UNIVERSITÀ DEGLI STUDI FIRENZE
DISEI
DIPARTIMENTO DI SCIENZE PER L'ECONOMIA E L'IMPRESA

Working Papers - Economics

An Economic Theory of Art History

Federico Etro

Working Paper N. 21/2025

DISEI, Università degli Studi di Firenze
Via delle Pandette 9, 50127 Firenze (Italia) www.disei.unifi.it

An Economic Theory of Art History

Federico Etro[1]

University of Florence

First version: July 2023
Current version: December 2025

Keywords: Art history, Artistic innovation, Art prices, Patron-artist contracts
JEL Codes: Z11

Abstract

We analyze the economic dynamics of art markets through workshops that transmit artistic tradition to apprentices and invest in innovations that shape art history. Initial innovations are more radical and associated with low prices and increasing profitability, but the subsequent evolution implies a gradual convergence toward a steady state with stable quality and prices. The equilibrium involves under-investment in creativity, a problem that can be solved through institutions setting payments for apprenticeship, such as art guilds. Heterogeneous talent can generate a highly skewed distribution of art prices with superstar effects. We analyze the role of principal-agent contracts between patrons and artists when quality is not verifiable, cost-saving innovations and mass production, price-setting artists and dealers, endogenous entry of artists and networks of interdependent artistic traditions.

Like other wares, art is dependent on producers and consumers
Rudolf and Margot Wittkower, "Born under Saturn" (1963).

[1]I am grateful to Paolo Bertoletti, Wylie Bradford, Bronwyn Coate, Paul Crosby, Lapo Filistrucchi, Lance Fisher, David Galenson, Bilgehan Karabay, Ye Longfeng, Jordi McKenzie, Jason Potts, Elena Stepanova and seminar participants at the University of Florence, Macquarie University (Sydney), RMIT University (Melbourne) and the National University of Taiwan (Taipei). *Correspondence.* Federico Etro: Florence School of Economics and Management, Via delle Pandette 32, Florence, 50127. Phone: 055-2759603. Email: *federico.etro@unifi.it.*

The evolution of art history can be seen as a sequence of technical, stylistic and conceptual innovations in the production of artworks. According to Gombrich (1960), it is a process of continuous experimentation with the conventions of representation through schemata, corrections and innovations. The influential theory of Kubler (1962) has analyzed art history as a process of changes, replications and mutations to solve evolving problems in the creation of artworks. And the social theory of art history has analyzed artistic innovations as cognitive adaptations to a social environment that changes over time.[2] But all these innovations take place in markets, whose structure can affect their evolution (Montias, 1982; Cowen, 2000; Galenson, 2009). This work develops a dynamic theory of the labor market for artists who transmit their style and tradition while exerting effort in quality-enhancing investments, and emphasizes the contribution of economic incentives to shape the evolution of art history. Primary applications are to figurative arts (painting and sculpture), as developed in classical and modern periods, but some of the insights can be adapted to other forms of art and craftmanship where training, talent and technique determine creativity.

One of the earliest systematic sequences of artistic innovations took place in Classical Greece, where, for the first time in history, rich patrons and rival city-states commissioned statues and paintings to free artists and negotiated on prices and quality, which was then identified with *mimesis*, the ability to imitate nature (Seaman and Schultz, 2017). This period left the earliest evidence of a network of masters and scholars engaged in the artistic profession, patrons in competition for commissions and an art market, where prices increased in parallel with artistic achievements across generations of artists (Stewart, 2019; Etro, 2024). Such a process reemerged in Renaissance art (Goldthwaite, 1995; Etro, 2018; Piano, 2022), in various related traditions of Western art (De Marchi and Van Miegroet, 2006), in Chinese art (Cahill, 1994) and elsewhere. As emphasized by Alsop (1983) each of these cases featured analogous developments of a network of masters and scholars, of art collecting and of an art market, although with different concepts of artistic quality.[3] Even modern art, characterized by different definitions of creativity that continuously emerge and contaminate each other, evolves through an analogous mechanism of creative destruction (Cowen, 2009; Galenson, 2009).

We formalize art history as a dynamic process where an artistic tradition is transmitted through apprenticeship, talent is monetized by artists through commissions negotiated with patrons, and artistic innovations are generated through creative effort. The basic framework suggests that the initial innovations of a new tradition are more radical and associated with low but rapidly increasing prices and profits for the artists, while subsequent innovations are less important and associated with prices and profitability that converge to stable levels. We also argue that the development of artistic innovations is slower than optimal

[2] See Baxandall (1972). A vast amount of research in this sociological tradition has been based on a marxist approach (Hauser, 1951) or influenced by it (Bourdieau, 1993).

[3] Alsop (1983) has identified the earliest independent artistic traditions with similar features in ancient Greece, China, Japan, Islam and in Renaissance Europe.

from a social point of view because artists do not internalize their impact on future art and the spillovers for society. This leads to a form of under-investment in creativity that could be cured by art subsidies. However, decentralized art markets have developed institutional solutions, for instance through art guilds since medieval times, that regulate transfers for apprenticeship and can restore the optimal path of creativity.

In the presence of heterogeneous talent, the evolution of artistic innovation is associated with a distribution of art prices that evolves over time and can be highly skewed, reflecting superstar effects (Rosen, 1981), where only few masters produce real masterpieces and a multitude of less talented masters produce most of the ordinary artworks. In particular, we can reproduce a price distribution that follows a power law in the tail of high prices, in line with evidence available for various periods since Renaissance art (Etro and Stepanova, 2018).

We emphasize contractual aspects of the labor market for artists that have emerged since Renaissance and Baroque periods (Nelson and Zeckhauser, 2008; Piano and Piano 2023a,b). In particular, we consider moral hazard in commissions whose quality is observable but not verifiable, which provides a rationale for principal-agent contracts based on measurable characteristics of artworks that are correlated with quality and for price equalization between genres of paintings. There is a clear evidence for both these principles in the artistic labor market of Baroque Rome, where notable patrons commissioned paintings of all genres and types from the most important artists of the period: in this context, Etro *et al.* (2015) have found evidence of price equalization between portraits, still life, genre paintings, landscapes and figurative paintings with a small enough number of human figures (after controlling for artists's and artwork's characteristics), while the price of figurative paintings increased with the number of figures, which was a contractable characteristic correlated with effort.

Introducing cost saving innovations by workshops in our framework, we show that changes in the size of markets can exert an interesting impact on art development (in the spirit of Cowen and Tabarrok, 2000). In particular, small and rich markets with high bargaining power for the patrons generate high investments in quality and therefore rapidly increasing prices, but large markets with high bargaining power for the workshops expand investments in cost reductions developing forms of mass production and stable prices, as in the Dutch market of the XVII century characterized by the emergence of a new and large demand of paintings by the middle class (Montias, 1982; North, 1997).

We also consider markets where prices are set for multiple artworks purchased by heterogeneous buyers, as typical of modern art markets with art dealers engaged in the commercialization of paintings, a customary practice since the end of the XIX century in Paris (see White and White, 1965; Galenson and Jensen, 2007). The evolution of the innovative activity follows the same principles as in markets based on negotiations, though we stress a potential bias toward lower prices and creativity when art dealers set prices to monetize on sales. Endogenous entry of artists follows profitability in the artistic sector relative to outside earnings, generating path-dependence of the number of artists, and we emphasize an underprovision of both artists and artworks compared to

the social optimum. In this environment, productivity growth in the non-artistic sector generates a cost disease effect *à la* Baumol and Bowen (1965) by reducing entry of artists, without effects on their innovative activity.

Finally we explore a relevant aspect of modern and contemporary art, where cultural transmission takes place not only through art academies but also through influences across different artistic traditions and *avant-garde* movements. We analyze a network of artistic traditions that exert a reciprocal impact on each other. In this environment the achievements of different traditions depend not only on economic determinants, but also on their centrality in the art network, and exogenous shocks can facilitate the development of new traditions. A prominent example was the move of modernist artists from Paris to New York during the Second World War, which created a new cluster of creativity fostering the development of Abstract Expressionism, once again starting with radical innovations and low and increasing prices in the primary art market (Galenson, 2009).

One of the earliest theories on the evolution of art history was by Kubler (1962), who related his analysis to anthropological theories where changes in the relative achievements of a population follow a self-limiting process;[4] here we endogenize such a process through an economic theory of artistic creativity. Many studies in art history have analyzed the labor market for artists in different historical contexts (see for instance Wittkower and Wittkower, 1963; Haskell, 1980; Cahill, 1994; O'Malley, 2005; Spear and Sohm, 2010). Our work is related to the cultural economics literature on the history of labor markets for artists (Lee Owen, 1977; Montias, 1982; De Marchi and Van Miegroet, 2006; Galenson, 2007; Nelson and Zeckhauser, 2008). In particular, we build on the empirical literature on the art market in historical periods (Etro and Pagani, 2012; Etro *et al.*, 2015, 2020; Greenwald, 2021; Piano and Piano, 2023a,b) and contemporary contexts (see for instance Throsby, 1994; Bille, Løyland and Holm, 2017; Makridis, 2025). Important works in the theory of cultural economics have developed models on the labor market for artists (Baumol and Bowen, 1965; Rosen, 1981; Throsby, 1994; Cowen and Tabarrok, 2000; Cellini and Cuccia, 2014), and we build on these and recent conceptual works on the high end of the market (Cowen, 2000; Galenson, 2009; Piano and Hardy, 2022; Piano, 2022). Beyond these contributions, we offer a unified framework to analyze the economic determinants of the evolution of art markets and their impact on art history.

The rest of the work is organized as follows. The next section presents the basic model. The following sections extend it in various directions to consider efficient apprenticeship, heterogeneous artists, principal-agent contracts, cost-saving investments, entry of price-setting artists for heterogeneous buyers and interdependent artistic traditions. The last section concludes.

[4] The theory of Kubler was largely inspired by his studies on the evolution of pre-Columbian artistic traditions.

1 A stylized model of art evolution

In this section we develop a simple economic model to describe the evolution of art, which is here defined by the quality of artworks as perceived and appreciated in the art market. While we are aware that a definition of "art" goes well beyond a unidimensional framework and that artistic quality cannot be "measured", what we need for our framework is a positive correlation between what is regarded as an increase in artistic quality and an increase in the willingness to pay for art, which appears a reasonable starting point. We consider a dynamic model with a representative artist, a representative patron, and a commission of verifiable quality in each period (the extensions to heterogeneous artists and patrons, and imperfectly verifiable quality will be discussed in later sections).

Let us consider an artist active in period t. After apprenticeship from an artist active in period $t-1$, the artist inherits some of the old traditions and techniques and exerts effort e_t in quality-enhancing investments at the cost $g(e_t)$ with $g(e)$, $g'(e)$, $g''(e) > 0$ for any $e > 0$. This investment contributes to increase the quality of artworks at a level q_t. The equation of motion of art quality is given by:

$$q_t = \lambda q_{t-1} + e_t \tag{1}$$

where $\lambda \in [0, 1)$ is the rate of transmission from a workshop to the next one. This rate of transmission depends on the effectiveness of scholarship at teaching the latest artistic achievements and on the natural obsolescence of traditions and techniques. Evidence on the importance of apprenticeship in the history of art markets is wide (see, for instance, De Marchi and Van Miegroet, 2006, on painters and Borowiecki, 2022, on classical music composers). The implication is that the level of artistic quality amounts to an immaterial form of cultural capital which is accumulated through innovations.[5]

In each period a workshop sells an artwork of verifiable quality q_t to a patron, whose utility is:[6]

$$v_t = \theta u(q_t) - p_t \tag{2}$$

where the willingness to pay depends on a demand-shifting parameter θ and a payoff function $u(q_t)$ depending on quality with $u(q)$, $u'(q) > 0$ and $u''(q) \leqslant 0$, while the price of the artwork is p_t. The artist is assumed risk neutral, and

[5] By backward iteration of (1), one obtains $q_t = \sum_{s=0}^{\infty} \lambda^s e_{t-s}$. Art history is the fruit of cumulative artistic innovations, which can be either technical (see Kemp, 1990) or stylistic and conceptual.

[6] The patron's payoff incorporates the aesthetic and symbolic value of the artwork (Nelson and Zeckhauser, 2008) and potentially a resale value. We implicitly assume stable an unambiguous preferences (in the sense of Stigler and Becker, 1977) within an artistic tradition, without addressing the ultimate sources of what defines and originates art or what determines changes in artistic preferences. For empirical evidence on the persistence of art preferences see Graddy (2014).

expects profits:[7]

$$\pi_t = p_t - g(e_t) \tag{3}$$

The price is negotiated under Nash bargaining, with zero outside options and a bargaining power of the artist parametrized by $\eta \in (0,1)$. Therefore, it is set as:

$$\begin{aligned} p_t &= \arg\max v_t^{1-\eta}\pi_t^{\eta} \\ &= g(e_t) + \eta\left[\theta u(q_t) - g(e_t)\right] \end{aligned} \tag{4}$$

This is an hedonic price function in the sense of Rosen (1974), which depends on the quality of the artwork and the observable innovative activity. It approaches the marginal cost of art production when the patron has all the bargaining power (as under a perfectly competitive art market) and the patron's surplus when the artist has all the bargaining power (as for a monopolist artist).[8]

Since the payoffs of the artist and the patron are constant fractions η and $1-\eta$ of the net surplus created, there is a consensus on the choice of effort that maximizes the joint payoff $v_t + \pi_t$ taking as given the equation of motion (1). We can also express the problem in terms of quality choice as:

$$\begin{aligned} & \max_{q_t \geqslant 0} \theta u(q_t) - g(e_t) \\ s.t. \quad : \quad & q_t = \lambda q_{t-1} + e_t \end{aligned}$$

The first order condition for effort in artistic innovation is:

$$\theta u'(q_t) = g'(e_t) \tag{5}$$

which equates the marginal benefit of investment in quality (in terms of incremental revenue per artwork) to the marginal cost of artistic innovation. The second order condition $D \equiv \theta u''(q_t) - g''(e_t) < 0$ is always satisfied. Therefore, an interior solution identifies a positive effort function $e_t = e(q_{t-1})$ as long as $\theta u'(\lambda q_{t-1}) > g'(0)$. We assume $\theta u'(0) > g'(0)$ to insure that $e(0) > 0$. And since the marginal utility is decreasing in past quality, the interior solution with positive effort exists for any $q_{t-1} < \bar{q}$ for some $\bar{q} \in (0, \infty)$.

This stylized framework tries to capture the fact that artistic innovation is a market driven phenomenon, which flourishes and evolves over time when artists can appropriate part of the fruits of their investment and these fruits are sensitive to artistic quality. These conditions have not been always present in the course of art history. Egyptian art preserved a traditional style for millennia without drastic and persistent innovations because it was largely the fruit

[7] One could augment the analysis with non-monetary rewards from quality or utility from effort exerted in the artistic activity, in the spirit of the work preference model of Throsby (1994), which has found wide evidence in contemporary markets for artistic labor (see Cowen and Tabarrok, 2000; Bille, Løyland and Holm, 2017; Makridis, 2025). This would increase innovation and reduce payments for the artists without affecting the qualitative implications for art evolution.

[8] We will later consider price-setting artists facing anonymous heterogeneous buyers, a typical feature of modern art markets.

of slave work and there was not an effective market for commissions by free artists.[9] Instead, Greek art flourished quickly when the art market started to incentivise commissions by free artists (Seaman and Schultz, 2017; Stewart, 2019; Etro 2024). Medieval painting stagnated until a market for altarpieces in new churches and portable panels was developed in early Renaissance Europe (O'Malley, 2005; Etro, 2018). And profitability fostered creativity in various modern artistic traditions, including not only Western traditions (for instance, see Montias, 1982 and North, 1997 on Dutch painting), but also Eastern traditions (see Li, 1989 and Clunas, 1991 on Chinese painting), as well as other arts (see, for instance, Giorcelli and Moser, 2020, on the opera).[10]

The equilibrium effort is weakly decreasing in past quality, with:

$$e'(q_{t-1}) = \frac{\lambda\theta u''(q_t)}{|D|} \in (-\lambda, 0]$$

The intuition is that a higher quality inherited from the past reduces the marginal benefit from producing better artworks (or increases the cost of additional investment). Moreover, it is immediate to verify that an increase in demand promotes investment ($\partial e(q_{t-1})/\partial\theta > 0$), while a more effective apprenticeship system disincentivizes investment ($\partial e(q_{t-1})/\partial\lambda \leqslant 0$). In practice, market demand drives artistic innovation, but inherited talent and effort are substitutes in the artistic profession.[11]

Combining the equation of motion and the effort function, we obtain the equilibrium path of artistic quality:

$$q_t = \lambda q_{t-1} + e(q_{t-1}) \tag{6}$$

which is also defined by the implicit difference equation $\theta u'(q_t) = g'(q_t - \lambda q_{t-1})$. Total differentiation implies the first derivative:

$$\frac{\partial q_t}{\partial q_{t-1}} = \frac{\lambda}{1 - \theta u''(q_t)/g''(e_t)} \in (0, \lambda)$$

with an ambiguous sign of the second derivative. Since $e(0) > 0$ and the slope of the dynamic equation is positive and less than unitary, the steady state exists, is unique and stable, and it is reached through a monotonic convergence of artistic quality. This also implies that prices and profitability of the representative workshop increase over time reaching stable levels at the steady state.

[9] This is remarkable given the presence of isolated achievements of realistic sculpture and painting since the Old Kingdom (see Smith and Simpson, 1998).

[10] Notice that reproducible arts such as opera, music and literature, require some form of intellectual property to foster the innovation process. This is not necessarily the case for the figurative arts.

[11] While our simple model abstracts from intertemporal decisions of heterogeneous artists over the life cycle, the last result resonates well with the celebrated distinction between conceptual and experimental innovators by Galenson (2007): artists who are naturally endowed with high talent can make their main conceptual innovations without substantial effort at an early stage of their career, while artists who feel more distant from the frontier of their possibilities tend to invest more in experimentation to gradually reach their main innovations at a later stage.

Such a dynamic model combines elements of stock accumulation *à la* Solow for an immaterial form of artistic capital with elements of creative distruction *à la* Schumpeter driven by endogenous steps of artistic effort.[12] Convergence toward the steady state takes place through artistic innovations of decreasing importance. The rate of increase of quality is high at the beginning of an art historical evolution, when artists find deeper creative opportunities in the sequence of innovations (Kubler, 1962), and decreases over time while prices increase. One can think of Classical Greece and Renaissance Florence as primary examples of intense artistic innovation determined by high and increasing demand by rich and competing patrons followed by a slow down in subsequent eras.[13]

The steady state level $\tilde{q}$ corresponds to the constant effort $\tilde{e}$ that satisfies:

$$\theta u'\left(\frac{\tilde{e}}{1-\lambda}\right) = g'(\tilde{e}) \tag{7}$$

and to a stable price of artworks. These steady state values are increasing in the demand intensity θ. Instead, it is easy to verify that a higher rate of transmission of artistic capabilities λ can reduce effort, but nevertheless enhances quality, with an ambiguous impact on prices in the long run.

The simplest example of our framework emerges assuming linear-quadratic specifications such as:

$$u(q) = q \quad \text{and} \quad g(e) = \frac{de^2}{2} \tag{8}$$

where d parametrizes the marginal cost of effort, and can be seen as an inverse measure of intrinsic talent. The equilibrium condition provides a constant effort $e_t = \theta/d$ for any t, and therefore a linear equation of motion:[14]

$$q_t = \lambda q_{t-1} + \frac{\theta}{d}$$

The steady state level of artistic quality is:

$$\tilde{q} = \frac{\theta}{(1-\lambda)d}$$

which is increasing in θ and λ, and decreasing in the cost parameter d.[15] In this environment, shocks to the art market that temporarily increase demand

[12] See Aghion and Howitt (2008).

[13] Piano and Hardy (2022) discuss the economic reasons behind the decline of Florentine art during mannerism in terms of rent seeking. Empirical evidence on Schumpeterian patterns of increasing art prices and artistic achievements driven by increasing demand for art investment are also available for the golden ages of Spanish art during the XVII century (Burke and Cherry, 1997) and British art since the end of the XVIII century (Solkin, 1996).

[14] It can be verified that, under this cost function, we have $\frac{\partial^2 q_t}{\partial^2 q_{t-1}} \lessgtr 0$ if $u'''(q) \lessgtr 0$.

[15] It is easy to enrich this example with power specifications where $\alpha < 1$ is the elasticity of payoff with respect to perceived quality and $\varphi > 0$ is the elasticity of effort with respect to its compensation. The steady state quality level tends to increase in both these elasticities. The model can be extended to more general technologies for artistic innovation, that depend on both effort and past quality, generating richer dynamics.

intensity or reduce the cost of artistic effort have a positive and persistent impact on art quality and prices.

2 Efficient apprenticeship and art guilds

What makes art history a dynamic process is the link between generations of artists through apprenticeship, which transmits style and technique and allows to build on the "giants' shoulders". One can isolate a sequence of masters and scholars in Renaissance Venice which included some of the most important painters of its school: in the middle of the XV century Jacopo Bellini had his sons as scholars, and one of them, Giovanni Bellini, was the teacher of Giorgione and Titian, the greatest Venetian master of the XVI century, who had briefly as a pupil Jacopo Tintoretto, whose son and scholar Domenico Tintoretto will be one of the leading Venetian painters at the beginning of the XVII century. But one could also trace parallel lineages from other scholars of these same masters, and the same could be done for other regional schools (for instance Florentine painters), as well as other artistic traditions (for instance Chinese painters) and other arts (for instance, music composers).

Artistic transmission through apprenticeship is crucial to foster new creativity, but does not necessarily generate the ideal accumulation of artistic innovations. The reason is that each generation does not internalize the impact of its choices on future generations of patrons and artists. In this section we explore the nature of this inefficiency and of institutional solutions.

Let us start by identifying the efficient sequence of artistic innovations in the baseline model. Given the equation of motion (1) for art quality and the generations of patrons and artists with payoffs (2) and (3), a socially optimal path would maximize the discounted value of art created net of its cost:

$$\max_{q_t \geqslant 0} \sum_{t=1}^{\infty} \beta^{t-1} \left[\theta u(q_t) - g(q_t - \lambda q_{t-1})\right]$$

where $\beta \in (0,1)$ is a social discount factor reflecting the net benefits of future art creation. This corresponds to a standard dynamic programming problem,[16] with a value function $\mathbf{V}(q_t)$ for quality as a state variable that satisfies the following *Bellman equation*:

$$\mathbf{V}(q_{t-1}) = \max_{e_t} \left\{\theta u(\lambda q_{t-1} + e_t) - g(e_t) + \beta \mathbf{V}(q_t)\right\}$$

Optimality implies the following *Euler equation* for effort as a control variable:

$$\theta u'(q_t^*) + \beta\lambda g'(e_{t+1}^*) = g'(e_t^*) \tag{9}$$

The equilibrium system can be analyzed in a phase diagram for (q_t^*, e_t^*), where (9) provides the non-increasing locus for constant effort (with effort decreasing below this locus and increasing above), and (1) provides the increasing

[16] See Stokey and Lucas (1989).

locus for constant quality (with quality increasing above this locus and decreasing below). On the saddle-path, the optimal effort level (weakly) decreases in quality toward the unique steady state $(\tilde{q}^*, \tilde{e}^*)$.

The additional positive term on the left hand side of (9), compared to the equilibrium condition (5), reflects the fact that a higher investment reduces the marginal cost of creating future quality: this additional benefit is larger when transmission through apprenticeship is more effective (larger λ) and future quality is more important (larger β).[17] The optimal development of art history involves more innovation than in equilibrium along the transition path and in steady state, where effort satisfies:

$$\theta u'\left(\frac{\tilde{e}^*}{1-\lambda}\right) = (1-\beta\lambda)\, g'(\tilde{e}^*)$$

The "golden rule" levels of effort and artistic quality are increasing in the discount factor on future art creation β. For instance, in our linear-quadratic example (8) we obtain a constant effort $\tilde{e}^* = \tilde{e}/(1-\beta\lambda)$, a linear value function and a steady state quality given by:

$$\tilde{q}^* = \frac{\theta}{(1-\beta\lambda)(1-\lambda)d} > \tilde{q}$$

In practice, a decentralized art market generates insufficient investment in art together with prices and profits for the artists that remain below what could be achieved in the optimal allocation. This form of under-investment is due to lack of internalization of the permanent effects of artistic creativity for the society. It could provide a novel argument for the long debated public support of the arts (see Netzer, 1978). Such an argument is not associated with externalities in art consumption on the demand side, which are often invoked in this debate, but with externalities in art production on the supply side. Unfortunately, from this argument one cannot derive a simple recommendation for the optimal art policy. A direct subsidy to the effort of the artists does foster innovation, but it is easy to verify that the optimal subsidy, financed with lump sum taxes to replicate (9), should be variable over time and conditional on the effort of the next generation of artists, which appears impractical.

Nevertheless, a decentralized market can reach optimality with the help of appropriate institutions. In our framework a natural way to implement the optimal allocation involves a payment for apprenticeship based on profit sharing. If masters obtain a fraction τ of the profits of their scholars, the representative workshop of each period t maximizes:

$$(1-\tau)\left[p_t - g(e_t)\right] + \tau\left[p_{t+1} - g(e_{t+1})\right]$$

[17] We should stress that, in contrast with OLG models of capital accumulation *à la* Diamond, here the equilibrium cannot be dynamically efficient: the socially optimal path makes older generations better off with a burden on earlier generations. By forward iteration of the optimality conditions, one can obtain $\theta u'(q_t^*) + \sum_{j=1}^{\infty} (\beta\lambda)^j \theta u'(q_{t+j}^*) = g'(e_t^*)$. The additional term, compared to the equilibrium condition, corresponds to a discounted value of future marginal benefits of the investments in quality where the effective discount factor is $\beta\lambda$.

with respect to q_t under two constraints for each period, namely the equation of motion (1) and the hedonic price function (4). The solution involves the condition:

$$(1-\tau)\theta u'(q_t) + \tau\lambda g'(e_{t+1}) = (1-\tau)g'(e_t)$$

which replicates (9) for a constant transfer rule:

$$\tau^* = \frac{\beta}{1+\beta} \in \left(0, \frac{1}{2}\right) \tag{10}$$

Art markets have developed rules of apprenticeship, often supervised by *art guilds*, which imply transfers of earnings from scholars to their masters, both during apprenticeship and in subsequent collaborations. In a sense, master artists are compensated for the positive externality that they create by transmitting their capabilities to the younger generations, and internalize it in their choices. An art guild that sets a transfer rule τ^* is actually implementing the allocation that maximizes the expected value of the surplus appropriated by all the generations of artists with a discount factor corresponding to the social discount factor.

In conclusion, our analysis suggests that guilds have been instrumental to promote efficient innovations. There is evidence of such a role for guilds in proto-industrial Europe (Ogilvie, 2004). And we have evidence of active art guilds (or St. Luke's academies, in honor of the patron of the artists) and substantial transfers from apprentices to masters in various artistic traditions (De Marchi and Van Miegroet, 2006). Especially in the golden ages of different periods, from Renaissance Italy to Flemish art in the XV-XVII centuries, they may have contributed to strengthen and coordinate the incentives to invest in artistic innovations.

3 The distribution of talent and superstars

A distinguishing feature of labor markets for artists is that only a few "geniuses" produce rare masterpieces and a multitude of less talented artists are responsible for the vast majority of artworks, generating a highly skewed distribution of art prices and earnings. Superstars, in the sense of Rosen (1981), drive the evolution of art history, which is however transmitted through the entire body of art production, allowing new generations of superstars to move the frontier of artistic creativity. In this section we capture this process introducing heterogeneous talent in the baseline model to explore the evolution of average art quality and the distribution of art prices.

We rely on the linear-quadratic specification (8), but assume that every artist draws a type d from a cumulative distribution $G(d)$ on the support $\left[\underline{d}, \overline{d}\right]$. Each artist inherits a fraction of the average past quality through apprenticeship, but a more talented artist, with a lower d, can create innovations at a lower cost. The artistic quality $q_t(d)$ of an artist of type d exerting effort $e_t(d)$ at time t is:

$$q_t(d) = \lambda q_{t-1} + e_t(d) \tag{11}$$

while the equation of motion of average quality q_t is still given by (1) in function of the inherited average quality q_{t-1} and the average current effort $e_t = \mathbb{E}[e_t(d)]$. Each artist is randomly matched with a patron and bargains on quality and price of a commission. The payoffs for a commission are still given by (2) for the patron and (3) for the artist, and we retain the assumption that quality and type are observable and verifiable in each negotiation.

The effort of each artist is selected to maximize the net surplus of the patron-artist pair. This provides the following effort and price for an artist of type d:

$$e_t(d) = \frac{\theta}{d}$$

$$p_t(d) = \eta\theta\lambda q_{t-1} + \frac{(1+\eta)\theta^2}{2d}$$

Accordingly, more talented artists innovate more and obtain higher prices from their commissions. The price function, often estimated in empirical work through hedonic regressions that control for the artist type d, should increase in the value of structural parameters reflecting demand intensity θ, artist's bargaining power η, effectiveness of scholarship λ and inherited quality. Finally, the gross profits per commission:

$$\pi_t(d) = \eta\left[\theta\lambda q_{t-1} + \frac{\theta^2}{2d}\right]$$

are decreasing and convex in the type d, implying a wide dispersion of profitability.

The evolution of art history is now captured by the evolution of the average quality:

$$q_t = \lambda q_{t-1} + \int_{\underline{d}}^{\bar{d}} \frac{\theta}{d} \mathrm{d}G(d) \tag{12}$$

which reaches an ergodic state where the average effort, quality and price are constant, and their distributions are stationary. For instance, let us consider a power law distribution for talent $G(d) = (d/\bar{d})^\kappa$ where $\underline{d} = 0$ and $\kappa > 1$ parametrizes concentration on low talent. We can compute the average effort and obtain the equation of motion:

$$q_t = \lambda q_{t-1} + \frac{\kappa\theta}{(\kappa-1)\bar{d}}$$

associated with a distribution of art prices that changes over time according to:

$$G_p(p) = 1 - \left(\frac{(1+\eta)\theta^2}{2(p - \eta\theta\lambda q_{t-1})}\right)^\kappa$$

In the long run, artistic quality converges to the steady state level:

$$\tilde{q} = \frac{\theta\kappa}{(1-\lambda)(\kappa-1)\bar{d}}$$

which is reduced by more concentration on low talent (high κ), and the distribution of prices converges to a stable distribution. The price distribution is not a power law distribution in itself, but its tail for high prices approximates a power law distribution. In particular, the "survival law" for a large enough price approximates:

$$\Pr[p_t(d) > p] \sim const * (p)^{-\kappa} \tag{13}$$

therefore the tail of the distribution follows a *power law* with exponent κ.[18] Etro and Stepanova (2018) have found consistent evidence that the distribution of the top prices of paintings per artist in different artistic traditions follows a power law in the tail. This applies to Renaissance Italy with a high frequency of "geniuses" led by Michelangelo, Leonardo and Raphael (and an estimated scale parameter close to 2), to the Dutch and Flemish golden age with a higher concentration of less talented painters (the estimated scale parameter is close to 4) but also peaks of creativity led by Rembrandt and Rubens, and it applies in similar ways to French rococo art and British neoclassical art (with scale parameters close to 3). Such highly skewed distributions reproduce *superstar effects* where few geniuses create rare and extremely valuable masterpieces, but most of the artist produce ordinary works with modest profitability (analogous phenomena emerge in modern cinema for the distribution of movies's profits, as shown by De Vany and Walls, 1999).

As for the baseline model, also the extended one with heterogeneous talent delivers under-investment. The social planner problem:

$$\max_{e_t(d)\geqslant 0} \sum_{t=1}^{\infty} \beta^{t-1} \left[\theta q_t - \int_{\underline{d}}^{\bar{d}} \frac{de_t(d)^2}{2} \mathrm{d}G(d) \right]$$

$$s.t. \quad : \qquad q_t = \lambda q_{t-1} + \int_{\underline{d}}^{\bar{d}} e_t(d) \mathrm{d}G(d)$$

identifies the optimal effort functions:

$$e_t^*(d) = \frac{\theta}{(1-\beta\lambda)d}$$

All types of artists should exert more effort to take into account the impact on the aggregate quality of all the future periods.

This framework can be extended to take into account *selection effects*,[19] where only the most talented scholars become masters. For instance, let us assume that opening a workshop involves some fixed setup cost, say F. Only apprentices that are talented enough decide to pursue the artistic profession. Then, a zero profit condition $\pi_t(\hat{d}_t) = F$ determines an activation threshold

[18] The frequency of high prices would change with a more flexible specification of the cost of effort. In particular, a constant elasticity of effort φ would deliver a power law distribution in the tail with exponent κ/φ. In such a case a higher elasticity increases the frequency of superstar prices. In this environment one could explore assortative matching with heterogeneous patrons in their willingess to pay.

[19] See Melitz (2003).

$\hat{d}_t = \hat{d}(q_{t-1})$ that increases with the inherited quality: artists who inherit more quality obtain higher profits and remain in business also when they are less talented. Then, the average quality depends on the average effort of the active masters according to the equation of motion:

$$q_t = \lambda q_{t-1} + \int_{\underline{d}}^{\hat{d}(q_{t-1})} \frac{\theta}{d} \frac{G'(d)\mathrm{d}d}{G(\hat{d}(q_{t-1}))}$$

Its slope is:

$$\frac{\partial q_t}{\partial q_{t-1}} = \lambda + \frac{\theta \hat{d}'(q_{t-1}) G'(\hat{d}(q_{t-1}))}{G(\hat{d}(q_{t-1}))} \left[\frac{1}{\hat{d}(q_{t-1})} - \int_{\underline{d}}^{\hat{d}(q_{t-1})} \frac{1}{d} \frac{\mathrm{d}G(d)}{G(\hat{d}(q_{t-1}))} \right] < \lambda$$

where the last term is negative because the expected value of $1/d$ conditional on activation must be larger than the extreme value $1/\hat{d}(q_{t-1})$. Intuitively, the average effort of the active masters decreases in periods of higher artistic profitability because this increases the threshold for activation, which in turn reduces also the average art price.[20]

Selection effects enrich the dynamics of quality levels and prices, opening up the possibility of a cyclical pattern. In such a case, a highly innovative generation expands profitability in the profession and attracts less talented artists in the subsequent generation, which reduces the average quality of their works and artistic profitability, but this selects only the most talented artists in the next generation, and so on, creating cycles of artistic expansion and contraction.[21] The frequency of masterpieces changes over time, but the stationary state remains characterized by stable conditional distributions of innovations and prices.

4 Patron-artist contracts with moral hazard

In practice, an artist cannot credibly commit to exert a certain effort or to provide a verifiable quality level by contract. Asymmetric information on the activity of the artists and uncertainty associated with creativity generate a classic *moral hazard problem* that can undermine the same process of artistic innovation. Renaissance art dealt with this problem by introducing written contracts between patrons and artists that were signed in front of notaries and potentially

[20] These selection effects can bias empirical work on price indexes. While Collins *et al.* (2009) have introduced general methodologies to address these concerns in hedonic price regressions, we are not aware of applications to the empirical analysis of historical labor markets for artists.

[21] This is what happens under a power law distribution for talent, with an average quality given by:

$$\tilde{q} = \frac{2F}{\left[(1-\lambda)(\kappa-1) + 2\lambda\kappa\right]\eta}$$

in steady state. One can also endogenize the mass of apprentices (and therefore the mass of active masters) through a free entry condition, and extend the framework to monopolistic competition between artists.

enforced by tribunals (O'Malley, 2005; Nelson and Zeckhauser, 2008). Piano and Piano (2023a,b) have examined contracts for paintings commissioned in Italy between 1285 and 1530, which typically included a description of the work, a list of materials to be used (such as expensive gold and blue colours), limits to delegation to assistants, a delivery date, the allocation of costs, the compensation for the painter, and enforcement mechanisms such as penalties and judgment by third party arbitrators for *ex post* payments based on quality. The evidence confirms a basic principle for which more expensive commissions were associated with more detailed contracts to incentivise effort. However, these contracts were incomplete because they could not specify and fully enforce an ideal level of quality, even when the artists had reputational incentives of their own.[22] In such a context, optimal *principal-agent contracts* should involve payments that are, at least in part, based on quantifiable aspects correlated with effort and quality, which would affect the development of artistic innovation.

To study the impact of patron-artist contracts on innovation, we return to the baseline model with homogeneous artists and augment it with uncertainty, risk aversion of the artist and moral hazard.[23] We assume that quality can be observable but not verifiable, and effort is not verifiable as well. An art commission offers a fixed payment independent of quality and an additional payment conditional on some measurable characteristic of the artwork that is correlated with effort and, therefore, quality. In particular, this quantifiable characteristic is given by $R_t = e_t + \varsigma_t$ for a commission of period t, where ς_t is a shock with zero expectation and positive variance σ^2. The artist is then paid a fixed amount w_t and a conditional amount $s_t R_t$ for a given incentive intensity s_t.

The representative patron is risk neutral and obtains an expected utility that depends on the expected payment:

$$v_t = \theta u(q_t) - w_t - s_t e_t \tag{14}$$

where the first term is the gross surplus, the second term is the fixed payment for the artwork and the last one is the expected value of the conditional payment.

The representative artist is risk averse with a constant absolute risk aversion ρ, therefore, by standard arguments, the relevant payoff can be expressed as:

$$\pi_t = w_t + s_t e_t - g(e_t) - \frac{\rho s_t^2 \sigma^2}{2} \tag{15}$$

which features the total expected payment, the cost of effort and the cost of uncertainty, which is increasing in the measure of risk aversion and the variance

[22] O'Malley (2013) has advanced the idea that in a dynamic contest, artists overprovide effort at the beginning of their career to signal their talent, and tend to shirk later in their career (Mailath and Samuelson, 2001). She also illustrates this principle with a variety of artists from Renaissance Florence. However, the evidence of Piano and Piano (2023a) provides limited support to this hypothesis because the degree of contractual completeness appears uncorrelated with the age of artists. For a theory of allocation of tasks within workshops and applications to Renaissance art see also Piano (2022).

[23] See Holmstrom and Milgrom (1991).

of the shock. The artist selects effort to maximize its payoff according to:

$$s_t = g'(e_t)$$

which identifies an effort function $e_t = e(s_t)$ increasing in the incentive intensity with $e(0) = 0$ and $e'(s_t) = 1/g''(e(s_t)) > 0$.

Nash bargaining selects the incentive mechanism to maximize the joint payoff $v_t + \pi_t$ under incentive compatibility, while the fixed payment is negotiated as in the baseline model. The patron-artist problem for the choice of incentive intensity is:

$$\begin{aligned} & \max_{s_t \geqslant 0} \theta u(q_t) - g(e(s_t)) - \frac{\rho s_t^2 \sigma^2}{2} \\ s.t. \quad : \quad & q_t = \lambda q_{t-1} + e(s_t) \end{aligned}$$

and implies a solution:

$$\theta u'(q_t) = g'(e_t) \left[1 + \rho \sigma^2 g''(e_t)\right] \tag{16}$$

which implicitly determines $s_t = s(q_{t-1})$ and the evolution of artistic investment $e(s(q_{t-1}))$ taking into account the new friction. In particular, a higher variance of the measurable characteristic and a higher risk aversion increase the marginal cost of incentives and limit the extent of artistic innovation.

As an example let us consider the linear-quadratic case (8). This implies an effort function $e(s_t) = s_t/d$ and contracts with a constant incentive intensity:

$$s_t = \frac{\theta}{1 + d\rho\sigma^2}$$

Hence, the incentive mechanism is strengthened for artists who are more talented (lower d) and less risk averse (lower ρ), and for a higher accuracy of the measure of performance (lower σ^2), as well as for patrons with higher willingness to pay (higher θ).[24] Artistic quality evolves toward the steady state level:

$$\tilde{q} = \frac{\theta}{(1 + d\rho\sigma^2)(1 - \lambda)d}$$

and both effort and quality are further reduced by the contractual friction when d is high. Incidentally, this suggests that an extension to heterogeneous artists would increase effort of the most talented artists and reduce effort of the least talented, strengthening the skewness of the price distribution.

A simple corollary of our analysis emerges considering artists engaged in multiple genres (say landscape and portrait) and allocating effort between them.

[24] This effect may reflect a *signalling* mechanism that has been emphasized for Renaissance patrons incentivising quality for commissions that could signal their "magnificence" (in particular, altarpieces for private chapels on public display) by paying more (Nelson and Zeckhauser, 2008). The evidence of Piano and Piano (2023b) appears consistent with this hypothesis because the degree of contractual completeness was correlated with the price of commissions.

As long as the patrons cannot observe the nature of the artistic process (i.e. effort dedicated to each activity), they are forced to equalize the marginal return of artists in each genre; otherwise the artists would only exert effort in the most profitable genre. This suggests a more general principle for primary artistic markets, for which prices of paintings of different genres should be equalized after controlling for painter's and painting's observable characteristics. To verify this in our framework, let us consider efforts e_{1t} and e_{2t} in two genres with a cost of effort $g(e_{1t}+e_{2t})$ and a payment based on two measurable characteristics of the artworks depending on genre-specific efforts and independent shocks as before. Given the incentive intensities s_{1t} and s_{2t} for the compensation of different genres, the artist selects efforts to maximize:

$$\pi_t = w_t + s_{1t}e_{1t} + s_{2t}e_{2t} - g(e_{1t} + e_{2t}) - \frac{\rho(s_{1t}^2 + s_{2t}^2)\sigma^2}{2}$$

implying a positive effort in both activities only if:

$$s_{1t} = s_{2t} = g'(e_{1t} + e_{2t})$$

that is, with a common incentive intensity. As a consequence, the optimal contract selects a common incentive intensity and generates the same expected payment for each genre.

Appropriate incentive contracts for artists have not been present in all artistic traditions. Byzantine art produced religious icons through monastic workers isolated from market incentives, and was virtually immune from stylistic and technical developments for centuries (including part of the inherited traditions of eastern orthodox christianity). Instead, at the origins of Renaissance art, court artists with a fixed wage started to be replaced by itinerant artists and workshops looking for commissions paid *per piece*, which stimulated competition and innovation (Etro, 2018; Piano and Piano, 2023b). Further contracts were developed to condition payments to quantifiable features of the artworks correlated with effort, such as the size of the paintings and even the number of human figures reproduced in religious, mythological and historical paintings. Not only Renaissance contracts specified the number of figures that had to appear in altarpieces and other figurative paintings (O'Malley, 2005), but we also have evidence of a positive correlation between prices and number of figures after controlling for the size of paintings and other quantifiable features (Etro and Pagani, 2012). We have also evidence from the labor market of Baroque Rome, where notable patrons commissioned paintings of all genres and types from the most important artists of the period such as Caravaggio, Guido Reni, Pietro da Cortona, Poussin and others (Haskell, 1980; Spear and Sohm, 2010). In particular, Etro *et al.* (2015) have exploited the matched patron-artist nature of contractual data from this period to evaluate the extent to which price heterogeneity was related to unobservable characteristics of painters and patrons. They have found robust evidence of price equalization between portraits, still life, genre paintings, landscapes and figurative paintings with a small enough number of human figures after controlling for painters' and paintings' character-

istics.[25] Moreover, the price of figurative paintings increased with the number of figures, preserving the equalization between subgenres such as religious, mythological and historical subjects as well as battles.

Also in this environment, the equilibrium does not correspond to the constrained social optimum, which solves a problem such as:

$$\max_{q_t \geqslant 0} \sum_{t=1}^{\infty} \beta^{t-1} \left[\theta u(q_t) - g(q_t - \lambda q_{t-1}) - \frac{\rho g'(q_t - \lambda q_{t-1})^2 \sigma^2}{2} \right]$$

with Euler conditions:

$$\theta u'(q_t^*) + \beta \lambda g'(e_{t+1}^*) \left[1 + g''(e_{t+1}^*) \rho \sigma^2 \right] = g'(e_t^*) \left[1 + g''(e_t^*) \rho \sigma^2 \right].$$

The additional benefit from investment on the left hand side is due to the fact that future artists build on the shoulders of giants, implying that the equilibrium involves incentive contracts that are too weak.

5 Cost-saving investment and mass production

Our basic framework was focused on product innovations by artists that enhanced the quality of art. However, artistic workshops invest also in process innovations that either reduce cost or offer more variety at the same cost, especially when they serve large markets. Dutch painting in the XVII century was characterized by a proliferation of workshops specialized in a single genre of painting (for instance landscapes) or even a subgenre (say marine views) adopting techniques that could speed up execution (for instance monochromatic painting, imitative works, co-authorship or small formats) to expand production and reduce the unitary cost in front of an expanding demand (North, 1997). Similarly, professional Chinese painters of the late Ming and early Qing dynasties moved from a detailed and realistic style of landscape painting toward the simpler and brushwork oriented style of the celebrated amateur scholar painters (and even hired ghost-painters) to satisfy an increasing demand (Cahill, 1994). We will now augment our baseline model with a trade-off between investments in product and process innovations and study how market size can affect the evolution of artistic production (in the spirit of Cowen and Tabarrok, 2000).

Let us introduce a sunk investment i_t which reduces the marginal cost of production of artworks of a given quality. Formally, the marginal cost is now $c(e_t, i_t)$ with $c_e(e,i) > 0$, $c_{ee}(e,i) > 0$, $c_i(e,i) < 0$, $c_{ii}(e,i) \geqslant 0$ and $c_{ie}(e,i) \geqslant 0$, and the sunk cost of setting up the workshop is $F(i_t)$ with $F'(i) > 0$ and $F''(i) > 0$. The assumptions on the direct derivatives are standard, while the assumption on the cross-derivative of the marginal cost formalizes the natural

[25] This is remarkable in front of the well known hierarchy of genres that justified higher prices for figurative paintings compared to minor genres (see Graddy, 2014, on the art critique of this period). In reality, it was better artists who were mostly engaged in large figurative paintings, and not figurative paintings that were intrinsically more valuable.

idea that it is typically harder to improve quality at a low cost or reduce costs for high quality.

We assume that an artist serves S patrons, obtaining the net profits:

$$\pi_t = [p_t - c(e_t, i_t)]\, S - F(i_t) \tag{17}$$

and the equation of motion of quality is still given by (1).

The timing is the following. First, the artist decides the cost-saving investment. Second, the artist and each patron negotiate on effort and price. Once, the investment i_t is selected, the negotiation takes place as before, leading to price and effort satisfying $p_t = c(e_t, i_t) + \eta\,[\theta u(q_t) - c(e_t, i_t)]$ and $\theta u'(q_t) = c_e(e_t, i_t)$. The expected profits of the artist become:

$$\pi_t = \eta\,[\theta u(q_t) - c(e_t, i_t)]\, S - F(i_t)$$

and the workshop is going to invest in process innovation if the product of market size S and its bargaining power η, or for short the "appropriable" market size ηS, are large enough. Assuming that this is the case, the equilibrium conditions become:

$$\theta u'(q_t) = c_e(e_t, i_t) \quad \text{and} \quad \eta S\,|c_i(e_t, i_t)| = F'(i_t) \tag{18}$$

The first one equates the marginal benefit of investment in quality to the marginal cost per artwork, and the second equates the appropriable marginal benefit of cost reduction over all sales to the marginal sunk cost. It is easy to verify that the investment in quality is decreasing in the one in cost reduction, and the latter is decreasing in the former. Together, these two conditions determine the equilibrium investments $e_t = e(q_{t-1})$ and $i_t = i(q_{t-1})$, and the evolution of art quality, which, under standard regularity conditions, converges to a steady state. In particular, applying Cramer's rule under the assumption $\Delta \equiv (\theta u''(q_t) - c_{ee})(\eta S c_{ii} + F'') + \eta S c_{ei}^2 < 0$, we can derive:

$$e'(q_{t-1}) = \frac{\lambda\theta u''(q_t)(S c_{ii} + F'')}{|\Delta|} \leqslant 0 \quad \text{and} \quad i'(q_{t-1}) = \frac{\lambda\theta\,|u''(q_t)|\,\eta S c_{ei}}{|\Delta|} \geqslant 0$$

This confirms that the evolution of art history is initially associated with major artistic innovations aimed at monetization on rapidly increasing prices, and implies also that the transition path is characterized by (weakly) decreasing quality-enhancing investments and (weakly) increasing cost-saving investments, while art prices increase and converge toward stable levels.

As an example, let us consider the extended linear-quadratic case with:

$$u(q) = q, \quad c(e, i) = \bar{c} + \frac{de^2}{2} - i(1 - e) \quad \text{and } F(i) = \frac{i^2}{2}$$

where $\bar{c} > 0$ is the marginal cost without investments and we assume $d > \theta > S$ to have interior solutions. Solving the system of first order conditions provides the constant investment levels:

$$e = \frac{\theta - \eta S}{d - \eta S} \in (0, 1) \quad \text{and} \quad i = \frac{(d - \theta)\eta S}{d - \eta S} > 0$$

which are positive under our assumptions. The steady state quality can be computed as:

$$\tilde{q} = \frac{\theta - \eta S}{(1-\lambda)(d - \eta S)}$$

The investment in cost-saving innovations increases in the appropriable market size ηS and also in d, while the one in quality-enhancing innovations and the steady state level of quality are decreasing in ηS and d. Incidentally, the last result suggests that an extension to hetereogeneous artists would lead the most talented to focus on increasing quality and the less talented to focus on reducing costs, strengthening the skewness of the price distribution.[26]

Some of these findings are general, since applying Cramer's rule on the equilibrium system we can compute $\partial e(q_{t-1})/\partial \eta S \leqslant 0$, $\partial i(q_{t-1})/\partial \eta S > 0$, $\partial e(q_{t-1})/\partial \theta > 0$ and $\partial i(q_{t-1})/\partial \theta \leqslant 0$. The results on the appropriable market size imply that small markets or markets where the patrons have a high bargaining power generate high investments in quality (strictly for $c_{ie} > 0$) and therefore rapidly increasing prices, while larger markets where artists have high bargaining power expand investments in cost-reductions, because these are spread through more sales at stable prices, and lower investments in quality (strictly for $c_{ie} > 0$). The results on the demand-shifting parameter θ imply that richer markets generate high investments in quality and therefore rapidly increasing prices, while poorer markets expand investments in cost-reductions. In practice, artistic innovations are deeper when few patrons have a high willingness to pay and also a high bargaining power, which induces the artists to focus more on quality-enhancing innovations:[27] this is what Cowen and Tabarrok (2000) associated with *avant-garde* art directed toward elitarian demand, in contrapposition with *popular* art that spreads in larger markets fostering mass production.

Historical examples of large markets shaping art production can be found during the Roman Empire, characterized by a huge integrated market around the Mediterranean Sea (Stewart, 2008), and during the Dutch golden age of the XVII century, characterized by the emergence of a new demand of art by the middle class (Montias, 1982, 2002). In both cases, workshops invested in cost-saving innovations, specialized in new and differentiated genres, and developed forms of mass production of art, with art prices that were stable or even declining in the later phase of the respective traditions (Etro, 2024; Etro and Stepanova, 2016).

In our framework with two dimensions of investment, the evolution of art

[26] This is also consistent with the fact that the Dutch golden age featured at the same time mass production of low quality paintings and the unique quality of paintings by Rembrandt and Vermeer.

[27] In this spirit, Vaubel (2005) has emphasized the rise of Renaissance and Baroque music in Italy and Germany as driven by political fragmentation generating high competition and demand for rival composers.

history is inefficient in both of them. The social planner problem:

$$\max_{q_t, i_t \geqslant 0} \sum_{t=1}^{\infty} \beta^{t-1} \left\{ \left[\theta u(q_t) - c(q_t - \lambda q_{t-1}, i_t) \right] S - F(i_t) \right\}$$

implies the optimality conditions:

$$\theta u'(q_t^*) + \beta \lambda c_e(e_{t+1}^*, i_{t+1}^*) = c_e(e_t^*, i_t^*) \quad \text{and} \quad S \left| c_i(e_t^*, i_t^*) \right| = F'(i_t^*)$$

The former involves the usual additional benefit from the quality-enhancing investment compared to the equilibrium. The latter involves a higher benefit from cost reductions compared to the equilibrium. Under-investment in cost reduction is due to a classic *hold up problem à la* Williamson: since artists appropriate only a fraction of the benefits from sunk investment in subsequent commissions, they are induced to invest less than jointly optimal.[28] The equilibrium involves too little of one or both forms of investments. However, it may also involve too much investment in the quality-enhancing activity to compensate for an insufficient investment in cost reductions.[29]

6 Price-setting artists, dealers and entry

In developed art markets, most of the artists do not bargain with patrons on content and price of commissions, but produce for anonymous and heterogeneous buyers who absorb their production at fixed prices. This practice was already common in the XVII and XVIII centuries, when painters were setting prices in their workshops.[30] An additional institutional change emerged in XIX century Paris when a new professional figure, the art dealer, started to specialize in the commercialization of paintings. With pioneering dealers such as Paul Durand-Ruel for the Impressionists and Ambroise Vollard for the post-Impressionists, this business model became standard in the modern art world (White and White, 1965). Such a change was made possible by the "liberalization" of the Paris art market that occurred with the end of the government-controlled Salon in 1880, and the emergence of new independent exhibition avenues for all the artists and dealers who were competing in that market (Galenson and Jensen, 2007). This reduced the barriers to entry erected by the *insiders* of the Salon (the conservative academic artists), who had monopolized the jury, its exhibition

[28] See Grossman and Hart (1986).

[29] For instance, in our linear-quadratic example we obtain the optimal investments:

$$e^* = \frac{\theta - (1 - \beta\lambda)S}{(1 - \beta\lambda)(d - S)} \quad \text{and} \quad i^* = \left(d - \frac{\theta}{1 - \beta\lambda} \right) \frac{S}{d - S}$$

where the former increases and the latter decreases in the discounted rate of artistic transmission $\beta\lambda$, and at least one of the two is above the equilibrium level. However, $e > e^*$ for low values of β and η.

[30] Remarkably, in this period we have wide evidence of price-setting artists for both the European painters (Montias, 1982; De Marchi and Van Miegroet, 2006) and professional Chinese painters (Cahill, 1994). Of course, portraits were excluded from this practice.

space, its awards and the primary commissions, keeping the *outsiders* of the Salon, such as the Impressionists or female painters, at the margin of the market. Free entry of the artists in the various exhibitions in Paris between the end of the XIX century and the beginning of the XX century fostered competition in the art market and artistic innovation.[31]

To incorporate these aspects in our framework we start by considering the behavior of a price-setting artist and then we study entry of artists in a market with free entry and conclude with a simple general equilibrium two-sector analysis.

6.1 Art production and pricing

Let us consider a demand of artworks by S heterogeneous buyers with surplus:

$$v_t = \theta u(q_t) - p_t - \xi_t$$

where ξ_t is a taste shock that, for simplicity, is uniformly distributed in the unit interval. This implies a market demand given by the probability of purchase of a buyer $x_t(p_t) = \Pr(v_t \geqslant 0)$ multiplied by the number of buyers S, where:

$$x_t(p_t) = \theta u(q_t) - p_t$$

is linear in the price. Quality depends on effort exerted on each work, so that the expected gross profits of the artist become:

$$\pi_t = [p_t - g(e_t)]\, x_t(p_t) S \tag{19}$$

to be maximized under constraint (1). This implies price and effort defined by the system:

$$p_t = \frac{\theta u(q_t) + g(e_t)}{2} \quad \text{and} \quad \theta u'(q_t) = g'(e_t) \tag{20}$$

independently from the market size, which affects linearly the gross profits:

$$\pi_t = \frac{[\theta u(q_t) - g(e_t)]^2 S}{4}$$

The price function follows a standard Lerner rule, with a markup on the marginal cost that is inversely related to the demand elasticity, which in turn depends on effort. However, the effort function is still the same as under (5), therefore art quality follows the same dynamic path (6) as in the model with patron-artist negotiations, though the purpose of innovation is not to bargain higher prices but to expand market demand to set higher prices. The dichotomy

[31] On the Impressionists, there is evidence (Etro *et al.*, 2020) that in the rare cases where an Impressionist had a painting exhibited at the Salon, his or her prices had a substantial increase in the market, while there was not such an impact for the insiders. Moreover, the end of the Salon contributed to start the price increase of the Impressionists relative to the insiders. On gender discrimination there is also evidence from the Paris Salon (de Beyssat *et al.*, 2023). For the contemporary art market see Vecco *et al.* (2024).

between price and effort holds for any distribution of the taste shock that determines a well behaved (non-linear) demand function, since the nature of the latter affects the demand elasticity and the price rule, but not the optimal effort associated with it.[32]

Art dealership can introduce further biases in artistic activity. As often lamented by artists, dealers tend to accept prices that are too low, frustrating the incentives of masters to focus on their art. There is a simple rationale for this, which is due to the business model of the dealers based on commissions on revenues. This creates an incentive for dealers to expand sales, reducing the incentives of the artists to invest in product innovation. Let us consider a commission rate $\mu \in (0,1)$ such that the dealer earns $\pi_t^D = \mu p_t x_t(p_t) S$ and the artist earns $\pi_t^A = [p_t(1-\mu) - g(e_t)]\, x_t(p_t) S$. For simplicity, let us imagine that the dealer sets the price and the artist sets effort independently from each other. Then, price and effort satisfy:

$$p_t = \frac{\theta u(q_t)}{2} \quad \text{and} \quad \theta u'(q_t) = \frac{g'(e_t)}{1-\mu-g(e_t)/p_t}$$

Therefore the price is reduced because the dealer does not internalize the effort cost of the artist, and effort is reduced because the artist obtains a lower margin on its works. The outcome is inefficient due to a form of double marginalization problem. The consequence is that art dealership distorts art innovation limiting creativity.[33] Of course, the rationale for dealership contracts relies on the comparative advantage of specialized intermediaries in increasing the demand intensity for their stable of artists,[34] and a partial solution to this "dealer paradox" involves artists bargaining for exclusivity with the dealer's platform and setting prices. Not by chance, some of the Impressionists, such as Monet, Renoir, Pissarro and Sisley, reached exclusive dealing agreements with Durand-Ruel, though they constantly argued on the prices of their works.

[32] Notice that the equilibrium of a market with anonymous buyers requires a commitment of the artist to stop production at the profit-maximizing level. Without such a commitment, the artist would be tempted to continue production and reduce the price to serve more buyers. Such an expectation would induce all buyers to search for lower prices, possibly in the secondary market, dissipating a large part of the profits of the artist (Coase, 1972). The inverse implication of the commitment issue, is that a sudden limitation of production below the optimal level is going to increase the price, as in the case of a premature death of an artist, which generates a supply-induced increase in demand of the outstanding works and increases prices in the secondary market. Evidence on the death effect exists at least since the art auctions developed in the XVIII century. For the contemporary art market see Penasse *et al.* (2021).

[33] Our leading example implies the steady state quality $\tilde{q} = \frac{\theta(1-\mu)}{(1-\lambda)(2-\lambda)d}$ which is below the one obtained through price-setting artists facing the same demand. Notice that the commission rate should compensate dealers for the opportunity cost of their activity in the primary market (as opposed to the activity in the secondary market) and internalize the impact on artistic effort.

[34] See Cellini and Cuccia (2014) for a theoretical analysis of contractual aspects of the artist-dealer relation, with strategic complementarities between effort of the artist and of the dealer (the latter aimed at increasing θ in our notation). See Velthuis (2013) on art pricing by dealers in the modern world.

6.2 Endogenous entry of artists

We now explore the incentives to become artists in this environment. Each artist supplies a different variety of artwork and, for simplicity, we assume that there is no substitutability between artworks. Under independent demands as above, symmetric choices by the artists determine the same price, effort and gross profit for each artist. We now assume that the fixed entry cost to set up an artistic workshop is $\mathcal{F}(N_t)$ and increases with the mass of artists N_t, implying a higher opportunity cost from giving up to alternative occupations when there are more artists. Entry takes place until the gross profits π_t from the artistic profession match the entry cost, in the spirit of a monopolistic competition model *à la* Chamberlin.[35]

The endogenous mass of artists satisfies in each period the free entry condition:

$$N_t = \mathcal{F}^{-1}\left\{\frac{\left[\theta u(q_t) - g(e_t)\right]^2 S}{4}\right\} \tag{21}$$

which delivers a few implications. The first is a positive correlation between profitability of the artistic profession and entry, with a number of artists that increases with demand intensity and the appropriable surplus, and reaches a stable level in the long run. The second implication is that the number of artists increases with the market size S, but can increase more or less than proportionally depending on the shape of the cost function, reflecting the balance of congestion effects and positive externalities in more crowded markets. The third implication is that the model delivers path-dependence for the number of artists, in spite of independent entry decisions by each generation. For instance, extending our linear-quadratic specification (8) with $\mathcal{F}(N) = N^2$ we can easily derive the endogenous auto-regressive process for the equilibrium number of artists:

$$N_t = \lambda N_{t-1} + \frac{(1+\lambda)\theta^2\sqrt{S}}{4d}$$

which converges to a steady state value:

$$\tilde{N} = \frac{(1+\lambda)\theta^2\sqrt{S}}{(1-\lambda)4d}$$

This is positively related to effectiveness of scholarship λ, demand intensity θ and market size S, with decreasing effects in this example due to strong congestion effects. There is a consistent evidence that the density of artists has been increasing with profitability in the leading art centres of European art (De Marchi and Van Miegroet, 2006). Moreover, focusing on the Dutch golden age, Etro and Stepanova (2017) have advanced evidence of (Granger) causality of profitability on the entry of painters, and have employed a vector

[35] See Spence (1976) for a primary reference on monopolistic competition in a quasi-linear environment. One can extend the analysis to heterogeneous artists (Melitz, 2003): in such a case, more talented artists would set higher prices and markups, and their workshops would produce more and obtain higher profits.

autoregression analysis to confirm that an increase in the average profitability of painting led to entry of new painters with a short delay, corresponding to the average length of apprenticeship of six years.

In an environment with endogenous entry of artists and production of artworks, new inefficiencies can emerge in the evolution of $x_t(p_t)$, N_t and total artistic production $x_t(p_t)N_tS$. To evaluate total welfare we need to consider consumer welfare generated by art and the total net profits. The first best allocation of resources selects price, effort and number of artists to solve the problem:

$$\max_{p_t,e_t,N_t\geqslant 0}\sum_{t=1}^{\infty}\beta^{t-1}\int_0^{N_t}\left\{\frac{[\theta u(q_t)-p_t]^2 S}{2}+[p_t-g(e_t)]\,[\theta u(q_t)-p_t]\,S-\mathcal{F}(i)\right\}di$$

The optimality conditions are:

$$p_t^*=g(e_t^*)$$

$$\theta u'(q_t^*)+\beta\lambda\frac{x_{t+1}(p_{t+1}^*)N_{t+1}}{x_t(p_t^*)N_t}g'(e_{t+1}^*)=g(e_t^*)$$

$$N_t^*=\mathcal{F}^{-1}\left\{\frac{[\theta u(q_t^*)-g(e_t^*)]^2 S}{2}\right\}$$

The ideal evolution of art production involves marginal cost pricing, expanding the production of each artist to serve the market at the competitive level. Artistic innovations are underprovided in the decentralized market, and a social planner selects the innovative activity taking into account the impact on future quality and also the growth rate of art production along the path toward the steady state. Moreover, there are too few artists in a decentralized market, because a social planner compares the entry cost with the sum of surplus functions of the buyers rather than with the gross profits of the marginal artist. It is worth noting that the result of insufficient entry and investment would also hold in a second best perspective *à la* Mankiw-Whinston that allows artists to select their profit-maximizing price. This implies that there are social gains from liberalizing art markets, in the sense of removing entry barriers (as a government control on admissions at art exhibitions), and also from designing an art policy that subsidizes entry and production of artists.[36]

6.3 Two-sector analysis and the cost disease

To conclude this section we advance an alternative interpretation of the entry process in terms of occupational choice between artistic and non-artistic professions. This allows us to study art production in a simple general equilibrium

[36] In a sense, artists could be seen as public goods, whose provision should be financed, and artworks as money, which should be printed to the point of satiating consumers.

two-sector environment and evaluate the *cost disease effect* associated with productivity growth in the industrial sector (Baumol and Bowen, 1965). Let us assume that in each period t a fixed population of N workers is allocated between the artistic activity and the production of a *numeraire* good with technology:

$$Y_t = A_t Z(L_t) \tag{22}$$

where A_t is productivity, L_t is employment in the industrial sector and $Z(L)$ is a production function with decreasing marginal productivity of labor, such that $Z'(L) > 0$ and $Z''(L) < 0$. Earnings in the industrial sector are given by the wage w_t. Earnings in the art sector are given by the gross profits π_t as above.

The market clearing wage at time t must match the marginal productivity of labor in the industrial sector:

$$w_t = A_t Z'(L_t)$$

and must also match the earnings in the art sector π_t to insure that occupation in both sectors equates total labor supply, $L_t + N_t = N$. This implies the equilibrium condition for N_t:

$$\frac{\left[\theta u(q_t) - g(e_t)\right]^2 S}{4} = A_t Z'(N - N_t) \tag{23}$$

where effort and quality are determined by (20) in each period. In a sense, the wage from a non-artistic occupation represents the opportunity cost of entry in the artistic profession, and increases in the employment of the art sector due to decreasing marginal productivity of labor in the industrial sector. Accordingly, the mass of artists N_t increases in the ratio between profits in their sector and productivity in the non-artistic sector π_t/A_t,[37] but without affecting the evolution of quality, which is determined by the independent activity of artistic creation.

We can finally evaluate the impact of a constant productivity growth in the industrial sector, retaining the assumption that population and market size remain constant. At the initial development of a new artistic tradition, when investment is high, art profitability can grow more than productivity in the industrial sector, attracting an increasing number of artist, which reaches its maximum level when the growth rates of art profitability and industrial productivity are the same. After that, the cost disease of Baumol and Bowen (1965) exerts its effects on the occupational level, and the number of artists declines, though the total production of artworks keeps increasing due to the expanding quality and production of each artist. In the long run, with stable prices, production levels and profits for the artists, we obtain that productivity growth keeps diverting workers from the art sector. Such a bell shaped pattern

[37] This resonates well with the Lopez (1953) hypothesis, for which the demand for artworks flourishes in societies with reduced investment opportunities. Adding physical capital as an input of the industrial sector would deliver a positive correlation between this and the number of artists.

for the number of artists has been typical of various artistic traditions around their golden ages, as documented for the number of painters active in Amsterdam during the XVII century (Etro and Stepanova, 2016). As known from semi-endogenous growth models, what can sterilize or invert the cost disease effect on the number of artists, besides the development of new artistic traditions (or even new arts), is a positive growth of population and market size.

7 Art history across time and space

Art history is a history of different traditions that are developed in interdependent markets. Not only because artists migrate in other regions for training or for work, and buyers purchase artworks from other regions, all of which fosters art price equalization and artistic convergence. But also because different artistic traditions and movements exert direct and indirect influences on each other, as in modern times through international fairs, art galleries and art criticism. This interdependence is always more important in the global market for contemporary art, though it is not a new phenomenon.[38] And the influence has been often multi-directional: the arrival of European prints in China influenced local painting since the XVII century, and Chinese art has always exerted an impact on Japanese art, but when *ukiyo-e* prints reached Europe at the end of the XIX century, they exerted a novel impact on Impressionist and post-Impressionist artists.

We can formalize reciprocal influences between J artistic regions or movements by considerng a $J \times J$ network where each node i exerts a delayed influence on each other node j. Given the vectors of quality levels $\mathbf{q}_t \equiv [q_{1t}, .., q_{Jt}]$ and effort levels $\mathbf{e}_t \equiv [e_{1t}, .., e_{Jt}]$ at time t, let us consider the dynamic system:

$$\mathbf{q}_t = \Gamma \mathbf{q}_{t-1} + \mathbf{e}_t \tag{24}$$

where Γ is a matrix of rates of transmission of quality across the art network. The effort choices follow behavioral rules as those of the baseline model, which allows one to analyze the interdependent evolution of art histories and the geographical diffusion of creative achievements.

To exemplify, let us consider two symmetric regions with own rate of transmission λ and inter-regional rate of transmission $\chi \in (0, 1-\lambda)$, implying the system:

$$\begin{cases} q_{1t} = \lambda q_{1t-1} + \chi q_{2t-1} + e_{1t} \\ q_{2t} = \chi q_{1t-1} + \lambda q_{2t-1} + e_{2t} \end{cases}$$

[38] The gradual emergence of artists around the globe over centuries emphasizes very clearly how geographical proximity has spread artistic traditions in the ancient world from Greece toward West (through Roman art) and East (through Gandhara art) and, after the spread of medieval cathedrals throughout Europe. A few local traditions have been developed through the original elaboration of foreign ones, as in national schools of peripheral European art (for instance in nordic and slavic countries), in Colonial art (for instance religious paintings in Cuzco, Antigua or Manila, absorbing the Spanish tradition) and also in Eastern art (for instance modern painting in Bali or even aboriginal painting in Australia).

The region with a more advanced tradition exerts strong spillovers on the other region, and the latter can catch up and increase its influence on the former. Assuming independent markets where artists select the profit-maximizing effort, the decentralized equilibrium involves the system of optimality conditions:

$$\theta u'(q_{jt}) = g'(e_{jt}) \quad \text{for } j = 1, 2 \tag{25}$$

For instance, our linear-quadratic setup implies a constant effort in each region with both artistic traditions converging to the same quality level:

$$\tilde{q} = \frac{\theta}{(1 - \lambda - \chi)d}$$

This is not only increasing in the rate of reciprocal spillovers ($\partial\tilde{q}/\partial\chi > 0$), but more so when the own rate of transmission is higher ($\partial^2\tilde{q}/\partial\chi\partial\lambda > 0$), implying that cross-fertilization of traditions provides a value added to each art. Moreover, recovering the endogenous entry process of the last section, the number of artists of a region should be characterized not only by a positive autocorrelation, but also by correlation at a cross-regional level.[39]

The relevant aspect of this analysis is that one can capture the evolution of art history not only over time but also across space considering the interdependence between traditions or artistic movements. Asymmetries in the network can rationalize the development and coexistence of a core and a periphery with different (but related) achievements. Let us consider the linear-quadratic example where $\boldsymbol{\theta} \equiv [\theta_1, .., \theta_J]$, D is a diagonal matrix with diagonal elements d_i, and Γ is a matrix with diagonal elements λ_i representing own persistence for tradition i and off-diagonal elements χ_{ij} representing cross-tradition influence from j to i. Standard conditions imply existence, uniqueness and global stability of the steady state:

$$\tilde{\mathbf{q}} = (I - \Gamma)^{-1} D^{-1} \boldsymbol{\theta} \tag{26}$$

which corresponds to the measure of *centrality à la* Katz-Bonacich of the art network and is independent from the initial conditions. In the long run, the artistic quality $\tilde{q}_i$ reached by tradition i increases when its market features higher demand θ_i and lower cost of creativity d_i, when own transmission λ_i is more effective, when there are stronger inflows χ_{ij} from other traditions j (especially from innovative ones, with high θ_j/d_j) and also when there are strong feedback

[39] Extending the linear-quadratic example used in the last section, and solving the system of free entry conditions in each region, we can compute the number of artists in region $i, j = 1, 2$ as:

$$N_{it} = \lambda N_{it-1} + \chi N_{jt-1} + \frac{(1 + \lambda + \chi)\theta^2\sqrt{S}}{4d}$$

This converges to a common steady state value:

$$\tilde{N} = \frac{(1 + \lambda + \chi)\theta^2\sqrt{S}}{(1 - \lambda - \chi)4d}$$

which is increased by spillovers. For an empirical analysis of entry of innovators across time and space (without a focus on the specificities of the art market) see Serafinelli and Tabellini (2022).

loops (through higher χ_{ji}), namely when the region i is more "central" in the network of artistic traditions.[40]

Modern art history has been characterized by the continuous interaction of the art movements born in European countries in the first half of the XX century, such as Symbolism, Expressionism, Futurism, Cubism, Surrealism, Abstract art and more. But the most drammatic case of a rapid transmission of artistic traditions has probably taken place in the middle of the century: leading modernists based in Paris played a decisive role in the development of a new American art when some of them (and their dealers) had to move to New York during Second World War, creating a new cluster of artistic creativity (see Hellmanzik, 2010). This exogenous shock contributed to stimulate the innovations of Jackson Pollock and the other artists of Abstract Expressionism, starting once again from low and rapidly increasing prices in the primary market. Since then, American art exploited an increasing demand and New York became the new center of international art, developing some of the most significant movements of contemporary art (Galenson, 2009; Etro and Stepanova, 2026).

In a multi-regional environment there is an additional reason for underinvestment in art, which is related to spillovers across traditions that are neglected by artists in their investment decisions. In our example with two symmetric regions, the maximization of the expected value of the total surplus of both regions implies the system:

$$\theta u'(q^*_{jt}) + \beta\lambda g'(e^*_{jt+1}) + \beta\chi g'(e^*_{it+1}) = g'(e^*_{it}) \quad \text{for } j, i = 1, 2 \tag{27}$$

which displays an additional term compared to (9) whenever $\chi > 0$. This term reflects the positive impact that investment of a region i exerts on the artistic tradition of a region j in the future, and the interaction creates a multiplier effect on quality levels. In such an open-economy framework, art policy becomes a *prosper-thy-neighbour* policy, in the sense that incentives to artistic creativity in a region create benefits also for other regions. For instance, in the linear-quadratic case the optimality conditions lead to a steady state with:[41]

$$\tilde{q}^* = \frac{\theta}{(1 - \beta\lambda - \beta\chi)(1 - \lambda - \chi)d}$$

which is clearly larger than the equilibrium $\tilde{q}$.[42]

[40] Analogous results would emerge with investments in cost-saving innovations, with traditions from larger markets developing a comparative advantage in mass production and traditions from high demand markets developing a comparative advantage in high quality production.

[41] In principle, such a joint golden rule could be achieved if both regions adopted a transfer $\tau^* = \frac{\beta}{\lambda/(\lambda+\chi)+\beta}$ larger than (10). These insights can be seen as providing an additional argument in favour of the international coordination of cultural policies that support art production, which may open new avenues for an international union focused on cultural policy (such as Unesco in modern times).

[42] In the general version of the asymmetric linear-quadratic case, the optimal steady state can be derived as $\tilde{\mathbf{q}}^* = (I - \Gamma)^{-1} D^{-1} (I - \beta\Gamma^T)^{-1} \boldsymbol{\theta}$. For a network analysis of contemporary art movements see Fraiberger *et al.* (2018).

Globalization has drastically changed the structure of international art markets in the last decades. The transmission of different artistic ideas is now faster than it has ever been, and regional growth allows new peripheries to catch up quickly. The evolution of contemporary art is guided by the rapid emergence of new styles, new genres and new definitions of what is art in a process of creative destruction led by conceptual innovators (Galenson, 2009) and a wider ecosystem (including mega-galleries, investors and intermediaries) that adjusts its narrative in response to market incentives (Thompson, 2010).

8 Conclusion

One of the most significant fields of human creativity and innovation, art, has not been independent from economic incentives and institutional determinants. This work has advanced a theory of the evolution of artistic traditions based on investments by workshops that transmit techniques through apprenticeship. The core insight of the model is that initial artistic innovations are more radical and associated with low and increasing art prices, but the subsequent evolution involves a gradual convergence toward a steady state with stable quality and prices. The framework can account for entry of heterogeneous talents, contractual frictions between artists and patrons, and the divergence between mass production of popular art and more innovative *avant-garde* art. The implications await for empirical validation and theoretical extensions in an interdisciplinary perspective.

The model could be fruitfully extended to include an explicit analysis of monopolistic competition between heterogeneous artists with style and genre differentiation and to endogenize the birth of new artistic traditions. The analysis of labor contracts could be developed further to explore important aspects of the relation between artists on one side and patrons or dealers on the other side. The model could be also exploited to study intertemporal decisions by heterogeneous artists (possibly young geniuses versus old masters) as well as patrons (possibly reselling works over time). Investigations in the spirit of cultural economics could go beyond the primary market and explore the secondary market, and in particular the consequences of investment decisions for art prices and return rates in auction markets as well as the role of hedonic dividends in affecting investment decisions. In this perspective one may also study the impact of different forms of *IPR* protection, the *droit de suite* and other complex forms of art policy. Finally, one may investigate the allocation of artworks across collectors and museums, and the absorption of masterpieces by museums as a channel for public good heritage.

References

Aghion, Philippe and Peter Howitt, 2008, *The Economics of Growth*, MIT Press.

Alsop, Joseph, 1983, *The Rare Art Traditions: The History of Art Collecting and Its Linked Phenomena*, Princeton University Press.

Baxandall, Michael, 1972, *Painting and Experience in Fifteenth-century Italy: a primer in the social history of pictorial style*, Clarendon Press.

Baumol, William and William Bowen, 1965, On the Performing Arts: the Anatomy of their Economic Problems, *American Economic Review*, 55, 1/2, 495-502.

Bille, Trine, Knut Løyland and Anders Holm, 2017, Work for Passion or Money? Variations in Artists' Labor Supply, *Kyklos*, 70, 3, 347-380.

Borowiecki, Karol, 2022, Good Reverberations? Teacher Influence in Music Composition since 1450, *Journal of Political Economy*, 130, 4, 991-1090.

Bourdieu, Pierre, 1993, *The Field of Cultural Production*, Polity Press.

Burke, Marcus and Peter Cherry, 1997, *Collections of Painting in Madrid, 1601-1755*, Getty Publications.

Cahill, James, 1994, *The Painter's Practice: How artists lived and worked in traditional China*, Columbia University Press.

Cellini, Roberto and Tiziana Cuccia, 2014, The Artist-Art Dealer Relationship as a Marketing Channel, *Research in Economics*, 68, 1, 57-69.

Clunas, Craig, 1991, *Superfluous Things: Material culture and social status in early modern China*, University of Haway Press.

Coase, Ronald, 1972, Durability and Monopoly, *Journal of Law and Economics*, 15, 1, 143–49.

Collins, Alan, Antonello Scorcu and Roberto Zanola, 2009, Reconsidering Hedonic Art Price Indexes, *Economics Letters*, 104, 2, 57-60.

Cowen, Tyler, 2000, *In Praise of Commercial Culture*, Harvard University Press.

Cowen, Tyler, 2009, *Creative Destruction: How globalization is changing the world's cultures*, Princeton University Press.

Cowen, Tyler and Alexander Tabarrok, 2000, An Economic Theory of Avant-garde and Popular art, or High and Low Culture, *Southern Economic Journal*, 67, 2, 232-253.

De Marchi, Neil and Hans Van Miegroet, 2006, The History of Art Markets, in *Handbook of the Economics of Art and Culture*, Eds. Victor Ginsburgh and David Throsby, Vol. 1, 69-122.

De Beyssat, Claire Dupin, Diana Seave Greenwald and Kim Oosterlinck, 2023, Measuring Nepotism and Sexism in Artistic Recognition: the awarding of medals at the Paris Salon, 1850–1880, *Journal of Cultural Economics*, 47, 3, 407-436.

De Vany, Arthur and David Walls, 1999, Uncertainty in the movie industry: Does star power reduce the terror of the box office?, *Journal of Cultural Economics*, 23, 4, 285-318.

Etro, Federico, 2018, The Economics of Renaissance Art, *Journal of Economic History*, 78, 2, 500-538.

Etro, Federico, 2024, Art and Markets in the Greco-Roman World, *Journal of Economic History*, 84, 2, 432-478.
Etro, Federico, Silvia Marchesi and Laura Pagani, 2015, The Labor Market in the Art Sector of Baroque Rome, *Economic Inquiry*, 53, 1, 365-87.
Etro, Federico, Silvia Marchesi and Elena Stepanova, 2020, Liberalizing Art. Evidence on the Impressionists at the end of the Paris Salon, *European Journal of Political Economy*, 62, 101857.
Etro, Federico and Laura Pagani, 2012, The Market for Paintings in Italy during the Seventeenth Century, *Journal of Economic History*, 72, 2, 423-47.
Etro, Federico and Elena Stepanova, 2016, Entry of Painters in the Amsterdam Market of the Golden Age, *Journal of Evolutionary Economics*, 26, 2, 317-348.
Etro, Federico and Elena Stepanova, 2018, Power-Laws in Art, *Physica A*, 506, 217-220.
Etro, Federico and Elena Stepanova, 2026, A Century of Art Dealing in New York: The rise of American art, *Economic History Review*, in press.
Fraiberger, Samuel, Roberta Sinatra, Magnus Resch, Christoph Riedl and Albert-Laszlo Barabási, 2018, Quantifying Reputation and Success in Art, *Science*, 362, 6416, 825-829.
Galenson, David, 2007, *Old Masters and Young Geniuses: The Two Life Cycles of Artistic Creativity*, Princeton University Press.
Galenson, David, 2009, *Conceptual Revolutions in Twentieth-century Art*, Cambridge University Press.
Galenson, David and Robert Jensen, 2007, Canvases and Careers: the rise of the market for modern art in nineteenth century Paris, in *Current Issues in Ninenteenth-Century Art*, *Van Gogh Studies*, Chris Stolwijk (Ed.), 1, 137-166, Waanders Publishers.
Giorcelli, Michela and Petra Moser, 2020, Copyrights and Creativity: Evidence from Italian opera in the Napoleonic age, *Journal of Political Economy*, 128, 11, 4163-4210.
Goldthwaite, Richard, 1995, *Wealth and the Demand for Art in Italy, 1300-1600*, Johns Hopkins University Press.
Gombrich, Ernst, 1960, *Art and Illusion: A study in the psychology of pictorial representation*, Phaidon Press.
Graddy, Kathryn, 2014, Taste Endures! The ranlings of Roger de Piles (1709) and three centuries of art prices, *Journal of Economic History*, 73, 3, 766-91.
Greenwald, Diana Seave, 2021, *Painting by Numbers: Data-driven histories of nineteenth-century art*, Princeton University Press.
Grossman, Sanford and Oliver Hart, 1986, The Costs and Benefits of Ownership: A theory of vertical and lateral integration, *Journal of Political Economy*, 94, 4, 691-719.
Haskell, Francis, 1980, *Patrons and Painters: A study in the relations between Italian art and society in the age of the Baroque*, Yale University Press.
Hauser, Arnold, 1951, *The Social History of Art*, Routledge & Kegan Paul, London.

Hellmanzik, Christiane, 2010, Location Matters: Estimating cluster premiums for prominent modern artists, *European Economic Review*, 54, 2010, 199-218.
Holmstrom, Bengt and Paul Milgrom, 1991, Multitask Principal-Agent Analyses: Incentive contracts, asset ownership, and job design, *Journal of Law, Economics & Organization*, 7, 24-52.
Kemp, Martin, 1990, *The Science of Art: optical themes in western art from Brunelleschi to Seurat*, Yale University Press.
Kubler, George, 1962, *The Shape of Time: Remarks on the History of Things*, Yale University Press.
Lee Owen, Virginia, 1977, The Florentine and Sienese Renaissance: A monopsonistic explanation, *Journal of Cultural Economics*, 1, 33-55.
Li, Chu-Tsing (Ed.), 1989, *Artists and Patrons. Some social and economic aspects of Chinese painting*, University of Washington Press.
Lopez, Robert, 1953, *Hard Times and Investment in Culture*, Metropolitan Museum of Art.
Makridis, Christos, 2025, The Labor Market Returns of being an Artist: evidence from the United States, 2006–2021, *Journal of Cultural Economics*, 49, 1, 1-21.
Mailath, George and Larry Samuelson, 2001, Who wants a Good Reputation?, *Review of Economic Studies*, 68, 2, 415-441.
Melitz, Marc, 2003, The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity, *Econometrica*, 71, 6, 1695-725.
Montias, John Michael, 1982, *Artists and Artisans in Delft: A Socio-Economic Study of the Seventeenth Century*, Princeton University Press.
Montias, John Michael, 2002, *Art at Auction in 17th Century Amsterdam*, Amsterdam University Press.
Nelson, John and Richard Zeckhauser, 2008, *The Patron's Payoff. Conspicuous Commission in Italian Renaissance Art*, Princeton University Press.
Netzer, Dick, 1978, *The Subsidized Muse*, Cambridge University Press.
North, Michael, 1997, *Art and Commerce in the Dutch Golden Age*, Yale University Press.
Ogilvie, Sheilagh, 2004, Guilds, Efficiency, and Social Capital: evidence from German proto-industry, *Economic History Review*, 57, 2, 286-333.
O'Malley, Michelle, 2005, *The Business of Art. Contracts and the Commissioning Process in Renaissance Italy*, Yale University Press.
O'Malley, Michelle, 2013, *Painting under Pressure: Fame, reputation and demand in Renaissance Florence*, Yale University Press.
Pénasse, Julien, Luc Renneboog and José Scheinkman, 2021, When a Master Dies: Speculation and asset float, *Review of Financial Studies*, 34, 8, 3840-3879.
Piano, Ennio, 2022, Specialization and the Firm in Renaissance Italian art, *Journal of Cultural Economics*, 46, 659-697.
Piano, Ennio and Tanner Hardy, 2022, Rent Seeking and the Decline of the Florentine school, *Public Choice*, 192, 59-78.
Piano, Ennio and Clara Piano, 2023a, Bargaining over Beauty: The economics of contracts in Renaissance art markets, *Journal of Law and Economics*, 66,

2, 225-257.
Piano, Ennio and Clara Piano, 2023b, Contracting Creativity: Patronage and creative freedom in the Italian Renaissance art markets, *European Review of Economic History*, 27, 3, 311-335.
Rosen, Sherwin, 1974, Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition, *Journal of Political Economy*, 82, 1, 34-55.
Rosen, Sherwin, 1981, The Economics of Superstars, *American Economic Review*, 71, 5, 845-858.
Seaman, Kristen and Peter Schultz, 2017, *Artists and Artistic Production in Ancient Greece*, Cambridge University Press.
Serafinelli, Michel and Guido Tabellini, 2022, Creativity over Time and Space, *Journal of Economic Growth*, 27, 1-43.
Smith, William Stevenson and William Kelly Simpson, 1998, *The Art and Architecture of Ancient Egypt*, Yale University Press.
Solkin, David, 1996, *Painting for Money: The visual arts and the public sphere in eighteenth-century England*, Paul Mellon Centre.
Spear, Richard and Philip Sohm, 2010, *Painting for Profit: The economic lives of Seventeenth-Century Italian painters*, Yale University Press.
Spence, Michael, 1976, Production Selection, Fixed Costs, and Monopolistic Competition, *Review of Economic Studies*, 43, 2, 217-35.
Stewart, Peter, 2008, *The Social History of Roman Art*, Cambridge University Press.
Stewart, Andrew, 2019, Patronage, Compensation and the Social Status of Sculptors, in *Handbook of Greek Sculpture*, Ed. Olga Palagia, De Gruyter, 50-88.
Stigler, George and Gary Becker, 1977, De Gustibus Non Est Disputandum, *American Economic Review*, 67, 2, 76-90.
Stokey, Nancy and Robert Lucas with Edward Prescott, 1989, *Recursive Methods in Economic Dynamics*, Harvard University Press.
Thompson, Donald, 2010, *The $12 million Stuffed Shark: The curious economics of contemporary art*, Macmillan.
Throsby, David, 1994, A Work-preference Model of Artist Behaviour, Chapter 6 in *Cultural Economics and Cultural Policies*, Eds. Alan Peacock and Ilde Rizzo, Springer, 69-80.
Vaubel, Roland, 2005, The Role of Competition in the rise of Baroque and Renaissance Music, *Journal of Cultural Economics*, 29, 4, 277-297.
Vecco, Marilena, Juan Prieto-Rodriguez and Simone Teerink, 2024, Climbing the Ladder? The gender gap in art prices across artists' cohorts in the Dutch art market, *European Economic Review*, 163, 104657.
Velthuis, Olav, 2013, *Talking Prices: Symbolic meanings of prices on the market for contemporary art*, Princeton University Press.
Wittkower, Rudolf and Margot Wittkower, 1963, *Born under Saturn. The Character and Conduct of Artists: a documented history from antiquity to the French Revolution*, Weidenfeld and Nicolson.
White, Harrison and Cynthia White, 1965, *Canvases and Careers: Institutional change in the French painting world*, University of Chicago Press.