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Entry of Painters in the Amsterdam Market of the Golden Age

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Entry of Painters in the Amsterdam Market of the Golden Age

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Abstract

We analyze the evolution of the price of paintings in the XVII century Amsterdam art market to test a hypothesis of endogenous entry: higher profitability should attract more entry of painters, which in turn should lead to artistic innovations and more intense competition. We build a price index for the representative painting inventoried in Dutch houses through hedonic regressions controlling for characteristics of the paintings (size, genre, placement in the house), the owners (job, religion, value of the collection, size of the house) and the painters. After a peak at the beginning of the century, the real price of paintings decreases until the end of the century: we provide anecdotal evidence for which high initial prices attracted entry of innovators, and econometric evidence on the causal relation between price movements and entry of painters. The time series analysis supports the idea for which increasing prices attracted entry of innovative painters.

"*Art likes to be near wealth so as to be maintained with rich rewards,*" Karel van Mander, Lives of the Illustrious Netherlandish and German Painters (1604)

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One of the most innovative and dynamic fields of human production is art. Through the course of art history a sequence of artistic innovations has shaped the market for paintings in a continuous process of creative destruction. To mention some of the technical innovations in painting, think of the introduction of oil colour to replace *tempera*, the theory of perspective and the use of *"sfumato"* to enhance realism, the specialization in new genres such as landscapes and still life paintings, the use of the *camera obscura* to help capturing details, and so on;[1] of course, also new stylistic approaches represent artistic innovations granting fame and market power to the painters that introduce them. From an economic point of view we would expect that the rate of profitability in the market for painters should be an important determinant of entry in that market and also of innovative contributions: not by chance, most of the innovations in the history of painting took place in highly dynamic and rich communities such as Medieval Flemish towns during the XV century, Renaissance Italian towns such as Florence and Venice during the XV and XVI century and Dutch towns during the XVII century. In this work we analyze historical data on the evolution of the market for paintings in Amsterdam during its Golden Age and we argue that the evolution of the return of the painting activity did cause to a large extent the entry of new and innovative painters.

The process of entry in the art market can be seen as a simple form of technological competition based on creative destruction.[2] This is based on the idea that profitability attracts entry and is consistent with evolutionary models of entry (Winter, 1984; Klepper, 1996) that abstract from optimizing behavior. This is important if one regards rational decision making as unlikely especially in a pre-modern market for artists. Klepper (1996) has characterized the typical life cycle of a mass market characterized by endogenous entry and innovation and we argue that the Dutch market for paintings did evolve in a very similar way during its Golden Age.

Since the pioneering work of Montias (1982), interdisciplinary research in economic history and cultural economics, has been focused on the organization of historical markets for paintings, mainly during the XVII century for both primary markets (for instance see De Marchi and van Miegroet, 1994; North, 1999; Spear and Sohm, 2010; Etro and Pagani, 2012, 2013) and secondary markets (Montias, 1991, 2002). Early investigations on art prices from historical archives have been focused on inventories mainly from Delft (Montias, 1982), Amsterdam and Dordrecht (Montias, 1996; Loughman and Montias, 2001) and on auctions from Amsterdam (Montias, 2002). These studies have pointed out a number of interesting stylized facts and provided descriptive statistics on the paintings found in houses and traded in auctions (for surveys see De Marchi and Van Miegroet, 2006). Here we add an econometric dimension aimed at verifying the determinants of art prices, their pattern over time and their role in attracting innovative painters.

We examine works by Dutch and Flemish painters contained in the inventories from Amsterdam.[3] The

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[1] See Kemp (1990) on the history of technical innovations in art history.

[2] In evolutionary economics the art sector could be seen as a Schumpeter Mark I sector. As well known, such a sector is characterized by turbulent environments with low entry barriers where innovations are mainly associated with the entry of new entrepreuners replacing the incumbents through a process of "creative destruction". Artistic creativity is often associated with this kind of innovation replacing the routines of an established style. On related aspects of evolutionary economics see Nelson and Winter (1982, Ch. 13) and Winter (1984).

[3] Inventories contain price evaluations rather than prices of effective transactions. However, as shown in Etro and Stepanova (2013), the analysis of prices from auctions leads to very similar results, suggesting that evaluations in inventories

dataset puts together information collected at the Frick Collection Research Center, the Getty Research Institute and the Ecartico project of the University of Amsterdam. Contrary to the past descriptive analysis of these data (Montias, 2002), we convert the nominal prices of paintings into real ones. To study the price of paintings in terms of purchasing power, we adjust nominal prices with yearly inflation derived from the van Zanden consumer price index built on the basis of multiple price series (see De Vries and van der Woude, 1997).[4] Therefore, our econometric investigation determines the relation between the relative price of paintings and the characteristics of the paintings, the painters (their fixed effects), the collection (purpose of the inventory, average price of its paintings, room of the house in which the painting was placed) and the owners (job, religion, number of rooms in their house). Controlling simultaneously for all the mentioned objective features and the indirect proxies for quality, we run hedonic regressions and obtain a price index that shows the evolution of the price of a representative painting during the Dutch Golden Age. As far as we know, this is the oldest hedonic price index constructed from historical prices of paintings.

The price regressions provide some interesting results in their own, showing, for instance, that smaller paintings, copies, anonymous paintings and paintings placed in private rooms or in the kitchen tend to have lower prices. The number of rooms in the house of the owner is a proxy for wealth and tends to be positively related to prices. Contrary to what emerges from descriptive statistics (Montias, 1982, 2002), price differentials for alternative genres (figuratives, landscapes, genre paintings, still life paintings) disappear after controlling for the unobservable quality of paintings with the artists' fixed effects.[5] Finally, inventories drawn after the death of the owner or for a marriage have higher prices on average than those due to the insolvency of the owner or drawn to build a collateral for debt.

Contrary to previous findings,[6] after controlling for inflation and paintings' characteristics, we find that the real price of paintings reached a peak at the beginning of the century and then declined slowly during the rest of the century. Similarly, the number of painters active in Amsterdam increased during the first half of the century and then declined until the end of it.[7] We argue that such a pattern may be the consequence of a typical evolution of markets from birth to maturity analyzed by evolutionary models started with Klepper (1996): first, market growth and high profitability attract entry of painters in the market, fostering product differentiation and innovation, then entry slows down despite continued market growth and, finally, exit overtakes entry and innovations are mainly aimed at improving the production process. There is some anecdotal evidence for such an evolutionary pattern in economic history and art

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did reflect prices from the secondary market. We focus on inventories because the available data cover the entire century while auctions data are available only with gaps for the first four decades and the last two of the century.

[4]See http://www.iisg.nl/hpw/brenv.php# biblio.

[5]The only exception is given by the portraits, whose specific use on the primary market explains lower prices in the secondary market. This suggests that a painting of given features was not paid differently depending on the genre, which may be the result of arbitrage opportunities in the primary market. For a similar point in the contemporary Italian market see Etro *et al.* (2014).

[6]Early investigations based on nominal prices (Chong, 1987; North, 1999) had pointed out an increase in average prices from the beginning to the end of the century, with only moderate price reductions for landscape paintings and genre paintings from the first to the second quarter of the century.

[7]Data on the number of painters in each Dutch city have been recently put together by the Ecartico project of the Amsterdam Centre for the Study of the Golden Age based at the University of Amsterdam.

historical studies (see for instance Prak, 2008). As well known, the economic boom and the increasing demand by the Dutch middle class between the end of the XVI century and the beginning of the XVII century determined high prices, which induced a process of entry of new and innovative painters attracted by the high profitability of the profession. Our price index and data on the evolution of the number of painters in Amsterdam appear to confirm this. As long as innovation is a process of search and selection of new techniques replacing established routines (artistic styles), the expansion in the number of painters at the beginning of the century increased the scope for artistic innovations and contributed to determine what is known as the Dutch Golden Age, with masters such as Honthorst (see Plate 1), Rembrandt, Vermeer, Metsu, Dou, Ruisdael and many others. At the same time, this also led to more intense competition, specialization in different genres, clustering (by genres in different towns) to create agglomeration economies, imitation and replication of paintings so as to reduce costs and prices. This may have induced the slow reduction in prices during the last part of the century.

Plate 1. Gerrit van Honthorst, "Supper Party" (1619, Uffizi, Florence). Artwork in the public domain.

While long run patterns for prices and entry of painters emerge clearly, short run causation is less obvious. We provide new econometric evidence for a direct link between profitability and entry by analyzing the time series of our price index and entry of painters in Amsterdam: the analysis suggests that causality works in the expected way, at least in the sense of Granger-causality, also in the short run. Indeed, we find increasing prices attracting entry of painters on one side and more painters inducing declining prices

on the other side. Moreover, a VAR analysis confirms that an increase in the average price of paintings leads to entry of new painters only after some years, possibly the time needed to enter in the market (six years of apprenticeship), with some weaker evidence that entry had an immediate negative effect on prices. These results appear in line with our thesis of endogenous entry applied to the art market: the same evolution of art history as a sequence of artistic innovations could have been endogenously affected by the evolution of profitability in the painting sector.[8]

The paper is organized as follows. In Section 1 we review related studies on Dutch inventories and sketch our main results. In Section 2 we describe the dataset and analyze the effects of demand and supply conditions on innovations. In Section 3 we discuss our hedonic regression analysis and derive the price index. Section 4 analyzes the time series of the price index and entry of painters to test our main hypothesis. Section 5 concludes.

1 The Dutch Golden Age and the Market for Paintings

The Low Countries became the dominant economic power in Europe during the early XVII century, with a innovative leadership in shipbuilding, the textile industry, selected manufacturing sectors and trade. The Dutch middle class was richer than in any other place at the time, and the real wage of the working class kept increasing between the end of the XVI century and the middle of the XVII century (De Vries, 1982; De Vries and van der Woude, 1997). As a consequence, the increasing demand of art by the Dutch middle class attracted new painters in all the main Dutch towns and in particular Amsterdam, which was the largest city in Europe. Some of them were immigrants from Flanders, where a solid artistic tradition was already established, but most of them were locals who decided to become artists.

The occupational choice to become a painter required an apprenticeship usually of six years which was rather costly in terms of fees and forgone earnings,[9] and of course was uncertain in its outcome. After completing this investment in human capital, the head of the local *Guild of St. Luke* could recognize the status of journeyman with the right to sign and sell paintings in town. The objective of this guild was to protect the earnings of the affiliates, regulating the apprenticeship, and trying to restrict the activity of foreign artists and the frequency of public sales (auctions and lotteries), but in a large town like Amsterdam competition was strong and it was even hard for the guild to control the membership of the painters active in town (see Prak, 2008).[10] It is well known that at the beginning of the century the artistic profession could be quite remunerative for a successful painter: Montias (1982) has estimated that Dutch artists at the beginning of the Golden Age had an average net income between 1,150 and 1,400

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[8] Similar thesis have been advanced to link the high prices of paintings to other innovative periods, such as Mannerism and Rococo in Venice (Etro and Pagani, 2013), the Neoclassical age in Paris (Etro and Stepanova, 2015a) and the Victorian age in London (Bayer and Page, 2011). However, as far as we know, this is the first attempt to provide causal evidence in support of this thesis.

[9] Some pupils paid up to 100 guilders a year (excluding board and lodging) to be trained by famous masters such as Rembrandt, Honthorst, Dou (North, 1999, p. 65). To have an idea of the size of such an investment, Montias (1982) calculates that artists paid an average rent of 142 guilders a year, and bought houses of an average price of 1785 guilders.

[10] There is an open debate on whether guilds were purely rent-seeking organizations or were transmitting human capital and insuring members' income so as to foster investment in innovation (Ogilvie, 2004). On Dutch guilds see Prak (2008).

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guilders, three times as much as a master carpenter, and more than other high skilled craftsmen.

Plate 2. Rembrandt, "The Night Watch" (1642, Rijksmuseum, Amsterdam). Artwork in the public domain.

Since the end of the XVI century Dutch and Flemish painters started to specialize in a single genre (still life, portrait, landscape, genre painting or figurative painting) or even in specific subjects, so as to exploit their comparative advantage and increase productivity. For the first time in art history, they mainly worked for an anonymous market rather than for commissions (Gombrich, 1995), except for portraitists and few important masters. Iconoclasm eliminated patronage from Calvinist churches and the commissions from the House of Orange were rare, though generous (the diplomat and poet Constantijn Huygens commissioned five works for the *Stadholder* from Rembrandt at a unitary price of 600 guilders).[11] Other public authorities occasionally commissioned monumental paintings: Ferdinand Bol, Jan Lievens and

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[11] Rembrandt asked the double without success. However, he was later paid 1200 guilders for an *Adoration of the Shepherds* (1646, München, Alte Pinakothek) and the same for a *Circumcision*. Exports were rare, but we know that three paintings by Rembrandt were sent to Antonio Ruffo in Sicily for 500 guilders each. See Sluijter (2008). The same price was reached for a *Susanna*, while Lodewijk van Ludick paid 600 guilders for a *Nativity* and a *Circumcision* (Crenshaw, 2006).

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Figure 1: Price indexes in Amsterdam. Source: Price regressions in Tables 2 and 6


Govert Flink received 1500 guilders for each painting prepared for the *Amsterdam Town Hall*. More frequent were the direct commissions for group portraits: Rembrandt was paid at least 1600 guilders for his portrait of Captain Cocq and the other civic militia guards (the famous "Night Watch", now at the Rijksmuseum in Amsterdam; see Plate 2). Most portraitists were however engaged in single figure portraits: Rembrandt was used to ask 50-100 guilders for a head and up to 500 for a full length portrait. However, the vast majority of the painters sold their works in their studios, through art dealers, at exhibitions and sales organized by the guild and at public sales (Montias, 1989). For this primary market we do not have systematic information. What we know a lot about, instead, is the secondary market.

The earliest data available on the price of paintings owned and traded in the Netherlands are from the XVII century. Their first systematic investigation is due to Bredius (1915-22) and, in modern times, to Montias (1982), who examined inventories and auctions drawn from notarial records and estate papers of the *Orphan Chamber* in Delft between 1610 and 1679. A main finding of the study was that the composition of the collections changed drastically during the century: while half of the paintings were figurative in the first decade (1610-1619), a quarter were landscapes and a sixth were portraits, with a marginal presence of still life and genre paintings, in the last decade under consideration (1670-1679) landscapes represented 41% of the paintings, still life paintings represented 17%, all the figurative paintings represented another 17%, portraits 15% and genre paintings reached 7% of all the paintings.[12]

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[12]Montias (1982) provided also a regression of the logprice of the value of art collections on a time trend and on the logarithm of the total value of the inventories as a proxy of the wealth of the art collectors. There was no evidence of a significant time trend, while the wealth elasticity was estimated at 1.23 (with a standard error of 0.052), suggesting that wealthier collectors were significantly increasing their share of artworks in their holdings. Montias (1996) estimates the same elasticity at 1.42 for Amsterdam in the period 1600-1669.

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Figure 2: Number of painters in Amsterdam. Source: Ecartico
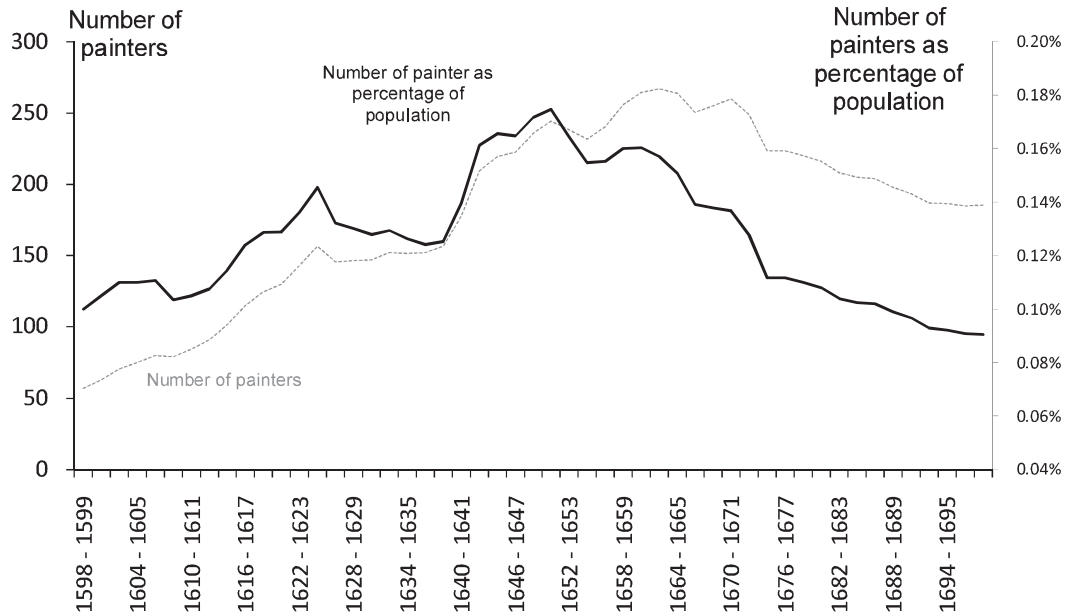
Early investigations of the Amsterdam inventories are presented in Montias (1996) and Loughman and Montias (2001). The first work emphasizes a reduction in the average price of landscape paintings conjecturing that this could be associated with an increase in productivity. The second work is entirely focused on the allocation of artworks between rooms of the Dutch houses, which in part depends on the quality of paintings. Our econometric analysis, controlling for all the objective features of the paintings and the proxies for quality, allows us to construct a bi-annual price index for the representative painting owned in Amsterdam during the Dutch Golden Age. This is based on our hedonic regressions for the price of paintings in Amsterdam inventories built in Section 3: we anticipate this inventories price index for the period 1616-1700 in Fig. 1. In Etro and Stepanova (2013) we have performed a similar hedonic analysis on auction data which are available for more limited periods (from Montias, 2002), especially the beginning of the century and the final decades: in Fig. 1 we also report this auctions price index using the same reference period (1616-1617) to be able to appreciate the continuity between the two indexes over the period 1598-1700. The picture emphasizes a rapid increase in the real price of paintings at the beginning of the century with a peak during the second decade,[13] and a subsequent decline of prices for the rest of the century. The initially high prices may be related to the large increase in demand by the middle class taking place at the end of the XVI century and the beginning of the XVII century, which attracted a massive entry of painters looking for new opportunities: in turn, the increase in the number of painters strengthened competition, specialization in genres and induced process innovations, which may

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[13]In 1609 the United Provinces concluded the twelve-year truce with Spain reaching the *de facto* recognition of independence. Remarkably, this opened the doors to trade with Flanders and, in particular, to the arrival of Flemish paintings which probably contributed to the drop in price during the second decade of the XVII century (see Sluijter, 2008).

have led to the subsequent decline in prices.

1.1 Number of painters and art prices

To check for our thesis, we display in Fig. 2 the number of painters active in Amsterdam (similar patterns emerge in the entire Low Countries) between 1598 and 1700. The figures are derived from the dataset collected in the Ecartico project[14] and correspond to the total number of artists active in Amsterdam in each year. We report also the ratio between number of painters and population in Amsterdam to control for scale effects.[15] Both figures show a clear pattern: the absolute and relative number of painters increased in an impressive way until the middle of the century and then started to decrease. A comparison of the evolution of the number of painters and of the profitability of the market proxied by the real price of paintings, suggests that high prices at the beginning of the century were probably responsible for the wide process of entry in the market, in line with evolutionary theories of entry as those by Winter (1984), Jovanovic and Lach (1989) and especially Klepper (1996).[16] The peak in the number of painters takes place three decades later compared to the peak in the price index, which may reflect a slow feedback of profitability on entry decisions, possibly due to imperfect information, inertia in the expectations on profitability and, most of all, because of time-to-enter in the market.

As long as the entry process was triggered by profitability calculated on the basis of industry experience over a short period of time (Winter, 1984), we would expect that also in the short run the net entry of painters should respond to price changes, that is to changes in the expected rate of return from the profession. Of course, imperfect information and time to enter in the profession (at least six years of apprenticeship for the young artists) would require a certain lag between price changes and entry (as a rate of change of the number of active painters). Such a relation is hardly visible comparing number of painters and price level in Fig. 1 and 2. Therefore, in Fig. 3 we compare the net entry of painters in Amsterdam, namely the rate of increase in the number of painters, with the lagged inventory price index, namely the price indes of six years before.[17] What we find remarkable is that the positive correlation between the price index and the (six years) later rate of entry is evident already by visual inspection, which is surprising given the totally independent nature of the two indexes. Testing the causal link between price changes and entry through time series analysis will be our main tasks in Section 4 and will

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[14] For an interesting descriptive analysis of these data see Rasterhoff (2012). Of course, historical data on the number of painters are not fully reliable, but this source appears to be the most comprehensive and, as usual, what matters for our purposes is that there are not systematic biases over time.

[15] We know that population was about 30,000 in 1575, 60,000 in 1600, 105,000 in 1622, 120,000 in 1635, 140,000 in 1650, about 200 thousands in 1675 and 1690, and 205,000 at the end of the century and we interpolated other values. See http://www.populstat.info/. The plagues of 1635 and 1663 caused sudden drops in population.

[16] Entry in the Klepper model is demand driven and reproduces basic stylized facts of the product life cycle of mass markets. Most of them are common to our market: at the beginning the number of entrants increases, the number of producers grows initially and reaches a peak, after which it declines steadily despite continued growth in output (Klepper, 1996, p. 564), the number of product innovations tends to reach a peak when the number of producers is increasing, these producers devote increasing effort to process innovation rather than product innovation and, during the period of growth in the number of producers, the most recent entrants account for a disproportionate share of product innovations (Klepper, 1996, p. 565).

[17] Since the price index is bi-annual, three periods correspond to six years.

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Figure 3: Entry of painters and Price index in Amsterdam
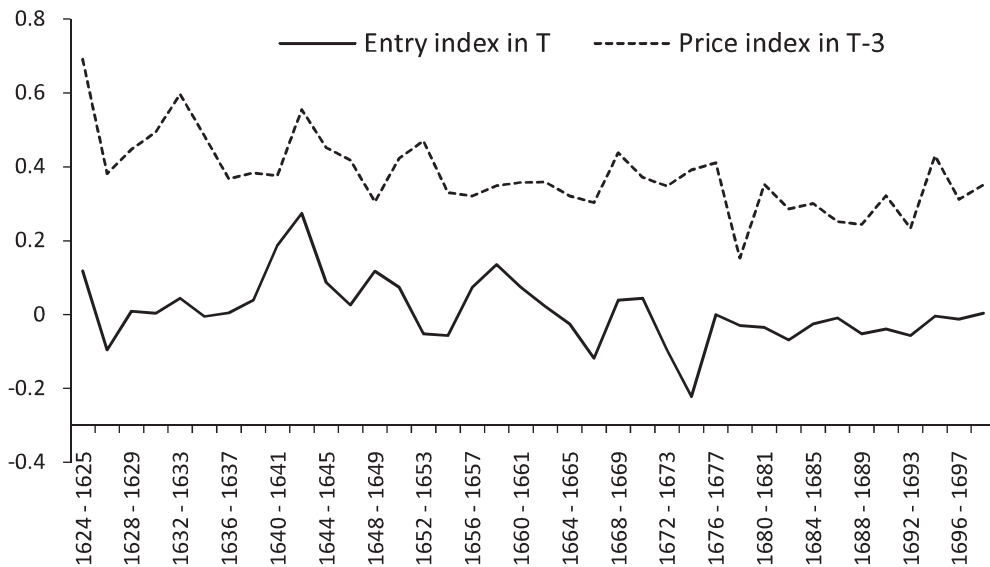
confirm the existence of a causal link. However, before that we need to describe and analyze in more detail the evolution of the price of paintings during the century.

1.2 Demand and supply effects on innovation

There is a wide anecdotal evidence on how demand of paintings increased between the end of the XVI century and the beginning of the XVII century and on how competition and artistic innovations increased the productivity of Dutch painters (see Prak, 2008). On the demand side, it is well known that the emerging middle class started to accumulate art works and therefore demand new paintings and paintings of new genres (Slive, 1995). This attracted the entry of new painters in the market, leading to the first mass market for art in history. The same increase in prices at the beginning of the century could be seen as the result of a slow process of entry in the market in front of a rapidly increasing demand. Moreover, this induced a demand-pull process of artistic (product) innovation,[18] with the specialization of painters in new or renovated subjects such as still lifes of flowers, banquets, *vanitas* (symbolic still lifes), *trompe l'oeil*, seascapes, Italianate landscapes, conversation pieces, interiors, *tronies* (portraits of stock characters in costume) and others. New stylistic approaches were directly associated with groups of innovative painters, such as the Utrecht Caravaggists (as Gerrit van Honthorst) who renovated genre paintings or the *Fijnschilders* (literally "fine-painters", as Gerard Dou) who adopted a time-consuming style with meticulously executed small-scale works. The core of the Golden Age was reached in the middle of the century, when also the number of painters reached its peak. Borrowing the terminology of the product life-cycle theory (Klepper, 1996), the market was saturated and the number of painters started

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[18]For a distinction between demand-pull and technology-push theories of technical change see Dosi (1982).

to decrease together with prices. Notice that this theretical interpretation relies on the relation between profitability and entry and not on profit maximizing agents (as hardly where the painters of the XVII century), therefore it is compatible with the spirit of evolutionary theories (Nelson and Winter, 1982, Ch. 13; Winter, 1984).

Plate 3. Rembrandt, "Christ and the Adulterous Woman"
(1644, National Gallery, London). Artwork in the public
domain.

On the supply side, the saturation of the market induced painters to focus on process innovations rather than artistic (product) innovations. This is exactly what predicted by the evolutionary theory of Klepper (1996). Painters started to replicate the same compositions over and over, learning how to save time to reach a given quality level.[19] Similarly, specialized painters tended to cluster in the same

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[19] As Neil De Marchi has noticed (private communication) painters did many things besides painting. This learned facility to work across different genres, in gilding or etching as well as painting, in multiple sizes and media, in marketing (dealing) as well as making, and so on, suggests that market behavior on the part of artists not only involved innovative methods (such as wet-in-wet painting, drawing with the brush, tonal painting and more evocative than strictly descriptive approach)

towns, fostering agglomeration economies and learning by doing in specific genres. This was the case for landscapes in Haarlem, flowers in Middelburg, figurative paintings in Utrecht, genre paintings in Leiden, perspectives and townscapes in Delft. Only Amsterdam was too wide to allow for specialization in a single genre (see Prak, 2008). All this created both internal and external scale economies which led to cost and price reductions. Moreover, many low quality painters focused on imitation rather than innovation, which again increased substitutability between works and contributed to reduce prices. Another factor that may have contributed to reduce prices was the introduction of cost-reducing innovations, as the tonal style[20] and the reduced size of paintings, especially for landscape and genre paintings.[21]

2 Dutch inventories and the evolution of art prices

In this section we describe the sources used for the construction of our dataset, provide a statistical description of the data and present some preliminary results in support of the anecdotal evidence discussed above. We rely on two main sources: the inventories collected by John Montias in the archives of Amsterdam, now maintained at the Frick Collection Research Center and the inventories administrated by the Getty Research Institute collected by multiple scholars. The two datasets provide a representative sample of the collections between 1616 and 1700 from the middle and high class, since their survival in archives is due to random reasons, and it is likely that collections of the low class were too small to be notarized (Montias, 1982, 1996). Prices are in guilders, stuivers and penningen and we have converted them in guilders.[22]

The typical record available contains year and place of the inventory, attribution of the painting, value assigned by the appraiser and the room where the painting was placed in the house. The original Dutch description of each painting was translated and analyzed to obtain dummies concerning the size, classified as small or large (unfortunately we do not have information on the exact size), the genre, the originality (copy and attribution to a painter) and more. In the Montias dataset we know the name of the owner with biographical details, including occupation and religious views, the date of the inventory, the city, the purpose of the inventory and the names of notaries and appraisers. We have selected the 347 inventories from Amsterdam, which contain 10,531 paintings.[23] However, an investigation including inventories from

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but conscious in-house modifications of workshop practice and changeable compositions of overall workshop output, to the end of maintaining or increasing earnings.

[20]Landscape painters Esaias van de Velde and Jan Porcellis introduced the tonal style, whose execution could be more rapid (this made Porcellis able to write a contract in 1615 that bound him to produce forty paintings in twenty weeks). The same style was also adopted in still life paintings, as by Willem Claesz. Heda. Its main diffusion, however, was in the field of landscapes, where it was taken to the extreme by Jan van Goyen, Salomon van Ruysdael and Pieter de Molijn: they were said to take only one day to paint their pictures and therefore were able to reduce dramatically the unitary price of their works.

[21]However, as noticed by a referee, these innovations were not always associated with cheaper production: some landscapes (by Ruysdael or van de Velde) used a reduced color scale, as one would see it at dusk, but they were not monochromatic, and some other works were small to accommodate domestic demand, but they were highly detailed.

[22]Prices are in guilders and are usually expressed as in the following example: f 2: 4: 6. This should be read as 2 guilders, 4 stuivers, 6 penningen. Notice that 20 stuivers (st.) correspond to a guilder (f.), and 16 penningen (pen.) amount to a stuiver.

[23]We excluded the rare Italian paintings but included both Dutch and Flemish paintings. In the Southern Netherlands

other Dutch towns, such as Dordrecht, Haarlem and Utrecht, leads to very similar results (see Etro and Stepanova, 2013). All the variables used in the regression analysis are listed in Table 1 together with their main statistics and the average price per category.

Table 1: Descriptive statistics

Variable	Mean	Std. Dev.	Av.price (guilders)	Variable	Mean	Std. Dev.	Av.price (guilders)
Price (guilders)	15.70	38.48		**Owner religion**			
anonymous paintings	0.809	0.393	9.34	catholic	0.056	0.231	18.78
copy	0.032	0.176	6.66	protestant	0.311	0.463	20.73
large	0.033	0.179	50.23	jewish	0.004	0.067	1.65
small	0.303	0.460	7.01	unknown religion	0.628	0.483	13.04
Nr. of paintings	2.430	3.822		**Owner occupation**			
evaluated together				merchant large scale	0.205	0.403	23.54
				art dealer	0.064	0.244	51.61
Genre of the Painting				merchant retail	0.053	0.224	5.31
landscape	0.299	0.458	16.09	services	0.068	0.252	7.65
figurative	0.201	0.401	24.02	craft	0.04	0.197	6.21
portrait	0.138	0.345	13.69	artisan	0.04	0.196	10.18
still-life	0.090	0.287	14.33	artist	0.029	0.168	14.21
genre	0.082	0.274	18.69	manufacturer	0.024	0.152	13.97
unknown genre	0.190	0.392	7.12	employee	0.015	0.121	13.7
				regent	0.01	0.101	26.99
Placement in the house				unknown occupation	0.45	0.5	10.86
Private rooms	0.199	0.399	9.37	**Inventory purpose**			
Public rooms	0.084	0.277	28.25	death	0.543	0.498	16.79
Voorhuys	0.124	0.330	14.26	insolvency	0.048	0.213	20.74
Kitchen	0.020	0.141	7.68	collateral	0.023	0.151	23.58
unknown placing	0.572	0.495	16.67	marriage	0.02	0.141	16.48
Number of rooms	4.970	4.300		unknown purpose	0.366	0.482	12.88

The average number of paintings per inventory increases constantly over the century from about 10 to almost 50 paintings, which confirms the idea that Dutch households increased their demand of art accumulating paintings over the century (Montias, 1982). The art value of the collections of paintings

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there was a Catholic-driven demand, which was differentiated by religious orders and ranged from cheap devotional prints to larger altarpieces. At the same time, individual artists became adept at moving quickly and easily from religious narrative to mythology, history and secular landscapes, borrowing compositions and individual figures from one genre for use in another, so that brand recognition by artist was facilitated and brand could be economically exploited whatever the ostensible subject. Antwerp artists painted everything from wooden trenchers to small copper plates for attachment to ebony cabinets, to musical instruments. Nevertheless, Flemish paintings reaching a domestic environment were probably comparable to the Dutch ones. We are grateful to Neil De Marchi for clarifications on this point.

varies from 2 to 36,724 guilders[24] with an average value of 514 guilders and a median value of 201 guilders.[25] Remarkably, half of the collections have an average price below 8 guilders and 95% of collections have an average price below 48 guilders, which supports the idea that this was becoming a *mass market*. The distribution of prices is characterized by a fat tail with some paintings extremely expensive and a multitude of low value paintings (many priced below one guilder). The highest recorded prices are 1,500 guilders for a *Christ and the Adulterous Woman* by Rembrandt (possibly the one today at the National Gallery in London; see Plate 3)[26] and 800 and 700 guilders for two works by Philip Wouwerman.

The most common purpose of the inventories is the division of property between heirs after the death of the owner. Art collections as part of inheritance were assessed normally by qualified appraisers (usually members of the guild of the painters) and certified by a notary. Paintings were often assessed in the case of being pledged as collateral for a loan or other kinds of debt and in the case of bankruptcy or insolvency of the debtor.[27] We have some useful information on the owners and therefore, indirectly, on the demand for art. The occupation includes over a hundred different professions in the dataset, which we classified into ten general categories, useful as control variables for the income of the owners and, in general for demand conditions. The upper class of the Dutch society was composed by the regents, the large scale merchants and some large manufacturers: 43% of the paintings, and by far the most expensive (excluding the art dealers), were owned by them. However, also the middle class was buying paintings, and the percentage of observations coming from middle class professions increases drastically over time (see Fig. 4) confirming the gradual development of the first mass market for art in history.

The religion of the owner (Protestant, Catholic or Jewish) may be related to the demand of art and may have an impact on the composition of paintings in a collection. It could affect the propensity of collectors to hold religious paintings (whose value was generally higher): iconoclasm in the Reformed Church (started around 1566) led to the destruction and elimination of most of the religious paintings within churches and heavily affected the preferences of the citizens. As a consequence, this contributed to a drastic reduction in the possession of religious paintings,[28] and, with them, of figurative paintings in general as can be seen in Fig. 5.

The decline of demand for religious paintings was paralleled by an increasing demand for the new genres. We classify genres in figurative paintings, genre paintings, landscapes, portraits, still-life paintings and paintings of unknown genre. As shown in Fig 5, landscapes become the prevailing genre during

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[24] This is the death inventory of the art dealer Johannes de Renialme. It also contains the most valuable painting in our dataset: a Rembrandt estimated 1500 guilders.

[25] To calculate the art value of the collections we took into account also the imported works and those of uncertain attribution.

[26] This came from the inventory of the art dealer Johannes de Renialme, who owned also other works by Rembrandt, Dou and Rubens evaluated respectively 600, 600 and 500 guilders.

[27] Rembrandt went bankrupt in 1656, but we do not have evaluations in our dataset. Nevertheless, we know that the subsequent sale did not record high prices. As Schama (1999) notices, "the *Negro Heads* and *The Descent from the Cross*, a *Jerome*, an *Ox*, and a *Bittern*, a *Danae* and *The Concord of the State*, fifty or so paintings fetching altogether less than a thousand guilders. How could this be, since ten Rembrandts sold from the estate of Johannes de Renialme, the dealer, made two thousand? Had there been some sort of foul play, some sort of advance agreement among the buyers, avid for bargains, to divide the spoils without competitive bidding?".

[28] See Montias (1987, p.459).

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Figure 4: Percentage of paintings belonging to the upper and middle class (10-years moving average).
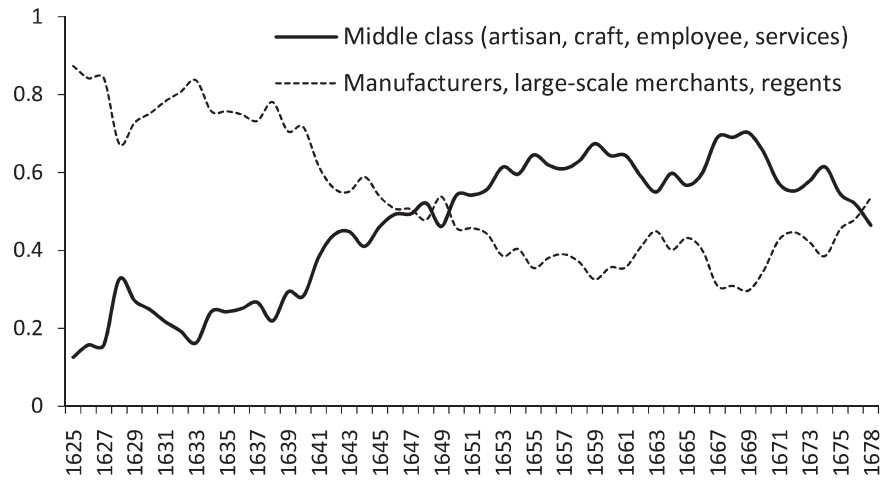

Figure 5: Percentage of paintings by genres in the inventories.
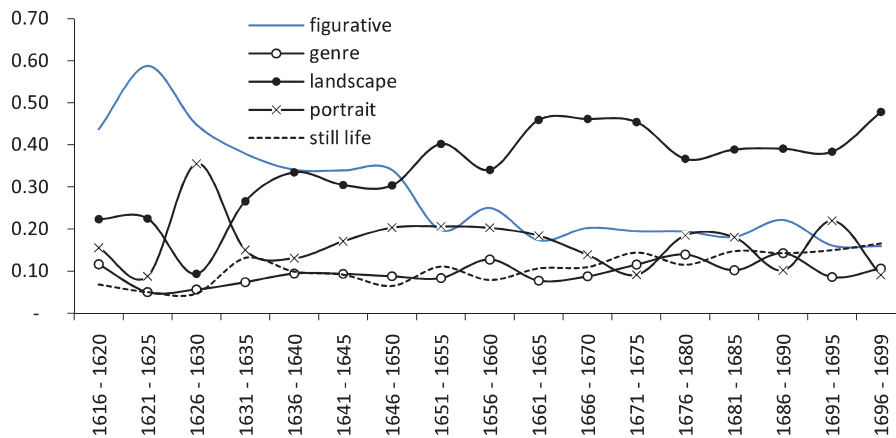
the century (and between the attributed paintings they have an even larger share, reaching half of the paintings in the collections). This pattern confirms what was already found by Montias (1982) in Delft: the increase in demand from the middle class led to more diversification across genres.

Earlier investigations on the evolution of prices in the Dutch Golden Age have been based on average *nominal* prices (see North, 1999) and have emphasized a general increase in the price of most genres, especially in the last quarter of the century and for genre paintings, figurative paintings and portraits, with an initial decline only for landscapes.[29] Contrary to this, we show in Fig. 6 that the average *real*

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[29] For instance, Chong (1987) focusing on a sample of high price paintings (excluding copies) has emphasized an average price of portraits increasing from 6 guilders in 1600-25, to 11 in 1626-50, 23 in 1651-75 and 37 in 1676-1700. The corresponding figures for genre paintings are 28, 22, 31 and 88 guilders respectively, while still life paintings were priced 27, 30, 24 and 41 guilders in the four consecutive periods. Figurative paintings of religious subject moved from 33 guilders, to 43, 70 and 52. Finally, the price of landscapes moved from 30 guilders in 1600-25 to 22 in 1626-1650, 24 in 1651-1675 and 44 guilders in

prices (adjusted for inflation) tend to decrease over the century, possibly with the exception of portraits and the oscillating behavior of the figurative paintings. Moreover, the distribution in terms of prices shows a general tendency toward convergence between prices of different genres during the century, especially through a decline in the price of still life and genre paintings, but also of landscapes. The reduction in the price of landscapes was partly associated with a change in the characteristics of the paintings (becoming smaller, as noticed by Montias, 1996) and partly due to the increasing supply shown in Fig 5, therefore it will be important to verify such a convergence of prices across genres controlling for paintings' characteristics with econometric techniques.

Figure 6: Average price by genre in guilders
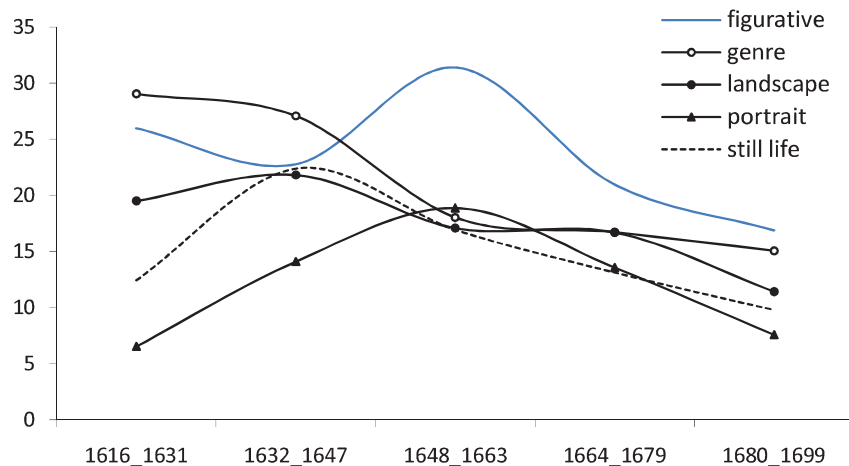
Our dataset contains about four hundred different artists (the most frequent being Jan Miense Molenaer, Jan Porcellis, Roelandt Savery and Rembrandt). For 67% of them we have more than one observation. The specialization of the Dutch painters in different genres and sometimes sub-genres was impressive. For most of the painters in our dataset we have identified a single genre for their works, suggesting extreme specialization. Nevertheless, it is normal that some of them were occasionally engaged in different works: for the 261 artists with more than two observations in the dataset (excluding observations of unknown genre) we find that 117 were diversifying their work among at least a couple of genres, 45 between at least three genres, 15 between four genres and only 4 artists have paintings in each genre within our dataset.

Another important trend emerging clearly from the Dutch inventories is a gradual reduction of the size of paintings over the century, which reflects a change in supply conditions. Even if precise measures are not available, the descriptive comments in the inventories report whether paintings were small or large. What we find is shown in Fig. 7: the share of small paintings increases from around 15% to 30-35%, while the fraction of large paintings remains constant, suggesting that there was a rapid reduction of the average size of the new paintings entering in the collections. This is in line with the idea that painters

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1676-1700. Montias (1996) has focused on landscapes drawn from two random samples of Amsterdam inventories, and has shown a decline in the average nominal price of landscape paintings from 11.65 gulden in the period 1600-1619 to 6.1 in the period 1650-1659.

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Figure 7: Share of small and large paintings (10-years moving average)
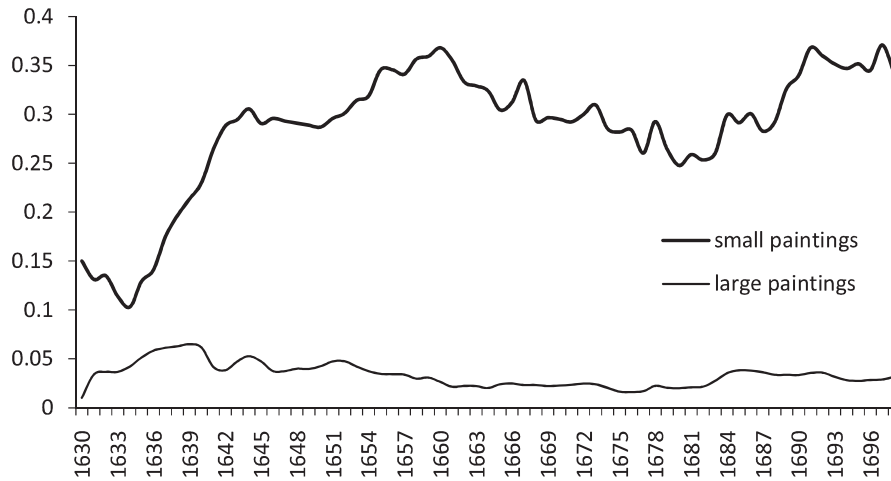
looked for cost savings artistic innovations in their production activity: the small size of paintings is one of them, because smaller paintings could reach a wider audience at lower prices.

Finally, for two thirds of the observations we know the room of the house in which the painting was placed, which provides additional indirect information on the quality of paintings. Following Loughman and Montias (2001), we group rooms in *voorhuys* (the main entrance), other public rooms, private rooms and the kitchen.[30] We also count the number of rooms in the house, which will be a proxy for the value of the house and therefore for the wealth of the owner. Loughman and Montias (2001) have found in a different dataset that paintings of large size, attributed to artists and described by subject in the inventory were more frequent in public rooms. They also found that the specialization of rooms by subject was relatively weak, but they could not control for a number of factors in their descriptive analysis. Within our dataset we confirm that public rooms and the *voorhuys* contained more expensive works (see Table 1) and that this pattern appears to be constant over time also after controlling for other factors.[31] Besides its historical value, this suggests that paintings of different quality were placed in different spaces of the house, therefore we will use this placement as an additional control variable for quality in the hedonic regressions.

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[30] To public rooms we attribute the main reception rooms such as the great hall (*saal*), the great room (*groote camer*) and the best room (*beste camer*), and the office (*comptoir*). To private rooms we attribute back (*achter-*) rooms, upstairs (*boven-*) rooms, the 'inner hearth' (*binnen camer*), and the sleeping and children rooms. We exclude from the classification the front (*voor-*) rooms and side (*zij-*) rooms, because their purpose is not generally clear and can change across houses, and all the rooms without any indication of their placement within the house.

[31] In Etro and Stepanova (2013) we run a multinomial Probit model for the placement in different rooms controlling for the main painting characteristics, such as whether it was a copy or whether it was attributed to an artist, whether it was large or small and its genre, including some sub-genres. Larger paintings were 18% more likely to be placed in the *voorhuys* while smaller paintings were more likely to be in private rooms or in the kitchen. Attributed paintings were 9% more likely to be displayed in public rooms, especially, when they represented figurative subjects (of both historical and religious content), while private rooms and kitchens tended to display lower quality paintings as, respectively, portraits and still life paintings.

3 Hedonic regressions and the price index

In this section we report the results of our main econometric investigation in Table 2. The dependent variable is the logprice of paintings adjusted for CPI, so that the coefficients can be interpreted in terms of semi-elasticities. We present two regressions, the first of which is on the entire dataset available without artist fixed effects, but with a dummy for paintings whose author is anonymous. A version of this regression has been used to derive the price index (of Fig.1 and 9) replacing the time trend with time period dummies. The second regression is limited to the attributed paintings and contains fixed effects for each artist with at least two observations (omitting a reference group that contains all the artists with a single observation), which serves the purpose of controlling in the most precise way for the unobservable characteristics of the paintings. Selected artist fixed effects are reported in Table 5. We used the full set of control variables in both regressions.

Plate 4. Jan Davidsz. de Heem, "Still Life, Breakfast with Champaign Glass and Pipe" (1642, Residenzgalerie, Salzburgh). Artwork in the public domain.

3.1 The main determinants of art prices

Our main macroeconomic control variable, the real wage, is positively correlated with prices but the relation does not appear to be significant (and omitting this control does not change any of the results). An obvious rationale for this is that the price of a painting in the secondary market reflects its value as

Table 2: Price regressions

	Baseline OLS regression		OLS regression on attributed paintings	
Year	-0.008***	(0.001)	-0.014***	(0.002)
Real wage	0.003	(0.002)	0.002	(0.004)
Artist fixed effects			(YES)	
Anonymous	-1.179***	(0.028)	-	
Copy	-0.621***	(0.058)	-0.985***	(0.089)
Large size	0.815***	(0.056)	0.661***	(0.097)
Small size	-0.491***	(0.023)	-0.578***	(0.046)
Nr. paintings evaluated	-0.049***	(0.003)	-0.164***	(0.030)
Genre of the Painting				
unknown genre		omitted		omitted
landscape	0.671***	(0.031)	0.005	(0.074)
figurative	0.742***	(0.034)	0.121	(0.082)
portrait	0.344***	(0.036)	-0.207**	(0.102)
still-life	0.524***	(0.042)	-0.033	(0.116)
genre	0.640***	(0.043)	-0.021	(0.093)
Placement of the Painting				
unknown room		omitted		omitted
private rooms	-0.093***	(0.027)	-0.423***	(0.065)
public rooms	0.368***	(0.037)	-0.066	(0.075)
voorhuys	0.127***	(0.032)	-0.122	(0.074)
kitchen	-0.322***	(0.072)	-0.339*	(0.176)
Number of rooms	-0.002	(0.003)	0.024***	(0.005)
Av. price rest of collection	0.029***	(0.001)	0.016***	(0.001)
Owner religion				
unknown religion		omitted		omitted
catholic	-0.169***	(0.048)	0.034	(0.117)
protestant	-0.104***	(0.028)	0.016	(0.067)
jewish	-0.408**	(0.160)		
Owner occupation				
unknown occupation		omitted		omitted
merchant large scale	0.115***	(0.034)	0.032	(0.081)
art dealer	0.128**	(0.059)	-0.045	(0.105)
merchant retail	-0.445***	(0.050)	-0.742***	(0.146)
services	-0.097**	(0.046)	-0.273**	(0.131)
craft	-0.521***	(0.057)	-0.324***	(0.116)
artisan	-0.346***	(0.055)	-0.300***	(0.105)
artist	0.081	(0.066)	-0.151	(0.158)
manufacturer	-0.015	(0.070)	-0.058	(0.152)
employee	0.057	(0.085)	-0.162	(0.171)
regent	0.517***	(0.103)	0.112	(0.185)
Inventory purpose				
unknown purpose		omitted		omitted
death	-0.240***	(0.033)	0.127*	(0.066)
insolvency	-0.249***	(0.054)	-0.004	(0.127)
collateral	0.246***	(0.073)	-0.032	(0.131)
marriage	0.267***	(0.081)	0.320*	(0.189)
Constant	15.232***	(1.360)	26.529***	(3.585)
Observations	10 525		2 007	
Adjusted (R^2)	0.54		0.60	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Standard errors in parentheses

an asset, which is largely independent from the short run behavior of the economy; the same occurs in data from contemporary Dutch auctions (see Etro and Stepanova, 2013).

In both the baseline regression and in the one on attributed paintings, price estimates are reduced when more paintings are evaluated jointly (for a sort of quantity discount), when they are copies (because cost and quality tend to be lower) and when they are of a small size.[32] As expected, the baseline regression emphasizes drastic price differentials between anonymous paintings and attributed ones. As mentioned above, the placement of paintings in the house was correlated with the quality of the work, and indeed we find that placement in private rooms and in the kitchen was associated with lower prices compared to paintings displayed in the entrance and in public rooms.

Let us move to the variables related to the owners. The number of rooms in the house could be seen as a proxy of the wealth of the owner or possibly of other characteristics of the collection (average size of paintings, number of paintings) and is positively correlated with prices at least in the full specification. Of course, we cannot control for all of the qualitative characteristics of the paintings, and some collections were simply more valuable because the owners had a higher preference or willingness to pay for art or for more valuable paintings. To capture these residual unobservable aspects, we control for the average price of the (other) paintings present within each collection (for this reason we have excluded from the regressions the few inventories with a single painting). As one would expect, the relation is positive and significant (even if of limited magnitude, suggesting that our control variables account already for a lot of variability in prices) and the coefficient is reduced when we control for the artists fixed effects.[33]

We have more information indirectly related to both income and preferences of the owners, such as their job and their religion. In the baseline regression we emphasize higher prices for paintings belonging to the upper class, namely regents, large merchants and to the art dealers, compared to typical professions of the emerging middle class (retail merchants, workers in services, craftsmen and artisans). Catholics and Jewish appear to have paintings with a lower average price: possibly, iconoclasm reduced the market value of their religious paintings. However, most of these correlations lose significance or are reduced when we control for the artists fixed effects, in line with the expectation that the market price of a painting with given characteristics should not strictly depend on its owner. It is remarkable that similar results emerge also within contemporary auctions, analyzed in Etro and Stepanova (2013). They are in line with the idea that in a competitive secondary market prices were independent from the identity of the traders: richer buyers were purchasing more expensive paintings, but there is no reason why they should pay more for a painting of given characteristics.

Another interesting piece of evidence is about the purpose of the inventory. Again, this may be correlated with prices, but the evaluation of paintings of a given quality should not be largely affected by the purpose of the same evaluation. Indeed, in the baseline regression we find higher prices in inventories prepared for a marriage and prepared as collateral for the creditors. This may reflect positive selection

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[32]It is important to remark that we do not have precise data on the size of paintings, and we could only classify them as small or large compared to the average size (when the description of the painting mentioned that), however the variability in size was lower in home collections compared to paintings destined to public commissions (which could be much larger).

[33]Controlling for the average price of painting in the collections can be problematic if there is a limited heterogeneity between collections, which is not the case in this dataset. However, the other results are robust when we omit this control.

effects: owners selected better paintings for these purposes or decided to organize inventories when they had paintings by better artists to use for these purposes. To the contrary, prices appear lower in inventories due to the insolvency of the owner or after the death of the owner. This may reflect negative selection effects: debtors and heirs were forced to record all paintings including those by worse painters. Nevertheless, once again, these correlations tend to lose significance after controlling for quality through the artists' fixed effects.

Price differentials between different genres appear to be extremely wide even when we control for the main features of paintings and owners. We compared the five main genres with the omitted category of paintings whose genre is unknown. Our baseline regression shows that figurative paintings were evaluated 110% more than the reference group, landscape and genre paintings 96% and 90% more, still life paintings 69% more and the portraits were evaluated 41% more than the omitted group. These differences almost disappear when we control for the unobservable characteristics of the painters, with the only exception of portraits that are evaluated 18% less of the paintings of unknown genre.[34] This could suggest that, after taking into account quantitative aspects of the paintings and unobservable quality of the painters, most of the price differentials between genres were negligible. This is in line with what found in the primary market for paintings during the same century in Rome by Etro *et al.* (2015). Here, however, we are looking at a secondary market, where price differentials between genres due to changes in preferences could persist even if they were absent in the primary market: more precisely, price differentials in the secondary market could induce adjustments in the production of different genres in the primary market, but this would lead to price convergence only gradually in the secondary market. This is exactly what we find when we look at the convergence of the price indexes by genre, as reported in Fig. 8, where we show the standard deviation of price changes across genres. This fact suggests that there was a pattern of σ-convergence of prices between genres. Summing up, contrary to what emerges from descriptive statistics where these differentials are large (Montias, 1982, 2002), we find that, after we control for the unobservable quality of paintings (with artists fixed effects), price differentials tend to disappear over time.

3.2 Artists fixed effects

We can finally look at the artists fixed effects found in the full specification (see Table 5). The omitted category (relative to which we should read all the other coefficients) is the group of over a hundred artists with a single observation: therefore, the ranking of fixed effects is the relevant aspect to notice (as opposed to the absolute coefficients). Some of the painters with high reputation nowadays appear between the best, but they are sometimes intermingled with painters of much lower reputation, which was probably due to a different perception of quality at the time relative to today. Nevertheless, the best figurative painters include some of the most famous Flemish and Dutch masters from the XVII century such as Jacob Jordaens, Pieter Paul Rubens, Pieter Lastman and the same Rembrandt,[35] but also old

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[34]One should notice that portraits were penalized in the evaluation of the secondary market since the value for the commissioner was higher than the value for another collector. On the correct interpretation of dummy variables in semilogarithmic equations see the classic note by Halvorsen and Palmquist (1980).

[35]As well known, Rubens organized his workshop as a real enterprise, exploiting a large number of collaborators to produce an impressive amount of well paid works (see Hauser, 1951).

Figure 8: Convergence of prices for different genres over time (standard deviation of returns between genres)
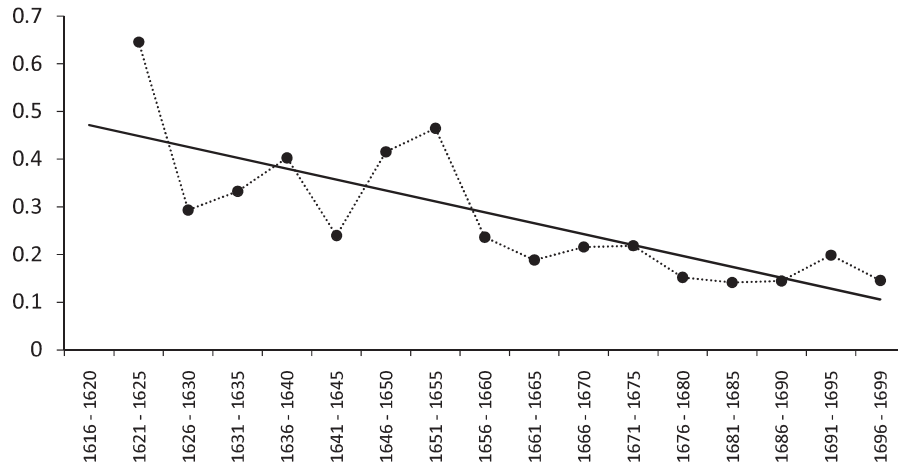
masters such as Lucas van Leyden and the German painter Hans Holbein, or famous mannerist artists such as Joachim Beuckelaer, Joachim Wtewael and Bartholomeus Spranger. The painter and biographer Karel van Mander provides us with some anecdotal information on mannerist artists which is consistent with our findings: according to van Mander (1604), Beuckelaer's works fetched low prices during his life, but after his death they increased in value twelvefold,[36] Spranger was always used to receive high rewards for small works, Willem Key was so highly esteemed that once he received forty guilders for a portrait of a cardinal without having asked anything, and Frans Floris was so appreciated and rapid to earn a thousand guilders per year, which was a fortune in those days.

The best paid still life paintings were by Jan de Heem (see Plate 4), Otto Marseus van Schrieck and the Flemish Frans Snyders, while prices for the tonal paintings of banquets by Willem Claesz. Heda and Pieter Claesz. were not significantly higher than average.

The best landscapists include Paul Bril, Jan Asselyn, Claes Berchem, Emanuel de Witte and, a step behind, Jacob Ruisdael and Jan Brueghel. Many famous landscape painters did actually face low prices, as for Hercules Seghers, Philips de Koninck, Hendrick Avercamp, Gillis van Conincxloo, Joost C. Droochsloot (see Plate 5) and Esaias van de Velde. It is remarkable that most of the painters that adopted the tonal style, such as Jan van Goyen, Pieter de Molijn, Salomon van Ruysdael and Simon de Vlieger, do not have an evaluation that is significantly higher than average (and the coefficient is relatively low also for Jan Porcellis): their increased productivity was probably compensated by lower unitary prices.

Top genre painters included Gabriel Metsu, Gerard Ter Borch, Gerard Dou, two Caravaggists as Gerrit van Honthorst and Hendrick ter Brugghen and, only behind, Pieter de Hooch (Vermeer does not appear in our inventories, but his few works appear to be well paid in auctions held at Amsterdam at the end of the century; see Etro and Stepanova, 2013).

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[36]Wetried to test for death effects, but the dataset is too limited to identify clear patterns.

Finally, distinguished portraitists included the same Rembrandt and Antoine van Dyck, as one would expect, while we confirm the well known fact that the Harleem specialist Frans Hals did not reach high prices for his portraits. According to Schama (1999, p. 330-331) this could be a matter of local taste: "while we recognize the universal quality of Hals' élan vital, in 1630 it probably seemed merely the best specimen of a parochial Haarlem-style, one that owed a lot to the animation and immediacy of Hendrick Goltzius's pictures and to the earthly and rumbustious manner of Judith Leyster and her husband Jan Miense Molenaer. The Hals style certainly appealed to some Amsterdammers, since they would commission him to paint one of their militia companies. But it's not hard to imagine the plutocrats who now disdained the bulk for the "fine" trades considering Hals's brassy ebullience as fit for the brewers and linen bleachers of Haarlem, but not for what they supposed to be their own more elegant fashion."

3.3 The Price Index for Dutch paintings

Both our main regressions in Table 2 emphasize a negative trend of the relative price of a representative painting (that is, controlling for its characteristics as much as we can) in the period 1616-1700. To provide a more precise account of the temporal trend of the relative prices, we have re-run the baseline regression replacing the linear trend with a set of time-period (bi-annual) dummies, which allows us to build a standard hedonic price index (given by the antilogs of the coefficients on the time-period dummies) shown in Fig. 9 with its 95% confidence interval.[37] Since the price distribution is characterized by a fat tail, we also run a quantile regression to confirm that the median price has a similar behavior as the average price: Fig. 9 reports also this index which appears largely in line with the baseline index. As far as we know, this is the oldest price index based on historical prices of paintings, and in the next section we will provide additional analysis on its evolution.

The negative trend of prices is in line with the anecdotal evidence for which, after a boom at the beginning of the century, the return from the artistic profession gradually decreased during the Golden Age. Many Dutch painters of the Golden Age had to turn to a second profession: van Goyen traded in tulips, van de Velde in linen, Steen and Aert van der Velde were innkeepers, Pieter de Hooch was a servant and Hobbema a tax collector. Rembrandt went bankrupt in 1656, in part because at the peak of his success he bought a house that he could not afford to pay with his subsequent earnings (Crenshaw, 2006) and, probably, also because he kept investing in art (even buying back his own prints in the vane attempt to increase their price)[38] in a period in which prices were declining. Many other painters did go bankrupt (Roelandt Savery, Jan Porcellis, Jan Weenix, Pieter Potter), while Hals escaped this but was

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[37]This is the same inventory price index of Fig. 1.

[38]Baldinucci (1686) commented on these acquisitions of prints: "con intollerabile spesa fecene ricomperare per tutta Europa quante ne potè mai trovare ad ogni prezzo, e fra l'altre una ne comperò in Amsterdam all'incanto per 50 scudi, ed era questa una Resurrezione di Lazero, e ciò fece in tempo, ch'egli medesimo ne possedeva il rame intagliato di sua mano. Finalmente con tal bella invenzione diminuì tanto suo avere, che si ridusse all'estremo, ed occorse a lui cosa, che rare volta si racconta di altri pittori, cioè, ch'ei diede in fallito."

Figure 9: Price index in Amsterdam (1616-1700)
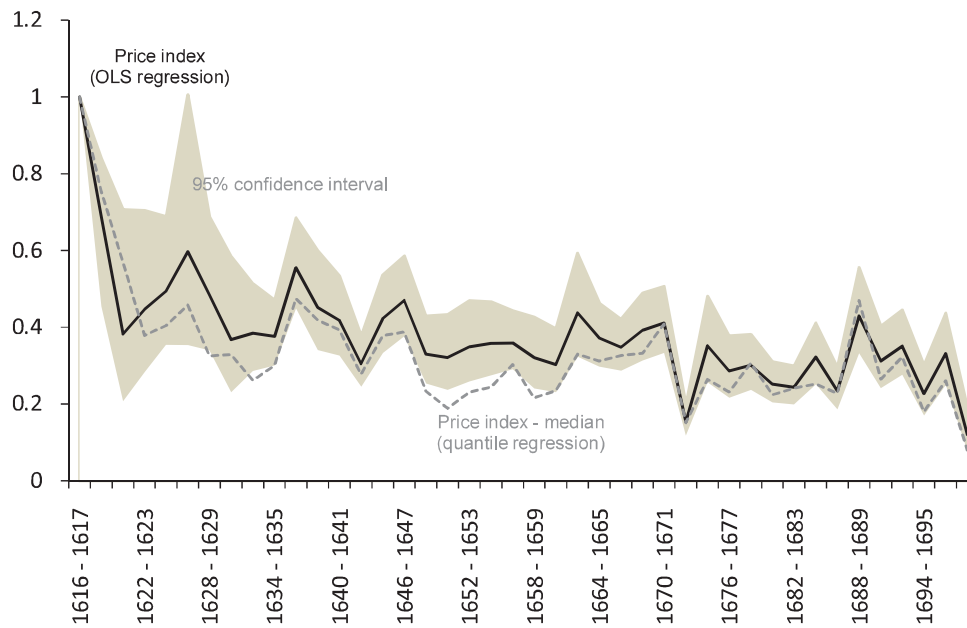
constantly in debt with shopkeepers (Gombrich, 1995).

Plate 5. Joost Cornelisz. Droochsloot, "A Village Street with a Maypole and a Inn" (1646, Etro Collection).

As noticed by Hauser (1951, Vol. II), "not only Rembrandt and Hals, but also Vermeer, the third leading painter in Holland, had to fight against material worries. And the other two greatest painters of the country, Pieter de Hooch and Jacob van Ruisdael, were also not highly esteemed by their contemporaries and by no means among the artists leading a comfortable life. The epic of Dutch painting is not complete unless one adds that Hobbema had to give up painting in the best years of his life." This is consistent with our finding that the real profitability of paintings kept decreasing over the second part of the century.

The price index emphasizes also a cycling behavior around its trend, and this must have been largely related to aggregate shocks. For instance, the price drop of 1672 corresponded to a drammatic year, known as the "year of calamites", in which England and France joined in a secret pact to start a war against the Dutch Republic. Our last inquiry is about the impact that price fluctuations exerted on the entry of painters.

4   Time series analysis

An important determinant of the decision to become a painter is the expected profitability of the profession, which is reflected in the growth of the price of paintings relative to the cost of living. As we have argued, the high prices of the beginning of the century and their subsequent decline are broadly compatible with the initial increase of the number of painters and the subsequent decline (Fig. 1 and 2). However, any attempt at finding causality should depart from a long run perspective and look at the link between profitability and entry in the short run: whenever the return from the profession was expected to be high new artists would enter in the market making more likely that artistic innovations could be developed and introduced in the sector.[39] Of course, imperfect information and time-to-enter in the market should be taken into account, leading to some delay in the feedback on entry. This is in line with evolutionary models of entry (Winter, 1984; Klepper, 1996).

In this section we provide a preliminary test of this hypothesis looking at the time series properties of our data. On one side we expect that increasing prices should attract more painters after few years (the endogenous entry hypothesis), and on the other side, an increase in the number of painters could determine more competition and (possibly) the introduction of process innovations, leading quickly to lower prices in the primary market and lower returns on paintings in the secondary market (the competition hypothesis). To test these hypothesis we look at data on the rate of entry of painters and on price changes from our inventory price index (see Table 6) and we check for Granger causality in both directions: a variable R is said to Granger-cause a variable E if the expectation of E_t conditioning on both the history of R and E, $\{R_{t-s}\}_{s=1}^{t}$ and $\{E_{t-s}\}_{s=1}^{t}$ differs from the conditional expectation of E_t given its past history alone.[40]

We follow the standard Box and Jenkins (1970) procedure and consider the relation between two time series: E_t is the rate of entry of painters in Amsterdam and R_t is the bi-annual change of the inventory

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[39] In this sense, we can look at the artistic sector as a Schumpeter Mark I sector where innovations are mainly associated with the entry of new artists that are going to replace older styles in a typical process of "creative destruction" (see Winter, 1984).

[40] In other words R Granger causes E if:

$$\mathbf{E}\left\{E_t \mid \{E_{t-s}\}_{s=1}^{t}, \{R_{t-s}\}_{s=1}^{t}\right\} \neq \mathbf{E}\left\{E_t \mid \{E_{t-s}\}_{s=1}^{t}\right\}$$

price index.[41] Both time series are stationary: i.e. Dickey-Fuller tests show that time series do not have unit-root. Three lags are optimal according to Akaike information criterion, final prediction error and the Hannan and Quinn information criterion. Post-estimation test of normal distribution of residuals and absence of autocorrelation in residuals are applied to validate the VAR model (Table 3).

Table 3: VAR estimation results

Lagged variables	Returns equation R_t		Entry equation E_t	
R_{t-1}	-0.83***	(0.16)	0.05	(0.04)
R_{t-2}	-0.35**	(0.17)	-0.01	(0.04)
R_{t-3}	-0.43***	(0.15)	0.09**	(0.04)
E_{t-1}	-1.74***	(0.59)	0.81***	(0.15)
E_{t-2}	1.11	(0.68)	-0.55***	(0.17)
E_{t-3}	-0.40	(0.60)	0.42***	(0.15)
Constant	2.70***	(0.39)	-0.13	(0.09)
Observations	38		38	
R^2	0.49		0.48	
Jarque-Bera normality test				
(χ^2 with 2 d.f.)	0.41		1.01	

** $p < 0.05$, *** $p < 0.01$ Standard errors in parentheses

In line with our conjecture, we find Granger causality in both directions (Table 4), that is an increase in prices Granger-causes positive changes in entry of painters (the relationship is significant at 1%), and an increase in entry Granger-causes negative changes in the price of paintings (the relation is significant at 5%). Causality from price changes to entry is not immediate, but appears at the third lag, which means after six years. Without overemphasizing this aspect, it is remarkably in line with what one would expect: it can be interpreted in terms of the few years of training that were needed for an young apprentice to become a painter and enter in the profession officially. Causality from entry to prices, instead, is immediate, with a large negative impact on the subsequent prices. All this supports the endogenous entry hypothesis for which profitability induces business creation in the art sector, but subsequently entry

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where $\mathbf{E}[\cdot]$ is the expectation operator. The concept is operationalized by estimating a model of the form:

$$E_t = \alpha_0 + \sum_{s=1}^{L} \alpha_s E_{t-s} + \sum_{s=1}^{L} \beta_s R_{t-s} + \varepsilon_t$$

and testing the null hypothesis:

$$H_0 = \bigcup_{s=1}^{L} (\beta_s = 0)$$

where L is the number of lags. See Granger (1969), Engle and Granger (1987) and Sims *et al.* (1992). As well known, Granger causality does not imply causality in the standard sense, however we hardly see any non-causal mechanisms that could associate an increase in prices of paintings with an increase in the number of painters.

[41] Similar results would emerge using the auction price index that covers a limited time period. However this is based on more limited data and control variables. For this reason we focus on the inventory price index.

Table 4: Granger causality test results

Classical approach (Box and Jenkins)					
From	To	Wald statistics (χ^2 with 3 d.f.)	p-value	Sum of lagged coefficients	Causality
R	E	12.661	0.005	0.13	R→E***
E	R	8.807	0.032	-1.03	E→R**

Toda and Yamamoto approach					
From	To	Wald statistics (χ^2 with 4d.f.)	p-value	Sum of lagged coefficients	Causality
P	Q	13.805	0.008	0.02	P→Q***
Q	P	3.806	0.433	0.00	No

*** , ** denote significance at 1 % and 5 % levels respectively

strengthens competition so as to reduce prices, which is the competition hypothesis.[42]

As a robustness check we run a VAR model for time-series of lower frequencies (5-years time steps instead of bi-annual), and we found causality in both directions also in this case. We also followed the approach of Toda and Yamamoto (1995) which does not depend on the cointegration properties of the system and allows us to run the VAR in levels, namely number of painters Q_t and prices P_t (see Table 4). Also in this case, we rejected the null hypothesis of absence of Granger-causality running from prices to the number of painters: an increase in prices Granger-causes a positive change in the number of painters as the sum of lagged coefficients is positive, and the relationship is significant at 1% level. However, causality running in the opposite direction is not confirmed. Therefore, the strong causal relation appears to be the one going from prices to the number of painters.

It would be interesting to test further our conjecture. In particular, the endogenous entry hypothesis on the economic source of artistic innovations could be tested through a preliminary channel that links exogenous shocks to price changes, which in turn determines endogenous processes of entry and innovation.[43] It would be also interesting to verify from art historical sources whether periods of increasing prices were associated with an increase in the number of apprentices and with more innovative new artists,[44] whether painters tended to specialize in those genres that were in demand and whether the timing of increasing specialization coincided with the entry of new artists.

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[42] We run the same analysis using the percentage of painters in the population obtaining very similar results.

[43] In our case this was not possible because the only available macroeconomic variable (the wage) is not directly related to the price of paintings, since the latter reflects asset pricing principles (it depends on the expected consumption dividend of holding a painting and the resale price). The return on different assets would be the ideal tool for this analysis.

[44] Anecdotal evidence suggests that a similar endogenous entry process could have been at work in other periods, such as the end of the '700s and beginning of the '800s in London (Bayer and Page, 2011) or Paris (Etro and Stepanova, 2015).

5 Conclusions

We have explored the secondary market for paintings of Dutch and Flemish artists during the Golden Age of the XVII century. Our main objective was to test the idea that profitability should be the main driver of entry of painters in the art market. The econometric analysis and some anecdotal evidence appear to confirm that when the price of paintings was increasing there were new and more innovative painters that entered in the market.

At the end of the '600s and at the beginning of the '700s the Dutch market was in decline and the number of painters kept decreasing. Many artists moved to England, where a new booming market was emerging and would have reached its golden age soon (see Bayer and Page, 2011). Future research could explore similar evolutionary patterns in this and other historical periods or in other fields of creativity with econometric techniques.[45]

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[45] See Borowiecki (2015) on the origins of cultural supply in Italy.

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Table 5: Artists fixed effects

Name	Coef.	St.err.	obs.	Name	Coef.	St.err.	obs.
HEEM, JAN DAVIDSZ. DE(1606-1683)	1.797***	(0.356)	5	WITTE, EMANUEL DE(1617-1692)	0.794***	(0.236)	12
METSU, GABRIEL(1629-1667)	1.728***	(0.454)	3	DYCK, ANTHONIE VAN(1599-1641)	0.780**	(0.326)	6
BRIL, PAUL(1554-1626)	1.644***	(0.355)	5	PYNACKER, ADAM(1622-1673)	0.777***	(0.3)	7
BEUCKELAER, JOACHIM(1533-1574)	1.629***	(0.556)	3	SPRANGER, BARTHOLOMEUS(1546-1611)	0.760*	(0.455)	4
JORDAENS, JACOB(1593-1678)	1.449***	(0.299)	7	COLLAERT, JOHANNES(1622-1678)	0.746*	(0.391)	4
HOLBEIN, HANS (II)(1497-1543)	1.380***	(0.327)	6	BRUGGHEN, HENDRICK TER(1588-1629)	0.729*	(0.392)	4
SNYDERS, FRANS(1579-1657)	1.240***	(0.363)	5	SCOREL, JAN VAN(1495-1562)	0.701*	(0.398)	4
BORCH, GERARD TER (II)(1617-1681)	1.236***	(0.452)	3	KEY, WILLEM(1515-1568)	0.694***	(0.24)	13
MARSEUS VAN SCHRIECK, OTTO(1619-1678)	1.168***	(0.259)	10	VRIES, HANS VREDEMAN DE(1527-1606)	0.648*	(0.362)	5
KONINCK, SALOMON DE(1609-1656)	1.093***	(0.243)	13	HOOCH, PIETER DE(1629-1684)	0.627**	(0.29)	8
BERCHEM, CLAES PIETERSZ.(1620-1683)	1.074***	(0.354)	5	BACKER, JACOB ADRIAENSZ.(1609-1651)	0.611*	(0.323)	6
DOU, GERARD(1613-1675)	1.073***	(0.357)	5	CORNELISZ. VAN HAARLEM, C.(1562-1638)	0.593***	(0.171)	26
BACKHUYSEN, LUDOLF(1630-1708)	1.067***	(0.351)	5	RUISDAEL, JACOB ISAACKSZ.(1628-1682)	0.586***	(0.216)	15
RUBENS, PIETER PAUL(1577-1640)	1.057***	(0.243)	11	LINGELBACH, JOHANNES(1622-1674)	0.584***	(0.207)	16
LEYDEN, LUCAS VAN(1494-1533)	1.020***	(0.324)	6	BRUEGEL, JAN (I)(1568-1625)	0.582**	(0.256)	10
BOSCH, PIETER VAN DEN(1614-1670)	1.002**	(0.401)	4	HEDA, WILLEM CLAESZ.(1593-1681)	0.581	(0.4)	4
HONTHORST, GERRIT VAN(1592-1656)	0.996**	(0.396)	4	GELDORP, GORTZIUS(1553-1618)	0.576*	(0.333)	6
ASSELYN, JAN(1610-1652)	0.952**	(0.393)	4	LIEVENS, JAN (I)(1607-1674)	0.572***	(0.15)	35
BALEN, HENDRICK VAN (I)(1575-1632)	0.909**	(0.357)	5	FLORIS, FRANS (I)(1520-1570)	0.565**	(0.268)	9
BOUT, PEETER(1658-1719)	0.907**	(0.418)	4	FRANCKEN, FRANS (II)(1581-1642)	0.562*	(0.333)	6
VELDE, ADRIAEN VAN DE(1636-1672)	0.891**	(0.35)	5	VRANCX, SEBASTIAN(1573-1647)	0.546**	(0.258)	10
VERTANGEN, DANIEL(1601-1683)	0.884***	(0.162)	30	BOL, FERDINAND(1616-1680)	0.522	(0.323)	6
REMBRANDT VAN RIJN(1606-1669)	0.868***	(0.15)	36	FLINCK, GOVAERT(1615-1660)	0.52	(0.327)	6
VENNE, ADRIAEN PIETERSZ.(1580-1662)	0.820***	(0.285)	8	BOTH, JAN(1614-1652)	0.466	(0.329)	6
WTEWAEL, JOACHIM(1566-1638)	0.810***	(0.309)	7	GRONINGEN, SWART JAN, VAN(1495-1563)	0.418	(0.287)	8
BOTH, ANDRIES DIRCKSZ.(1611-1642)	0.805**	(0.392)	4	CAPPELLE, JAN VAN DE(1626-1679)	0.414	(0.333)	6
LASTMAN, PIETER(1583-1633)	0.799**	(0.35)	5	SAVERY, ROELANDT(1576-1639)	0.395***	(0.152)	37

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Standard errors in parentheses

Artists fixed effects(continued)

Name	Coef.	St.err.	obs.	Name	Coef.	St.err.	obs.
PORCELLIS, JAN (I)(1584-1632)	0.381***	(0.139)	44	VROOM, HENDRICK(1562-1640)	-0.11	(0.207)	17
POELENBURGH, CORNELIS VAN(1594-1667)	0.373*	(0.202)	17	HALS, FRANS(1582-1666)	-0.139	(0.271)	9
VINCKBOONS, DAVID(1576-1632)	0.37	(0.289)	8	PEETERS, BONAVENTURA(1614-1652)	-0.172	(0.212)	17
NEER, AERTVAN DER(1603-1677)	0.361**	(0.184)	23	PYNAS, JACOB SYMONSZ.(1592-1650)	-0.178	(0.238)	12
WOUWERMAN, PHILIPS(1619-1668)	0.340*	(0.187)	21	DROOCHSLOOT, JOOST CORNELISZ.(1586-1666)	-0.182	(0.281)	8
TENIERS, DAVID (II)(1610-1690)	0.315	(0.352)	6	MOLENAER, JAN MIENSE(1610-1668)	-0.188	(0.129)	66
HEYDEN, JAN VAN DER(1637-1712)	0.301	(0.323)	6	GOYEN, JAN JOSEPHSZ. VAN(1596-1656)	-0.201	(0.174)	24
AERTSEN, PIETER (LANGE PIER)(1508-1575)	0.284	(0.194)	19	BROUWER, ADRIAEN(1605-1638)	-0.224	(0.233)	13
VLIEGER,SIMON DE(1601-1653)	0.28	(0.185)	21	WYCK, THOMAS(1616-1677)	-0.247	(0.281)	8
MOLENAER, CLAES(1626-1676)	0.278	(0.301)	7	SCHELLINKS, WILLEM(1627-1678)	-0.271	(0.301)	7
BARENDSZ., DIRCK(1534-1592)	0.26	(0.356)	5	VELDE, ESAIAS VAN DE(1587-1630)	-0.371	(0.228)	13
BLOEMAERT, ABRAHAM(1566-1651)	0.257	(0.237)	12	TROYEN, ROMBOUT VAN(1605-1655)	-0.424***	(0.164)	32
CRANACH, LUCAS(1472-1553)	0.209	(0.335)	6	HALS, DIRCK(1591-1656)	-0.488*	(0.26)	11
MOSTAERT, GILLIS(1528-1598)	0.171	(0.298)	7	MARSEUS VAN SCHRIECK, EVERT(1619-1678)	-0.522*	(0.285)	8
MOUCHERON, FREDERICK DE(1633-1686)	0.164	(0.304)	7	CLAESZ., PIETER(1597-1660)	-0.530**	(0.215)	17
RUYSDAEL, SALOMON VAN(1602-1670)	0.164	(0.306)	7	MANDER, KAREL VAN(I)(1548-1606)	-0.562*	(0.3)	7
CAMPHUYSEN, GOVERT DIRCKSZ.(1624-1672)	0.151	(0.199)	18	MOLIJN, PIETER DE(1595-1661)	-0.567***	(0.186)	20
EVERDINGEN, ALLART VAN(1621-1675)	0.149	(0.154)	34	MOMPER, JOOS DE(1564-1635)	-0.588***	(0.154)	33
HONDECOETER, GILLIS DE(1577-1638)	0.134	(0.166)	28	DOES, JACOB VAN DER (I)(1623-1673)	-0.648*	(0.391)	4
HEEMSKERCK, MAERTEN VAN(1498-1574)	0.128	(0.309)	7	QUAST, PIETER JANSZ.(1606-1647)	-0.662**	(0.258)	10
SEGHERS, HERCULES(1589-1638)	0.125	(0.166)	35	GRIMMER, JACOB(1526-1590)	-0.724*	(0.395)	4
PYNAS, JAN SYMONSZ.(1582-1631)	0.112	(0.233)	12	HEER, GERRIT ADRIAENSZ.DE(1606-1664)	-0.815**	(0.39)	4
KONINCK, PHILIPS DE(1619-1688)	0.097	(0.253)	10	MOEYAERT, CLAES CORNELISZ.(1592-1655)	-0.843***	(0.324)	6
AVERCAMP, HENDRICK(1585-1634)	0.047	(0.353)	5	VRIES, GUILLIAM DE(1624-1678)	-0.865***	(0.317)	7
CODDE, PIETER JACOBS(1599-1678)	0.047	(0.258)	10	LANG, WILLEM ARENTSZ. DE(1590-1626)	-0.914**	(0.402)	4
CONINCXLOO, GILLIS VAN(1544-1607)	-0.06	(0.258)	10	FRIS, JAN(1627-1672)	-0.964**	(0.453)	3
WILLAERTS, ADAM(1577-1664)	-0.07	(0.3)	7	VONCK, ELIAS(1605-1652)	-1.075***	(0.258)	11
VICTORS, JAN(1619-1679)	-0.1	(0.301)	7	GRAS, WILLEM(1620-1680)	-1.257***	(0.41)	4

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Standard errors in parentheses

Table 6: Time series of bi-annual VAR model

Time period	price index P_t	returns on paintings R_t	number of painters index Q_t	entry E_t
1616 - 1617	1		1	
1618 - 1619	0.691	0.691	1.083	0.083
1620 - 1621	0.382	0.553	1.13	0.047
1622 - 1623	0.447	1.17	1.243	0.113
1624 - 1625	0.494	1.104	1.361	0.118
1626 - 1627	0.597	1.208	1.265	-0.096
1628 - 1629	0.484	0.811	1.274	0.009
1630 - 1631	0.368	0.76	1.278	0.004
1632 - 1633	0.384	1.043	1.322	0.044
1634 - 1635	0.376	0.981	1.317	-0.005
1636 - 1637	0.555	1.475	1.322	0.005
1638 - 1639	0.452	0.815	1.361	0.039
1640 - 1641	0.418	0.924	1.548	0.187
1642 - 1643	0.305	0.729	1.822	0.274
1644 - 1645	0.423	1.388	1.909	0.087
1646 - 1647	0.47	1.111	1.935	0.026
1648 - 1649	0.33	0.703	2.052	0.117
1650 - 1651	0.321	0.971	2.126	0.074
1652 - 1653	0.349	1.088	2.074	-0.052
1654 - 1655	0.358	1.028	2.017	-0.057
1656 - 1657	0.359	1.002	2.091	0.074
1658 - 1659	0.321	0.893	2.226	0.135
1660 - 1661	0.303	0.943	2.3	0.074
1662 - 1663	0.438	1.447	2.322	0.022
1664 - 1665	0.372	0.848	2.296	-0.026
1666 - 1667	0.348	0.937	2.178	-0.118
1668 - 1669	0.392	1.125	2.217	0.039
1670 - 1671	0.411	1.048	2.261	0.044
1672 - 1673	0.153	0.373	2.165	-0.096
1674 - 1675	0.352	2.298	1.943	-0.222
1676 - 1677	0.286	0.812	1.943	0
1678 - 1679	0.301	1.052	1.913	-0.03
1680 - 1681	0.252	0.838	1.878	-0.035
1682 - 1683	0.244	0.968	1.809	-0.069
1684 - 1685	0.322	1.32	1.783	-0.026
1686 - 1687	0.234	0.728	1.774	-0.009
1688 - 1689	0.43	1.834	1.722	-0.052
1690 - 1691	0.312	0.727	1.683	-0.039
1692 - 1693	0.351	1.125	1.626	-0.057
1694 - 1695	0.227	0.645	1.622	-0.004
1696 - 1697	0.331	1.461	1.609	-0.013
1698 - 1699	0.121	0.365	1.613	0.004