing over time. After running the hedonic regression in the estimation window, it is expected that the positive change with an increase in the number of notorious musicians playing a violin will have a positive influence on violin prices, and that the abnormal return will be significantly different from 0.

The result in Table B -5 below illustrates the result of event study taking into account the change in hands of musicians playing same violin which is a proxy of revaluation/revising the instrument's rating.

When all data is included in Panel A, a negative impact on prices is found when violins are downgraded by musicians (<=1). This negative impact diminishes over time as the market reflects this change in hands mostly during the period closest to the event date and loses

sensitivity in the following weeks. A similar result appears in the positive revision case, when an additional musician plays the same instrument – it is observed that the cross average of cumulative abnormal return is 19.17% during the first two weeks and, decreases over time to 3.36% after one month. The cross average of cumulative abnormal return for the whole period is 10.81% and remains significant when 3 or more musicians play the instrument.

Table B -5

Abnormal returns of musician revision in event study

		Event Window (# of days)				
	Δmusician	1-14	15-28	29-42	whole period	Obs
Panel A. All data	<=1	**-9.97%****	-4.14%	1.89%	-2.07%	
		(0.0398)	(0.0240)	(0.0362)	(0.0201)	33
	(1, 2)	1.01%	8.81%	2.27%	3.88%	
		(0.0262)	(0.0112)	(0.0226)	(0.0163)	47
	>=3	**19.17%***	**14.23%***	**3.36%***	**10.81%****	
		(0.0669)	(0.0485)	(0.0484)	(0.0364)	27

Remarkably, the post-announcement effect is long lasting for positive news, and there exists a possibility to gain abnormal returns in the days after the information becomes publicly available. However, one should interpret the results with caution. Since these events are not very frequent and the data collection process still has room for improvement, there exists a need for further investigation.

A last consideration has been explored: the volume difference before and after musician's revision, and the results can be seen in Table B -6. Violins left/downgraded by musicians tend to be exposed (or at least sold) less, around 15% to 35%, in auction sales for all time horizons, and the opposite result is found for upgraded violins. Musician's adverse revision has a negative impact on violin auction volume.

As result, this event study demonstrates that musicians are seen as the best violin connoisseurs and this is demonstrated by the fact that they do have a strong influence on violin auction price via their instrument preferences. When the instrument is played by 3 or more musicians, the price immediately reflects this by a sharp and immediate increase in price that lasts throughout the whole sample period.

Table B -6

Volume change before and after musician's revision

Period/days	Revision	Vol_before	Vol_after	Chng%
(30,30)	[1,∞)	32	37	15,63
	(-∞,-1]	45	36	-20,00
	[3,∞)	16	21	31,25
(60,60)	[1,∞)	78	96	23,08
	(-∞,-1]	138	98	-28,99
	[3,∞)	41	54	31,71
(90,90)	[1,∞)	158	181	14,56
	(-∞,-1]	229	176	-23,14
	[3,∞)	79	101	27,85

B.4 Conclusion

In this study, a particular focus has been put on musician's influence on violin prices.

Based on the largest violin auction database constructed to date, a first analysis has found that both objective and subjective factors in the last decades of violin market booming explain 87% of the price variation in violins. Although natural endowments are essential for determining the quality of an instrument, auction-wise attributes and subjective determinants such as musician's preferences are also crucial for violins which are enjoyable alternative assets.

The musician's effect on violin prices has an influence of 14.5% that is economically and statistically significant throughout the sample period and exhibits convexity. Musician's effect is present regardless the past provenance of a violin. Additionally, after controlling for the demand side of the violin market induced from relative wealth growth, musician's effect exhibits steadiness across different time spans, which implies that violin buyers (consumers, investors or collectors) use quality information including musician's reputation to decide which violin to purchase.

It can be also concluded that 'musician effect' has its own influence regardless of the investor's wealth, which determines the marginal utility of buying and consuming a top violin.

It is also seen that 'musician effect' increases with musician reputation from 8.7% to 10.9% as market gives more credit to notorious musicians, and the overall reputation effect exhibits convexity.

Another empirical result rejects the assumption that the 'musician effect' has a more significant impact in the violins with more important provenance. No significant difference in 'musician effect' exists between the violins with little provenance and the ones with a rich historical past. Therefore, it could be concluded from this result that the 'musician effect' has a more important role as a price determinant of a violin than the past ownership of that same violin. It is also revealed that 'musician effect' increasingly influences violin prices over time.

Another interesting result from the study also reveals that musician's effect has a more significant influence on prices of violins made by non-top luthiers and with lower provenance history. It is seen that there is a 16.3% price premium for one extra unit of a musician playing a non-top maker violin with low provenance compared to only a 6.9% in the case of a top maker violin with a high provenance track record. Violin buyers rely on musician's preferences when distinguishing a high-quality violin and hence, the price they are willing to pay remains more sensitive to musician's choice.

Finally, by using event study methodology, the 'musician effect' is isolated from other price determinants and this unveils that the market significantly reflects musician's revisions by the fact of changing hands to more talented musicians in the short term and, that this effect diminishes over time. More specifically, a negative impact on prices is found when violins are downgraded by musicians that diminishes over time as the market reflects this change in hands mostly during the period closest to the event date and loses sensitivity in the following weeks. A similar result appears in the positive revision case, when an additional musician plays the same instrument – it is observed that the cross average of cumulative abnormal return is 19.17% during the first two weeks and decreases over time to 3.36% after one month. The cross average of cumulative abnormal return for the whole period is 10.81% and remains significant when 3 or more musicians play the instrument.

Violins left/downgraded by musicians tend to be exposed (or at least sold) less, around 15% to 35%, in auction sales for all time horizons, and the opposite result is found for upgraded violins. Musician's adverse revision has a negative impact on violin auction volume.

Without receiving professional intra market knowledge and acoustic training, non-expert violin investors and consumers rely on well-known musician' preferences for guidance; thus, consumers seem to be willing to pay extra based on violin's musician track history.

7.Discussion and General Conclusion

7.1 Discussion

What picture of violins as an alternative form of investment emerges from my overall thesis? In general, violins seem to underperform other asset classes, which makes it a rather poor investment vehicle. Although most studies underline that violins retains real value in the long run, some authors observe that the studied violins have actually depreciated in value in real terms over certain periods of time. No matter whether as a result of some behavioral factors or unfavorable shifts in tastes and fashions, this shows that investing in violins is a risky undertaking. Preferences change and new trends set in; also, potential theft, damage, fire, forgery, or misattribution all further add to the risk of holding a violin for purely financial gains.

Nevertheless, this does not mean that an individual wishing to allocate his/her financial means in a violin should abandon the idea and choose a more lucrative form of investment. Even though, due to the high risk and fairly low rate of return, violins might appear to be ill-suited for this purpose, it seems that investors may actually benefit from making such a move.

Investing in violins can yield personal satisfaction, alongside the preservation of an art-form that has been cherished throughout several centuries, while offering a stable and rewarding return. Both to musicians and to most collectors and investors they provide non-monetary dividends in the form of enjoyment.

From the analysis I have made, we can see that violin market seems to offer some avenues for benefiting from owning a violin. Moreover, potential gains could be further enhanced by constructing an optimal violin portfolio, diversified across different stringed musical instruments. This should be of interest not only to the individuals considering investing in a collection of violins, but primarily to music funds and other business interested in the music market as a source of financial gains.

However, the crucial question for those wishing to hold a violin in hope of its monetary appreciation is whether it is really possible to predict violin price movements and thus beat the market. This still remains a puzzle. The ‘nobody knows’ seems to be inherent to the emotional assets world. However, the history shows that major makers systematically appreciated over time. Connoisseurship and experience may give an

investor a competitive edge over other market participants and enhance the returns. On the other hand, the experience of some failed violin funds might indicate that even expert knowledge and extensive net may not guarantee a successful investment.

If we look into the practical implications for the fund sector for an investment into the fine violin sector. The fund industry is extremely large and the size of the musical instrument market, although growing, is relatively small in comparison. It is therefore implausible for extremely large institutional investors to adapt a strategy of a large investment into fine violins into their investment strategies. More interesting however, is the choice for more tailor-made solutions to be offered to high net worth clients, who are aiming for a high-risk investment in an alternative asset.

7.2 Overall Conclusion

In this thesis, various aspects of the violin auction market have been revised and its relevance to financial investments has been examined. Violins are first introduced as an alternative investment asset class and the violin auction market is explored. In order to reach solid conclusions, the most extensive violin auction dataset has been constructed, spanning from 1900 until today, although for this research there is a focus on the period spanning from1980's to today. The readiness of this data sample has contributed in order to investigate some fundamental concepts of this niche market and provides a concrete foundation for further research on this particular alternative investment asset class. In addition to creating this unique dataset, the main contributions are summarized as follows.

Individual and institutional investors have started allocating fine and rare violins to their portfolios for investment purposes given that in the recent decades the market for this particular investment has gained attention, specially, from the emerging economies. Researchers, however, have not done extensive research in this area but, rather very little research exists. In order to contribute to this gap, I have studied the viability of violin investment.

Proper price indices have been constructed taking into account the heterogeneous characteristics of violins. Therefore, I initially constructed well-diversified violin indices based on the unique individual sales auction dataset to study the investment perspective of violins and to analyze its diversification potential in an optimal portfolio. First results find that the violins made by Stradivari luthier provided the highest performance since the 1980's until today, with an unsmoothed geometric annual return between 4.9- and 7.7%. The rest of violins in the sample, however, provided a less favorable performance although stable in the long-run

of almost 3.5-6.7% unsmoothed annual geometric mean return per year. The historical violin price indices indicate that investing in fine violins, specially, from top makers, may provide a promising return potential in the long run.

The thesis also moves one step further to unveil investing in fine violins illustrates a valid mean of diversification. Including Stradivari into a diversified portfolio raises the Sharpe ratio by 12%, after unsmoothing, from 1980 until today and improves the efficient frontier under CAPM assumption.

It is interesting to note that when accounting for the bias nature of the series, and by unsmoothing the data to adjust the volatility to values more in line with the true underlying series, the same positive conclusion arises due to the low correlation between violins and other financial asset classes, including art, that renders an investment into violins highly attractive as part of a diversified portfolio strategy.

After unsmoothing the violin return series, it is found that the standard deviation of real returns is higher than that of bonds, and relatively close to equities. After accounting for non-synchronicity in the returns of violins and equities, it can be concluded that there is a positive correlation between real equity and violin returns, but that the beta of violins is still relatively low.

Further, strong evidence is found that violins hedge against expected inflation, and with weaker support, it is also found that violins hedge against unanticipated inflation.

In addition, when taking into account differences in holding periods and in transaction costs, it is observed that the realized returns on violins and equities may be closer to each other than one might conclude at first sight. The transaction costs associated with buying and selling violins are significantly higher than on an average trade of financial securities. However, if one takes into account the long average holding periods of violins on the one hand, and the high turnover in many financial portfolios on the other, the transaction cost drag associated with an average violin may actually be lower than that of many financial portfolios[18]. Of course, the low turnover in collectibles may in part be endogenous: there can be little doubt that high round-trip costs curtail turnover. It has been seen that positive returns start after 4 years of a buy-and-hold strategy.

[18] There is evidence that investors trade too much in financial markets: see, for example, Barber and Odean (2000). Therefore, my argument might be flawed to the extent that we are comparing violin investments with suboptimal behavior in financial markets.

As an alternative asset class, violins have characteristics that are clearly different from those of stocks or other financial securities. Just like other collectibles, violins do not give rise to future cash flows, on which the valuation of traditional assets is based. In line with this idea, the analysis has hinted at the existence of a wealth effect: there is a positive correlation between the returns on equities and those on violins.

To continue my analysis, I have explored the price-determined factors of violins with a particular focus on maker and musician influence. It was observed that in regression results, the variable maker played an important role on price. Both objective and subjective factors resulted in the last two decades of violin market booming.

In the study of the 'masterpiece effect' on violin price, I assert whether Stradivari's influence is economically and statistically significant throughout the sample period. For this study, a repeated sales database from 1860-2011 is constructed. We test the 'masterpiece effect' under two different criteria: by top prices and by reputation and reach the same conclusion, that violins made by Stradivari and del Gesù have higher returns than the rest. We also further analyze the database by dividing it into two sub-samples, one for violins sold through auction houses and another for violins sold through private dealers, in order to explore if there is a difference when looking into 'masterpiece effect'. We find that returns of violins sold through private dealers, as expected, are higher. We also certify that the 'masterpiece effect' appears when violins are sold privately through dealers. On the contrary, no 'masterpiece effect' seems to arise when violins are sold through auction houses, which is an interesting finding.

It is important to note that even though a 'work-of-art effect' has been proved negative in the art market for most studies, we have seen that it is positive in the violin market, specially in the case of violins sold through private dealers. It is therefore more advisable to put all the money in an important violin piece rather than in various violins of lower value. Therefore, we can agree with Agnello (2002), who advises to "buy the very best you can afford, so long as you can afford to buy the very best".

Regarding the second study exploring the so-called "musician" effect, I can conclude that enjoyable asset classes such as violins include subjective price determinants that should be accounted for when analyzing the investment opportunity of this asset class. In the case of fine stringed instruments such as violins, musician preference over a violin clearly has an impact on its price. The analysis carried out allows to conclude that regardless past provenance record of the instrument or demand factors such as investor's wealth, musicians' choice over an instrument influences price significantly and this effect increases with musicians'

reputation. Further "musician" effect is more amplified in the case of violins made by less renown makers and with a low provenance track. When isolating 'musician effect' by event study methodology, we observe that revisions done by musicians over violins (revisions defined as interest over renting and playing a violin by musicians) impacts significantly the price of the violin changing hands. It is also observed that this effect diminishes in the long run, specially, when there is a downgrade. Finally, we observe a lower trading volume in those violins downgraded while the trading volume rises in violins upgraded by talented musicians. These empirical results are new to this niche market and contribute to the existing literature by adding a new perspective.

As an overall conclusion, owing to the smaller scale of the market I would not advise institutional investors to participate in such a strategy; however, for the private client, an investment into violins could be an interesting alternative to include in the portfolio as optimal portfolio allocations using empirical returns over the past 39 years provide support for investors to consider an investment into violins as an attractive, albeit small addition to their investment strategy. The results depend crucially on the assumption about the risk involved in such a strategy. The highly illiquid market is a factor that should increase the riskiness to the private investor from such a strategy. I would conclude that collecting for "passion over profit" — a statement true for 57% of collectors with at least $1 million who were surveyed by UBS[19]; should be the best advice for an investor.

19 "For Love Not Money" report in 2017 UBS found that of 2,475 wealthy individuals surveyed, about 25% collect something — whether coins, jewelry, art, violins or cars. They collect because it's their passion (57%), because they want to be surrounded by beautiful things (42%), because it connects them to family or their culture (26%) or because they enjoy the social aspects (18%). Only 14% want to diversify from traditional assets and 13% plan to profit. As evidence of their passion, four out of five clients surveyed say they would sell stocks from their investment portfolio in case of an emergency before turning to their collection.

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Appendix

1.1 General

Table 2- 1 Summary Statistics for the whole Database

Variable	Obs.	Mean	Std Dev	Min	Max
Sold_USD	50485	13111,76	92369,36	101	15821285
LOB	28466	39,41	11,04	22,5	39,32
AGE	18678	114,21	70,69	1	444
Year_made	18686	1881,46	81,68	1574	2018
Auction_year	50485	1999,04	10,65	1855	2019

Table 2- 3 Summary Statistics by Maker

Nicolo Amati was the grandson of Andrea Amati, one of the very first violin makers and the founder of the Amati dynasty. Nicolo's instruments are considered the most refined and concert-worthy of the family's production, which extended over a two-hundred-year period. Since 1980, prices for his instruments have increased at an average annual rate of 8.6%. Dealer prices for fine Nicolo Amati violins are around USD600,000.

Giovanni Battista (abbrev. G. B. or J. B.) Guadagnini (1711-1786) was an itinerant violin maker who plied his trade in Piacenza, Milan, Cremona, Parma, and Turin, with stylistic developments marking his work in each locale. Auction prices have risen at an average annual rate of 9.5%. Dealer prices for fine examples have exceeded USD1.5M.

A contemporary of Nicolo Amati and Antonio Stradivari, Francesco Ruggieri made elegant instruments that are moderately priced by comparison. At auction, his violins have increased at an average annual rate of 3.9% It is likely that Ruggieri's instruments will see a dramatic upturn in the future.

Born in 1777 in Lequio Berria, a small town in the vicinity of Alba, Giovanni Pressenda moved to Turin around 1818, where he worked for a number of French violin makers established there. He opened his own shop in that city around 1822 and continued to work there until his death in 1854. He is considered one of the finest makers of the nineteenth century. Since the early 1980s, his violins have increased at an average annual rate of 5.0%.

The younger brother of the noted maker Giuseppe Scarampella, Stefano Scarampella was born in Brescia in 1843. In his early years, he worked as a shopkeeper and carpenter. He moved to Mantua in 1886, though he was not formally registered there as a maker of violins until around 1890, the same year he was awarded a silver medal at a crafts exposition in that city. Noted for their fine tonal quality, Stefano Scarampella's violins have increased at an average annual rate of 9.3%.

Carlo Antonio Testore, the son of the violin maker Carlo Giuseppe Testore, was born in Milan in 1687 and worked there under the "Sign of the Eagle" until his death in 1765. The

workmanship and appearance of his instruments are often rough, but the tonal quality is superb. The auction prices of his violins have increased at an average annual rate of 4.8%.

Antonio Gragnani (1740-1794) worked in Livorno. His instruments show the influence of Stradivari, Amati, and Gagliano, and are noted for their tonal fullness and brilliance. They are generally branded "A.G." on the button and at the end pin. At auction, they have increased at an average annual rate of 6.0%.

Stradivari	Obs.	Mean	Std Dev	Min	Max
Sold_USD	265	76038,97	19168,93	57991	15821265
AuctionDate	265	1985,69	15,80	1901	2019
LOB	55	412,49	431,75	353	355
Year_made	85	1709	17,81	1667	1738

Guarnieri del Gesù	Obs.	Mean	Std Dev	Min	Max
Sold_USD	258	189347,17	315446,47	3840	2333182
AuctionDate	258	1986,49	18,15	1900	2019
LOB	43	354,20	1,58	350	358
Year_made	56	1714,11	16,67	1680	1743

Amati	Obs.	Mean	Std Dev	Min	Max
Sold_USD	234	102331,36	130391,93	1837	654590
AuctionDate	234	1993,40	13,31	1963	2017
LOB	72	351,69	3,78	335	357
Year_made	74	1646,09	29,37	1574	1710

Gagliano	Obs.	Mean	Std Dev	Min	Max
Sold_USD	707	55799,38	51472,72	1036	344229
AuctionDate	707	1994,86	12,73	1966	2017
LOB	253	353,72	8,11	296	421
Year_made	238	1769,86	29,87	1700	1880

Grancino	Obs.	Mean	Std Dev	Min	Max
Sold_USD	143	64754,30	51795,45	4764	233338
AuctionDate	143	1996,93	11,28	1969	2017
LOB	39	354,28	2,13	350	363
Year_made	30	1701,10	15,43	1662	1736

Guadagnini	Obs.	Mean	Std Dev	Min	Max
Sold_USD	250	139848,30	205421,78	1000	1390000
AuctionDate	250	1993,69	12,47	1966	2019
LOB	84	354,60	2,25	348	361

Year_made	92	1790,74	59,83	1736	1946

Pressenda	Obs.	Mean	Std Dev	Min	Max
Sold_USD	124	144168,34	117267,09	2304	475750
AuctionDate	124	1997,61	12,85	1969	2015
LOB	50	355,44	1,342	353	360
Year_made	124	1834,18	6,70	1824	1848

Villaume	Obs.	Mean	Std Dev	Min	Max
Sold_USD	378	44446,12	82506,08	268	1361015
AuctionDate	378	1996,58	11,2150182	1967	2018
LOB	272	357,05	7,63	288	377
Year_made	217	1851,80	18,90	1694	1885

OTHER_MAKER	Obs.	Mean	Std Dev	Min	Max
Sold_USD	38912	9822,88	25410,42	101	1001386
AuctionDate	38912	1997,70	9,73	1963	2019
LOB	20650	356,75	14,72	145	1938
Year_made	17770	1886,45	78,72	1672	2012

Table 2- 6 Violin Returns

Table 6 shows the descriptive statistics of returns for all asset classes. We can see that real estate enjoyed overall the highest average return in these 39 years given the financial crisis, whereas corporate bonds provided the highest Sharpe ratio due to its low variation. Stradivari index provided relative higher average returns to investors than S&P, Gold and the MSCI ACWI but lower than REITs. All_Violins provide similar returns to Gold. Stradivari violins achieved the highest performance in 1998 with 40% increase, and All_Violins produced its highs in 2010, with 33% and 13% annual return respectively.

Year	Violin_ALL	Stradivari	S&P GSCI	MSCI ACWI	Gold	WORLD-DS REITs
1980	0,2159	0,3459	0,1152	0,0501	0,1597	0,8924
1981	0,1050	0,1052	-0,2400	0,1624	-0,3347	0,0851
1982	-0,0016	-0,1714	0,0027	0,0980	0,1658	0,5975
1983	0,1469	0,1893	0,0615	0,1567	-0,1696	0,2297
1984	0,1143	0,0719	-0,0938	-0,2415	-0,1938	0,0576
1985	0,1041	0,1668	0,0134	-0,1295	0,0600	0,6026
1986	-0,1192	-0,1418	-0,1960	0,0912	0,1852	0,3567
1987	-0,0063	0,2111	0,0362	0,1404	0,2547	-0,0438
1988	-0,1018	0,1625	0,1057	0,0369	-0,1617	0,1174
1989	0,0172	-0,2322	0,1357	-0,0516	-0,0107	0,1578
1990	-0,1295	0,6201	0,0482	0,4959	-0,0249	-0,4632

1991	0,0404	-0,3320	-0,1918	-0,2072	-0,0992	0,6081
1992	0,0423	0,0513	0,0303	-0,1741	-0,0593	0,3223
1993	-0,0479	0,0681	-0,0922	0,0136	0,1719	0,3630
1994	-0,0836	-0,0364	0,0938	0,1195	-0,0197	-0,0904
1995	-0,0338	-0,0278	0,1329	0,2104	0,0119	0,2301
1996	0,0598	-0,0952	0,0620	0,1532	-0,0456	0,2895
1997	0,0904	-0,0838	-0,1837	0,1501	-0,2122	0,3692
1998	0,0252	0,5187	-0,2519	0,1309	-0,0165	-0,2136
1999	0,1251	-0,0695	0,4948	0,1843	0,0155	-0,0565
2000	-0,2179	0,1294	0,2516	0,0714	-0,0630	0,2691
2001	0,0384	-0,1702	-0,3016	-0,2027	0,0152	-0,0063
2002	-0,1772	-0,0819	0,4135	-0,1613	0,2627	-0,0331
2003	0,1320	0,1341	0,0642	-0,0060	0,1878	0,2599
2004	-0,0210	0,1052	0,1978	0,2250	0,0521	0,2260
2005	-0,1201	0,0101	0,3747	0,1168	0,1826	0,0041
2006	0,1465	0,1842	0,0152	0,1678	0,2340	0,3302
2007	0,1310	0,0177	0,4072	0,1718	0,3175	-0,1468
2008	-0,0250	-0,4555	-0,4639	-0,1793	0,0449	-0,4907
2009	-0,1626	0,3499	0,6010	-0,2247	0,2523	0,2887
2010	0,1782	0,4293	0,2016	0,1811	0,2852	0,1520
2011	-0,1079	-0,0364	0,0261	0,0963	0,0962	-0,0326
2012	0,3279	0,0151	-0,0021	-0,0042	0,0703	0,1828
2013	-0,0598	-0,2716	-0,0058	0,1532	-0,2671	-0,0250
2014	0,0699	0,3812	-0,3379	0,1165	-0,0248	0,1848
2015	-0,0433	-0,2592	-0,2569	-0,0053	-0,0964	-0,0264
2016	1,0173	-0,3421	0,2641	0,1053	0,0836	-0,0127
2017	-0,0485	0,9826	0,1103	0,1527	0,1245	0,0894
2018	-0,0852	0,2294	-0,1525	-0,0390	-0,0167	-0,0926
2019	-0,0570	-0,1010	0,2327	0,0201	0,1180	-0,0189
	3,70%	6,43%	4,31%	5,36%	3,84%	13,78%

1.2 Study 1

Table A- a Summary Statistics

Variable	N	Mean	St Dev	Min.	Max.
Year Made	337	1 730,86	55,67	1 570,00	1 899,00
PurchaseYear	337	1 934,10	46,86	1 849,00	2 001,00
PurchasePrice	337	14 127,64	51 195,50	20,00	672,60
SalesYear	337	1 964,98	39,50	1 860,00	2 009,00
		124	405		3 496
SalesPrice	337	668,61	791,78	46,00	500,00
HoldingPeriod	337	30,87	27,77	5,00	147,00

Channel	%
AA	39,38
AP	8,49
PA	19,31
PP	32,82

Property	%
Violin	87,65
Viola	2,32
Cello	9,65

Table A- b Strad and del Gesù Instruments Included in Dataset

ID	Maker	Built	Property	Name
64	Guarneri del Gesù, Giuseppe	1740	violin	Ysaye
88	Guarneri del Gesù, Giuseppe	1735	violin	Mary Portman
90	Guarneri del Gesù, Giuseppe	1742	violin	Wieniawski
97	Guarneri del Gesù, Giuseppe	1740	violin	David, Heifetz
121	Guarneri del Gesù, Giuseppe	1735	violin	Ladenburg
213	Guarneri del Gesù, Giuseppe	1737	violin	King Joseph
255	Guarneri del Gesù, Giuseppe	1741	violin	ex-Carrodus
256	Guarneri del Gesù, Giuseppe	1742	violin	Lord Wilton
395	Guarneri del Gesù, Giuseppe	1734	violin	ex-Gillott; Lord Dunmore
406	Guarneri del Gesù, Giuseppe	1731	violin	Gibson
422	Guarneri del Gesù, Giuseppe	1736	violin	Count Cessol
428	Guarneri del Gesù, Giuseppe	1739	violin	Spanish Joseph
436	Guarneri del Gesù, Giuseppe	1744	violin	Doyen
447	Guarneri del Gesù, Giuseppe	1743	violin	Carrodus
453	Guarneri del Gesù, Giuseppe	1744	violin	Ole Bull
2723	Guarneri del Gesù, Giuseppe	1733	violin	Soil
3519	Guarneri del Gesù, Giuseppe	1736	violin	Pollitzer
3582	Guarneri del Gesù, Giuseppe	1743	violin	Baron Heath
3700	Guarneri del Gesù, Giuseppe	1729	violin	Balkovic
3826	Guarneri del Gesù, Giuseppe	1734	violin	Ferni
4918	Guarneri del Gesù, Giuseppe	1720	violin	
7249	Guarneri del Gesù, Giuseppe	1737	violin	
7698	Guarneri del Gesù, Giuseppe	1732	violin	Ferni
47	Stradivari, Antonio	1680	violin	Paganini-Desaint
50	Stradivari, Antonio	1736	cello	Paganini-Ladenburg
52	Stradivari, Antonio	1702	violin	Lord Newlands
55	Stradivari, Antonio	1714	violin	Dolphin
62	Stradivari, Antonio	1736	violin	Muntz
66	Stradivari, Antonio	1716	violin	Colossus
111	Stradivari, Antonio	1716	violin	Messie
117	Stradivari, Antonio	1699	violin	Castelbarco
118	Stradivari, Antonio	1704	violin	Betts
135	Stradivari, Antonio	1726	violin	
147	Stradivari, Antonio	1713	violin	Gibson
205	Stradivari, Antonio	1688	violin	Avery; Mercury
207	Stradivari, Antonio	1709	violin	Greffuhle
212	Stradivari, Antonio	1709	violin	La Pucelle
237	Stradivari, Antonio	1679	violin	Hellier
238	Stradivari, Antonio	1690	violin	Tuscan
239	Stradivari, Antonio	1687	violin	Spanish

244	Stradivari, Antonio	1873	violin	Rode
261	Stradivari, Antonio	1696	viola	Spanish Court
262	Stradivari, Antonio	1701	viola	MacDonald
264	Stradivari, Antonio	1734	viola	Gibson
267	Stradivari, Antonio	1696	cello	Aylesford
269	Stradivari, Antonio	1689	cello	Aylesford
273	Stradivari, Antonio	1701	cello	Servais
278	Stradivari, Antonio	1713	cello	Bass of Spain
283	Stradivari, Antonio	1720	cello	Piatti
287	Stradivari, Antonio	1709	cello	Lady Halle
288	Stradivari, Antonio	1712	violin	ex-Viotti
289	Stradivari, Antonio	1721	violin	Lady Blunt
291	Stradivari, Antonio	1722	violin	de Chaponay
312	Stradivari, Antonio	1700	violin	Taft
413	Stradivari, Antonio	1689	violin	Arditi
438	Stradivari, Antonio	1696	cello	ex-Bonjour
472	Stradivari, Antonio	1698	violin	Marie Schumann
473	Stradivari, Antonio	1683	violin	Martinelli
486	Stradivari, Antonio	1710	violin	Magaziner
491	Stradivari, Antonio	1713	violin	Sancy
495	Stradivari, Antonio	1714	violin	Leonora Jackson
497	Stradivari, Antonio	1715	violin	Lipinski
503	Stradivari, Antonio	1717	violin	Piatti
540	Stradivari, Antonio	1737	violin	Swan Song
545	Stradivari, Antonio	1734	violin	Ames
620	Stradivari, Antonio	1723	violin	Jules Falk
622	Stradivari, Antonio	1679	violin	Parera
643	Stradivari, Antonio	1707	violin	Hammer
707	Stradivari, Antonio	1710	cello	Gore-Booth
713	Stradivari, Antonio	1703	violin	Dancla
726	Stradivari, Antonio	1690	violin	Stephens
728	Stradivari, Antonio	1711	violin	Vogelweith
729	Stradivari, Antonio	1667	violin	Jenkins
742	Stradivari, Antonio	1684	violin	Soames
753	Stradivari, Antonio	1686	violin	Nachez
755	Stradivari, Antonio	1687	violin	Bertier
756	Stradivari, Antonio	1685	violin	ex-Mackenzie
760	Stradivari, Antonio	1688	violin	Derenberg
771	Stradivari, Antonio	1694	violin	Hegedus
775	Stradivari, Antonio	1694	violin	Muir-Mackenzie
931	Stradivari, Antonio	1677	violin	Sunrise
1039	Stradivari, Antonio	1732	violin	Red Diamond
1221	Stradivari, Antonio	1703	violin	Emiliani
1263	Stradivari, Antonio	1697	violin	Prince Uchtomsky
1265	Stradivari, Antonio	1698	violin	Rouse-Boughton
1277	Stradivari, Antonio	1699	violin	Kelvey

1282	Stradivari, Antonio	1715	violin	Alard
1289	Stradivari, Antonio	1710	violin	Duc de Camposelice
1306	Stradivari, Antonio	1700	violin	Jupiter
1335	Stradivari, Antonio	1707	violin	Rivaz
1336	Stradivari, Antonio	1707	violin	Marquis de Champeaux
1348	Stradivari, Antonio	1709	violin	Marie Hall
1358	Stradivari, Antonio	1709	violin	Nachez
1378	Stradivari, Antonio	1712	violin	Hrimali
1380	Stradivari, Antonio	1714	violin	Payne
1381	Stradivari, Antonio	1714	violin	Vaillant
1383	Stradivari, Antonio	1714	violin	Adam
1389	Stradivari, Antonio	1714	violin	de Barreau
1391	Stradivari, Antonio	1715	violin	Emperor
1393	Stradivari, Antonio	1715	violin	Titian
1398	Stradivari, Antonio	1716	violin	Cessol
1418	Stradivari, Antonio	1720	violin	Gillott
1425	Stradivari, Antonio	1717	violin	Nightingale
1430	Stradivari, Antonio	1684	cello	Visconti
1446	Stradivari, Antonio	1690	violin	Theodore
1450	Stradivari, Antonio	1691	violin	Dancla
1455	Stradivari, Antonio	1698	cello	Cholmondeley
1473	Stradivari, Antonio	1720	viola	Kux
1488	Stradivari, Antonio	1720	violin	Bavarian
1489	Stradivari, Antonio	1720	violin	Woolhouse
1499	Stradivari, Antonio	1720	violin	Kreutzer
1503	Stradivari, Antonio	1722	violin	Joachim
1517	Stradivari, Antonio	1724	violin	Abergavanny
1533	Stradivari, Antonio	1727	violin	Reynier
1552	Stradivari, Antonio	1729	violin	Innes, Loder
1564	Stradivari, Antonio	1734	violin	Hercules
1565	Stradivari, Antonio	1732	violin	Arkwright
1573	Stradivari, Antonio	1736	violin	Roussy
1574	Stradivari, Antonio	1737	violin	Lord Norton
1580	Stradivari, Antonio	1697	cello	Castelbarco
1980	Stradivari, Antonio	1736	violin	Spencer Dyke
2274	Stradivari, Antonio	1692	violin	Falmouth
2275	Stradivari, Antonio	1697	violin	Molitor
3062	Stradivari, Antonio	1694	violin	Ovcharov
3088	Stradivari, Antonio	1717	violin	Eck
3952	Stradivari, Antonio	1716	violin	ex-Nachez
4303	Stradivari, Antonio	1729	violin	Lambert
6137	Stradivari, Antonio	1686	violin	
6813	Stradivari, Antonio	1709	violin	Viotti
8507	Stradivari, Antonio	1690	violin	Ralph

Annex

A. Database Construction

A1. Data Collection

The whole dataset is the combination of data currently available from the websites of auction houses, data coming directly from auction houses upon request, data incorporated from the Red Book and those coming from Tarisio's own database. We merged all of these sources, deleted the duplication records and cleaned the data.

We created the world's largest source of stringed instrument and bow data, containing over 3,500 makers, 36,000 instrument and bow records, 14,000 certificates and documents, and 57,000 historical auction price records. Tarisio incorporates its own extensive photo archive of instruments and bows, which contains over 210,000 photographs.

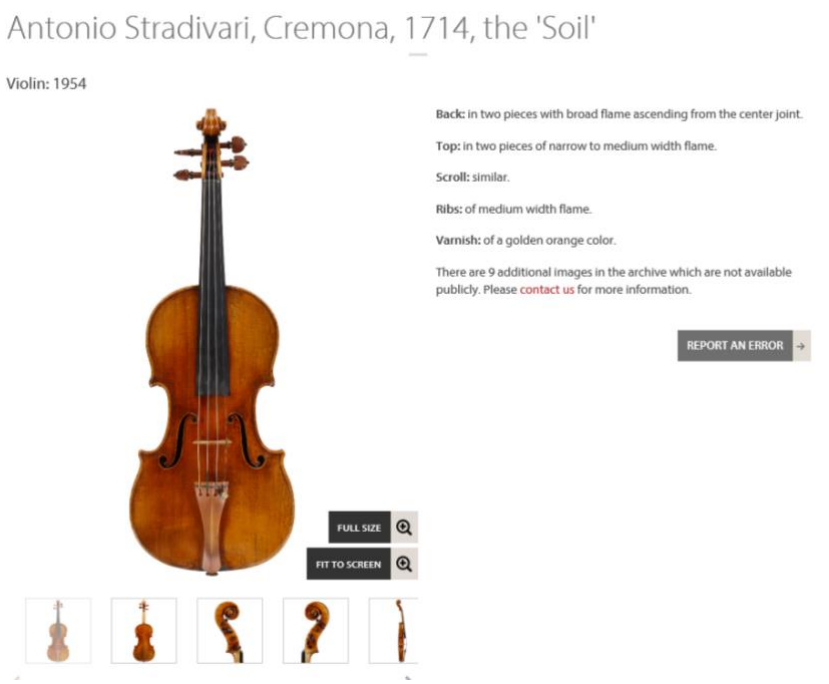
A2. Data Cleaning and Processing

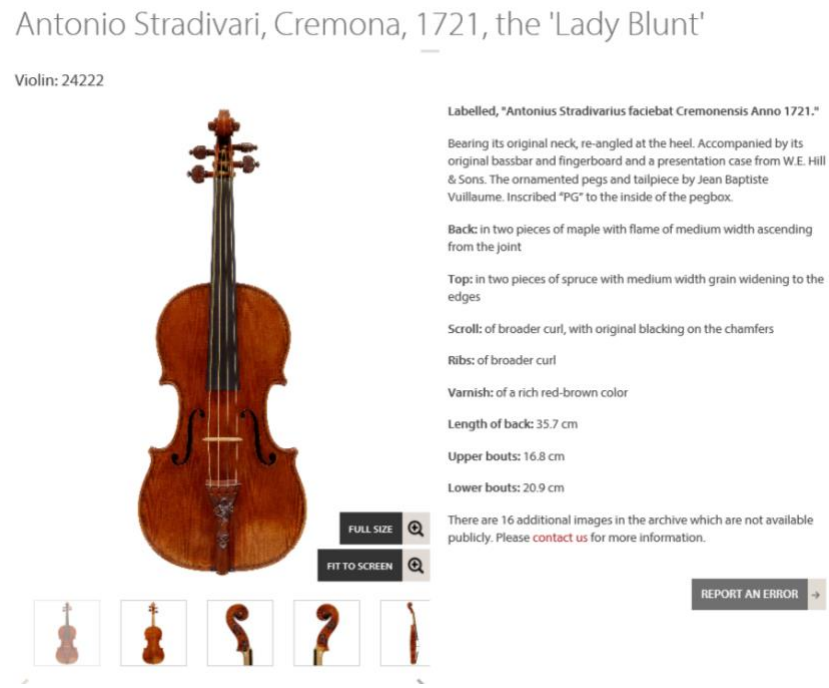
The primary methods used for cleaning the data have been SAS programming and manual operation. We performed the majority of the cleaning work via SAS programming and Excel, however, we encountered some obstacles: some of the original data source was coded into small subsamples of datasets that had to be assembled into a larger one; we also found input mistakenly inserted by auction house staff; and, the information order was registered different in the various auction houses which we consulted. Therefore, a part of the work required manual review and entry, which consumed much time. After cleaning the original data to make it orderly, we also needed to complete the stringed instrument related information, such as locations of the auction houses, the year built, authenticity documentation, varnish/colour, dimensions of the violins and so on. When we tried to obtain this information, we confronted the obstacles as follows.

A2.1. Varnish Identification

Most of the records from the websites of auction houses fail to include color information. Therefore, we needed to match the records with the color by looking into the Cozio register, which contains a vast number of photographs. When we did this, however, the problem appeared that records show different tones of red and we had to come up with an appropriate colour for the top violins. We concluded that the Stradivari were known for its deep red colour - "the lustruous red varnish"; and therefore, reached the agreement to include this colour into our sample.

Figure AA 1 One example of difficulty to identify violin color
This figure shows that we cannot identify the color of this violin lot from the information of this auction house without looking at the picture.





A2.2. Hammer Price Calculation

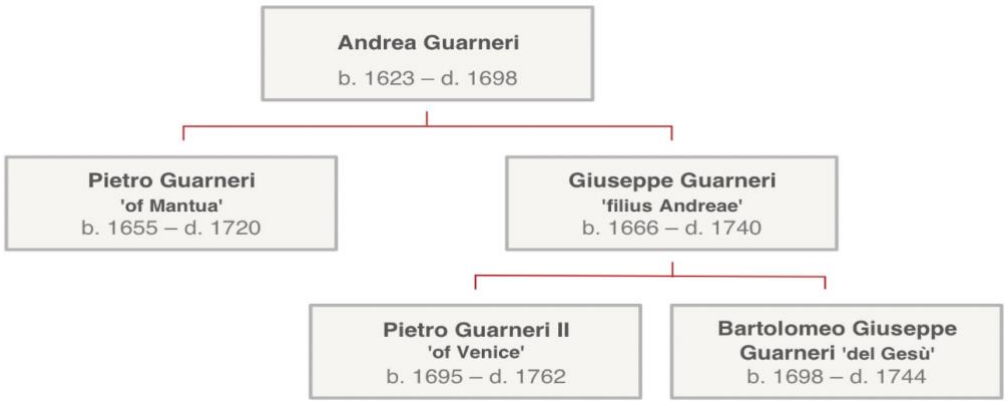
The raw price data collected from those websites is realized prices instead of hammer prices. This realized price bears different meaning depending on the auction house. Since old auction results, does not charge a buyer's premium, the prices are hammer prices already. For recent auction houses, the realized price equals the hammer price plus buyer's premium and VAT tax. However, for the remaining auction houses, the realized price includes hammer price and buyer's premium only. The buyer's premium rates change according to the auction house, time and hammer price. Therefore, we had to calculate the original hammer prices by deducing backward. We could obtain the hammer prices from the Red Book records.

Figure AA 2 Family trees

This figure shows the family tree description provided from Cozio's website of Stradivari and del Gesù.

Guarnieri Family Tree

Highest Sales
Violin (164 sold) : **$15,821,285**, Tarisio Jun 22 2011
Cello (15 sold) : **$1,205,571**, Sotheby's Jun 22 1988
Small Violin (3 sold) : **$24,808**, Sotheby's Apr 7 1983
Viola (6 sold) : **$2,474**, Hôtel Drouot May 15 1886



A.3. Glossary of Terms in Database

Auction houses use standard terms and phrases when describing the authenticity of instruments and bows. They are careful to state that the descriptions of authorship, attribution, origin, date, age, provenance and condition are strictly the opinions of the house and not to be considered as ultimate statements of truth. Furthermore, the definitions of terms and their warranties are specific to each house and the reader is encouraged to read the legal terminology related to each sale to understand their specific meaning. The following is a list of the terms most commonly used.

IS BY: In the house opinion, the instrument is the work of the named maker. This category also includes instruments that were originally sold under the name of a particular dealer and that were made specifically for that dealer by a maker or workman who is in many cases unknown or unidentifiable.

PROBABLY BY / POSSIBLY BY: In the house opinion, the instrument is probably or possibly by the named maker in whole or in part.

ATTRIBUTED TO: The instrument is believed to be by the named maker by popular consensus or past opinion, but the auction house does not necessarily agree with the attribution.

ASCRIBED TO: The instrument is believed to be by the named maker in the opinion of the accompanying certificates or letters, author(s) or authority(ies) whose literature or certificates are referred to in the footnote to the lot, but the auction house does not necessarily agree with the attribution.

FIRM OF: In the house opinion, the instrument is the commercial production of a known business entity sharing the same name of the maker.

WORKSHOP OF: In the house opinion, the instrument was probably executed by an unknown hand on the premises of and under the direct supervision of the named maker [Or] . . . executed in the basic style of the maker and possible under his direct supervision.

MADE FOR: In the house opinion, the instrument was explicitly made for the named maker or company by another unknown maker or company.

SCHOOL OF: In the house opinion, the instrument is by a follower of the named maker or in the style of works associated with the place.

IN THE CIRCLE OF: In the house opinion, the instrument was executed by a contemporary of the named maker and exhibits his characteristics.

IN THE STYLE OF / IN THE MANNER OF: In the house opinion, the instrument is after the style of but later than the work of the named maker.

LABELLED / STAMPED / BRANDED / INSCRIBED: The instrument bears such a label, stamp etc. but is not, in the house opinion, by the maker indicated and may be a later copy or modeled after work of that maker.

A.3. 1 Abbreviations used in the Database

c.	circa	Al/__	Aluminum	__/E	Ebony
C.	Century	G/__	Gold	__/fT	Faux Tortoiseshell
cm	centimeter	N/__	Nickel/brass	__/H	Horn
g.	gram weight	S/__	Silver	__/I	Ivory
LOB	length of back, excluding button	= Ø	not original	__/MM	Mountain Mahogany
		__/B	Bone	__/T	Tortoiseshell

A.4. Auction Houses contacted

Auction Atrium
97C &101B Kensington Church Street
London W8 7LN
CONTACT: Pipa Wilkins
TELEPHONE: +44 (0) 7792 9020
EMAIL: info@auctionatrium
WEB: www.auctionatrium.com

Bongartz Geigen Auktion
Am Chorusberg 57
D-52076 Aachen, Germany
CONTACT: Georg Bongartz
TELEPHONE: +49 (0)241 69090
FAX: + 49 (0)241 63586
EMAIL: contact@bongartz-auktionen.de
WEB: www.bongartz-auktionen.de

Babuino Auction House
Casa d'Aste Babuino s.r.l.
00187 Roma, Via dei Greci 2/a
CONTACT: Giovanni Antonioni,
Laura Moreschini
TELEPHONE: +39 06 322 83800
FAX: +39 06 322 83215
EMAIL: lmoreschini@astebabuino
EMAIL: g.antonioni@astebabuino.it
WEB: www.astebabuino.it

Bonhams
101 New Bond Street
London W1S 1SR, UK
CONTACT: Philip Scott
TELEPHONE: +44 (0)20 7393 3848
FAX: +44 (0)20 77447 7438
EMAIL: music@bonhams.com
WEB: www.bonhams.com

Bloomsbury Auctions Italia s.r.l.
Musical Instrument Sales – Inactive as of 2009

Butterfield: Los Angeles
Inactive as of 1999

Brompton's
The Royal Institution,
21 Albemarle Street
Mayfair, London W1S 4BS
CONTACT: James Buchanan
TELEPHONE: 020 7670 2932
info@bromptonsauctioneers.com
WEB: www.bromptonsauctioneers.com

Casa Guarneri Ltd. Internet Auction
2009 Only – Currently Inactive

Christie's (New York)
20 Rockefeller Plaza
New York, NY 10020 USA
Contact: Kerry Keane, Katie Banser
TELEPHONE: + 1 212 636 2434
FAX: +1 212 636 4929
EMAIL: kkean@christies.com
EMAIL: kbanser@christies.com
WEB: www.christies.com

"da S@lo" Internet Auction
2004~2006
Inactive as of 2006

Gardiner Houlgate Auction Rooms
9 Leafield Way, Corsham, Nr Bath,
Wiltshire, SN13 9SW, UK
CONTACT: Jamie South
TELEPHONE: +44 (0) 1225 812912
FAX: +44 (0) 1225 811777
EMAIL:
jamie.south@gardnerhoulgate.co.uk
WEB: www.gardinerhoulgate.co.uk

Million & Associates
19 rue de la Grange Batelière
75009 Paris, France
CONTACT: M. Gilles Chancereul
TELEPHONE: +33 01 48 00 99 44
FAX: +33 01 48 00 98 58
EMAIL: contact@millon-associes2.com
WEB: www.millon-associes.com

Palais Dorotheum
A-1010 Vienna, Dorotheergasse 17
CONTACT: János Márkus-Barbarossa
TELEPHONE: +43 1 515 60 519
FAX: +43 1 515 60 453
EMAIL: janos.markus@dorotheum.at
WEB: www.dorotheum.com

Phillips London
1980 ~ 2001 Musical Instrument Sales – Inactive as of 2001

Skinner Inc.
The Heritage On The Garden
63 Park Plaza
Boston, MA 02116, USA
CONTACT: David Bonsey
TELEPHONE: +1 508 970 3224
Fax: +1 508 970 3100
EMAIL: dbonsey@skinnerinc.com
WEB: www.skinnerinc.com

Sotheby's Musical Instruments
34-35 New Bond Street
London W1A 2AA, UK
CONTACT: Tim Ingles, Paul Hayday
TELEPHONE: +44 (0)20 7293 5034
TELEPHONE: +44 (0)20 7293 5344
EMAIL: tim.ingles@sothebys.com
EMAIL: paul.hayday@sothebys.com
WEB: www.sothebys.com

Tarisio Auctions

244-250 West 54th Street, 11th Floor
New York, NY 10019, USA
CONTACT: Jason Price
TELEPHONE: 1 800 814 4188
TELEPHONE:1 212 307 7224
TOLL FREE: 1 800 814 4188
EMAIL: info@tarisio.com
WEB: www. tarisio.com

Vichy Encheres

16 Avenue de Lyon,
03200 Vichy, France
CONTACT: Guy Laurent
TELEPHONE: +33 04 70 30 11 20
FAX: +33 04 70 30 11 29
EMAIL: vichy.encheres@gmail.com
WEB: www.interencheres.com

Tarisio Europe LTD

Leroy House, 1M
436 Essex Road
London N1 3QP
UK
CONTACT: Naomi Sadler
TELEPHONE: +44 (0)20 7354 5763
EMAIL: info@tarisio.com
WEB: www. Tarisio.com

A.5. Stolen and Recovered Instruments registered in the Database

Instrument	Stolen	Recovery
Giovanni Battista Rogeri, Brescia, 1699, Violin	2 016	2 019
Antonio Stradivari, Cremona, 1734, Violin, the 'Ames, Totenberg'	1 980	2 015
Francesco Ventura Di Linarol, c. 1580, Viola	2 015	2 015
Antonio Stradivari, Cremona, 1715, Violin, the 'Lipinski'	2 014	2 014
Antonio Stradivari, Cremona, 1696, Violin, the 'ex-Kym'	2 010	2 013
Andrea Guarneri, Cremona, 1684, Violin	2 001	2 012
Antonio Stradivari, Cremona, 1721, Violin, the 'Sinsheimer, Iselin'	2 008	2 009
Antonio & Girolamo Amati, Cremona, 1595, Viola, the 'del Crocifisso'	1 980	2 005
Antonio Stradivari, Cremona, c. 1727, Violin	1 985	2 005
Antonio Stradivari, Cremona, 1684, Cello, the 'General Kyd, Leo Stern'	2 004	2 004
Antonio Stradivari, Cremona, 1671, Violin, the 'Oistrakh'	1 996	2 001
Antonio Stradivari, Cremona, 1694, Violin, the 'Muir-MacKenzie'	1 996	1 996
Antonio Stradivari, Cremona, 1732, Violin, the 'Duke of Alcantara'	1 967	1 995
Antonio Stradivari, Cremona, 1717, Violin, the 'Kochanski'	1 987	1 991
Pietro Guarneri of Venice, Venice, 1750, Violin, the 'Bailly'	1 985	1 990
Antonio Stradivari, Cremona, 1713, Violin, the 'Gibson, Huberman'	1 936	1 985
Antonio Stradivari, Cremona, 1712, Violin, the 'Karpilowsky, Benjamin'	1 953	1 953
Antonio Stradivari, Cremona, 1713, Violin, the 'Gibson, Huberman'	1 916	1 916

B. Identification of Regressors

1.2 Violin-specific factors

Many studies, especially those applying hedonic regression, identify determinants of emotional assets prices that are related to the characteristic features of the item. Whereas many are easily observable, some, especially artistic and acoustic quality, are hard to measure. As a consequence, translating them into quantitative terms implies a certain degree of subjectivity.

1.2.1 Length of Back (LOB)

Size (dimensions) and weight of a violin are among the most commonly named factors affecting prices[20]. Even though size effects differ across instrument classes, a common finding of many studies is that prices are positively correlated with the right size. In the case or art or classic cars, there seems to be a critical dimension beyond which prices increase at a decreasing marginal rate (Sagot- Duvauroux, 2003). This is due to the fact that private and corporate buyers, unlike museums, are constrained in their choice by the size of the rooms in the apartments and offices or garages, and prefer works/cars of 'reasonable' size. Therefore, demand for the biggest artworks or cars is usually restricted to cultural institutions, which are able to display them (Frey and Pommerehne, 1989b). In the specific case of violins, we do not have this limitation but there exists an ideal 'right-size' (LOB of 353-355 mm) and 'right-weight' (360 grams) which needs to be optimal for acoustic reasons.

For these reasons, I have included in the data regression this variable in terms of the ideal LOB and weight desired for a violin.

1.2.2 Properties, technique and instrument classes

Most studies investigate the impact of an instrument's physical properties (in the case of violins: the type of wood, colour/varnish, the period and technique) on the price. The common conclusion is that, on average, Cremonese violins are the most demanded, because of its wood properties, compared to e.g. French or other English violins. It applies even further to works executed during the golden period. As a result, Cremonese violins from the 17th century are valued the most. This can be explained by its greater durability, superior skills required for playing it, as well as the broader spectrum of artistic and acoustic effects it allows for (Sproule and Valsan, 2006 make a similar analysis for artworks). Finally, in general, violins are more demanded than violas, and the latter are valued higher than cellos. From the historical point

20 However, Rengers and Velthuis (2002) argue that differences in size do not explain differences in prices across artists, only within the particular artist's oeuvre.

of view, this might be perceived as a result of differences in use and popularity of use. However, nowadays, discrepancies in prices between various violin classes and country/region-specific techniques reflect rather buyers' preferences (Sagot-Duvauroux et al., 1992 find this same argument in emotional assets).

In the data sample examined I have focused only in violins and therefore excluded other categories such as violas and cellos.

1.2.3 Condition

The overall condition of a violin can influence its price. According to Singer and Lynch (1997), poor condition of an artwork may result in a price reduction of up to 80 per cent. In general, better preserved violins should be valued higher. However, even though poor condition of a superior-quality artifact will not be, most probably, reflected in its price, it might be of substantial importance in the low end of the market (ibid.).

This is experienced in violins segment, unfortunately, the problem with reaching any conclusions on this matter is that data on the state of preservation is hard to obtain and verifying violin's condition would imply its visual examination. Therefore, this was not possible to examine in the data sample.

1.2.4 Attribution

Attribution emerges from a consensus on the nature, origin, creator and date of execution of a particular violin that is reached by experts. Its impact on the price is best illustrated by the fact that changes in attribution are always followed by adjustments in the price. The direction, in which the market value will change, depends ultimately on the reputation and standing of both the previous and newly established luthiers. Moreover, attribution may be accompanied by a certain degree of uncertainty, which is discounted in the monetary valuation (Savage, 1969). This is of particular importance on the market for old violins, which were often created in luthiers' workshops and only signed by the master. Therefore, there exists a 'hierarchy' of degrees of attribution, which affect the hammer price to a varying extent.

In the sample, we measure for the violins that have been: "attributed", "made by", "ascribed to" and "signed by" and where we have the certificates, signature, label or any other kind of proof of being created by the maker itself. These are contrasted to items that are: "made for", "school of", "in the circle of", "in the workshop of" which do not show a firm certainty of its creation by the luthier itself. This is collected under the variable "authenticity" that will be

explained next.

1.2.5 Authenticity

Authenticity[21], a variable that reflects the value of originality and novelty of the maker's oeuvre, is one of the major factors affecting violin prices. This is reflected in the fact that once violin's genuineness is questioned, a substantial drop in its market valuation can be observed (Sagot-Duvauroux et al., 1992). Therefore, some authors (e.g. Renneboog and Van Houtte, 2002) conclude that a signature positively affects the price, as it is commonly perceived as a proxy for authenticity. Moreover, a visible signature may provide the owner with consumption and prestige benefits (Czujack, 1997). However, it could be equally argued that a signature might be forged, and thus violin's authenticity can be proved only through expertise[22]. Therefore, some makers do not identify such an ample effect of signature on the price. This may be due to the fact that a signature matters more in the mid-to-high end of the market, since it serves as the only proxy for item's authenticity, whereas the genuineness of superior/top-quality items can be determined even if they are not signed (Ursprung and Wiermann, 2008). In violins, this can be seen in Strads and del Gesu which are all already cataloged and individualized.

1.2.6 Provenance

The question whether violin's provenance has a significant impact on the price is still open to debate. It can be argued that prestigious provenance can be interpreted as a proof of superior quality and authenticity, and thus positively affect its price (de la Barre et al., 1994). It may also reduce the risk that its quality will be negatively verified by history, which would result in a future loss of value (Landes, 2000). Moreover, esteemed provenance might reconfirm the buyer's aesthetic judgment (Plattner, 1996). Finally, previous owners' high reputation may be a source of prestige and status benefits for the buyer (Landes, 2000).

21 Those include: 'work by' ('signature of') (work was executed by the luthier herself), 'attributed to' (work may have been wholly or partly created by the luthier), 'studio (workshop) of' (work was executed in luthier's workshop under her supervision), 'school of' (work was created by a pupil or follower of the luthier up to 50 years after her death), 'in the style (manner) of' (attribution is dubious) (Sagot-Duvauroux, 2003).

22 Violins with proven authenticity are registered in catalogue raisonné. However, this does not totally eliminate the risk of misattribution. In the new market segment, violin's authenticity is confirmed by certificates obtained from makers, auction houses or art dealers.

International auction houses seem to share this point of view, since they include information on past owners in the pre-auction catalogues. However, this considerable 'celebrity premium'[23] could be equally attributed to connoisseurship and superior knowledge that enabled them to compose the collection only of the top-quality works (ibid.). Moreover, the positive effect of provenance on the price could be also a result of auction house's promotional efforts and media hype surrounding the sale. On the other hand, based on her findings, Czujack (1997, p.239) concludes that 'prestigious provenance hardly matters'.

This variable was not available for all violins in the database, therefore it could not be examined in the analysis.

1.2.7 Time of creation

Time of creation is an important factor for several reasons. First of all, it may be correlated with violin's style and preciseness. Secondly, it is also associated with the maker period, in which the luthier was active when he executed the work – time of top achievements and greatest innovations, or rather artistic indolence and misconceptions[24]. All those aspects may be, in turn, reflected in the price (Anderson, 1974). Some studies (e.g. Ursprung and Wiermann, 2008) identify the effect of the period of creation on the price.

This component is gathered under variable "year made" in the dataset.

1.2.8 Rarity and scarcity[25]

Although it might seem that violins typical for a particular maker should fetch higher prices, since buyers might rather want to own something representative for his oeuvre, this is not necessarily the rule. If violins are rare in style, varnish, material, etc., but at the same time their quality is not inferior, scarcity may positively further affect prices. As a general

23 Pesando and Shum (2007) refer to it as 'irrational exuberance'.

24 For example, for a selected group of artists, de la Barre et al. (1994) observe substantial differences in prices fetched by works executed at different points in artists' careers. Also in the case of Antonio Stradivari, the violins performed during his early years share similarities to the ones from his tutor Amati, and the ones elaborated later have the famous red varnish as well as the noted decorations which make them more valuable.

25 Rarity and scarcity refer also to the supply side. Scarce works may be valued higher on average, since their limited supply can enhance buyers' willingness to pay (Czujack, 1997). According to Ursprung and Wiermann (2008), and Lazarro (2006), a significant increase in supply might lead to a decline in price, although this effect is not very large. Moreover, Sagot-Duvauroux et al. (1992) claim that the impact of scarcity on prices is positively correlated with artist's fame. Finally, growing scarcity of works within a particular market segment, especially in the lower end of the market, might lead to an increase in prices of works considered close substitutes (ibid.). Low supply may be caused by many factors, e.g. dealer's conscious strategy (ibid.), or cultural institutions' reluctance to deaccession works created by a given artist.

rule, old European violins are limited in supply and supply is in decrease which preserves the high and ever increasing prices in this market.

This is a component inherent in all the violins in the sample as the database is dedicated solely to fine old violins and rare modern ones.

1.2.9 Violin's history

Many events in violin's history can positively influence its price. Those include, among others: taking part in domestic and international concerts, being mentioned in literature and academic publications, remaining in major public or private collections, being considered a part of national heritage. In general, the number of exhibitions and publications the item appeared in is positively correlated with the price (Wieand et al., 1998). The same applies to touring exhibitions, which, by reaching a wide audience, have a promotional effect (Czujack, 1997). However, it might be equally argued that pieces of superior quality are shown or discussed in the literature more often. Therefore, the fact that they command higher prices may result from greater artistic quality, rather than higher number of exhibitions or publications (ibid.).

As this effect is ambiguous, it has left out of the current analysis.

1.2.10 Varnish and Sound quality

This variable is probably the most important among violin-related aspects (Anderson, 1974 refers to artistic quality in a similar logic). It implies a subjective collective judgment of the members of the specific market's segment, which is verified in the course of history. Expert valuations serve as guideposts for prospective buyers and are reflected in violin's prices. Since a layman might find it difficult to evaluate sound quality, it needs to be ascertained by experts that are credible to the public. They, in turn, lend their credibility to the luthier's violin (artist's oeuvre in Bonus and Ronte, 1997).

The varnish is correlated to sound potential, therefore is utmost important for the market of violins. We selected 5 tones of varnish typical of different locations and periods in time to see how prices react to this variable.

1.2.11 Past prices and reference dependence ('anchoring effect')

Some authors (e.g. Beggs and Graddy, 2007) suggest that, in making their valuations of a particular work, bidders may be strongly influenced by its previous hammer price (so called 'anchoring effect' or reference dependence[26]). Moreover, 'anchoring effect' may also appear on the auction house's and seller's side, and affect both pre-sale price estimates and reserve prices[27].

This could, in turn, have an indirect impact on the hammer price, or even influence violin's future market value although the average holding period of a violin is quite long and this diminishes this said effect.

1.3 Luthier-related factors

According to Velthuis (2005), this group of factors plays a more important role in price formation than violin-specific variables. As already mentioned, it is due to a historical process, as a result of which an ever-increasing attention is being paid to individual luthiers/makers, rather than particular violins. However, whereas luthier's name, reputation and standing are all significant determinants of violin prices, other aspects, such as age, nationality or gender seem to be of lesser importance.

This section will further explain the maker's important weight in price formation of violins.

1.3.1 Reputation and standing

Among maker-related factors, artist's reputation and standing seem to have the strongest impact on emotional assets prices (Frey and Pommerehne, 1989b). Similarly to artistic quality, they are determined by market experts, whose opinions are verified in the course of history. Those collective judgments are based on many aspects, such as artistic quality of the violin, its innovation and originality, but also maker's past achievements and career. Opinions formed by members of the violin world (dealers, ateliers, restoration experts, directors of cultural institutions, etc.) are then disseminated through literature, scholarly publications and media.

1.3.2 Violin's historical significance

26 Even though those terms are usually used interchangeably, Beggs and Graddy (2007) underline that their meaning is slightly different.

27 However, Beggs and Graddy (2007) argue that the path-dependent nature of pre-auction price estimates could be also interpreted as experts' response to the 'anchoring effect' on the bidders' side.

This factor is closely related to luthier/maker's reputation and standing, and is determined by artistic merit and innovativeness of a particular artist, artistic group or movement (especially its formative years) (Singer and Lynch, 1997). Its impact on prices is supported by the findings of Singer and Lynch (ibid.), who discover significant discrepancies in market valuations of works created by innovative artists and their followers. Violin historical significance is reflected in many ways, e.g. in the number of historical publications mentioning a luthier/maker, collections or exhibitions featuring his works, museum acquisitions, etc.

Most, if not all, violins included in the database share this feature.

1.3.3 Fame

Whereas maker's reputation and standing are determined by experts' judgments, fame can result from dealers' and auction houses' promotional activities, or wide media coverage. However, in contrast to reputation and standing, fame does not always go in line with quality and can be equally attributed to e.g. extravagant lifestyle, or controversies surrounding luthier/maker's life and her oeuvre. Nevertheless, in some cases it might assure an artist a place in history (Sagot-Duvauroux, 1992).

Stradivari had an interesting relationship with Amati and the rivalry between them left some history in the 17th century which probably contributed for its framework days.

1.3.4 Achievements

Past solo concerts, prizes and awards by renown musicians, domestic and international publications, violins lent with grants and scholarships to emerging top players, commissions by cultural institutions, etc. may be interpreted as signs of quality, and thus contribute to luthier's reputation and success. They also serve as guideposts for potential buyers, who, in order to economize on information and search costs, often concentrate their demand only on items selected by experts and cultural institutions (Velthuis, 2005). Therefore, the number and importance of achievements is generally positively correlated with demand and, consequently, prices (Plattner, 1998). Therefore, the evidence on the influence of this variable on emotional assets prices is mixed (Rengers and Velthuis, 2002). Moreover, Bonus and Ronte (1997) argue that the number of exhibitions and prizes awarded to an artist is not correlated with the price of artworks, since it is their significance, rather than the number, that may affect the market valuation

of the works.

In the case of violins the same argument could be applied as their supply is constrained and the achievement of the top makers has been completely attained.

1.3.5 Nationality

In general, luthier's nationality should not be correlated with the price level, since it is not related to artistic quality. In most cases (e.g. Schneider and Pommerehne, 1983), authors fail to identify any impact of this variable on prices. However, de la Barre et al. (1994) discover a relationship between the nationality and the market valuation of his works, although this might be also associated with the criterion the authors have chosen for constructing the underlying sample. Nevertheless, nationality might matter in so far as it is sometimes linked with the artistic period, movement or school a maker was active in.

In the case of violins, we find the Italian and French ones always at the high end of the market for fine old stringed instruments. This is because the varnish quality and craftsmanship developed in both countries at that time in history.

1.3.6 Age and creativity patterns

Luthier's age plays a role in price formation in a number of ways. First of all, some authors (e.g. Agnello and Pierce, 1996) identify a non-linear relation between artist's age at the time of sale and artwork's price. This can be a result of buyers' willingness to pay more for works created by makers in the end of their career, since they might be perceived as more experienced and their violins as having superior-quality. Furthermore, longer presence on the market might have allowed him to become more recognized and thus increase the demand for his oeuvre (Velthuis, 2005). Secondly, his age at the time of execution is related to the artistic period, school or movement, as well artistic quality. In his various papers, Galenson[28] investigates the relationship between age at the time of execution and hammer price for different artistic movements and periods. He argues that creativity patterns vary across particular market segments[29].

Therefore, since luthier's produce works of highest quality at various points in life, age at

28 For more details see e.g. Galenson (1999, 2000, 2004), Galenson and Jensen (2001), Galenson and Weinberg (2000, 2001).

29 The issue of creativity patterns is also analyzed by Edwards (2004) in a study on Latin American art.

which a violin was created can partly account for price differences.

1.3.7 'Death effect'

In some cases, authors (e.g. Czujack, 1997) identify the so called 'death effect', i.e. an immediate sharp increase in prices following artist's death. When the maker dies, the supply of his works becomes fixed. Therefore, buyers become certain that potential (over)production will not depress future prices. This can, in turn, stimulate demand (also as a result of speculative purchases) and thus put an upward pressure on prices (Ekelund et al., 2000). On the other hand, during the lifetime, a luthier may be able to further enhance his reputation or adjust the style to current trends, which could result in higher market valuation of his oeuvre[30] (Agnello and Pierce, 1996). Therefore, some authors (e.g. Buelens and Ginsburgh, 1993) conclude that the evidence on the impact of artist's living status at the time of sale on the price is mixed, or even question its significance (e.g. Kräussl and van Elsland, 2008). In their recent study, Ursprung and Wiermann (2008) shed new light on this issue. They associate death-induced price changes with artist's age at the time of death and find an inversely U-shaped relationship between both factors[31].

All the old fine stringed instruments in the dataset have suffered this effect and thus they are totally driven by it. The supply of Stradivari is limited to the 640 units surviving and thus its individual price surpasses the 600,000 dolls estimate. It is important to note that condition and the combination of variables mentioned before play a role in price differentiation between units. Moreover, the absolute magnitude of the 'death effect' depends on the artistic quality of the deceased maker's oeuvre.

1.4 External factors

1.4.1 Experts

Experts' influence, even though often indirect, is probably the most significant factor

30 This argument is questioned by Ekelund et al. (2000), who underline that it refers rather to the supply side, whereas the 'death effect' occurs on the demand side.

31 On the one hand, an untimely death of a promising artist may reduce demand and therewith prices of his oeuvre, since buyers can no longer expect the maker to build up his reputation. This reputation-driven negative effect on prices diminishes, however, as the maker's career progresses and finally totally disappears. Beyond certain critical age, a positive 'death effect' resulting from the supply being fixed sets in, which, as already mentioned, puts an upward pressure on prices. This scarcity-driven effect also approaches zero together with the decreasing life expectancy.

affecting violin prices. Judgments and choices made by credible critics, dealers, directors of cultural institutions, etc. who serve as gatekeepers and legitimizing bodies, determine makers' reputations and careers, but also shape buyers' tastes and preferences. Their opinions, based on acoustic quality, merit and past achievements, are disseminated through media, publications, rankings, exhibitions, etc. Experts' judgments serve, in turn, as reference points for buyers, who may find it hard to assess acoustic quality and, in order to minimize the risk of acquiring poor-quality violins, seek reassurance of their aesthetic valuations (Plattner, 1998). Moreover, buyers may rely on experts so as to economize on information and search costs (Sagot- Duvauroux, 2003). This concentration of demand on a limited number of selected artists further enhances their renown (so called 'superstar phenomenon'[32]) and contributes to an increase in prices of their oeuvre (Velthuis, 2003a). Experts in the field of violins would be, to mention some Florian Leonhard, Jason Price, Peter Biddulph, Gregg T. Alf, Simon Morris and, Chris Reuning.

1.4.2 Economic factors

i. State of the economy

This variable refers to the state of the economy at the national, as well as global level. Whereas periods of boom on the violin market and within the economy as a whole do not necessarily have to occur simultaneously, they do overlap. Violins, similarly to e.g. luxurious goods, are purchased only when other, more basic needs are satisfied, and in general emotional assets are of the first commodities to be sold during economic downturns, especially with regard to lower-quality pieces (Mamarbachi et al., 2008). Therefore, times of boom on the violin market may proceed with a certain time lag, and violin slumps can set in only at the onset of the economic recession. Although, in general, increasing economic growth should be followed by higher emotional assets' price, the overall effect is not always easy to forecast (Sagot-Duvauroux et al., 1992).

On the one hand, it can stimulate demand and supply as a result of buyers' increasing wealth and sellers' expectations of future growing prices. On the other hand, it may reduce demand due to greater attractiveness of some alternative forms of investment (Frey and Pommerehne, 1989b).

It may be argued, however, that the latter effect applies only to alternative assets

32 For more details see e.g. Adler (1985), Rosen (1981), Towse (1997) and Schulze (2003).

investment-oriented buyers and has thus a limited impact on general violin prices.

ii. Correlation within the violin market and with other markets

Several authors (e.g. Ginsburgh and Jeanfils, 1995) examine the relationships between particular market segments and observe a strong correlation in price movements across various sub-markets. Moreover, violins' prices seem to be influenced by market valuations of high-end works, which act as an exogenous price determinant. Various studies also investigate the correlation between emotional assets and other markets, such as stock or real estate market. Whereas some experts fail to identify any relationship, others argue that violin prices may be influenced by prices of other commodities, financial instruments or real estate.

Those simultaneous or lagged co-movements could be explained by the overall impact of economic trends on price levels in general (Wieand et al., 1998). Moreover, since booming economy is often accompanied by bull stock market, growing share prices might imply an increase in violin prices. It is because a part of the gains made on the financial markets might be allocated into emotional assets (Chanel, 1995). On the other hand, individuals driven by pure investment motives could be deterred from purchasing a violin, if alternative forms of investment offer higher returns (which is often the case during bull markets).

We can see his movements in Section 2 where new correlations between different asset classes are displayed. As it will be mentioned later, it is difficult to compare them as assets differ substantially and carry different elements that need to be adjusted before any analysis takes place.

iii. Inflation

It is argued that emotional assets (such as violins) are one of the best stores of value, since they retain real value in the long run and can thus serve as a hedge against inflation (Frey and Pommerehne, 1989b). This would imply that in times of high inflation, demand for violins and, therewith, violins prices should rise. However, evidence on the hedging potential of violins, and correlation between violin prices and inflation is mixed. Whereas Campbell (2004) argues that emotional assets can serve as a good inflation hedge, Renneboog and Van Houtte (2002) conjecture the opposite. Therefore, the role of this variable in violin price formation remains uncertain.

1.3.3 Legislation and tax regulations

In general, changes in legislation may have an indirect impact on the demand and, therewith, prices of violins. For example, favorable tax regulations can attract buyers and thus contribute to price increases. Especially in the U.S., tax benefits associated with donations to cultural institutions may play some role in emotional assets price formation. This, however, does not apply to most European countries. Probably the Brexit will bring some advantages to cultural goods as investment assets traded in the U.K but it is yet to be determined.

1.4.4 Buyers[33]

i. Type

Authors (e.g. Chanel et al., 1996) argue that prices may vary according to the buyer's type[34]. This interrelation is a result of differences in behavior, purchase motives, valuations, historical knowledge, information sets, and responsiveness to changing market conditions (e.g. risk, costs, taxes) (Frey and Eichenberger, 1995). Especially public museums' purchases might generate above-average hammer prices (Pommerehne and Feld, 1997). Pommerehne and Feld (ibid.) explain this phenomenon by the tendency of public institutions to ignore the opportunity costs, which is a result of lower budget constraints and lesser external control over their purchases. Moreover, in general, museums' demand is highly inelastic, since it is concentrated only on particular top-quality works. Another explanation provided by Singer and Lynch (1997) is that public museums tend to buy at the top of the demand curve – i.e. they purchase only when having gathered all relevant information, which minimizes the risk, but also results in a price premium paid. It is due to the fact that acquisitions made by public institutions are subject to many constraints and are scrutinized by the relevant government bodies (Frey and Eichenberger, 1995). Furthermore, Velthuis' (2005) findings suggest that prices paid by museums affect the general price level of works within the luthier/maker's oeuvre. This is because institutional recognition serves as a proxy for artistic quality, enhances maker's

33 The impact of buyers' and sellers' characteristics on art prices is observed by i.e. Sagot-Duvauroux et al. (1992).

34 Among different types of buyers, one can name: collectors, investors and speculators, as well as private, corporate and institutional buyers.

reputation and thus stimulates demand. It should be, however, noted that the positive effect of a museum purchase on the hammer price refers mainly to the high end of the market (Pommerehne and Feld, 1997). In addition, museum acquisitions, but also purchases made by famous collectors, can create new fashions and influence buyers' tastes, which may contribute to price increases. Finally, it can be argued that the hammer price may also depend on the information set possessed by the prospective buyer. Due to information asymmetry, prevalent on the violin market, the usually less well- informed individual buyers may be prepared to pay a price premium, as compared to better informed violin dealers, or individuals having expert or insider knowledge (Singer and Lynch, 1994). Moreover, as a part of gallery's or art dealer's strategy to maintain a certain price level for their maker's works, as well as to avoid unfavorable price differences between the primary, secondary and tertiary market, auction prices might be inflated by the demand of those buyers (Sagot-Duvauroux et al., 1992).

ii. Nationality

The impact of buyers' nationality on violin's prices becomes clear when considering the fact that, in times of boom, demand is often driven by buyers of a particular nationality. This was, for example, the case in the end of the 1980s and beginning of the 1990s when extraordinary prices of Italian golden period violins resulted mostly from Japanese, often speculative, purchases[35]. It is also the case today, with the ever-growing demand coming from Korean, Russian and Chinese new rich classes. Since their choices are often uninformed, driven by either speculative or patriotic motives (Mamarbachi et al., 2008), virtually any price level is accepted. This does not only increase prices in particular market segments, but also attracts speculators who want to profit from the emerging trends and fashions, and thus put an upward pressure on violin prices.

iii. Wealth

Buyers' wealth, a variable correlated with the overall state of the economy, is one of the decisive factors affecting the demand side and, therewith, prices (Schneider and Pommerehne, 1983). However, it may be argued that the increasing prosperity of potential buyers can affect prices in the higher end of the market to a greater extent, relative to other market segments.

iv. Behavior at auction

35 For more details see e.g. Hiraki et al. (2005).

Although most buyers enter the auction with some assumptions as to their willingness to pay (based on i.e. past prices and price estimates published in the pre-auction catalogues, experience, specific historical knowledge, available financial means), the hammer price might be an outcome of their emotional, rather than rational behavior. Under the influence of other auction participants' bids, valuations might change as the auction proceeds. Therefore, the final price might be contingent on the 'excitement" of a single night' (Velthuis, 2005, p.84). Competitive behavior at an auction, resulting from bidders' desire to acquire a certain piece, may inflate the hammer price. As noted by Moulin (1994), the price is a result of the presence (or absence) of particular individuals with certain valuations and financial means, determined to own an artifact. The fact that the buyer pays a certain price does not mean he would not be prepared to pay more, where he overbid by an individual with a higher willingness to pay.

v. Number

Some authors (e.g. Sagot-Duvauroux et al., 1992) suggest that the number of bidders present at the auction may be positively correlated with the hammer price. This might be explained by the fact that a higher number of potential buyers might stimulate competitive behavior, which may translate into a higher final bid. However, the effect of this variable on the price is argued to depend on the bidders' type – it is positive only if bidders have independent private values[36] (Pesando, 1993).

1.4.5 Sellers[37]

1.4.5.1 Owner

As already mentioned, previous owner's name and reputation can positively influence violin's prices (see section Provenance). However, there are some other seller-related aspects that can affect the price of a violin.

i. Reserve price

Even though the reserve price is an outcome of negotiations between the seller and auction house, the final decision on its magnitude belongs to the owner of the violin. The level, at which the reserve price is set, has twofold consequences. First of all, it determines

36 This means that bidders' valuations are not influenced by valuations of other auction participants.

37 Since the center of my focus is the auction market, I introduce only the variables related to the owners and auction houses. However, it should be noted that characteristics of galleries and art dealers may play an equally important role in art price formation.

whether the auctioned object gets sold, or (if the hammer price does not reach the reserve price) is 'bought in' by the auction house. The latter event may, in turn, have a negative impact on the valuations of prospective buyers and result in the so called 'burned' anomaly. Secondly, it can indirectly influence the hammer price, as it is usually correlated with the lower bound of the pre-auction estimate[38], which, in turn, serves as a reference point for potential buyers. Since it is a common practice among major auction houses to set the pre-sale estimate equal to or above the reserve price, by being able to negotiate a higher reserve price, seller might affect the estimate and thus have an indirect impact on the hammer price (Candela and Scorcu, 1997).

ii. Time of sale and holding period

The decision to sell an emotional asset at a particular point in time may be determined by many factors, such as: expected price, state of the economy, situation on the specific market, seller's financial situation, etc. Timing is of importance not only with reference to the overall state of the economy and situation on the specific market (i.e. boom versus downturn period), but also time of the year. This is because, due to seasonality of sales, each auction market has its own business cycle. Therefore, depending on the month of sale, emotional assets may be bought at a discount or premium (Wieand et al, 1998). However, contrary to expectations, Agnello (2002) observes that whereas prices of emotional assets sold during top auction seasons are highest on average, stagnant periods are not associated with lowest prices. However, this finding refers to the most renowned international auction houses present on the market and might not necessarily apply to other national markets. Moreover, time of sale defines also the overall holding period (i.e. time that has elapsed since the last sale of the item). Some authors suggest that it may have an impact on the price. In particular, a decision to resell within a short period of time might result in a loss of value (so called 'winner's curse'). Czujack's (1997) findings seem to support this view. However, Goetzmann and Spiegel (1995) find no evidence for the existence of this phenomenon. In the analysis, this did not show relevant either probably because there are only a few auction houses having stringed instruments and they all have the same seasonality when it comes to sales and consignments.

1.4.5.2 Auction house

38 It is estimated that the reserve price amounts to about 70-80 per cent of the lower bound of the pre-sale price estimate (Ashenfelter and Graddy, 2006).

i. Name and location (violation of the 'law of one price')

Economic theory assumes that, on a competitive and efficient market, prices for a certain good are a result of the market equilibrium. If price differences occur, they do not last long, for they are evened out by arbitrage (Velhuis, 2005). However, empirical evidence suggests that the 'law of one price' does not hold for the emotional market[39]. Many authors observe systematic differences in prices obtained for the same or similar[40] works sold at different auction houses[41] (with greatest price premiums paid for works sold at Sotheby's and Christie's), in distinct cities or geographic regions. It could be argued that each auction is unique and thus the same object sold within a short period of time may fetch different prices. Moreover, those discrepancies could be attributed to differences in the lot ordering, 'winner's curse', information asymmetry prevalent especially in the low end of the violin market, or buyers' willingness to economize on search costs. The positive effect of major auction houses on the hammer price could be also explained by the selective manner in which they accept objects for sale. In addition, their reputation and top-quality offer might enhance buyers' valuations (Sproule and Valsan, 2006). Finally, auction houses' promotional efforts could also attract a larger number of wealthy bidders, which might, in turn, increase the hammer price (Landes, 2000). It should be, however, noted that the impact of the auction house on the price may vary across different sub-markets. In the dataset, most sales took place in London and New York (25% approx. in each city), followed by France, the market is already location-settled as dealers, restorer and all other players of the market are established in these locations.

ii. Strategy and pre-auction price estimate (bias)

Auction houses may exert indirect influence on the hammer price in various ways. First of all, as observed by Agnello (2002), works illustrated in the pre-auction catalogues may fetch higher prices. However, it could be equally argued that the choice to reproduce a photo of a particular violin in the catalogue may be guided by its superior quality, which is, in turn, positively correlated with the price. An auction house may also affect the hammer price through

[39] The 'law of one price' implies that, in the absence of different transaction costs, as well as trade and other barriers, no systematic price discrepancies between distinct markets can be observed (Ashenfelter and Graddy, 2006; Pesando and Shum, 2007).

[40] By similar works I mean prints from the same edition, which are of comparable quality.

[41] For more details on the efficiency of auction houses, and the relationship between the auction house and hammer price see Førsund and Zanola (2001, 2002, 2006).

the lot ordering. Moreover, a diversified offer at a particular auction might stimulate demand and have a positive effect on the prices fetched (Candela and Scorcu, 1997). Finally, auction houses might be able to indirectly influence hammer prices through pre-auction price estimates (Ashenfelter and Graddy, 2003). Since experts' appraisals may serve as reference points for credulous bidders ('anchoring effect' or reference dependence), their increase might positively affect their valuations (Beggs and Graddy, 2007). For example, Mei and Moses (2002a) observe that an upward bias in pre-auction estimates has a positive effect on hammer prices. On the other hand, Czujack (1997) does not identify any link between the pre-sale estimates and auction results. Moreover, the evidence on the existence and direction of the pre-sale estimate bias is mixed. Even if auction houses make systematic mistakes in their predictions, the question remains whether this can be attributed to their strategic behavior.

1.4.6 Media

By focusing on certain aspects (e.g. auction records, works and careers of makers), wide media coverage can enhance demand and contribute to price increases in particular market segments (Lourgand and McDaniel, 1991). By selectively highlighting some makers, artistic movements, exhibitions, publications, etc. media may influence tastes and create fashions. Media coverage can also reinforce promotional efforts of galleries, violin dealers, auction houses, some famous collectors or musicians.

1.4.7 Anomalies

Similarly, to; e.g. January-, Holiday-, Christmas- or Small-firm-effect encountered on the financial markets, emotional assets market-specific anomalies might have an impact on their prices (Frey and Eichenberger, 1995). Besides the 'winner's curse' and violation of the 'law of one price', one should also mention the so called 'declining price' anomaly ('afternoon effect') and 'morning effect'. Both phenomena indicate that the lot ordering and lot number might affect hammer prices. The former implies that the hammer prices, as well as hammer prices relative to the corresponding pre-sale estimates are more likely to fall than to rise towards the end of the auction. This could be a result of a smaller number of bidders (i.e. lower competition) present as the auction proceeds, auction houses' strategy to order objects by date of creation or appraised value (in a declining manner), buyers' risk aversion, or biased pre-auction price estimates[42] (Beggs and Graddy, 1997). The latter phenomenon has the reverse

[42] However, Pesando and Shum (1996) suggest that it might be also due to unobserved differences in quality.

effect and may be explained by the affiliated values of bidders[43] (Picci and Scorcu, 2003). It should be noted that, in general, more studies identify the existence of the 'declining price' anomaly (e.g. Agnello and Pierce, 1996; Pesando and Shum, 1996).

As violin price formation is a very fine-grained and complex process, the list of violin price determinants encompasses probably even more aspects. However, I do believe that the most important factors have been introduced in this section. It should be also noted that many of them play also an important part in determining the financial performance of violins.

Some, specially the latest mentioned, phenomena are difficult to track in a dataset with as many observations as the one I completed, but it is important to mention in order to better understand the complex market we are analyzing.

[43] Bidders' values are affiliated (or common) when bidder's valuation of the object is correlated with valuations of other auction participants (Keser and Olson, 1996).