# Peer effects in art prices

Marchenko, Maria

*DOI:*
10.57938/0c072114-ef22-4b23-a542-34ec9d48fef8

*Published: 01/01/2020*

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

*Document License:*
Unspecified

Department of Economics
Working Paper No. 298

# Peer Effects in Art Prices

Maria Marchenko

May 2020

WIRTSCHAFTS
UNIVERSITÄT
WIEN VIENNA
UNIVERSITY OF
ECONOMICS
AND BUSINESS

# Peer Effects in Art Prices

Maria Marchenko *

February 1, 2020

**Abstract**

Art often serves as an investment tool. However, the prices for some of the pieces are not easy to predict, and removing the price uncertainty is crucial to attracting even more investment in the art market. This paper assumes that the reputation of the artists and their social connections can play a significant role in determining the prices of their work. I check if a link to a higher valued or more famous peer has a positive effect on the prices of art pieces and on the probability of a successful sale. To test this hypothesis, I use the network of abstract artists, whose works' value is not always straightforward determined, and the prices of their works auctioned in 2000-2015 at Sotheby's, one of the most significant art and collectibles brokers in the world. The results suggest that consumers are willing to pay more for a particular artist's work, once there is a connection between the artist and a more valuable set of peers. However, the probability of sale is not affected. The auctioneer's predictions about future prices exhibit a similar trend.

*JEL classification codes: C49, D44, D85, Z11

WU Vienna, Austria. Email: maria.marchenko@wu.ac.at.

This research has benefited from discussions with Andreas Dzemski, Andrea Weber, Enno Mammen, Tim Fry, Jan Nimczik, Kathryn Graddy, Karol Borowiecki, Maria Isabel Santana, my friends in the art business and many participants at ACEI conference in Melbourne and ACEI workshops in Copenhagen and Fort Lauderdale. The IT support of Sergey Merzlikin is highly appreciated.

# 1 Introduction

Art is receiving significant attention in recent years as a possible investment. For example, global auction turnover since 2010 has never fallen lower than ten bln. dollars.[1] It is often attributed to the category of so-called passion investments, which also includes jewelry, antiques, classic cars, wine, and similar objects. Passion investments are assessed to amount to 6% of total wealth (The Wall Street Journal, 2010), and the high-net-worth investors allocate globally around 17% of their cash to art (World Wealth Report 2013). According to Knight Frank Luxury Investment Index 2014, the 10-year capital appreciation of art is among the highest and equal to 226%[2]. However, the existing literature often shows the underperformance of art in comparison to other types of investments and the high volatility of art prices[3]. Hence, the attractiveness of the art market cannot be explained by investment purposes only. Buying pieces of art is also a widespread tendency among high earners to strengthen their status and to yield respect in society (Goetzmann, 1993). As a result, global art and antique sales are steadily high in the last several years, with a total value close to 50 billion Euros (except for the 2009 crisis)[4].

It is common to explain art prices with the hedonic price model with the following standard set of explanatory variables: artists' characteristics, works' characteristics, such as medium, authenticity, attribution, size, and topic, as well as the sales characteristics, such as a date and a place[5]. Artists' reputation plays an important role, but it is not always clear how to account for it, especially in samples of similar artists. Renneboog and Spaenjers (2013) include a dummy for mentioning of the artist in the classic art history textbook "Gardner's Art Through Ages" and a dummy of exhibiting at Documenta in Kassel, one of the most influential contemporary art exhibitions. While such an approach is useful to analyse a relatively broad sample of artists, it is not suitable to control for the reputation and professional recognition of the abstract artists

[1] Report by Artprice.com, more details here.
[2] Consult here for more details.
[3] For example, Goetzmann (1993) reports an average annual real return on oil paintings of 3.8% for the period between 1850 and 1986, with returns around 15% after 1940. Mei and Moses (2002) calculate the return of 4.9% for 1875-1999, with 8.2% after 1950. Renneboog and Spaenjers (2013) are more cautious in their estimation, with 3.97% over the period 1957-2007. See Ashenfelter and Graddy (2003) for a summary of findings.
[4] European Fine Art Foundation report
[5] See Ashenfelter and Graddy (2003) and Ashenfelter and Graddy (2006) for a detailed summary

in my sample as the majority of them were included in the first Documenta in 1955.

This paper proposes a novel approach to explore price formation and account for reputation. Additionally to the commonly used determinants, I am looking at the artists' connections as a crucial determinant of the artist's development and the resulting price formation, which is missing in the existing analysis. I expect connections to influence art sales in two ways. First of all, following the classical peer effect logic, artists' links are influencing the development of artists' style and quality of the works. Artists may learn from better peers, and produce works of improved quality, adopt peers' style or modify their style. Thus, connections to well-established peers may improve the artist's quality. Second, the prices of the work of one artist may be driven by the prices of the connected artists. If the artists worked together or belonged to the same movement, their works will likely carry some similarities and face similar demand and prices on the market. Alternatively, the following scenario is possible: if the demand for some artist's works increases, and thereby also their price, this artist may become too expensive, and buyers would be willing to switch to similar (most likely connected) artists, causing the rise of demand and resulting market price for the latter.

The movie "Exit Through the Gift Shop" about street artist Banksy provides anecdotal evidence on the importance of connections in creating a reputation on the art market: a previously unknown artist used a quote about him by a famous street artist Banksy on the posters advertising his solo show. The phrase boosted the interest of the general public and attracted many visitors along with big money to the show. Mediocre pieces of art brought millions of dollars to their creator. However, it would not have happened without the stated connection between the artist and Banksy. While this is just a fun anecdote, also scientific literature investigating the importance of connections and peers is growing in cultural economics. However, while previous literature has focused on the effects of peers on creativity and productivity, my paper investigates effects on market outcomes. For example, Vedres (2017) explores the joint participation in jam sessions on jazz musicians' creative success; Borowiecki (2013) looks at the relationship between the productivity and potential connections inside geographical clusters in classical music. A recent article by Fraiberger et al. (2018) shows the importance of connections in the art market using co-exhibition networks that affect the success of the artists' careers. The

length and trajectory of the career depend on the location of the artist in the network. My paper is, however, the first to look at the connections between the individual artists, and how such connections are reflected in the art prices.

To do so, I use data on the artists from the abstract movement and their works, which I collected manually from the open resources specifically for this project. Abstract art is one of the art movements, along with contemporary art, for which the price is especially challenging to determine. Hence, exploring networks as an additional channel of price formation will help to understand the price differences better.

I apply the peer effect model discussed by Manski (1993) to the panel data on the prices of abstract artists' works auctioned at Sotheby's in 2000 - the first half of 2015. I am interested in the *endogenous effect* of peers' prices, i.e. how the individual outcomes (prices of works) will be affected by the average prices of their peer group. I am using the average of past auction prices and the same-period prices of connected artists as a predictor of each work's price. The presence of the simultaneous outcomes causes the identification problem of *the endogenous effect* due to the reflection problem. The price of works will not only be affected by peers' prices but will itself affect the prices of peers' works sold in the same period. Bramoullé et al. (2009) suggest an identification strategy for networks that deals with the reflection problem, which can also be applied in my analysis. To identify the effect of the peers' prices, I need the network to have intransitive triads, i.e. there should exist two artists that are not connected directly, but via one more artist. This assumption allows for exogenous variation in the peer groups that ensures that the endogenous effect of peers' outcomes is identifiable. This assumption is plausible for most of the networks and the network of abstract artists in particular.

Even though the data has a panel structure and the outcome variable is constructed differently in comparison to the classical peer effect model, I can apply the instrumental variables approach proposed by Bramoullé et al. (2009) following Lee (2003) to find the consistent estimator of the endogenous effect. Exogenous characteristics of the second-level connections (friends of friends) are serving as instruments for the average past prices of connections. The presence of intransitive triads ensures that friends of friends are not influencing prices directly, but only via the prices of common friends. A similar analysis is also applied to the estimation of the probability

of sale based on the realized sales of connections.

The main finding of the paper is the presence of a positive peer effect in art price formation. A 10% price increase in the peers' average past prices leads to the 2-3% increase in one's own hammer and auctioneers' estimated prices. I further argue that the sample's most famous artist, Pablo Picasso, is likely to be influencing the sales of connected artists, but his works' prices might not be affected by the prices of connections. I treat Picasso's prices as independent of peers' prices and only include them as the elements of the explanatory variable and repeat the analysis as before. The positive peer effect becomes even more prominent in such setting: a 10% price increase in the peers' average past prices leads to the 4,5-6% increase in one's own hammer and auctioneers' estimated prices. The probability of sales, on the contrary, does not exhibit any significant peer effect in both settings. So buyers would have been willing to buy the works independent of the value of artist's connections, but are ready to pay more for the "better" connected artists. The reputation of the connecting artists, therefore, might force more potential buyers to bid higher, resulting in higher hammer prices, but seems not to affect the overall market perception of the work. If the market likes some art piece, it will be bought anyways; if the market does not find the work attractive, connections to valuable artists will not likely change it.

The paper is organized as follows. Section 2 discusses the proposed peer effect model and suggested estimation method. Section 3 introduces the data and provides some of the descriptive analysis. Section 4 provides the empirical results. Section 5 concludes.

## 2 Methodology

I am analyzing the sample of all works sold at Sotheby's for the sample of abstract artists.[6] In order to estimate the endogenous effect of average prices of connected artists on the prices of the artist's own work, I am proposing the peer effect model, similar to Manski (1993), with the

[6]The sample is defined and discussed in the next section.

appropriate modification. For artworks $i \in [1, I]$ in the set of all artworks by all artists $j \in [1, J]$:

$$P_i^j = \alpha_0 + \alpha_1 t_i + \beta_0 Z_i + \beta_1 X_j + \beta_2 \sum_{l \neq j} G_{jl} X_l + \gamma \sum_{l \neq j} G_{jl} \bar{P_l}^{-t} + \nu_j + \epsilon_i^j \tag{1}$$

where $P_i^j$ - the price of the piece $i$ by artist $j$.

$\bar{P_l}^{-t}$ - average prices of works by artist $l$, sold before piece $i$ was auctioned.

$Z_i$ - the characteristics of art piece that include the type of work, their size, date of creation, provenance, exhibition history etc.[7]

$X_j, X_l$ - the characteristics of the artists, such as major work mediums (paintings, sculptures, and others), country of birth and living, years active, etc.

$G_{jl}$ - an adjacency matrix with $1/n_j$ in the $jl$ cell, if an artist $j$ is connected to an artist $l$, and $n_j$ is the total number of connections of an artist $j$.

$\nu_j$ - the unobserved characteristics of the artists.

Here $\beta_2$ represents the exogenous effect, how the similar characteristics of the connected artists influence the outcomes, $\gamma$ is the endogenous effect, showing how the outcomes of the connections may influence the outcome of the individual. The presence of an individual unobservable effect creates an additional issue for the identification of the endogenous effects.

Potentially, the correlated effects can also be present in the model, making the smaller group within the network to behave similarly due to the unobserved similarities of the group. However, the network used in this paper is rather small, and the similarities of the subgroups will be captured by observed characteristics, such as the country of origin or/and work, the group affiliation, and similar. In a more general setting, the local differences can deal with the correlated effects problem, averaging over the first level connections' outcome variables. The presence of links of the length three or more is then ensuring the identification of endogenous effect, and so $G_{jl}^3 X_l$ can be used as instruments for the endogenous covariates.

Since the network is held constant in the panel, the fixed effects model, which is more suitable from the empirical point of view, is not applicable. The connections' average exogenous characteristics will be invariant for all works by the same author, and therefore, the exogenous peer

[7]The variables will be discussed in detail in later sections.

effects cannot be identified. So one should either use the random effects analysis or Hausman and Taylor type models.

Both possibilities are plausible, depending on the assumptions one believes in. The unobserved individual effects in our setting might represent, for example, the level of talent of the particular artist, his/her popularity, as well as characteristics not included or missing in the vector of relevant covariates attributed to the artist. The level of talent and some potential covariates are more likely to be uncorrelated with explanatory variables, so there might be a correlation between popularity and one of the explanatory variables. In particular, the artists from a specific movement might be more attractive at a particular point in time, and hence, I expect a positive correlation with the characteristics and outcomes of the artists' connections. In this case, the random effects will produce inconsistent estimators of all parameters, and the Hausman and Taylor type models are more suitable. Such models are, however, more computationally demanding, and once the correlation mentioned above is absent, the random effects are preferable.

### Hausman and Taylor type model

If there is a potential correlation between individual unobservables and the explanatory variables and time-constant variables are of interest[8], as follows from the arguments mentioned above, neither fixed effects nor random effects are suitable for the analysis. As discussed, I can ignore the possibility of correlated effects since they are not very likely to be present in the current setting.

I am combining the Hausman and Taylor (1981) approach and the instrumental variable approach to the peer effect model proposed in Bramoullé et al. (2009). First, I divide all explanatory variables into two vectors: time-variant $\boldsymbol{Z_i^j} = \{t_i, Z_i^j, \sum_{l \neq j} G_{jl} \bar{P_l}^{-t}\}$ and time-constant $\boldsymbol{X_j} = \{1, X_j, \sum_{l \neq j} G_{jl} X_l\}$. I follow Hausman and Taylor (1981) and partition both vectors as follows: $\boldsymbol{Z_i^j} = (\boldsymbol{Z_{i1}^j}, \boldsymbol{Z_{i2}^j})$ and $\boldsymbol{X_j} = (\boldsymbol{X_{j1}}, \boldsymbol{X_{j2}})$, where $\boldsymbol{Z_{i1}^j}$ is $1 \times K_1$, $\boldsymbol{Z_{i2}^j}$ is $1 \times K_2$, $\boldsymbol{X_{j1}}$ is

[8]Note, that notion of time is used here not in the direct sense, but instead follows the conventional terminology of panel data analysis. Time here denotes each time one of the works was auctioned.

$1 \times J_1$, $\boldsymbol{X_{j2}}$ is $1 \times J_2$, and the following assumptions hold:

$$\mathbb{E}(\boldsymbol{X_{j1}}\nu_j) = 0 \quad \text{and} \quad \mathbb{E}(\boldsymbol{Z^j_{i1}}\nu_j) = 0$$

Additionally, the further assumption is necessary:

$$\mathbb{E}(\epsilon^j_i | \boldsymbol{X_j}, \boldsymbol{Z^j_1}, \ldots, \boldsymbol{Z^j_{w_j}}, \nu_j) = 0, \quad i = 1, \ldots, w_j$$

with $w_j$ being the number of works of artist j in the sample.

I can then rewrite the original model in a simplified way:

$$P^j_i = \beta Z^j_i + \alpha X_j + \nu_j + \epsilon^j_i \tag{2}$$

where $\beta = (\alpha_1, \beta_0)$ and $\alpha = (\alpha_0, \beta_1, \beta_2, \gamma)$.

Note that under assumptions in this subsection, the time-variant variables are likely to include the endogenous outcome variable of connections. I am suggesting a modification of the HT approach with the appropriate use of instrumental variables to identify the endogenous peer effect, which are the exogenous characteristics of friends of friends, as suggested by Bramoullé et al. (2009). The estimation procedure is as follows:

1. First, one needs to estimate the model with fixed effects to get the consistent estimators of time-variant variables' coefficients. However, time-variant variables include endogenous outcomes of the friends. In order to achieve consistent estimation in the first step, I propose using the IV approach with the following vector of instruments $\{t_i, Z^j_i, \sum_{l \neq j} G_{jl} \sum_{k \neq l} G_{lk} X_k\}$, and with fixed effects. Then the vector $\hat{\beta}_{FE}$ consistently estimates the coefficients of the time-variant variables.

2. Using the estimator of the first step, calculate the residuals as follows:

$$\hat{d}_j = \bar{P}^j - \hat{\beta}_{FE} \bar{Z}^j = \alpha X_j + \nu_j + \bar{\epsilon}^j \tag{3}$$

3. Now, I estimate 3 with a 2SLS approach using the standard vector of instruments in the

Hausman and Taylor (1981) approach $[\boldsymbol{Z^j_{i1}}, \boldsymbol{X_{j1}}]$.

4. Using the residual variance $\sigma^{*2}$ from the previous step and estimator of $\sigma^2_\epsilon$ from the first step, calculate $\sigma^2_\nu = \sigma^{*2} - \sigma^2_\epsilon/\bar{T}$, where $\bar{T}$ is a harmonic mean of $T_j$'s. Then compute the weighting coefficients for GLS as:

$$\theta_j = 1 - (\frac{\sigma^2_\epsilon}{\sigma^2_\epsilon + T_j\sigma^2_\nu})^{0.5}$$

5. Finally, the following transformations are made: $P^{j*}_i = P^j_i - \theta_j \bar{P^j}$, $Z^{j*}_i = Z^j_i - \theta_j \bar{Z^j}$, $X_j* = X_j - \theta_j \bar{X}$. Then I regress $P^{j*}_i$ on $Z^{j*}_i, X_j*$, using a 2SLS approach with the vector of instruments $[Z^j_i - \bar{Z^j}, Z^j_{i1}, X_{j1}, \sum_{l\neq j} G_{jl} \sum_{k\neq l} G_{lk} X_k]$.

The proposed approach provides consistent estimators of endogenous peer effects, as well as of all additional covariates, including time-constant determinants of connections. I do not prove the consistency of the resulting estimators in this paper, but the result follows from a straightforward application of the proofs in Hausman and Taylor (1981) and Lee (2003).

# 3 Data description

The data in this paper consists of several parts: the data on the artists' connections, the data on the artists' characteristics, and the collection of the prices for the artists' work sold at the auctions at Sotheby's since 2000.

The network data is taken from the diagram prepared by the group of researchers for the exhibition "Inventing Abstraction, 1910-1925" at the Museum of Modern Art, New York, in December 2012-April 2013.[9]

*Insert Figure 1 here*

This diagram represents documented relationships among the artists, who played significant roles in the development of the new art language.[10] Appendix C lists all the artists in the

[9] A detailed interactive network can be found online at the MOMA website.

[10] Description of the links on the exhibition website: "Vectors connect individuals whose acquaintance with one another during these years could be documented".

sample. I manually transformed this diagram into adjacency matrix, with $1/n_i$ at the $ij$ cell, if the artist $i$ is connected to the artist $j$, and $n_i$ is the total number of connections of the artist $i$. Moreover, I collected additional information about art groups at the time, such as Der Blaue Reiter (The Blue Rider), De Stijl, and others, to be able to distinguish between the links of different intensity. Table 1 shows the number of artists affiliated with the groups and the number of artists worked in a particular country. Some of the artists worked in more than one country, and I included each of them if it was mentioned either on the official website of the MOMA exhibition or in "A Dictionary of Twentieth-Century Art," Chilvers (2003).

*Insert Table 1 here*

The existing network determined the sample of the artists used for the analysis. However, the final sample does not include several of the names from the initial list. The excluded personalities are people essential for establishing abstract movement, but not creative artists, for example, Guillaume Apollinaire, a writer and an art critic, or Claude Debussy, a composer. Therefore, the auctioned items related to these people are mostly representing some personal items, books, manifests, or similar. There are 83 artists in the initial list; I excluded 11 of them.

The set of artists' characteristics comes from different biographical sources. It includes years of life and years active, the country of birth and the country, where the artist was the most active, primary artistic medium (such as paintings, sculpture, photography), belonging to a specific group.

The dataset on prices was collected for this paper from the Sotheby's auction house website. I obtained all lots for each artist in the sample, auctioned at Sotheby's, sold and not sold. The data were available for the auctions that took place from the year 2000; earlier lots are not available online. For each lot, the following information is mostly available: a presale price estimates of the work, hammer price of sold lots, date of creation, type of work, size, provenance, history of exhibitions. Some descriptive information, however, is missing for many observations. There are also some additional catalog notes, including conditions, authenticity information, exhibition history, and some others. However, it is challenging to use all this information in the analysis, as there is no obvious way to re-translate these descriptions into quantitative variables.

Several data limitations should be pointed out. **First of all**, I am analyzing only the data from one auction house. Potentially, it can cause some distortion of the results. For example, looking at one auction house does not allow controlling for the availability of the works of a particular artist on the market. However, each auction house tends to exhibit similar patterns and to be a good proxy for the art market in general. Adding data on the sales in other auction houses is computationally demanding; however, I believe that my results have strong external validity and can be extrapolated on the other auction houses. Discussions in Ashenfelter (1989) and Ashenfelter and Graddy (2006) confirm this argument.

**Secondly**, the types of works included in the sample differ a lot: oil paintings, watercolors, lithographs, different types of sculptures, photographs. I control for each type of work with the set of dummy variables. However, the description is missing for almost 30% of lots; hence, not I cannot attribute them to a particular medium. Since most of the artists in the sample used different media in their work, I cannot univocally determine the medium based on the works' author. I am treating these lots as not attributed. However, buyers at the auction were aware of the type of work on sale. This missing information can cause a bias in estimation. However, most of the missing information corresponds to the sales in the years 2000-2003. I will compare the results of the full sample with the results from the restricted sample of the sales after 2003 to address this issue.

The prices are reported in the local currency of the auction, which requires price adjustment not only for the inflation but also for the exchange rates. Most of the prices are in USD (43,3% of the lots), in GBP (42,3%), or EUR (13,6%). Several lots are in Swiss Franks, Australian, and Hong Kong Dollars. I use daily historical exchange rates to convert all of the prices into US Dollars. I then adjust prices by CPI of USD, taking the beginning of the sample, January of 2000 as a baseline of 1. In both nominal and real terms, the most expensive transaction in my sample is "Garcon á la Pipe" by Pablo Picasso sold at Sotheby's New York in May 2004 for 104 million USD.

The total sample consists of about 12000 auctioned lots; the sample of sold lots is smaller and consists of 9857 lots.

## Description of the sales

*Insert Table 2 here*

Table 2 shows the differences in prices for different media. The oil paintings are expectantly the most expensive, and the photographs have the lowest prices. Drawings form the most prominent group, with almost half of all the sales. Not attributed works amount to more than 40% of all sold lots, which is more than in a full sample. The distribution of prices of unattributed works suggests that most of them are likely to be either drawings or photographs. So not attributed works will rarely belong to the categories with higher prices. Hence, I can still analyze the full sample, controlling for oil paintings, watercolors, and sculptures only.

*Insert Figure 2 here*

Figure 2 demonstrates the distribution of the auctioned and sold lots of the observed period. The number of lots in abstract art varies during the observed period, with the most prominent decrease around the 2008 crisis. However, the percentage of the lots sold in the first years after the crisis is among the highest (82% in 2009 and 96% in 2010), suggesting the cautious behavior of sellers, choosing potentially better selling works, and cautious behavior of buyers willing to protect their money in more stable investment during the crisis period. In comparison to the other financial instruments, usually unstable and volatile in the crisis years, art can be seen as a more reliable way to invest. In recent years, the level of sales recovered to the pre-crisis year. Note that the data was collected in the middle of 2015, determining the low amount of sales this year.

*Insert Table 3 here*

Table 3 provides more details on the dynamics of the prices and sales of abstract art over the discussed period. The first four years of the observations show the relatively low total value of sales, as well as the average price of the lots. After that, the sales increased significantly with a slight decline around after 2008. Demand for abstract art auctioned during that period is not homogeneous; therefore, year dummies should be included in the analysis.

Data also includes minimal and maximal presale price estimates of each lot, set by the auction house before the beginning of the auction. For the sold lots, these prices are quite an accurate estimate of the hammer price, with a correlation of around 95%. However, these prices do not help to predict whether the lot will achieve the reserve price set by auction and seller together. I am using both hammer prices and presale estimates as an outcome variable to estimate the endogenous peer effect on price formation. However, the two have a different meaning. The former represents the market response, whereas the latter can be viewed more as an objective valuation of works. I will discuss both possibilities.

### Network characteristics

The network, as was already mentioned, consists of 83 artists. Table 4 gives some of the characteristics of the network.

*Insert Table 4 here*

The network has quite a high number of average connections, more than 12. It is highly likely that not all connections affect the outcome variables. However, it is almost impossible to restrict connections further. One option is to put a higher weight on those, working in the same country or affiliated with the same group. Most of the links connect artists who lived or worked in the same country for a significant amount of time. The share of the links in the same group is, however, rather small. Not all artists belonged to official groups, even though they belonged to a particular movement, whereas some of the artists had affiliations to several groups. Therefore, the group affiliation might be useful as a control variable of artists' characteristics, but not as an indicator of the tightness of connections.

The transitivity of the network is 46%, which means there are enough intransitive triads and it is sufficient for identifying assumption to hold.

## 4 Results

I am considering several scenarios in the analysis. Recall that there are no hammer prices for some works, as not all lots were sold. Unsold lots do not necessarily indicate the quality or

importance of the work, but more likely to be a characteristic of the market situation or the reservation price the seller puts on the work. First, I am analyzing the sample, excluding these observations. The results characterize the price formation determinants but do not describe the overall market trends. Therefore, I am also looking at the full sample, using the presale price estimates, established by the auction house, instead of the hammer prices, and representing a possibly more objective value of the work. Moreover, I am using a similar approach to estimate the probability of the work to be sold at the auction.

## 4.1 Subsample of sold lots

As was described in Section 2, I am relying on the modified version of Hausman-Taylor Type models. Table 5 shows the estimation results for the subsample of sold lots. Note that some of the exogenous characteristics of friends have a slightly different meaning than the works' or sales' own exogenous characteristics. The characteristics related to the works or the auction are not artist-specific; therefore, the average is taken as links' characteristics, which in many cases has the meaning of shares. For example, averaging the dummy variable of oil paintings as a type of work gives the share of oil paintings among the works of the artist's connection. Since most of the variables are either dummy variables or shares, the logarithm of prices is more appropriate than raw prices. To avoid the problem with the logarithm of zero, I take a logarithm of $Price + 1$.

*Insert Table 5 here*

The model detects a highly significant positive effect of the average prices of friends' works on the price of one's own work. The magnitude is, however, not very high. For example, the increase in friends' average price by 10% will increase the work's price by around 2%. Works' and sales' characteristics, as well as some of the links' characteristics, have a greater magnitude of the effects. Note the positive effect of one's own work sale in all the crisis and post-crisis years in the model. It probably suggests that once the work got on the auction in these years, it is more likely to be less risky since the share of sold lots in these years is very high; hence,

the prices are slightly higher.

As was discussed in Section 3, most of the missing information in the sample is for the sales in the period 2000-2003. I am, therefore, restricting the sample to the sales after 2003 to check whether the results remain stable in the subsample with fuller information. Table 6 presents the estimation results.

*Insert Table 6 here*

It can be observed that most of the results hold for the restricted sample. First of all, the positive effect of the average price of works of friends exists and is more prominent than in the sample of all sold lots. The 10% increase in the average price of connections' sold works will cause almost a 5% increase in the price of work.

In general, the restriction of the sample is not changing the results of the estimation significantly. I will discuss the determinants of the price other than the average price of works of connected artists later in the section.

## 4.2 Full sample

I am using two approaches for the analysis of the full sample. First, I am using presale estimates as the outcome variable. Then I am looking at the probability of works to be sold.

### 4.2.1 Presale Price Estimates

The estimation with new outcome variables: maximal and minimal auctioneer's presale price estimates of the lot delivers similar results to the ones obtained for the hammer prices of sold lots.

*Insert Table 7 here*

Results, presented in Table 8, suggest that the higher average price expected by the auctioneer for the artists' connections is, the higher the expected price of the artist's own work, similar to the hammer price results obtained previously. Once the auction house expects the high demand, and hence, high price for the works of artist's connections, it also expects similar demand trends

for the artist's own works. This assumption of the auctioneers confirms by the hammer prices of connected artists moving in one direction. The increased interest in one artist leads, indeed, to raising interest in the artist's connections, setting higher prices for all of them.

The other coefficients exhibit quite similar behavior to ones in Section 4.1.

### 4.2.2 Probability of successful sale

Next, I am looking at the linear probability model to estimate the effect of the share of successful connections' sales on the probability of the work to be sold. Table 8 summarizes the results for such estimation.

*Insert Table 8 here*

Unlike for the prices, the probability of selling the work is independent of the share of sold works of the artist's connections. This additional evidence suggests that the willingness of the buyers to pay and the expected by auctioneer payments are moving in the same direction for connected artists, but the quantity demanded is not. On the one hand, connected artists might be viewed as substitutes, but it is not reflected in the probabilities of works to be sold. For the substitute goods, the probability of selling the work should have decreased with the increase in sales in the network. On the other hand, the comovement of prices suggests the existence of similar demand behavior of buyers of the connected artists. It would then increase not only the prices of works but also the probability of selling the work when the share of sold works of connected artists is increasing. The resulting insignificance of the endogenous effect is most likely reflecting the existence of both the above-mentioned effects.

## 4.3 Sample without Picasso

Pablo Picasso is probably the most famous and established artist among the artists studied in this paper. Clearly, being connected to Picasso might bring additional attention to the lesser-known artists. However, it is not very likely that Picasso's prices depend on the artist from his network. Therefore, I am repeating the analysis for the sample that does not include Picasso's works in the dependent variable, treating the Picasso-peers links as directed links. Picasso's

prices only play a role as a factor, influencing the prices of his network.

Note that the peers were still influencing Picasso in the past, potentially affecting his style and quality, therefore. Hence, the analysis of the full sample of artists, as discussed in Sections 4.1 and 4.2, is still crucial to fully explore peer effects on the art market.

*Insert Table 9 here*

Peer effects on the prices of works of art become even more prominent in such a setting. Once only the prices for the works of lesser-known artists depend on the average prices of connections, the magnitude of the peer effect becomes 2-3 times higher than in the full sample of artists. A 10% increase in prices of connections leads to a 4.4 - 6.1 % change in the price of an artist's work.

I repeat the analysis for the presale estimates.

*Insert Table 10 here*

Similarly, the endogenous peer effect is more prominent in a case when the prices of Picasso's works are considered not to be dependent on the prices of works of connected artists. A 10% increase in prices of connections leads to a 5.6 - 6 % change in the price of an artist's work.

I also look at the probability of selling the works of all artists except Picasso (Table 11) and find similar results as for the full sample.

*Insert Table 11 here*

The other determinants more or less follow the same trends as previous models. I am discussing some of the other detected effects in the next subsection.

## 4.4 General observations about other determinants

- All models could capture the differences in the prices for different media: oil paintings have the maximum premium. Moreover, the higher share of oil paintings among connections also results in the higher own price.

- The hammer price and the presale estimates are higher in the 2008 crisis year, and two years after it when the art market still did not recover from the crisis. 2009 and 2010 also have a positive effect on the price of the estimated prices, reflecting the caution behavior of the sellers in these years. However, these estimates become insignificant once Picasso's works are not part of the dependent variable. It suggests that the big share of 2008-2010 positive effects was driven by Picasso, whose works have high chances of a successful sale, thus confirming the "safe investment" argument.

- Sotheby's London, New York, and Paris are the central auction locations and attract more buyers; hence, the more valuable lots are likely to be auctioned there. The price of sold lots is, therefore, likely to be higher for sales in one of the three locations.

- Russian art is trendy in recent decades[11], with every auction house having their own Russian Art Auction a couple of times per year, and "works by Russian Avant-Garde are among the most sought-after on the international market" (Hewitt, 2014). The result of my analysis suggests that the prices of Russian artists are, on average, lower, but being connected to more Russian artists increase the price. The high demand for Russian art does not result in higher prices in comparison to the other nationalities, and hence more Russian artists in the artist's network will, on average, increase the artist's own price, as she or he is more likely not to be Russian. It is reasonable to assume that the affordability and availability of Russian abstract art is one of the determinants of high demand and lower prices.

- Similar to the existing literature, I find the positive effect of the signed work on the price. The signature provides additional authenticity confirmations. Interestingly though, the share of connections' signed works drives the price downwards. Even if the artists were friends or collaborators in real life, the market often views connected artists as competitors. Hence, the more signed works there are among the works of connected artists, the tighter the competition to attract the buyer. The buyer has more chances to switch to similar authentic work once more pieces are signed.

[11] See, for example, the report on London Russian Weeks Auction sales

# 5 Conclusion

This paper adopts the peer effect logic to analyze the price formation on the art market. I explore the auction results for abstract art from Sotheby's auction house for 2000-the first half of 2015 and the connections between the abstract artists as reported for the MOMA exhibition "Inventing abstraction." The artists' connections serve as an essential determinant of the artists' style, works' quality, and of the resulting price of their works. The effect of the peers can be channeled by collaborations, joint exhibitions, resulting in similar style and quality of works, or the particular reputation of one of the artist's connections.

I am proposing the model, combining Hausman and Taylor (1981) approach for the panel data with the Manski(1993) peer effect model and Bramoulle et al. (2009) instrumental variables strategy.

I am analyzing both the sample of only sold lots and the full sample using presale estimates. Both settings exhibit the positive peer effect of connections' average prices. The market is, therefore, quite responsive to the artist's connections performance and reputations, and the buyers are willing to pay more if the artist has a connection to the "better" artist. The auctioneers' behavior towards price formation is similar. The auction house views the connected artists similarly, expecting the demand to move in the same direction and setting the presale estimates for the connected artists similarly.

The results are even stronger when the connections to the most famous artist in the sample, Pablo Picasso, are treated as directed. I make the links between Picasso and others to be relevant only for one direction: Picasso is influencing his peers, whereas his peers are not influencing him. Such an assumption can hold when talking about the prices, as Picasso has an established market reputation, and it doesn't matter for the buyers, whether he was connected to Natalia Goncharova or not.[12] However, peers could have influenced Picasso during their work interactions. Therefore, both analyses of the full sample of artists and the sample without Picasso in the dependent variable are relevant for the discussion of the peer effect on art prices.

The probability of sales, unlike the prices, is not influenced by peers' performance. The buyers

[12]He actually was.

are willing to purchase the work regardless of peers' quality and reputation; however, once the peers are valued higher, they are willing to pay more for the work.

The paper is the first looking at the effect of artists' connections on art prices and shows clear evidence of the importance of them for the price formation and market outcomes at the art market.

## References


Ashenfelter, Orley (1989). "How auctions work for wine and art". In: *The Journal of Economic Perspectives* 3.3, pp. 23–36.

Ashenfelter, Orley and Kathryn Graddy (2003). "Auctions and the price of art". In: *Journal of Economic Literature* 41.3, pp. 763–787.

– (2006). "Art auctions". In: *Handbook of the Economics of Art and Culture* 1, pp. 909–945.

*Auction results at Sotheby's*. URL: http://www.sothebys.com/en.html.

Banksy (2010). *"Exit through the Gift Shop"*. Movie.

Baumol, William J (1986). "Unnatural value: or art investment as floating crap game". In: *The American Economic Review* 76.2, pp. 10–14.

Borowiecki, Karol Jan (2013). "Geographic clustering and productivity: An instrumental variable approach for classical composers". In: *Journal of Urban Economics* 73.1, pp. 94–110.

Bramoullé, Y., H. Djebbari, and B. Fortin (2009). "Identification of peer effects through social networks". In: *Journal of econometrics* 150.1, pp. 41–55.

Capgemini (2013). *World Wealth Report*. URL: https://www.worldwealthreport.com/download/68/b95e0b47.

Chilvers, Ian (2003). *A dictionary of twentieth-century art*. Oxford University Press.

*Consumer Price Index Data*. URL: http://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/.

Fraiberger, Samuel P, Roberta Sinatra, Magnus Resch, Christoph Riedl, and Albert-László Barabási (2018). "Quantifying reputation and success in art". In: *Science* 362.6416, pp. 825–829.

Goetzmann, William N (1993). "Accounting for taste: Art and the financial markets over three centuries". In: *The American Economic Review* 83.5, pp. 1370–1376.

Goetzmann, William N, Luc Renneboog, and Christophe Spaenjers (2011). "Art and money". In: *The American Economic Review* 101.3, pp. 222–226.

Hausman, Jerry A and William E Taylor (1981). "Panel data and unobservable individual effects". In: *Econometrica*, pp. 1377–1398.

Hewitt, Simon (2014). *London's Russian Auction Market. Russian Art Week Analysis 2007-2014*. URL: http://www.russianartweek.co.uk/wp-content/uploads/2012/10/Russian-Art-Market-Report-by-Simon-Hewitt-Nov14.pdf.

Horowitz, Noah (2014). *Art of the deal: Contemporary art in a global financial market*. Princeton University Press.

*Inventing Abstraction at MOMA*. URL: http://www.moma.org/interactives/exhibitions/2012/inventingabstraction/.

Jackson, Matthew O. (2010). "An overview of social networks and economic applications". In: *The handbook of social economics* 1, pp. 511–585.

Kleiner, Fred S. (2015). *Gardner's Art through the Ages: A Global History*. Cengage.

Lee, Lung-fei (2003). "Best Spatial Two-Stage Least Squares Estimators for a Spatial Autoregressive Model with Autoregressive Disturbances". In: *Econometric Reviews* 22.4, pp. 307–335.

Manski, C.F. (1993). "Identification of endogenous social effects: The reflection problem". In: *The review of economic studies* 60.3, pp. 531–542.

McAndrew, Clare (2010). *The International Art Market 2007-2009: Trends in the Art Trade during Global Recession*. European Fine Art Foundation (TEFAF).

Mei, Jianping and Michael Moses (2002). "Art as an investment and the underperformance of masterpieces". In: *The American Economic Review* 92.5, pp. 1656–1668.

Paula, Áureo de (2015). "Econometrics of Network Models". In: *cemmap Working paper* CWP52/15.

Renneboog, Luc and Christophe Spaenjers (2013). "Buying beauty: On prices and returns in the art market". In: *Management Science* 59.1, pp. 36–53.

*Representative Exchange Rates*. URL: `http://www.imf.org/external/np/fin/data/param_rms_mth.aspx`.

Sagot-Duvauroux, Dominique (2003). "Art prices". In: *A Handbook of Cultural Economics*, p. 57.

Shirley, Andrew (2014). *Knight Frank Luxury Investment Index update 2014*. URL: `http://www.knightfrankblog.com/wealthreport/news-headlines/knight-frank-luxury-investment-index-update-2014/`.

Thompson, Don (2010). *The $12 million stuffed shark: The curious economics of contemporary art*. Macmillan.

Vedres, Balazs (2017). "Forbidden triads and creative success in jazz: the Miles Davis factor". In: *Applied network science* 2.1.

## Tables and Figures

Figure 1: Network of abstract artists

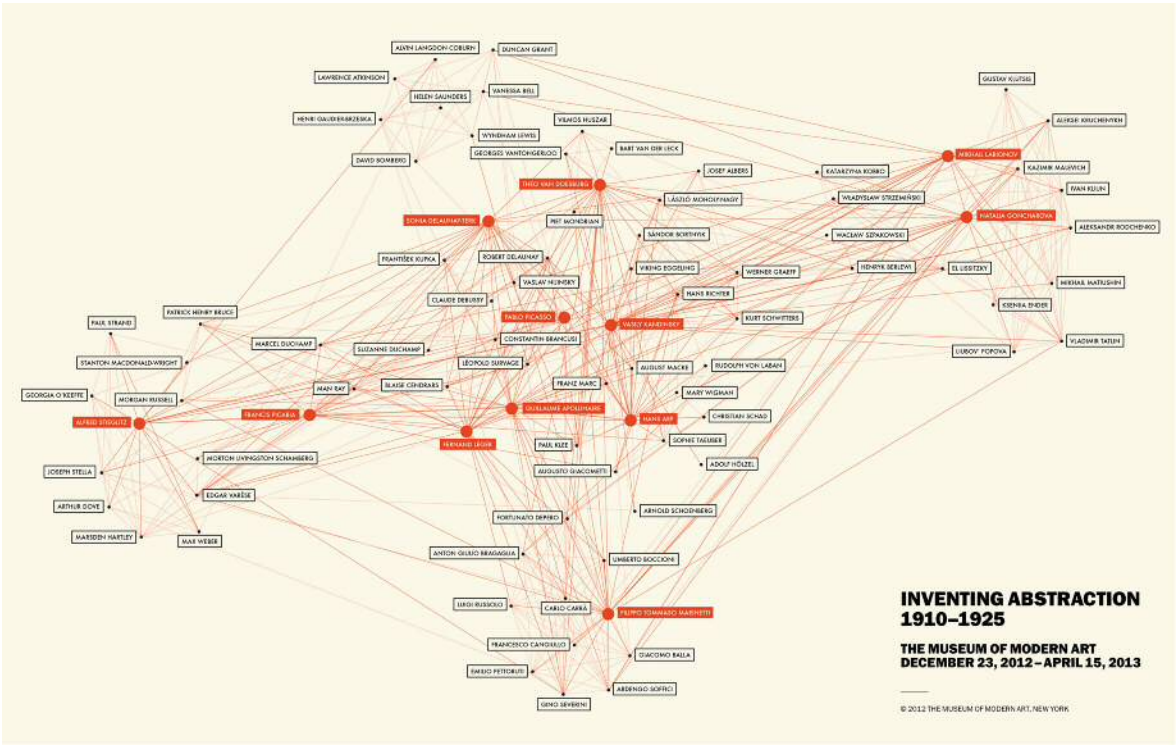

Figure 2: Distribution of sales over the years

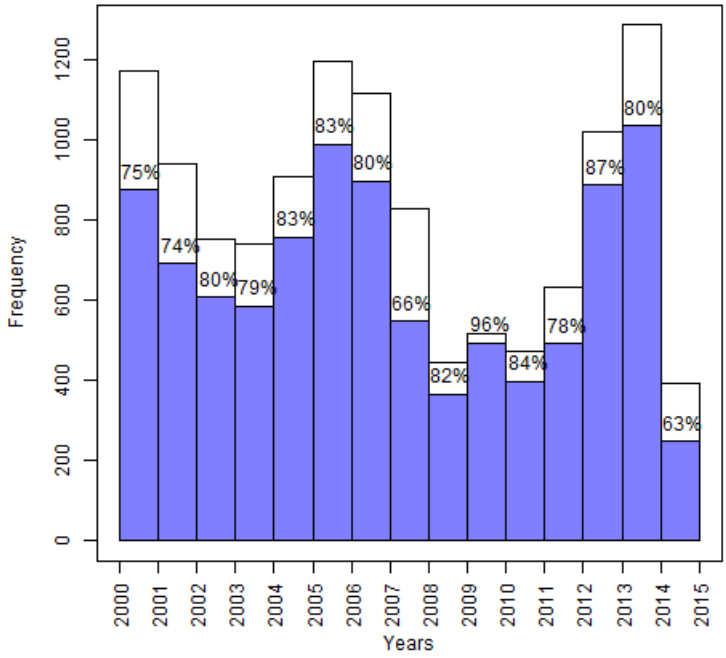


Table 1: Countries and art groups allocation

| Countries | Art groups |
|---|---|
| France (30), USA (20), Germany (18), Russia (18), Italy (15), Switzerland (9), England (8), Poland (5), Spain (4), The Netherlands (4), Hungary (3), Romania (2) | Der Blaue Reiter (7), Puteaux Group (6), De Stijl (4), Union of Youth (4), Donkey's Tail (3), Supremus (3), 291 Gallery (3), Jack of Diamonds (2), Societe Anonyme (2), Bloomsbury group (2) |

Table 2: Average prices

| | Median | Mean | Standard deviation | # of observations |
|---|---|---|---|---|
| All sold | 20 570 | 384 000 | 2 701 223 | 9857 |
| Sold after 2003 | 25 550 | 463 620 | 3 041 266 | 7686 |
| Oil paintings | 195 800 | 1 919 583 | 6 727 491 | 1637 |
| Watercolors | 86 040 | 396 300 | 1 238 530 | 351 |
| Drawings | 27 270 | 179 300 | 824 219 | 4166 |
| Sculptures | 43 810 | 541 300 | 3 144 502 | 225 |
| Photographs | 21 900 | 91 480 | 281 245 | 389 |
| Not attributed | 11 000 | 83 191 | 545 287 | 4103 |

Table 3: Prices over time (in 2000 prices)

| | Average | Sum | Maximum | Sold lots | Total lots |
|---|---|---|---|---|---|
| 2000 | 181 916.44 | 57 121 761 | 10 064 195 | 314 | 421 |
| 2001 | 55 504.83 | 31 138 212 | 3 016 847 | 561 | 749 |
| 2002 | 97 233.27 | 67 090 953 | 5 634 195 | 690 | 938 |
| 2003 | 109 052.58 | 66 085 862 | 10 659 028 | 606 | 753 |
| 2004 | 497 636.84 | 291 117 551 | 116 695 313 | 585 | 740 |
| 2005 | 179 560.06 | 135 747 408 | 21 430 066 | 756 | 906 |
| 2006 | 300 164.66 | 296 562 685 | 114 225 355 | 988 | 1195 |
| 2007 | 430 133.71 | 385 399 804 | 36 309 073 | 896 | 1114 |
| 2008 | 704 978.33 | 385 623 149 | 50 360 523 | 547 | 826 |
| 2009 | 424 994.75 | 155 548 077 | 14 712 432 | 366 | 446 |
| 2010 | 374 195.48 | 184 478 373 | 12 049 552 | 493 | 515 |
| 2011 | 803 838.78 | 319 123 997 | 53 231 183 | 397 | 471 |
| 2012 | 700 985.01 | 343 482 657 | 56 631 229 | 490 | 632 |
| 2013 | 549 474.89 | 486 834 749 | 61 579 591 | 886 | 1018 |
| 2014 | 464 436.80 | 480 227 654 | 44 430 080 | 1034 | 1285 |
| 2015 | 400 162.95 | 99 240 411 | 18 688 892 | 248 | 392 |

Table 4: Network characteristics

| Network statistics | Definition | Value |
|---|---|---|
| Average indegree | Average number of ingoing ties | 12.84 (6.44) |
| Minimum indegree | Minimal number of ties | 2 |
| Maximum indegree | Maximal number of ties | 28 |
| Density | Proportion of existing ties in the network | 0.1566 |
| Transitivity | The ratio of the triangles and the connected triples in the graph | 0.4629 |
| Links from the same country | | 0.8435 |
| Links inside the group | | 0.0999 |
| Links inside the group, if belonged to a group | | 0.2807 |

Table 5: Results for sold lots

| | HT coefficient | St.errors |
|---|---|---|
| Intercept | 5.8431*** | (0.4502) |
| Av.log price of friends' works | **0.2100*** ** | (0.0396) |
| *Work's characteristics* | | |
| Oil painting | 1.8821*** | (0.0564) |
| Watercolor | 0.8831*** | (0.0951) |
| Drawings | 0.0712*** | (0.0211) |
| Sculpture | 0.4373*** | (0.1018) |
| Signed | 0.0905* | (0.0409) |
| *Sale's characteristics* | | |
| 2008 | 0.5067*** | (0.1099) |
| 2009 | 0.6001*** | (0.1445) |
| 2010 | 0.4253*** | (0.1054) |
| London | 1.1734*** | (0.0611) |
| New York | 1.3110*** | (0.0602) |
| Paris | 1.2232*** | (0.0836) |
| *Artist's characteristics* | | |
| Germany | 0.8917*** | (0.1953) |
| USA | 0.4346*** | (0.1222) |
| Russia | -0.5319*** | (0.1494) |
| France | 0.1702 | (0.1251) |
| *Link's characteristics* | | |
| Share of oil paintings | 4.4817*** | (0.7365) |
| Share of watercolors | -13.7987*** | (1.7828) |
| Share of drawings | 3.0995*** | (0.4698) |
| Share of sculptures | 19.3141*** | (2.8638) |
| Share of signed | -4.2331*** | (1.0076) |
| Share of 2008 | -2.8661 | (2.3180) |
| Share of 2009 | 7.9435* | (3.4122) |
| Share of 2010 | 2.0724 | (2.1864) |
| Share of London | -2.0054*** | (0.3252) |
| Share of New York | -1.6443*** | (0.4181) |
| Share of New York | -1.8742* | (0.8974) |
| Germany | -1.2918** | (0.4090) |
| USA | 1.3554*** | (0.3210) |
| Russia | 1.5394*** | (0.3464) |
| France | 0.4408 | (0.2897) |
| *** - p-value $< 0.001$, ** - p-value $< 0.01$, * - p-value $< 0.05$ | | |

Table 6: Results for sold lots, after 2003

| | HT coefficient | St.errors |
|---|---|---|
| Constant | 0.7785 | (0.8236) |
| Av.log price of friends' works | **0.4748*** ** | (0.0629) |
| *Work's characteristics* | | |
| Oil painting | 2.0393*** | (0.0592) |
| Watercolor | 0.9451*** | (0.0971) |
| Drawings | 0.0942*** | (0.0220) |
| Sculpture | 0.5057*** | (0.1048) |
| Signed | 0.1344** | (0.0425) |
| *Sale's characteristics* | | |
| 2008 | 0.4485*** | (0.1133) |
| 2009 | 0.6417*** | (0.1479) |
| 2010 | 0.4513*** | (0.1098) |
| London | 1.2308*** | (0.0736) |
| New York | 1.2279*** | (0.0734) |
| Paris | 1.3054*** | (0.0920) |
| *Artist's characteristics* | | |
| Germany | 0.5054* | (0.2356) |
| USA | -0.0653 | (0.1452) |
| Russia | -0.8252*** | (0.1846) |
| France | 0.4353** | (0.1444) |
| *Link's characteristics* | | |
| Share of oil paintings | 3.8206*** | (0.8498) |
| Share of watercolors | -25.5104*** | (2.1668) |
| Share of drawings | 4.6402*** | (0.5863) |
| Share of sculptures | 31.6601*** | (3.4135) |
| Share of signed | -4.2900*** | (1.0503) |
| Share of 2008 | -4.8166* | (2.4015) |
| Share of 2009 | 5.5946 | (3.5738) |
| Share of 2010 | 3.7339 | (2.3060) |
| Share of London | 2.7894*** | (0.7378) |
| Share of New York | 0.0581 | (0.5187) |
| Share of Paris | -2.7023* | (1.0609) |
| Germany | -1.6585** | (0.5258) |
| USA | 3.1815*** | (0.4670) |
| Russia | 2.4603*** | (0.4056) |
| France | -0.7833$^{\bullet}$ | (0.4134) |

*** - p-value $< 0.001$, ** - p-value $< 0.01$, * - p-value $< 0.05$, $^{\bullet}$ - p-value $< 0.1$

Table 7: Results for the full sample, max and min EP

| | HT, Max | St.errors | HT, Min | St.errors |
|---|---|---|---|---|
| Constant | 6.0498*** | (0.5291) | 5.5607*** | (0.5127) |
| Av.log price of friends' works | **0.2582*** ** | (0.0589) | **0.2824*** ** | (0.0592) |
| *Work's characteristics* | | | | |
| Oil painting | 1.9814*** | (0.0482) | 1.9850*** | (0.0483) |
| Watercolor | 0.7853*** | (0.0793) | 0.7773*** | (0.0794) |
| Drawings | 0.1147*** | (0.0181) | 0.1197*** | (0.0181) |
| Sculpture | 0.3649*** | (0.0889) | 0.3701*** | (0.0891) |
| Signed | -0.0027 | (0.0352) | 0.0024 | (0.0352) |
| *Sale's characteristics* | | | | |
| 2008 | 0.4159*** | (0.0917) | 0.4128*** | (0.0919) |
| 2009 | 0.3286** | (0.1228) | 0.3394** | (0.1230) |
| 2010 | 0.3367*** | (0.0956) | 0.3394*** | (0.0958) |
| London | 1.0497*** | (0.0520) | 1.0589*** | (0.0521) |
| New York | 1.3784*** | (0.0514) | 1.3771*** | (0.0514) |
| Paris | 1.0408*** | (0.0728) | 1.0752*** | (0.0729) |
| *Artist's characteristics* | | | | |
| Germany | 0.8262*** | (0.1633) | 0.8128*** | (0.1638) |
| USA | 0.0364 | (0.1032) | 0.0343 | (0.1036) |
| Russia | -0.2953* | (0.1184) | -0.2973* | (0.1188) |
| France | -0.0302 | (0.1039) | -0.0378 | (0.1043) |
| *Link's characteristics* | | | | |
| Share of oil paintings | 3.8181*** | (0.6082) | 3.7477*** | (0.6090) |
| Share of watercolors | -8.6305*** | (1.4906) | -8.3245*** | (1.4927) |
| Share of drawings | 2.7959*** | (0.4001) | 2.7872*** | (0.4008) |
| Share of sculptures | 18.9193*** | (2.4763) | 19.0783*** | (2.4806) |
| Share of signed | -5.2945*** | (0.8565) | -5.3716*** | (0.8569) |
| Share of 2008 | 2.0565 | (1.8858) | 1.9166 | (1.8880) |
| Share of 2009 | 4.2149 | (2.9067) | 3.7798 | (2.9115) |
| Share of 2010 | -0.4010 | (1.9024) | -0.3303 | (1.9047) |
| Share of London | -2.1043*** | (0.2902) | -2.2078*** | (0.2910) |
| Share of New York | -0.9220* | (0.4685) | -1.0074* | (0.4684) |
| Share of Paris | -0.1922 | (0.7501) | -0.3167 | (0.7512) |
| Germany | -1.2763*** | (0.3550) | -1.2084*** | (0.3562) |
| USA | 0.4926$^{\bullet}$ | (0.2791) | 0.4820$^{\bullet}$ | (0.2797) |
| Russia | 0.2748 | (0.2677) | 0.3010 | (0.2683) |
| France | 0.3970 | (0.2437) | 0.4625$^{\bullet}$ | (0.2446) |

*** - p-value $< 0.001$, ** - p-value $< 0.01$, * - p-value $< 0.05$, $^{\bullet}$ - p-value $< 0.1$

Table 8: Probability of the lot to be sold

| | HT coefficient | St.errors |
|---|---|---|
| Constant | 0.7068*** | (0.0616) |
| Share of friends' sold lots | **-0.1132** | (0.1954) |
| *Work's characteristics* | | |
| Oil painting | -0.0262* | (0.0125) |
| Watercolor | -0.0169 | (0.0202) |
| Drawings | -0.0203*** | (0.0046) |
| Sculpture | 0.0028 | (0.0227) |
| Signed | 0.0544*** | (0.0090) |
| *Sale's characteristics* | | |
| 2008 | -0.0743** | (0.0231) |
| 2009 | 0.1026*** | (0.0311) |
| 2010 | 0.1561*** | (0.0242) |
| London | 0.0171 | (0.0133) |
| New York | -0.0123 | (0.0131) |
| Paris | 0.0667*** | (0.0184) |
| *Artist's characteristics* | | |
| Germany | 0.0930* | (0.0383) |
| USA | 0.0396 | (0.0247) |
| Russia | -0.0949*** | (0.0273) |
| France | 0.0368 | (0.0245) |
| *Link's characteristics* | | |
| Share of oil paintings | 0.5299** | (0.1661) |
| Share of watercolors | -1.0326** | (0.3779) |
| Share of drawings | 0.1310 | (0.1078) |
| Share of sculptures | 0.5539 | (0.6039) |
| Share of signed | -0.1355 | (0.2121) |
| Share of 2008 | -2.2870*** | (0.4808) |
| Share of 2009 | 2.4864*** | (0.7361) |
| Share of 2010 | 0.1707 | (0.4761) |
| Share of London | 0.1982 | (0.1370) |
| Share of New York | -0.0133 | (0.1441) |
| Share of Paris | -0.2351 | (0.2116) |
| Germany | -0.2189** | (0.0843) |
| USA | 0.2395*** | (0.0605) |
| Russia | 0.1925** | (0.0696) |
| France | -0.1078$^{\bullet}$ | (0.0572) |

*** - p-value $< 0.001$, ** - p-value $< 0.01$, * - p-value $< 0.05$, $^{\bullet}$ - p-value $< 0.1$

Table 9: Results for the sample without Picasso on the LHS

| | All sold | St.errors | Sold after 2003 | St.errors |
|---|---|---|---|---|
| Constant | 3.8993*** | (0.5719) | -0.4896 | (0.9530) |
| Av.log price of friends' works | **0.4597*** ** | (0.0517) | **0.6231*** ** | (0.0744) |
| *Work's characteristics* | | | | |
| Oil painting | 1.0888*** | (0.0793) | 1.1756*** | (0.0824) |
| Watercolor | 0.8341*** | (0.1138) | 0.7206*** | (0.1147) |
| Drawings | -0.2806*** | (0.0347) | -0.2396*** | (0.0359) |
| Sculpture | -0.0498 | (0.1353) | -0.0435 | (0.1373) |
| Signed | 0.3694*** | (0.0713) | 0.3752*** | (0.0733) |
| *Sale's characteristics* | | | | |
| 2008 | 0.1245 | (0.1582) | 0.1468 | (0.1555) |
| 2009 | -0.1371 | (0.2076) | -0.0069 | (0.2077) |
| 2010 | 0.0149 | (0.1619) | 0.0171 | (0.1646) |
| London | 1.3951*** | (0.1072) | 1.5571*** | (0.1337) |
| New York | 1.5996*** | (0.1088) | 1.5325*** | (0.1340) |
| Paris | 1.2554*** | (0.1391) | 1.4067*** | (0.1564) |
| *Artist's characteristics* | | | | |
| Germany | 0.8059*** | (0.2071) | 0.1638 | (0.2493) |
| USA | 0.2239$^{\bullet}$ | (0.1309) | -0.0893 | (0.1517) |
| Russia | -0.7599*** | (0.1652) | -1.1390*** | (0.2015) |
| France | 0.1608 | (0.1376) | 0.3179* | (0.1589) |
| *Link's characteristics* | | | | |
| Share of oil paintings | 0.2319*** | (1.0877) | 4.4027*** | (1.2365) |
| Share of watercolors | -18.3184*** | (2.1469) | -27.8025*** | (2.6108) |
| Share of drawings | 2.9076*** | (0.5231) | 4.3018*** | (0.6445) |
| Share of sculptures | 17.3978*** | (3.5088) | 26.1035*** | (4.0578) |
| Share of signed | -0.8457 | (1.2234) | -3.4278** | (1.2584) |
| Share of 2008 | 6.3985* | (2.9183) | 0.3624 | (2.9536) |
| Share of 2009 | -2.9528 | (4.9374) | 2.2323 | (5.1334) |
| Share of 2010 | -1.9334 | (2.8878) | -4.7293 | (3.0562) |
| Share of London | -1.6651*** | (0.3790) | 4.5658*** | (0.8390) |
| Share of New York | -2.9554*** | (0.4663) | 0.3661 | (0.5765) |
| Share of Paris | 1.1411 | (1.1435) | 4.3993** | (1.4047) |
| Germany | -1.8619*** | (0.4344) | -2.0329*** | (0.5552) |
| USA | 2.3924*** | (0.3662) | 3.2146*** | (0.5130) |
| Russia | 1.2149** | (0.3773) | 2.2288*** | (0.4432) |
| France | -0.5185 | (0.3211) | -2.5326*** | (0.4727) |

*** - p-value $< 0.001$, ** - p-value $< 0.01$, * - p-value $< 0.05$

Table 10: Results for the sample without Picasso on the LHS, estimated prices

| | Max EP | St.errors | Min EP | St.errors |
|---|---|---|---|---|
| Constant | 3.9348*** | (0.6183) | 3.4616*** | (0.5999) |
| Av.log price of friends' works | **0.5645*** ** | (0.0698) | **0.6000*** ** | (0.0702) |
| *Work's characteristics* | | | | |
| Oil painting | 1.2587*** | (0.0620) | 1.2581*** | (0.0622) |
| Watercolor | 0.7065*** | (0.0880) | 0.7040*** | (0.0882) |
| Drawings | -0.2172*** | (0.0266) | -0.2195*** | (0.0266) |
| Sculpture | -0.1063 | (0.1065) | -0.1028 | (0.1068) |
| Signed | 0.2528*** | (0.0551) | 0.2571*** | (0.0552) |
| *Sale's characteristics* | | | | |
| 2008 | 0.1022 | (0.1224) | 0.0912 | (0.1229) |
| 2009 | -0.3977* | (0.1652) | -0.4033* | (0.1657) |
| 2010 | -0.2697* | (0.1358) | -0.2692* | (0.1362) |
| London | 0.9875*** | (0.0792) | 0.9857*** | (0.0795) |
| New York | 1.3052*** | (0.0805) | 1.2858*** | (0.0808) |
| Paris | 0.8283*** | (0.1055) | 0.8326*** | (0.1058) |
| *Artist's characteristics* | | | | |
| Germany | 0.7993*** | (0.1649) | 0.7809*** | (0.1656) |
| USA | -0.0663 | (0.1054) | -0.0622 | (0.1060) |
| Russia | -0.4160*** | (0.1230) | -0.4144*** | (0.1235) |
| France | -0.0661 | (0.1080) | -0.0778 | (0.1084) |
| *Link's characteristics* | | | | |
| Share of oil paintings | 2.6990*** | (0.7983) | 2.5530** | (0.8010) |
| Share of watercolors | -10.1409*** | (1.6409) | -9.9890*** | (1.6460) |
| Share of drawings | 3.2245*** | (0.4131) | 3.1785*** | (0.4145) |
| Share of sculptures | 19.4740*** | (2.8037) | 19.5856*** | (4.0578) |
| Share of signed | -5.7133*** | (0.9301) | -5.7064*** | (0.9322) |
| Share of 2008 | 10.4938*** | (2.2149) | 10.5450*** | (2.2218) |
| Share of 2009 | 1.3098 | (3.8174) | 1.2472 | (3.8288) |
| Share of 2010 | -7.9089*** | (2.3057) | -8.1817*** | (2.3117) |
| Share of London | -1.9985*** | (0.3118) | -2.0970*** | (0.3126) |
| Share of New York | -2.5320*** | (0.4928) | -2.6480*** | (0.4926) |
| Share of Paris | 3.1677*** | (0.8834) | 3.1899*** | (0.8859) |
| Germany | -1.5540*** | (0.3570) | -1.4986*** | (0.3587) |
| USA | 1.2207*** | (0.2923) | 1.2325*** | (0.2930) |
| Russia | -0.3242 | (0.2860) | -0.3139 | (0.2872) |
| France | -0.4941 | (0.2549) | -0.4637 | (0.2564) |

*** - p-value $< 0.001$, ** - p-value $< 0.01$, * - p-value $< 0.05$

Table 11: Probability of the lot to be sold, no Picasso

| | HT coefficient | St.errors |
|---|---|---|
| Constant | 0.5946*** | (0.0733) |
| Share of friends' sold lots | **0.3069** | (0.2573) |
| *Work's characteristics* | | |
| Oil painting | -0.0052 | (0.0177) |
| Watercolor | -0.0017 | (0.0250) |
| Drawings | -0.0066 | (0.0076) |
| Sculpture | 0.0205 | (0.0302) |
| Signed | 0.0522*** | (0.0156) |
| *Sale's characteristics* | | |
| 2008 | -0.0067 | (0.0334) |
| 2009 | 0.1249** | (0.0454) |
| 2010 | 0.2206*** | (0.0376) |
| London | 0.0174 | (0.0219) |
| New York | 0.0247 | (0.0222) |
| Paris | 0.1166*** | (0.0289) |
| *Artist's characteristics* | | |
| Germany | 0.0029 | (0.0383) |
| USA | 0.0575* | (0.0256) |
| Russia | -0.0432 | (0.0291) |
| France | -0.0242 | (0.0256) |
| *Link's characteristics* | | |
| Share of oil paintings | -0.3767 | (0.2720) |
| Share of watercolors | -1.2597** | (0.4482) |
| Share of drawings | -0.0650 | (0.1218) |
| Share of sculptures | -0.8938 | (0.7336) |
| Share of signed | 0.5914* | (0.2629) |
| Share of 2008 | -1.3261* | (0.621) |
| Share of 2009 | 1.3954 | (1.0481) |
| Share of 2010 | 0.3024 | (0.6252) |
| Share of London | -0.0599 | (0.1782) |
| Share of New York | -0.2157 | (0.1820) |
| Share of Paris | -0.2706 | (0.2706) |
| Germany | -0.1202 | (0.0854) |
| USA | 0.1699** | (0.0647) |
| Russia | 0.1175 | (0.0732) |
| France | -0.0455 | (0.0608) |

*** - p-value $< 0.001$, ** - p-value $< 0.01$, * - p-value $< 0.05$, $^\bullet$ - p-value $< 0.1$

## Appendix. Additional figures

Table A.1: Artists in the sample

| Name | Years | Main mode | Country born/active | Group belonging |
|---|---|---|---|---|
| Josef Albers | 1888-1976 | Paintings | Germany/ USA | - |
| Guillaume Apollinaire (not incl.) | 1880-1918 | Art critic | Poland, Italy/ France | - |
| Hans Arp | 1886-1966 | Sculpture | Germany, France | Der Blaue Reiter |
| Lawrence Atkinson | 1873-1931 | Paintings (graphical) | England | - |
| Giacomo Balla | 1871-1958 | Paintings | Italy | - |
| Vanessa Bell | 1879-1961 | Paintings | England | Bloomsbury group |
| Henryk Berlewi | 1894-1967 | Paintings | Poland/ Germany, France | - |
| Umberto Boccioni | 1882-1916 | Paintings (Sculpture) | Italy | - |
| David Bomberg | 1890-1957 | Paintings | England | Whitechapel Boys |
| Anton Giulio Bragaglia | 1890-1960 | Photography | Italy | - |
| Constantin Brancusi | 1876-1957 | Sculpture | Romania/ France | - |
| Patrick Henry Bruce | 1881-1936 | Paintings | USA | - |
| Francesco Cangiullo | 1884-1977 | Paintings | Italy | - |
| Carlo Carra | 1881-1966 | Paintings | Italy | - |
| Blaise Cendrars (not incl.) | 1887-1961 | Writer | Switzerland/ France | - |
| Alvin Langdon Coburn | 1882-1966 | Photography | USA | Linked Ring |
| Claude Debussy (not incl.) | 1862-1918 | Composer | France | - |
| Robert Delaunay | 1885-1941 | Paintings | France/ Spain, France | Der Blaue Reiter, Puteaux Group |
| Sonia Delaunay-Terk | 1885-1979 | Paintings | Ukraine/ Spain, France | - |
| Fortunato Depero | 1892-1960 | Paintings (Sculpture) | Italy/ Italy, USA | - |
| Theo van Doesburg | 1883-1931 | Paintings | The Netherlands | De Stijl |
| Arthur Dove | 1880-1946 | Paintings | USA | - |

| | | | | |
|---|---|---|---|---|
| Marcel Duchamp | 1887-1968 | Paintings (Sculpture) | France/ France, USA | Societe Anonyme, Puteaux Group |
| Suzanne Duchamp | 1889-1963 | Paintings | France | - |
| Viking Eggeling | 1880-1925 | Various media | Sweden/ Germany | Das Neue Leben, Novembergruppe |
| Kseniia Ender | 1894-1955 | Paintings | Russia | - |
| Henri Gaudier-Brzeska | 1891-1915 | Sculpture | France/ France, England | - |
| Augusto Giacometti | 1877-1947 | Paintings | Switzerland/ Switzerland, Italy | - |
| Natalia Goncharova | 1881-1962 | Paintings | Russia/ Russia, France | Puteaux Group, Donkey's Tail |
| Duncan Grant | 1885-1978 | Paintings | England | Bloomsbury Group |
| Marsden Hartley | 1877-1943 | Paintings | USA/ USA, Germany | - |
| Vilmos Huszar | 1884-1960 | Paintings | Hungary/ The Netherlands | De Stijl |
| Vasily Kandinsky | 1866-1944 | Paintings | Russia/ Russia, Germany | Der Blaue Reiter |
| Paul Klee | 1879-1940 | Paintings | Switzerland/ Germany, Switzerland | Der Blaue Reiter |
| Ivan Kliun | 1873-1943 | Sculpture | Russia | Union of Youth, Supremus |
| Gustav Klutsis | 1895-1938 | Photography | Latvia/ Latvia, Russia | - |
| Katarzyna Kobro | 1898-1951 | Sculpture | Russia/ Russia, Poland | - |
| Aleksei Kruchenykh (not incl.) | 1886-1968 | Poet | Russia | - |
| Frantisek Kupka | 1871-1957 | Paintings (Graphics) | The Czech Republic/ France | Puteaux Group |
| Rudolph von Laban (not incl.) | 1879-1958 | Dancer | Hungary/ Germany, Switzerland | - |

| | | | | |
|---|---|---|---|---|
| Mikhail Larionov | 1881-1964 | Paintings | Russia/ Russia, France | Jack of Diamonds, Donkey's Tail |
| Fernand Leger | 1881-1955 | Paintings | France | Puteaux Group |
| Wyndham Lewis | 1882-1957 | Paintings | Canada/ England | - |
| El Lissitzky | 1890-1941 | Graphics (Photography) | Russia/ Russia, Germany | UNOVIS |
| Stanton Macdonald-Wright | 1890-1973 | Paintings | USA | Synchromism |
| August Macke | 1887-1914 | Paintings | Germany | Der Blaue Reiter |
| Kazimir Malevich | 1878-1935 | Paintings | Russia | Union of Youth, Supremus, UNOVIS, Donkey's Tail |
| Franz Marc | 1880-1916 | Paintings (Printmaker) | Germany | Der Blaue Reiter |
| Filippo Tommaso Marinetti (not incl.) | 1876-1944 | Poet | Italy/ Italy, France | - |
| Mikhail Matiushin | 1861-1934 | Paintings | Russia | Union of Youth |
| Laszlo Moholy-Nagy | 1895-1946 | Photography (various media) | Hungary/ Germany, England, USA | - |
| Piet Mondrian | 1972-1944 | Paintings | The Netherlands/ France, The Netherlands | De Stijl |
| Vaslav Nijinsky (not incl.) | 1889-1950 | Dancer | Russia/ France, Russia | - |
| Georgia O'Keeffe | 1887-1986 | Paintings | USA | 291 Gallery |
| Emilio Pettoruti | 1892-1971 | Paintings (Drawings) | Argentina/ Italy, Argentina | - |
| Francis Picabia | 1879-1953 | Paintings | France/ France, USA, Spain | Puteaux Group |
| Pablo Picasso | 1881-1973 | Paintings (Sculpture) | Spain/ France, Spain | - |
| Liubov Popova | 1889-1924 | Paintings | Russia/ Russia, France | Knave of Diamonds, Supremus |
| Man Ray | 1890-1976 | Photography (Various media) | USA/ USA, France | - |
| Hans Richter | 1888-1976 | Paintings (Filmmaker) | Germany/ Germany, Switzerland, USA | Artistes Radicaux |

| | | | | |
|---|---|---|---|---|
| Aleksandr Rodchenko | 1891-1956 | Photography (Sculpture) | Russia | October Circle |
| Morgan Russel | 1886-1953 | Paintings | USA/ USA, France | Synchromism |
| Luigi Russolo | 1885-1947 | Paintings (Composer) | Italy/ Italy, Argentina | - |
| Helen Saunders | 1885-1963 | Paintings | England | - |
| Christian Schad | 1894-1982 | Paintings | Germany/ Germany, Switzerland, Italy | - |
| Morton Livingston Schamberg | 1881-1918 | Paintings (Photography) | USA | Societe Anonyme |
| Arnold Schoenberg (not incl.) | 1874-1951 | Composer | Austria/ Germany | Der Blaue Reiter |
| Kurt Schwitters | 1887-1948 | Various media | Germany | - |
| Gino Severini | 1883-1966 | Paintings | Italy/ Italy, France | - |
| Ardengo Soffici | 1879-1964 | Paintings (Writer) | Italy/ Italy, France | - |
| Joseph Stella | 1877-1946 | Paintings | Italy/ USA, France, Italy | - |
| Alfred Stieglitz | 1864-1946 | Photography | USA | 291 Gallery |
| Paul Strand | 1890-1976 | Photography | USA | 291 Gallery |
| Wladyslaw Strzeminski | 1893-1953 | Paintings | Poland/ Russia | Blok |
| Leopold Survage | 1879-1968 | Paintings | Russia/ France | - |
| Waclaw Szpakowski | 1883-1973 | Graphics | Poland | - |
| Sophie Taeuber-Arp | 1889-1943 | Paintings (Graphics) | Switzerland | Cercle el Carre |
| Vladimir Tatlin | 1885-1953 | Paintings (Architecture) | Russia | Union of Youth |
| Tristan Tzara (not incl.) | 1896-1963 | Poet | Romania/ Romania, Switzerland, France | - |
| Georges Vantongerloo | 1886-1965 | Sculpture | Belgium/ The Netherlands, France | De Stijl |
| Edgar Varese (not incl.) | 1883-1965 | Composer | France/ Germany, USA | - |
| Max Weber | 1881-1961 | Paintings | Russia/ USA | - |
| Mary Wigman (not incl.) | 1886-1973 | Dancer | Germany/ Germany, Switzerland | - |