Creative production and peer effects: evidence from the exodus of superstar painters from Paris *

Christiane Hellmanzik†
Department of Economics,
University of Hamburg

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Abstract

This paper presents evidence of peer effects in creative production using an IV estimation based on the exodus of artists from Paris due to the Second World War. If proximity of peers matters for the distribution of artistic knowledge and the production of high quality art, it can be expected that the departure of high quality peers from Paris has an impact on the value of artworks produced by artists who remain in Paris. The study is based on a global sample of 273 'superstars' of modern art born between 1800 and 1945. For this sample peer quality is measured using 34,141 auction results of paintings made by these artists and a historiometric measure of their prominence. The findings of this quasi-experiment confirm the OLS result that there are significant localised peer effects. That is, a higher quality peer group has a significant, positive impact on the quality of artworks produced by modern artists. This result is robust across different measures of peer quality.

Keywords: Peer effects, economic geography, migration, creativity, modern artists, human capital

JEL Classification: J61, R39, N90, Z11

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†University of Hamburg, Department of Economics, von-Melle-Park 5, 20146 Hamburg, Germany. E-mail: christiane.hellmanzik@wiso.uni-hamburg.de

1 Introduction

Silicon valley is the centre for software production, Hollywood is the centre for films, and Venice was the capital of glass. Similarly, Paris was the centre of modern art in the late 19th and early 20th century having hosted such luminaries as Pablo Picasso, Salvador Dalí, and Vincent van Gogh. Paris was where innovations took place and where the first abstract paintings and collages were famously created. One of the reasons for the existence of such agglomerates in creative production - next to the numerous economies of scale in the production process - is the likelihood of being able to work where the best in the field are located. There are two advantages of being amongst peers: first, collaborations with peers might have a positive effect on one's own productivity. Second, the competition of peers is a source of motivation and thereby increases productivity. In the case of Paris physical proximity to peers is arguably the most efficient channel through which artists were able to benefit from each other as communication would have been extremely difficult and untimely otherwise. This paper analyses such historic peer effects using a sample of important visual artists in the creative cluster of Paris.

This paper contributes to the literature on peer effects by using a historic, high-frequency dataset on the value of modern art products and locational indicators for the quality of peers with focus on the artistic cluster of Paris. Paris makes for a particularly interesting case as 42.4% of all paintings in the sample were produced there and it was the birth place of abstraction and ultimately of modern art. For example, art history gives detailed account of how Pablo Picasso and George Braque working together and exchanging ideas resulted in Cubism.

The role of peer effects and associated human capital spillovers in creative production has received growing interest in the last years. This paper links peers by their common work location. The effect is assessed in an OLS as well as in an IV setting using the Second World War as an exogenous shock to the composition of local peers. The exodus of artists caused by the onset of the Second World War - 31% of artists in the sample living in Paris in 1938 left the city between 1939 and 1945 - serves as such an external shock to the composition of the Parisian peer group. Paris is a particularly interesting case as it is one of the few outstanding agglomerates of creative production and the Second World War provides a unique, extreme shock to the quality of the peer group. Furthermore, many of the artists leaving Paris were leading figures of the Parisian art scene, such as Salvador Dalí and Piet Mondrian, and often were members of frequently interacting, well-established artistic groups. Using such a quasi-natural experiment, a clean, causal link between the quality of an artist's output and the quality of their peers can be established.

The key finding of this paper is that artists producing paintings in Paris and therefore benefiting from a dense high-quality peer group produce systematically higher priced paintings than artists working elsewhere. This effect is driven by the quality of peers as measured by various indicators, such as yearly prices yielded at auction and a historiometric prominence indicator. These OLS findings are confirmed using WWII as a natural experiment, showing that the exodus of artists from Paris indeed implies a significant decrease in the quality of art work produced by artists who stay in Paris. The finding is robust to using the various measures of peer quality.

The analysis is based on an extensive dataset encompassing auction results of a sample of superstars of modern visual art who were active between 1820 and 2007. Artists are sampled based on a prominence indicator and each artist in each year of their career is uniquely identified with one work location (see Section 2 for details). The resulting superstar sample of modern arts is matched with prices of artists' paintings yielded in modern art auctions between 1988 to 2007. These auction data are used as a measure for the value of paintings executed during the sample period. The main advantage of using these auction results is that they provide a yearly productivity measure with high frequency and over a long time period for each artist. Based on these records, yearly peer quality in a location can be calculated.

The impact of peer effects has been the focus of an emerging literature, much of which centers on scientists. This paper builds on the empirical methods of this area of research. Most importantly, Waldinger (2009) who uses the dismissal of scientists in Nazi Germany to assess peer effects. He does not find evidence for localised or departmental peer effects, however, he finds strong evidence of peer effects among co-authors. This paper uses the same identification strategy as Waldinger (2009) for the IV estimation. Moreover, Azoulay et al. (2008) find positive spillover effects for life scientists, which they attribute to 'proximity in ideas space, but not in physical or social space'. Kim et al. (2006) find a positive effect of elite university affiliation on research productivity of economics and finance researchers. However, the effect weakens with the rise of the internet revolution which renders physical location externalities less powerful. In addition, Storper and Venables (2004) stress the importance of face-to-face interaction for creative activities in an urban environment.

Furthermore, several researchers have used econometric techniques as well as economic explanations to analyse creative production and artistic careers. Most notably, Galenson and Weinberg (2000, 2001) show that painters of later cohorts peak earlier in their lives for a Parisian and New Yorker sample, respectively. They attribute this shift to different

innovation methods.[1] Also for a sample of visual artists, Hellmanzik (2010) shows that art works produced in artistic clusters benefit from peer effects - driven by peer quality - and hence are more valuable. Hellmanzik (2010) measures peer quality by a time-invariant bibliographic measure of an artist's importance in an OLS setting.

This paper establishes the existence of peer effects for paintings produced in Paris over a longer time span (for artists born between 1800 and 1949) and uses three different measures of peer quality. Moreover, it provides clean evidence for the existence of peer effects using a subset of artists active in Paris before and during World War II. Although, this subsample is much smaller, the great advantage is that Paris experiences an exogenous shock to the peer group and thus provides a good setting for testing the role of peer effects in creative production. In essence, this paper combines the two strands of literature by using the methodology of the aforementioned literature on scientists and the literature on creative production.

The paper is organised as follows. Section two briefly describes the dataset and presents some first insights from summary statistics. In Section three, the empirical evidence is discussed, firstly, based on OLS for the full sample, secondly, using WWII as a natural experiment for a Parisian subsample. The last section concludes.

2 Data and sample characteristics

In order to analyse peer effects among important modern artists active in the centre of Paris, I compile an extensive historic dataset which expands considerably on other papers on artistic production in terms of the time period and sample width covered.[2] The dataset used in this paper combines three dimensions: the artist, the painting, and artists' changing work locations. It encompasses a sample of the 273 most important visual artists worldwide who were born between 1800 and 1945, and roughly 35,000 paintings auctioned between 1988 and 2007 by these artists. Modern day auction results are used to measure the value of paintings made by the superstar sample in the respective countries and years covered in this study. This is matched with the work location of each artist in the sample for each year of their careers obtained from biographical sources. Artists in the sample were active in 31 countries between 1820 and 2007 with a marked concentration of artistic activity in Paris as reflected by the fact that 42.4% of all paintings in the sample were

[1] Similar work on scientists and the role of age in producing innovations over the life cycle has been undertaken by Jones (2010).

[2] Such as Hellmanzik (2010), Hodgson (2007), or Galenson and Weinberg (2000, 2001).

produced by Parisian artists.[3] The different data dimensions will be introduced in turn.

2.1 Superstar sample

The sampling of superstars in the profession under consideration is standard in the literature on human capital externalities. See for example, Azoulay et al. (2010), Kim et al. (2009), or Waldinger (2009). In general, there are two main reasons for superstar sampling: firstly, superstars are the drivers of innovation in their field and thus it is arguably more interesting to study their careers than those of lesser known creative minds. From a more practical point of view it is also easier to obtain accurate data for the sample of superstars than for less eminent artists.

The sampling technique for artists is based on a historiometric measure as discussed in Kelly and O'Hagan (2005). The space dedicated to each artist in terms of columns and inches in the *Oxford Dictionary of Art: New Edition* (1997) is used to rank artists by importance and the sample-entry cut-off point is a minimum of 0.2 column-inches.[4] In this fashion, the superstars of modern art can be ranked according to their importance: Vincent van Gogh for example has 2.2 column-inches, Andy Warhol 1.45, and Pablo Picasso 3.0, the highest number in the sample.[5]

2.2 Matching superstars with work locations

Every artist in the superstar sample is uniquely matched to a work location in each year of his/her career. For this purpose, data on artists' residence were collected based on entries in the *Grove Dictionary of Art: Online* (2007). If an artist worked in more than one place in a given year, the one where he or she spent more time during the calendar year was deemed to be the artist's country of residence in that year. If an artist traveled or worked somewhere else on a temporary basis during a given year, this did not influence the work location in that year. However, if what had been intended to be a temporary work location became permanent, the temporary work location is coded to be the new work location for all years the artist has worked in his/her new place of residence.

[3]New York is, of course, the other big centre of modern arts as shown in Hellmanzik (2010). Given that this paper uses the Second World War as a natural experiment to capture peer effects, New York is not considered as the city lacks such an exogenous event in its history.

[4]A potential bias toward English artists is handled by cross comparison with *Reclam's Kuenstlerlexikon* (2002), so only those artists from the British Isles and the USA are included that had an entry in both dictionaries.

[5]Vincent van Gogh's 2.2 column-inches, for example, indicate that 2 full columns and 2 inches of page space are devoted to his career.

There is a clear concentration of artists in Paris with 45.1% of the sample having lived in Paris at some point during their careers. The residential pattern over time for Paris is depicted in Figures 1 and 5, respectively. The Parisian artistic crowd reaches a peak in terms of numbers in 1930 after a constant increase during the years before that. This peak comes after a chain of innovations such as Impressionism, Cubism, and others.

2.3 Auction data on paintings

To measure the productivity of artists I use prices yielded at modern day art auctions for paintings by the sample of artists. Auction results on paintings sold between 1988 and 2007 by this sample of artists were collected from *artvalue.com* (2010);[6] all prices are in real US dollars and are hammer prices adjusted using the US CPI retrieved from the IMF's *International Financial Statistics*. In addition, several control variables were obtained: the size, support, and medium of the painting, the year in which the painting was made, whether or not the painting was signed by the artist, and if the painting was auctioned at either Christie's or Sotheby's. In the final dataset, each painting can be uniquely identified in terms of the artist who made it, his or her age at the time of production, location and year in which it was painted, and its value at auction today. Moreover, it is important to note that any vintage effects or market fads do not affect the results presented below as all estimations include sale year fixed effects.[7] These auction results are used as a measure for artists' yearly productivity.

2.4 Quality of peers

In order to estimate the quality of the Parisian peer group three measures of locational peer quality are employed: the column-inch measure used as the sample entry criterion and the average and median price of all paintings made in that year minus the ones by the artist considered. All three measures are particularly high around the time of major innovations (see Figures 2, 3, and 4), for example around the turn of the 19th and 20th century for Paris.[8] The peak in the quality of the peer group coincides with high density

[6] Only artists with a minimum of 10 auctioned paintings were considered.

[7] The dataset was collected in two waves. All auction data of the sample of artists born between 1850 and 1945 cover sale years up to and including the year 2007. The second wave of artists (born between 1800 and 1849) was collected in 2010 and thus sale data encompass the year 2010. It was thoroughly tested whether excluding paintings sold after 2007 (amounting to 684 paintings), which might create a potential imbalance in sales data, changes the findings of this paper. However, the findings remain valid when the analysis is based on paintings which were sold between 1988 and 2007 only.

[8] The correlation between the column-inch measure and average and median prices amounts to 59% and 77%, respectively. The correlation between the two price measures is 80%.

of peers suggesting that it is a critical mass of brilliant creative minds concentrated in a place which serves as an ideal breeding ground for innovation. Each measure and the implicit assumptions they are based on are:

1. *Career column-inches* refers to the columns and inches dedicated to each artist in the Oxford Dictionary of Art (2008). It is a bibliometric, art-historic measure based on expert opinions of the portfolio of an artist in most cases appraised long after their deaths. It is constructed to equal the average column-inches of all artists resident in each location in a given year minus the score of the one considered. That is, it measures the aggregate human capital available to each artist in Paris in each year of the sample. The main advantage of this measure is that it is independent of market prices and thus it captures artistic quality on a somewhat wider trajectory than market price - given that experts base their verdict on more than prices fetched.[9] As each artist only caries one value over his/her entire career the variable is time-invariant. This implies that someone like Pablo Picasso always has the same impact on his/her colleagues in every year in which he lives in Paris despite his own career fluctuations. That is, the channel through which an artist impacts his colleagues is his latent genius rather than the contribution of individual ideas and concepts.

2. *Average prices* refer to the yearly average price of paintings produced by each artist in the sample. The measure of peer quality is constructed to be the average of all artists working in Paris in a given year. Using yearly average prices implicitly assumes that the effect of having, say, Picasso as a peer changes over time depending on the stage of Picasso's career cycle and therefore the quality of Picasso's paintings. That is, in a particularly good year in terms of artistic output the measure will be higher than in relatively weaker years. This variable therefore is expected to do a better job at capturing the role of breakthrough innovations which are often started by a single masterpiece or a sequence of innovative paintings, such as Cubist paintings by Picasso and his colleagues.

3. *Median prices* refer to the yearly median price of works made by each artist in each year. The same considerations as for average prices apply while extreme outliers are less likely to affect the estimation.

[9]This question is discussed by Ginsburgh (2003) and Galenson (2002), for example.

3 Using the exodus of artists from Paris as an instrument for the quality of peers

Several events in the context of the Second World War prompted artists to leave Paris in particular and continental Europe more generally. The Nazi party coming into power in 1933 and subsequently deeming art which was to their dislike degenerate (*entartet*) was the first indication of looming trouble for artists. Most artists whose work was displayed in the original 'degenerate show' in Munich in 1937 worked in Germany, but out of my sample, works by Marc Chagall and Piet Mondrian - who both left Paris in 1940 - were among those works by foreign artists shown in the exhibition. In 1939 physical threat came on top of the latent moral censorship when Nazi Germany attacked Poland on September 1, 1939 and in response, France and the UK declared war on Germany two days later. Only eight months later Germany invaded France and Paris was occupied on June 14, 1940. Another important symbolic attack on artists was the bonfire on the night of July 27, 1942 when the Nazi occupiers burned paintings by Picasso, Dalí, Ernst, Klee, Léger, and Miró. Out of these artists, Dalí, Léger and Miró had left Paris in 1940 or 1941, respectively.

In total 12 artists left Paris between 1939 and 1945 which is equivalent to 27% of the Parisian sample at the time. Figures 1 and 5 show that during the time of Wold War II the artistic population of Paris shrunk considerably. It is important to notice that artists who left Paris did so between 1939 and 1942 - soon after the onset of actual warfare and at the latest during the year of the infamous bonfire. Table 2 gives a detailed overview of the emigrating artists. The biographies of all of these artists suggest that they were long-standing, established Parisians who were integrated in the art scene and whose lives and careers do not indicate that leaving Paris was anything but the result of the arriving Nazi threat.[10]

In addition, two of the artists in the sample died suddenly and unanticipatedly in 1944.[11] Although their deaths are unrelated to the Second World War, the timing coincides and in terms of the identification their death is also an exogenous shock to the Parisian peer group. This approach is also used by Azoulay et al. (2010) who base their

[10]For example, Yves Tanguy was born in Paris and had spent his entire life there and emigrated to the US due to the Second World War. S.W. Hayter went back to England as he was on the army's reserve list. And Marc Chagall, whose work was deemed 'degenerate ' by the Nazis already in 1937, fled Paris for Southern France from where he was rescued from the Nazis thanks to American efforts.

[11]These are M. Denis who died as a consequence of a car accident and C. Soutine who died of a stomach perforation.

entire identification on the death of one of a dyad of co-authors. Hence, I also use the deaths of these two painters in the instrumental estimation.

Moreover, Table 2 depicts the impact these leavers had on the quality of Parisian human capital and the value of their output. Collective artistic quality in Paris wanes markedly after 1938 (Figure 2, 3, and 4) and the exodus of artists results in considerably lower average quality of Parisian artists as measured by their column-inches. The impact on average prices, however, is less clear (Table 2).

In terms of the identification strategy it is important to note that all artists who left Paris did so for remote places, mostly to the USA. Thus, it can be assumed that the distance was sufficient to change the mode of communication and thereby the exchange of (tacit) knowledge considerably due to the disruption of personal communication. It is also worth noting that New York became the next destination for many of those who left Paris and the continent during those years; this is the case for 36% of former Parisians (leavers) in the sample.

Table 3 analyses the stayer and leaver sample of Parisian artists in more detail to ensure that the findings are not biased by some underlying pattern in either of these groups. On average, stayers and leavers are of the same age in the two years prior to World War II. Stayers produce more valuable paintings in terms of average prices, while leavers produce more valuable paintings in terms of median prices. Moreover, leavers have a higher average column-inch measure by about one inch of space in the dictionary. The estimation strategy is based on changes in productivity as measured by prices between stayers and leavers due to the outbreak of the Second World War.

Anecdotal evidence shows that this exodus of artists changed the Parisian work environment considerably and in many ways the Second World War was breaking up a successful group of creative minds. After emigration it was extremely difficult to maintain communication with artists and other intellectuals staying in Paris due to the lack of infrastructure on the continent. The aggregate number of emigrations from Paris hides the fact that some artists who were particularly important and established or relatively old were more likely to leave Paris, while relatively young art movements such as Art Informel had almost none of their artists leaving Paris. Another important factor in terms of our identification strategy is the fact that the pool of artists in Paris was not replenished by artists migrating to Paris.

4 Empirical analysis

4.1 OLS estimation

Using these data on modern artists' work locations and auction results, location and peer effects are estimated. Firstly, a pure location effect is estimated in order to assess whether the production location for modern art matters for its quality. However, as it is not clear per se that the location effect is solely driven by the quality of peers available, three direct measures of peer productivity are used. In this paper I only consider the quality of peers rather than the quantity as various papers show that peer effects in science (see for example Waldinger, 2009, and Azoulay et al., 2009) as well as the art (Hellmanzik, 2010) mainly work through the quality channel, which is also intuitively appealing.

In order to estimate the Parisian peer effect on artistic output, I use a hedonic estimation which allows all observations to be included as discussed by Ashenfelter and Graddy (2006). A hedonic regression framework is suitable as it implicitly prices observable value-adding characteristics of an artwork. However, when applying the hedonic framework to auction results of modern art, incorporating unobservables might be important. In addition to the observable features of a painting, like size and medium used, less tangible characteristics may impact its price. For example, Picasso's work may sell for more because of his unique, cubist style and international reputation. Traditionally, hedonic models would only use an artist fixed effect to account for these artist level unobservables. Due to the difficulty of obtaining data on artists' lives and working methods, this has only been a relatively recent development in the literature. In this paper we expand on this by including the quality of peers available to an artist in his/her work location.

Although there is no formal decision criterion for variables to include in a hedonic framework, the trend in the literature is to go beyond features observable at auction to include artists' characteristics as explanatory factors for prices yielded at art auctions.[12]

In the aforementioned studies the inclusion of those artist-specific characteristics in a hedonic framework yields consistent coefficients on the traditional hedonic estimators while at the same time provides new insights on the valuation of art works. In line with the recent literature, the same applies to this paper's analysis as shown in Table 4, column 1.

[12]For example, Reeneboog and Spaenjers (2009) use proxies for artistic reputation in order to explain prices at auction while Galenson and Weinberg (2000, 2001) use birth cohorts - interpreted as innovation methods - to explain price variations over artistic careers. Hellmanzik (2010) estimates the effect for modern artists of being located in New York and Paris - two clusters of the modern art - on auction prices and Hellmanzik (2012) analyses the impact of travel on auction results.

I employ a broad set of traditional hedonic variables and complement these by including Paris-specific indicators of peer quality. This paper focuses on Paris, as it is one of the most important clusters of modern art and paintings produced there sell at a premium in the market (Hellmanzik, 2010). One of the reasons for that could be the existence of human capital spillovers in Paris. Formally, the baseline specification is given by

$$\begin{aligned} ln\,(price)_{ij} = {} & \delta(peer\ quality\ Paris_{ij}) + \gamma_1 canvas_{ij} + \gamma_2 ln(size)_{ij} + \gamma_3 oil_{ij} + \gamma_4 signed_{ij} \\ & + \gamma_5 deceased_{ij} + \gamma_6 auction\ house_{ij} + [\beta_1 age_{ij} + \beta_2 age_{ij}^2 + \beta_3 age_{ij}^3 + \beta_4 age_{ij}^4] \\ & + \sum_{y=1988}^{2007} \theta_y(sale\ year_{ij} = y) + \alpha_i + e_{ij} \end{aligned} \tag{1}$$

Index i indicates the artist and j the painting. Peer quality in Paris is measured using one of the three quality measures discussed in the previous section - either the average column-inches of the sample of artists on location or the respective yearly average or median prices of paintings produced by the relevant peer group.

Age_{ij} reflects an artist's career age at the time the painting was executed and enters as a fourth-order polynomial. It captures fluctuations in quality over the course of a career.[13] Moreover, there are several control variables for the hedonic characteristics of the painting: a dummy variable to indicate if the support used for the painting is canvas or some other material, the size of the painting in square centimeters, a dummy variable to indicate an oil painting, an indicator for signed artworks, for works by artists deceased at time of auction, and for works sold by the two main auction houses Christie's and Sotheby's. Moreover, I include an indicator for the sale year of the painting j to adjust for potential fads in the art market. All of these variables are expected to impact auction results.

In addition to the i and j specific variables, period and artist fixed effects are used to control for other influences on the quality of creative output. Artists' fixed effects are used to account for any individual specific characteristics which might explain prices at auction and period fixed effects divided by historic events (see Table 1) with the period from 1820 to 1870 as the base. In addition, heteroskedasticity-robust standard errors are employed in all specifications.[14]

[13] This has been shown in the literature to be the most appropriate reflection of career paths of artists. See for example Galenson and Weinberg (2000, 2001), Hellmanzik (2009, 2010), and Hodgson (2010). This polynomial is used for comparability with these studies.

[14] The findings of this paper remain valid when the standard errors are clustered at the artist level.

The specification based on a location index for Paris for the full sample of artists is presented in Table 4, while Table 5 shows the results of the estimations using the three different quality measures.

4.2 OLS results for the full sample

In this section the OLS estimates on the location and peer quality variables over the full sample period are briefly analysed to provide a benchmark for the IV estimation in the next section. Estimation results are presented in Tables 4 and 5.

Column 2 of Table 4 shows that paintings made in Paris sell for a significant mark-up of 12.9%. This is a first indication that working in a cluster location is beneficial to the quality of modern artists' works. This mark-up is in line with Hellmanzik (2010) where a mark-up of 11.4% based on a smaller sample of artists is presented. However, a simple location indicator cannot capture all factors which might make a location attractive for modern artists. Table 5 depicts the results of the OLS measure of peer quality in Paris. There is a consistent significant and positive effect of peer quality on the quality of art works. This is independent of using a time-invariant measure (column-inches in Column 1) or the yearly measures of peer quality, i.e. average prices and median prices (Columns 2 and 3, respectively). Even when an indicator variable for paintings made in other cities - such as New York, Berlin, Rome, and Milan - are included in the regression the results are still robust.

Altogether, the OLS evidence for the full sample suggests that there are positive location effects in the artistic cluster of Paris. Focusing on the case of Paris, the locational effect is associated with the strong presence of high quality peers.

4.3 IV estimation using the impact of WWII in Paris 1928-1945

It is not entirely clear that the OLS estimates of δ are unbiased as the peer measure could be endogenous due to artists selecting into their respective work location. For example it could be that promising artists moved to a centre of modern art at an early stage of their careers, but subsequently did not benefit from peer effects. Instead they rather flourished due to their own inherent genius. If this was the case, the estimation would be biased upwards due to self-selection of talented painters into artistic clusters. Moreover, IV estimations fare better at dealing with measurement error in variables and omitted variables in the model. This is why an exogenous shock to the peer composition is a promising set-up to answer the question of whether peer effects in the production of

modern art exist. The Second World War and the eminent threat to many artists working in Paris is used as such an external shock in the following Section.

In order to obtain a clean estimate of the peer effect I focus on the city of Paris as the Second World War was an external shock on the composition of peers in Paris with 31% of artists in my sample leaving Paris between 1939 and 1945. I use this exodus of superstar artists from Paris to instrument for the quality of peers. The instrument is just identified as I use one instrument for one potentially endogenous variable. Based on Waldinger (2009), I run the following 2SLS estimation for the years from 1928 to 1945:[15]

$$\begin{aligned} ln(price)_{ij} = \delta \hat{peer\ quality}\ (price)_{ij} + \gamma_1 canvas_{ij} + \gamma_2 ln(size)_{ij} + \gamma_3 oil_{ij} + \gamma_4 signed_{ij} \\ + \gamma_5 deceased_{ij} + \gamma_6 auction\ house_{ij} + [\beta_1 age_{ij} + \beta_2 age_{ij}^2 + \beta_3 age_{ij}^3 + \beta_4 age_{ij}^4] \\ + \sum_{y=1988}^{2007} \theta_y (sale\ year_{ij} = y) + \alpha_i + e_{ij} \end{aligned} \tag{2}$$

where $WWII\ induced\ quality\ drain_{ij}$ instruments for peer quality. It is constructed to be zero until 1938 and then becomes:

$$WWII\ induced\ quality\ drain_t = (avg\ peer\ quality_{1937/38}) - (avg\ peer\ quality_{1937/38} | Stayers_t) \tag{3}$$

The instrumental variable *WWII induced quality drain* is mostly positive during the Second World War using both prices and column-inches as peer quality measures. This is indicative of the fact that leavers are of above average quality (see Figures 6 to 8) while at the same time leavers' quality is heterogeneous both in terms of prices and column-inches. This instrument captures how much peer quality in Paris decreases due to the exodus of artists initiated by the onset of World War II while excluding the years where World War II already had an impact on artists' productivity.

As a first step, I estimate a reduced form where I replace peer quality in equation (2) with the instrument in order to show the instrument's impact on artworks' prices. This estimation effectively compares the quality of artistic output before and during World War II for artists who remained in Paris. If artists leaving Paris had a negative impact on the value of artistic production of artists remaining in Paris, *WWII induced quality drain* would have a negative coefficient. The results of this reduced form are presented

[15] This period is chosen to have a sufficient amount of data points before the beginning of World War II to reflect artists' productivity. For comparison, Waldinger's (2009) data starts in 1925.

in Table 6. *WWII induced quality drain* is significant and negative which indicates that artists who leave Paris due to the Second World War indeed previously had a positive impact on artists who stayed in Paris.

4.4 IV results using the impact of WWII in Paris 1928-1945

The previous section has shown an indication of artists faring better at creating valuable paintings in the creative cluster of Paris where the quality of superstar painters was particularly high. In order to assess the causality of this effect I use World War II as an exogenous shock to the peer composition in Paris as proposed in the previous section.

In order to have a reliable 2SLS estimator, we need the instrument to be uncorrelated with the error term in (1) and strongly correlated with *peer quality*. If both requirements hold the IV estimator is consistent. The latter requirement is tested in the first stage (not reported) including the proposed instrument next to all exogenous variables of the model. The results indicate that the correlation between *peer quality* and the instrument *WWII induced quality drain* is negative and significant, while at the same time *WWII induced quality drain* is not being 'caused' by high quality peers and their paintings as artists are leaving Paris out of fear for their lives (as shown in Section 3).

Turning to the results of the IV estimation presented in Table 7 where peer quality is instrumented with *WWII induced quality drain* we see that the OLS findings can be confirmed by the instrumental variable approach. The coefficients across the various quality measures are positive and significant at the 1% level. Interestingly, the IV coefficients are larger in magnitude than the OLS ones and are also more significant. This suggests that the quality of peers indeed matters for productivity of artists. The model is just identified as the number of instruments equals the number of endogenous variables. In order to make sure that our instrument is not weak and therefore producing biased estimates we use the Cragg-Donald statistic on size distortions of hypothesis tests on the IV parametres (Stock and Yogo, 2005). In all case, this statistic is above the critical value of 16.4 and thus the null hypothesis of a weak instrument can be rejected comfortably, thus indicating that the instrument is indeed valid (bottom of Table 7).[16] Moreover, in a different set of estimations, we run the same set of regressions as in Table 7, but we also account for economic and political factors that capture the changing living conditions in Paris over the period considered.[17] In particular, the results reported in Table 7 are

[16] In particular, the test reports a minimum eigenvalue statistic where a Wald test at the 5% significance level will have an rejection rate of less than or equal to 10%.

[17] To conserve space these estimations are not reported in a table, but are available upon request.

robust to including the political environment (as provided by the democracy indicator of the Polity IV Project, 2009) and the economic circumstances (as proxied by both GDP per capita and GDP per capita growth, based on Maddison, 2007).

The finding of the IV estimations based on the quasi-natural experiment provided by the Second World War and its impact on the Parisian art scene confirms Hellmanzik's (2010) finding of locational effects in the clusters of Paris in New York. Moreover, it is in line with Azoulay et. al. (2008) and Kim et. al. (2006) who find positive peer effects for their respective samples of life scientists and economists, although only Azoulay uses a natural experiment. Interestingly, this finding is different from Waldinger's (2009) result that there is no significant evidence for locational peer effects for natural scientists in Nazi Germany. This is despite the fact that my research set-up largely relies on the one Waldinger presents in his paper. One explanation could be that the dissemination of knowledge is organised differently for artists. As soon as artists finished new, potentially innovative pieces they sought a broader audience in galleries and shows in order to sell their work. In addition, it is relatively easy for artists to incorporate new trends into their works and thus imitate their colleagues' successful strategies. Thus, innovations and new trends spread relatively fast. For scientists however, this process might be somewhat different, as spillovers might be harder to internalise in terms of the required skill, time, and capital investment.

5 Conclusion

If proximity of peers matters for the distribution of artistic knowledge and the production of high quality art, it can be expected that the departure of high quality peers from Paris has an impact on the value of artworks produced by artists who remain in Paris. This paper presents evidence of such peer effects in creative production using an IV estimation based on the exodus of artists from Paris due to the Second World War. The study is based on a global sample of 273 'superstars' of modern art born between 1800 and 1945. For this sample peer quality is measured using 34,141 auction results of paintings made by these artists and a historiometric measure of their prominence. The findings of this quasi-experiment confirm the OLS result that there are significant localised peer effects. That is, a higher quality peer group has a significant, positive impact on the quality of artworks produced by modern artists. This result is robust across different measures of peer quality.

The finding of this paper - that peer effects exist - is consistent with the literature on

individual creative production. Nevertheless, there is mixed evidence in the literature on how these peer effects and the dissemination of knowledge work. Depending on the field investigated, it is either the physical proximity to peers and colleagues that is important for knowledge spillovers or it is working jointly on a project, such as a publication or a new art stream. For future research it would be desirable to assess which characteristics of the production process determine the way in which peer effects can be materialised across the various disciplines of creative production.

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Figure 1: Number of artists in Paris

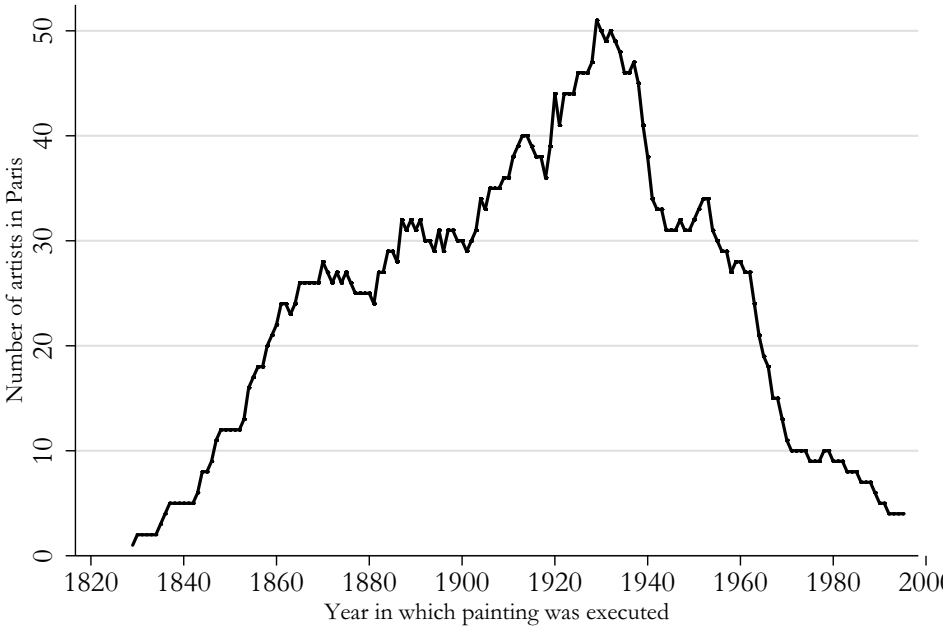

Figure 2: Column-inches in Paris

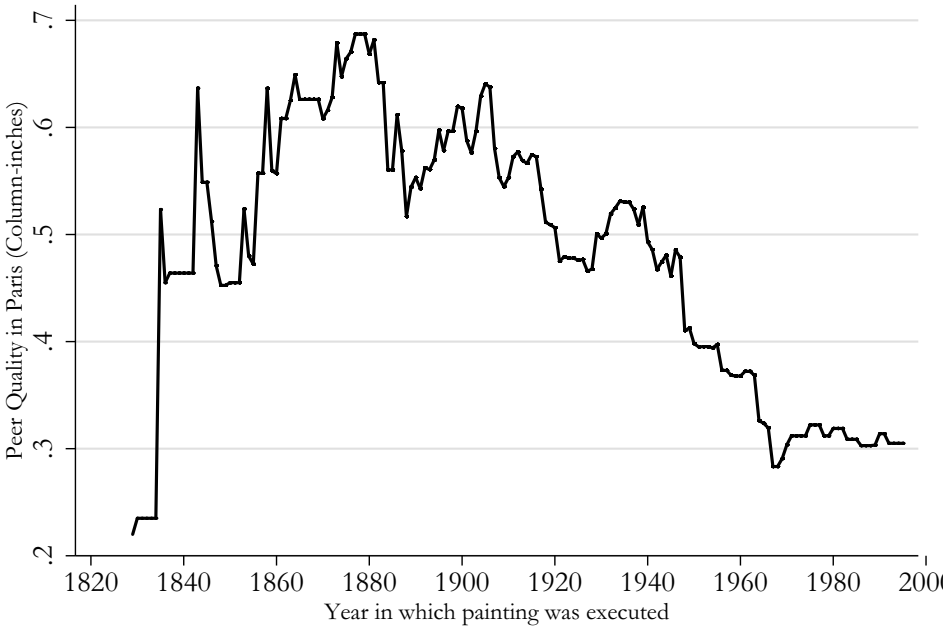

Figure 3: Average price in Paris

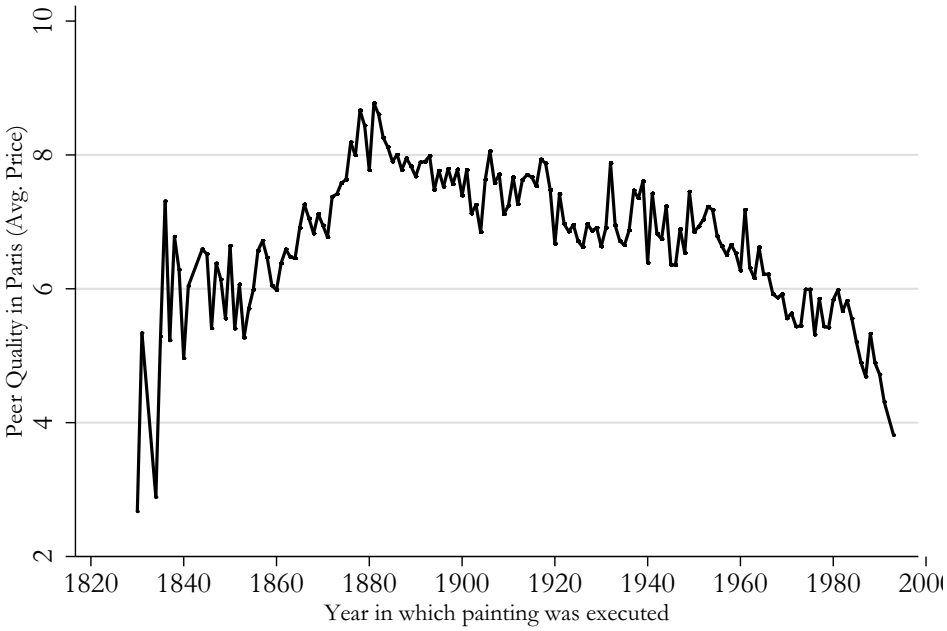

Figure 4: Median price in Paris

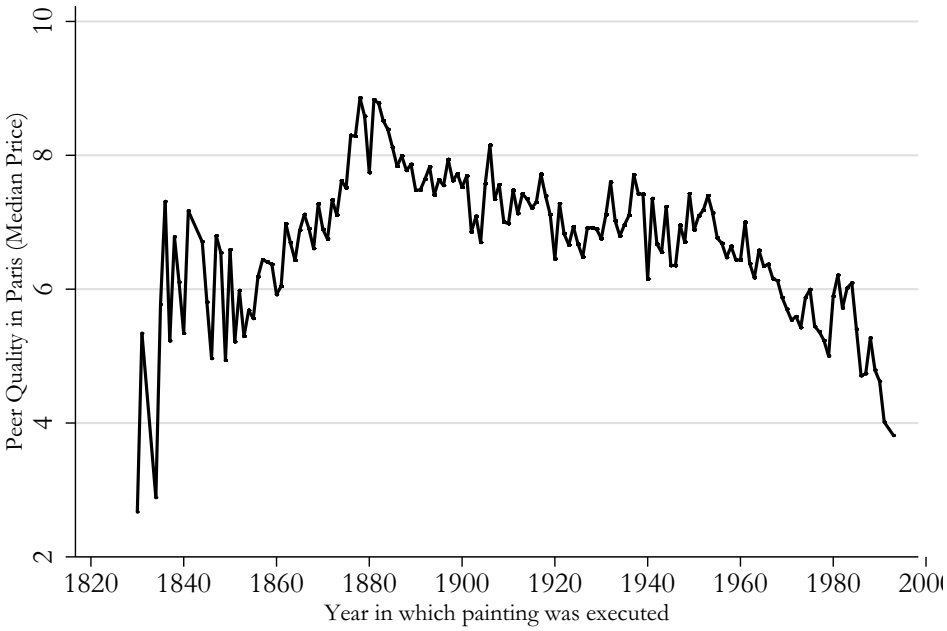

Figure 5: Number of artists in Paris: 1928-1945

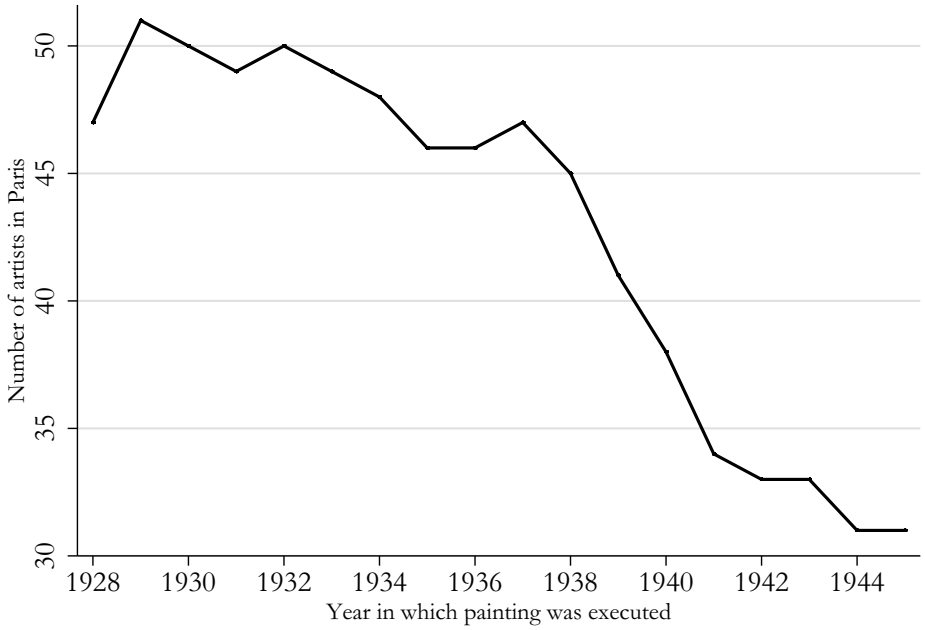

Figure 6: World War induced quality drain in Paris (column-inches)

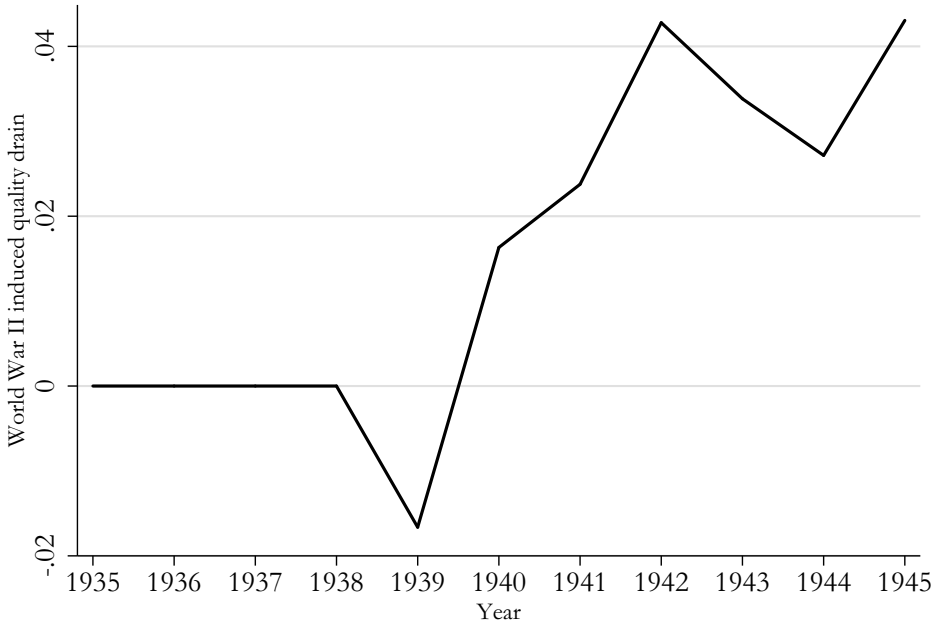

Figure 7: World War induced quality drain in Paris (avg. price)

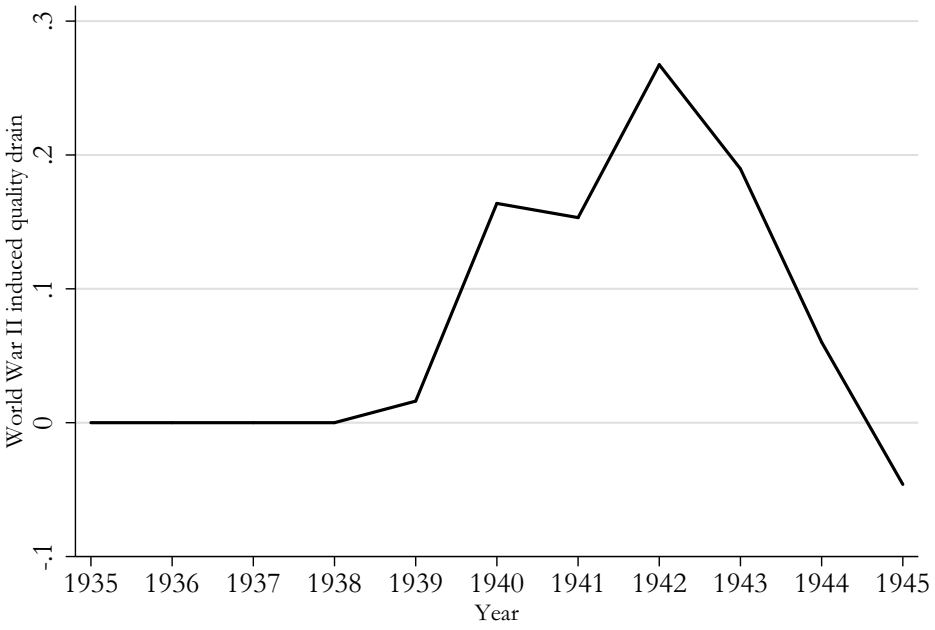

Figure 8: World War induced quality drain in Paris (median price)

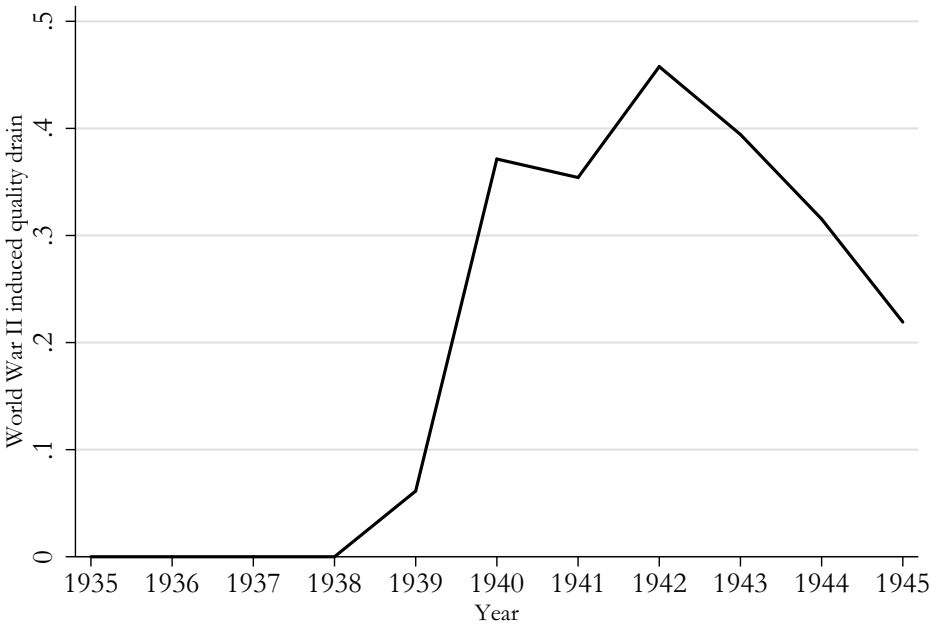

Table 1: Summary statistics

	All	1820-1870	1871-1913	1914-1918	1919-1938	1939-1945	1946-1975	1976-2007
Year of birth	1885	1821.6	1851.8	1872	1880	1887	1906	1920
	(30.7)	(11.0)	(20.4)	(14.0)	(12.2)	(12.9)	(15.8)	(11.9)
Year of execution	1936	1859	1895	1916	1928	1942	1961	1984
	(33.6)	(9.3)	(12.6)	(1.4)	(5.7)	(2.1)	(8.0)	(6.6)
Age at execution	50.8	37.4	43.7	44.4	48.1	54.7	54.7	63
	(15.3)	(10.6)	(14.9)	(14.0)	(12.5)	(12.8)	(14.9)	(12.2)
Year of sale	1999	2000	1999	1999	1998	1998	1999	2000
	(5.6)	(6.1)	(5.8)	(5.5)	(5.3)	(5.3)	(5.6)	(5.4)
Price	511,847	220,456	879,759	921,078	442,808	438,533	384,463.50	222,709
	(2,278,277)	(661503)	(33181472)	(2,961874)	(2038241)	(2,521,888)	(1,718,427)	(889,875)
Area	6,726	3,290	3,699	4,038	4,024	3,957	9,511	11,670
	(41,659)	(5215)	(15204)	(4405)	(4554)	(8445)	(66958)	(15,618)
Canvas	0.68	0.69	0.74	0.7	0.72	0.62	0.65	0.56
	(0.47)	(0.46)	(0.44)	(0.46)	(0.45)	(0.48)	(0.48)	(0.49)
Column-Inches	0.57	0.6	0.62	0.59	0.56	0.64	0.52	0.62
	(.55)	(.74)	(.63)	(.49)	(.51)	(.64)	(.49)	(.46)
As share of sample:								
Paris								
Paintings	42.4%	74.4%	66.9%	40.2%	51.7%	35.1%	28.5%	15.9%
Artists	45.1%	56.0%	48.4%	33.0%	38.7%	28.4%	25.5%	12.1%
Observations	34,877	1,087	8,069	1,370	5,995	1,860	12,738	3,650
Number of artists	273	50	157	106	163	134	157	66
Paintings per artist	127.7	21.7	51.4	12.9	36.8	13.9	81.1	55.3

Notes: Data presented are the respective period's averages and standard deviations. The nominal prices were adjusted using the US CPI retrieved from the IMF's International Financial Statistics. *Sources:* Information on artists were obtained from Grove Dictionary of Art: Online (2008). Data on paintings were obtained from artvalue.com (2007).

Table 2: Statistics for Paris from 1935 to 1945

Year	# artists	# leavers	% artists	Avg. prices	Avg. column-inches	Emigrated	Death
1938	45	-	-	869,527	0.51	-	-
1939	41	4	9.76	724,635	0.53	R. Bissiere, S.W. Hayter, T. de Lempicka, Y. Tanguy	-
1940	38	3	7.89	293,596	0.49	M. Chagall, F. Leger, P. Mondrian	-
1941	34	4	11.76	2,255,266	0.49	S. Dali, R. Delaunay, W. Lam, E. Vuillard	-
1942	33	1	3.03	424,961	0.47	J. Miro	-
1943	33	0	0.00	349,179	0.47	-	-
1944	31	2	6.45	638,573	0.48	-	M. Denis, C. Soutine
1945	31	0	0.00	159,205	0.46	-	-

Notes: There were no immigrants to Paris at the time with the exception of 1937. All prices and measures as above. *Sources:* Information on artists were obtained from Grove Dictionary of Art: Online (2008). Data on paintings were obtained from artvalue.com (2007).

Table 3: Artists residing in Paris in 1938

	All	Stayers	Leavers
# artists	45	31	14
		68.9%	31.1%
Avg. age	50.9	51.6	49.3
# artists with CI >0.5	11	6	5
Avg. CI	0.51	0.47	0.59
Avg. price	726,688	817,013	558,019
Median price	170,500	119,090	285,336

Notes: Average and median prices are calculated over the period 1937/1938. CI refers to artist prominence as measured by column-inches. *Sources:* All information on artists were obtained from Grove Dictionary of Art: Online (2008). All data on paintings were obtained from artvalue.com (2007).

Table 4: OLS estimation - baseline hedonic regression and Paris premium

Log (price)	(1)	(2)
Age	0.373	0.354
	[0.031]***	[0.031]***
Age^2	-0.011	-0.010
	[0.001]***	[0.001]***
Age^3	0.000	0.000
	[0.000]***	[0.000]***
Age^4	0.000	0.000
	[0.000]***	[0.000]***
Log (size)	0.595	0.596
	[0.006]***	[0.007]***
Canvas	0.293	0.292
	[0.015]***	[0.015]***
Oil	0.340	0.340
	[0.021]***	[0.021]***
Signature	0.180	0.179
	[0.030]***	[0.030]***
Artist deceased	0.158	0.157
	[0.029]***	[0.029]***
Christie's	0.401	0.401
	[0.014]***	[0.014]***
Sotheby's	0.383	0.383
	[0.014]***	[0.014]***
1871-1913	0.575	0.562
	[0.049]***	[0.049]***
1914-18	0.569	0.557
	[0.063]***	[0.063]***
1919-38	0.581	0.562
	[0.064]***	[0.064]***
1939-45	0.683	0.683
	[0.074]***	[0.074]***
1946-75	0.630	0.628
	[0.080]***	[0.080]***
1976-2007	0.393	0.386
	[0.092]***	[0.092]***
Paris		0.129
		[0.025]***
Artists fixed effects	yes	yes
Year of sale dummy	yes	yes
Observations	34,868	34,868
R-squared	0.70	0.71

Notes: Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Locational peer quality in Paris

Log (price)	(1)	(2)	(3)
	Column-inches	Average price	Median price
Peer quality in Paris	0.335	0.028	0.030
	[0.048]***	[0.003]***	[0.003]***
Hedonic characteristics	yes	yes	yes
Age polynomial	yes	yes	yes
Time period fixed effects	yes	yes	yes
Artists fixed effects	yes	yes	yes
Year of sale dummy	yes	yes	yes
Observations	34,868	34,868	34,868
R-squared	0.71	0.71	0.71

Notes: The estimation is based on the baseline hedonic regression (1) in Table 4 adding three measures for locational peer effects in the artistic cluster of Paris, respectively. Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 6: Reduced form - Paris 1928-1945

Log (price)	(1)	(2)	(3)
	Average Column-inches	Average price	Median price
Age	-0.448	-0.472	-0.438
	[0.193]**	[0.190]**	[0.194]**
Age^2	0.020	0.020	0.020
	[0.007]***	[0.006]***	[0.007]***
Age^3	0.000	0.000	0.000
	[0.000]***	[0.000]***	[0.000]***
Age^4	0.000	0.000	0.000
	[0.000]***	[0.000]***	[0.000]***
Log (size)	0.626	0.629	0.627
	[0.029]***	[0.029]***	[0.029]***
Canvas	0.198	0.196	0.202
	[0.060]***	[0.060]***	[0.060]***
Oil	0.969	0.981	0.983
	[0.143]***	[0.144]***	[0.144]***
Signature	0.218	0.201	0.205
	[0.141]	[0.141]	[0.142]
Artist deceased	0.359	0.439	0.414
	[0.511]	[0.528]	[0.527]
Christie's	0.243	0.236	0.241
	[0.048]***	[0.048]***	[0.048]***
Sotheby's	0.211	0.213	0.211
	[0.047]***	[0.047]***	[0.047]***
WWII induced quality drain	-6.941	-1.029	-0.698
	[1.585]***	[0.258]***	[0.155]***
Artists fixed effects	yes	yes	yes
Year of sale dummy	yes	yes	yes
Observations	2,278	2,278	2,278
R-squared	0.79	0.79	0.79

Notes: Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 7: IV estimation - Paris 1928-1945

Log (price)	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	IV	OLS	IV	OLS	IV
	Avg. Column-inches	Avg. Column-inches	Avg. price	Avg. price	Median price	Median price
Age	-0.446	-0.359	-0.556	-0.417	-0.523	-0.345
	[0.218]**	[0.215]*	[0.216]**	[0.245]*	[0.217]**	[0.220]
Age^2	0.020	0.017	0.023	0.022	0.022	0.017
	[0.007]***	[0.007]**	[0.007]***	[0.008]***	[0.007]***	[0.007]**
Age^3	0.000	0.000	0.000	0.000	0.000	0.000
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
Age^4	0.000	0.000	0.000	0.000	0.000	0.000
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
Log (size)	0.626	0.625	0.626	0.601	0.627	0.625
	[0.020]***	[0.020]***	[0.020]***	[0.024]***	[0.020]***	[0.020]***
Canvas	0.206	0.210	0.201	0.189	0.201	0.199
	[0.050]***	[0.049]***	[0.050]***	[0.056]***	[0.050]***	[0.049]***
Oil	0.989	0.973	1.004	0.879	1.010	1.005
	[0.092]***	[0.090]***	[0.092]***	[0.109]***	[0.092]***	[0.091]***
Signature	0.210	0.210	0.208	0.158	0.215	0.233
	[0.098]**	[0.096]**	[0.098]**	[0.110]	[0.098]**	[0.097]**
Artist deceased	0.384	0.369	0.402	0.368	0.408	0.425
	[0.320]	[0.314]	[0.321]	[0.359]	[0.321]	[0.318]
Christie's	0.243	0.243	0.244	0.246	0.243	0.242
	[0.047]***	[0.046]***	[0.047]***	[0.053]***	[0.047]***	[0.047]***
Sotheby's	0.215	0.210	0.221	0.182	0.220	0.206
	[0.046]***	[0.045]***	[0.046]***	[0.053]***	[0.046]***	[0.046]***
Peer quality	2.838	4.917	0.151	2.695	0.113	0.606
	[0.796]***	[0.993]***	[0.099]	[0.703]***	[0.067]*	[0.134]***
Artists fixed effects	yes	yes	yes	yes	yes	yes
Year of sale dummy	yes	yes	yes	yes	yes	yes
Observations	2,278	2,278	2,278	2,278	2,278	2,278
R-squared	0.78		0.78		0.78	
CraggDonald EV Stat.		3560.1		55.3		704.8

Notes: Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%
$WWII\ induced\ quality\ drain_{ij}$ instruments for peer quality. It is constructed to be zero until 1938 and then becomes:

$$WWII\ induced\ quality\ drain_t = (avg\ peer\ quality_{1937/38}) - (avg\ peer\ quality_{1937/38}|Stayers_t)$$