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Waves and Cycles: Explorations in the Pure Theory of Price for Fine Art

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Abstract

This paper models price movements in the market for fine art. Consumers of art are assumed to value art for its own sake, but are also subject to externalities in consumption whereby the utility of consuming the work of a painter is affected by the consumption choices of other consumers of art. Painters are arranged in space, and positive externalities arise when the painter consumed is coming into fashion; negative externalities arise when the painter is going out of fashion. Because supply is fixed, popularity can be measured by price, so externality effects can be expressed through prices. Motion to the prices arises through the presence of some consumers who are fashion leaders, driving up the prices of coming artists. Rising prices indicate rising popularity, and the market moves towards these painters, shunning those who were previously popular. The paper makes reference to a companion paper by Peter Swann which is an empirical exploration of the same phenomenon. His paper suggests that painters can effectively be placed in a circular space, which makes the spatial assumptions of the analysis in the current paper reasonable. Results on trends in prices, and steady state prices under certain conditions are derived. The model is simulated numerically to illustrate some of the dynamics that arise.

Acknowledgements

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1. Introduction

The popularity of painters rises and falls. The Impressionists were scorned in the mid 1800s, become the mode a few decades later; largely disappeared from view early in the twentieth century, and stormed back to popularity at the end of that century. Their history illustrates two interesting phenomena. First is the rise and fall in popularity of artists. Artists become the mode; their prices rise, and galleries, critics and the public alike praise them as expressing the spirit of the times. But later they fade from view, and are replaced by others. Second is that artists often come and go as a group. While there may be the ultimate Impressionist (some say that Manet was "the finest painter of all the Impressionists", Janson and Janson, 1997, p. 722), as his popularity rises and falls so does that of other 'similar' artists. Whatever is driving the popularity of Manet drives also the popularity of Monet and Renoir. This grouping together of painters acts as a type of conformity effect in art fashion — if Van Gogh is popular, artists whose work is similar to his in the appropriate respects will also be popular, whereas painters whose work is different from his will tend to be unpopular. If one can imagine painters located in a space, with their popularity represented as a distribution over that space, then the modal painter will be surrounded by similarly popular painters. The mode, though, moves through the space over time.

There is another striking feature of the market for fine art. This is the presence of 'avant garde' consumers. These are the fashion setters who are unwilling to have yesterday's heroes on their walls. This need not sound quite so snobbish. One explanation for the behaviour of the avant garde is that their search for new painters is driven by their need to express new ideas and concerns. Currently popular art will express today's (or yesterday's) concerns and ideas, but will in all likelihood not express tomorrow's. Avant garde consumers perform the valuable role of finding the modes of expression for emerging concerns. While the conformity effect of painting 'schools' creates inertia in fashion, the presence of avant garde consumers creates motion. These consumers will create popularity for painters situated far from the modal painter in painting space.

These two features of the art market suggest the possibility of waves in popularity. Groups of painters become popular together, though one may stand out, but their popularity fades as avant garde consumers look for new painters. The choices of these fashion leaders are thereafter taken up by less forward-looking consumers, which contributes to a shift in overall demand within the market. This is the phenomenon at the centre of this paper. Our concern here is to model it in a way that sheds light on the patterns that can emerge from this interplay of conformity and distinction.

The world of fine art is not the only one in which waves of fashion come and go. While the consumers of textbook theory have preferences independent of each other, this seems restrictive when considering the wide variety of both behaviour and type within the population of agents referred to as consumers. And indeed, a more general view, namely that there are externalities in consumption, or that the utility of an agent will depend in part on what other particular agents are consuming (whether there are physical spillovers such as pollution or not) is not new in economics. It stretches back to Smith, who claimed that the "the chief enjoyment of riches consists in the parade of riches". Recently, the idea has been taken up by Becker (1997) and Ackerlof (1998) each in his own way.

One key aspect of externality in consumption, and the one emphasized by sociologists, is distinction.[1] The idea here is that individuals gain utility from what they perceive to be their relative status in some hierarchy, and that one way to express, or even to change that status is through consumption. Consumption of some things will raise our relative status, and others will lower it. Frank (1985) has described some of the economic effects of the desire for distinction. Desire for distinction may be a powerful motivator, but nonetheless for most agents it is important to function within a peer group—after all, from whom would we like to distinguish ourselves but our "former peers"—so it is important that some activities create conformity with at least some part of the population around us. Thus within any utility function we would expect to see two (possibly occasionally conflicting) forms of non-independence: desire for distinction; and desire for conformity.

The effects of conformity and distinction have been addressed in a general way by Cowan et al. (1997). That model forms the background for much of the work presented in this paper.

[1] See most notably Bourdieu (1984).

Curiously, given the occasion for which this paper was written, the model developed here shows no path dependence. It is a dynamic model, but the dynamics are deterministic, and the final, very long run outcome is predictable from the start. One place it does pick up ideas from Paul David (ignoring the general idea that some things are better than others) is in the notion of bandwagons, heroes and herds. Bandwagons of taste form, leaving yesterday's hero a mere member, or at best icon, of today's herd. How this comes about is through a form of standardization—ideas and their expression become standardized. A new idea or new form of expressing something important emerges, to the scorn of the majority of the population. It is picked up by those who can see the coming thing, and pushed by them, they perhaps acting as translators, or gateways, between the new, unusual idea, and the old standard. Slowly, the herd come to see its value, and it is absorbed (somewhat twisted perhaps to fit) by the mass of the population, and before you know it, everyone is doing it. But what of the innovator? Is he doomed to a future of anonymity? Not if he is able to continue producing new, unusual ideas to address emerging issues. If history is anything to go by, and especially if it matters, this is not something that need concern us on this occasion.

We turn now to a very stylized model of the art world, in which prices are determined through the utility that paintings (or more properly the works of painters) provide the consumer. This utility is driven in part by externalities, and if snobbery is an unappealing trait on which to build a model, externalities can be seen as an expression of the notion that some art forms or genres are better fitted to the concerns of the day. Avant garde consumers are looking at tomorrow's ideas, and they pull the market with them in their search for new means of expression or needs to express new ideas. From these simple externalities we can derive rich dynamic patterns in which prices rise and fall as painters come into and go out of fashion.

2. A Simple Model of Art Price Dynamics

In this model we examine demand for painters' outputs. That is, we consider a painter to be a brand name, associated with which there is a fixed supply of the commodity. We acknowledge the fact that painters produce nothing after they have died, but assume also that none of their works disappear. We consider the median consumer as representative of the market demand. While this is acknowledged to be problematic in some cases (see Kirman, 1992) this problem is alleviated somewhat in the heuristic wherein we treat the consumer's demand as distributed over painters. This can be seen as capturing the notion that the median consumer represents a population of heterogenous consumers whose demand will be distributed. The model is developed in the usual way as a consumer maximization problem. The assumption of a fixed supply of every good immediately produces the equilibrium quantities consumed. What is of interest, however, rather than quantity is price. Prices change to equilibrate the market for each painter. This is not the trivial problem it seems, due to the presence of externalities in consumption—the popularity of a painter, indicated by a high price for his works, will affect the utility gained from consumption of other like, and unlike, painters. In addition price adjustment is temporal in the sense that because not every painting is auctioned every period (neither in the model nor in the actual art market) price adjustments are necessarily partial.

There are two types of goods — paintings and other goods. Other goods are aggregated into the good Z, whereas paintings remain branded by painter. Define A as the set of painters: $A = \{a \in [1, N]\}$. The consumer's utility function is additively separable, written as $U(X_1, X_2, \ldots, Z) = \sum_A U_a(X_a) + Z$ where Z is the aggregate bundle of other goods, and X_a represents consumption of the paintings of artist a.

Normalize by setting the price of Z to 1. Utility maximization under a fixed budget yields a first order condition:

$$dU/dX_a = \sum_{b \in A} dU_b/dX_a = p(a).$$

where $p(a)$ is the price of the work of artist a.[2]

Separating a from the other artists:

$$p(a) = dU_a/dX_a + \sum_{b \neq a} dU_b/dX_a. \qquad 1$$

The first term is simply the marginal utility of consuming paintings by painter a; the sum represents the effects of consumption of painter b on the utility gained from consuming painter a. Assume now that $d^2U_a/dbdc = 0 \; \forall c \notin \{a, b\}$. If the number of painters is large, this permits us to approximate equation 1 as

$$p(a) = g(a) + \int_{b \in A} F(b, a) db, \qquad 2$$

where $g(a) = dU_a/dX_a|_{\overline{X}}$. We can suppress the X_a argument since by assumption there is a fixed number of paintings per painter, $\overline{X}$, and the market clears through

[2] Because we are interested in the evolution of prices of all the painters, rather than using the common p_a notation we treat price as a function of the painter, $p(a)$.

price adjustments. The term $g(a)$ can be seen as representing the inherent value of artist a, regardless of his current (un)popularity. Some artists are just simply better than others.

The integral contains externality effects: consumption of other painters affects the marginal utility of the consumption of a. We decompose $F(a,b)$ into a product: $1/\alpha f(b-a)p(b)$. The first element represents the strength of the externality as determined by the distance between the two painters in question—made up of the conformity and avant garde effects; the second is the standing price of the second painter, which is a measure of the extent to which he is consumed, or how popular he is (recalling that supply is fixed). To ease the presentation that follows we do a small violence to the notation and will treat b as indicating 'the painter at distance $b-a$ from a'. This allows us to write $f(\cdot)$ as a function of b alone: $f(b)$.

Equation 2 describes the equilibrium price vector for the set of artists A.[3] The nature of the art market, however, makes the disequilibrium process extremely important. Many out of equilibrium trades take place, in part because for any painter, only a small proportion of his work is traded in any period. This is the nature of the art auction market. To capture this effect we assume that the work of every artist is traded at the rate α. That is, speaking in discrete time, each period, $\alpha \times 100$ percent of every artist's works come up for auction. The price of paintings actually traded is set by equation 2. Consider now the 'standing' price for work by a particular artist, a. Exposition is more transparent in discrete time:

$$p(a,t+1) = (1-\alpha)p(a,t) + \alpha g(a) + \int_{b\in A} f(b)p(b)db, \tag{3}$$

or,

$$p(a,t+1) - p(a,t) = -\alpha p(a,t) + \alpha(g(a) + \int_{b\in A} f(b)p(b)db. \tag{4}$$

Writing now in continuous time,

$$\frac{dp(a)}{dt} = \alpha\left(g(a) - p(a)(t)\right) + \int_{b\in A} f(b)p(b)db.$$

[3] The price on the left hand side of equation 2 is the "standing price", that is, the average prices most recently paid for the entire oeuvre of an artist. This introduces some history into the notion of popularity, which seems appropriate in this context. The market for fine art, at least for the painters that survive the test of time is indeed fad-ish to some degree, but nonetheless it has a strong sense of value and history. History is gradually eliminated (and replaced) however, as the entire work of an artist comes to auction over time, and must face competition from other artists and in other eras.

This dynamic structure has been studied in other contexts. (See for example Cowan et al. 1997). A solution is generated by doing a Laplace transform on the time variable, and a Fourier transform on the a variable. (See the appendix of Cowan et al. 1997.) Drawing on that work we can state three propositions:

Proposition 1: If the system is convergent, the steady state is described by the limit:

$$\lim_{t\to\infty} P(k,t) = \frac{\alpha G(k)}{\alpha - \mathcal{F}(k)}$$

where we use the definitions $P(k,t) = \int_{-\infty}^{\infty} e^{-ika} p(a,t)da$, $\mathcal{F}(k) = \int_{-\infty}^{\infty} e^{-ikb} f(b)db$ and $G(k) = \int_{-\infty}^{\infty} e^{-ika} g(a)da$.

This proposition states that the "natural prices", namely those that would prevail if behaviour were based solely on the inherent worth of the artist and not on any considerations of externalites, are, in equilibrium, "distorted" by any externalities that exist.

We can retrieve the dependence of p on a by the following transformation: $p(a,t) = \int_{-\infty}^{\infty} 1/(2\pi)e^{ika}P(k,t)dk$. In the absence of specified functions, the form of $p(a,t)$ is less easy to interpret than $P(k,t)$. Consider an arbitrary painter a. $P(k,t)$ measures the extent to which a painter of distance π/k from painter a affects the price (or equivalently the popularity) of painter a. Thus large values of k are associated with effects of nearby painters, small values of k are associated with effects of distant painters.

The next two propositions concern the dynamics of this market, and whether waves of popularity will be observed.

Proposition 2: If $f(b)$ is an even function ($f(-b) = f(b)$) then the dynamics are strictly diffusive. That is, the initial state decays and the final equilibrium state builds up exponentially.

Proposition 3: If $f(b)$ is an odd function ($f(-b) = -f(b)$) then the dynamic behaviour is captured by travelling waves.

These two propositions follow from basic properties of Fourier transformations. For a discussion of these results see Cowan et al. (1997).

Remark 1: Any well-defined function can be expressed uniquely as the sum of even and odd functions.[4] When $f(b)$ contains both even and odd elements non-trivially, price dynamics will be a sum of the dynamics described in propositions 2 and 3. The quantitative features will depend on the detailed forms of the even and odd parts of $f(b)$.

3. Pure Fad

There is almost certainly a strong 'fad' component to taste in art. That is, the externalities represented by the sum in the utility function (equation 1) are a major source of utility from art consumption. We can consider two extreme cases. In the first case, art per se has no inherent value to the consumer. Formally, $dU_a/dX_a = g(a) = 0$. In the second case, there is inherent value to the consumption of art, but no painter is better or worse than any other as a direct source of utility: for all a, $g(a) = c$ where c is a constant.

Proposition 4: If $g(a) = 0$ then if the system is convergent the limiting price is $p(a) = 0$ for all a.

From Proposition 1, the limiting price function is described by the limit of its transform $\lim_{t\to\infty} P(k,t) = \alpha G(k)/(\alpha - \mathcal{F}(k))$. If $g(a) = 0$ then $G(k) = 0$ by definition of the transform. Thus the inverse transform of $P(k,t)$ is also equal to 0: $\lim_{t\to\infty} p(a,t) = 0$ for all a.

Proposition 5: If $g(a) = c$ then if the system is convergent

$$\lim_{t\to\infty} p(a,t) = \frac{\alpha c}{\alpha - \int_{-\infty}^{\infty} f(b)db}.$$

If $g(a) = c$ then $G(k) = 2c\pi\delta(k)$ where $\delta(k)$ is the Dirac delta function. Substituting into the limit from Proposition 1:

$$\lim_{t\to\infty} P(k,t) = \alpha 2c\pi\delta(k)/(\alpha - \mathcal{F}(k)).$$

Since $\delta(k) = 0\ \forall k \neq 0$, this reduces to

$$\lim_{t\to\infty} P(k,t) = \frac{\alpha 2c\pi}{2\pi}\frac{1}{\alpha - \mathcal{F}(0)}.$$

[4] Formally, any function satisfying the Dirichlet conditions can be so written. The Dirichlet conditions are that the function is square integrable, single valued, piece-wise continuous and bounded above and below.

By definition, $\mathcal{F}(k) = \int_{-\infty}^{\infty} e^{-ikb} f(b)db$ so $\mathcal{F}(0) = \int_{-\infty}^{\infty} f(b)db$, and substitution yields the proposition.

Corollary: If $g(a) = c$ and $\alpha/(4c) > \int F(b)db$ then there is a positive price p^* such that $p(a) = p^* \ \forall \ a \in A$.

This can be shown be checking consistency. Substitute p^* for $p(a)$:

$$p^* = \frac{\alpha c}{\alpha - \int_{-\infty}^{\infty} F(b)p^* db}.$$

$$1/p^* = \frac{\alpha - p^* \int F(b)db}{\alpha c}.$$

Define $q = 1/p^*$. Then

$$qc - q + 1/\alpha \int F(b)db = 0,$$

which has real roots (and therefore at least one positive root), if and only if $\alpha/(4c) > \int F(b)db$.

Propositions 4 and 5 give insight into the stability of demand over long periods. The fact that prices have not gone to zero, even for painters long since dead, suggests that there is some inherent utility to be gained from consuming art. On the other hand, the fact that there is variation in the prices fetched by different painters implies one (or both) of two things: either not all painters are equal in the eyes of the median consumer, or there are strong 'fad' elements in the consumption of art works, and the market continues to exhibit out-of-equilibrium behaviour. We have not analyzed the case in which some painters are 'better' than others — analytical results are extremely difficult to generate. This is a situation we explore below, however, by simulating the model.

4. Convergence

One concern that always exists with dynamic systems is whether or not they converge. Steady state results given above were conditional on the system converging. In this section we explore the conditions for convergence.

From the solution in the appendix of Cowan et al. (1997), in terms of the conjugate variables k and z the dynamics of the system are defined by

$$\mathcal{P}(k,t) = \frac{\alpha G(a)}{\alpha - \mathcal{F}(k)} - \frac{\alpha G(a) - (\alpha - \mathcal{F}(k))\mathcal{P}(k,0)}{\alpha - \mathcal{F}(k)} e^{-(\alpha - \mathcal{F}(k))t}. \qquad (A4)$$

Thus convergence turns on the final term: $e^{-(\alpha-\mathcal{F}(k))}$. If, for some k, $\alpha-\mathcal{F}(k)<0$ then the system is divergent. Recall that $\mathcal{F}(k)$ is the transform of the externalities in consumption, defined as $\mathcal{F}(k)=\int_{-\infty}^{\infty}e^{-ikb}f(b)db$ where $f(b)$ is the sum of the conformity and avant garde effects. Convergence is determined in a critical way by the functional forms of these externalities.

Assume that the conformity effect is even and the avant garde effect is odd. We can then write the total, net externality effect as $f(b)=f_c(b)+f_a(b)$ where $f_c(-b)=f_c(b)$, and $f_a(-b)=-f_a(b)$. In passing we can note that from Remark 1 the dynamics in this case will exhibit both waves in prices and a secular trend toward the final price distribution. Fourier transforms are linear, so $\mathcal{F}(k)=\int_{-\infty}^{\infty}e^{-ikb}f_c(b)db+\int_{-\infty}^{\infty}e^{-ikb}f_a(b)db$. Because $f_c(b)$ is even and $f_a(b)$ is odd, this simplifies to $\mathcal{F}(k)=\int_{-\infty}^{\infty}2\cos(bk)f_c(b)db+\int_{-\infty}^{\infty}-2i\sin f_a(b)db$.

To illustrate, suppose that the two externality effects are each a member of families of functions: $f_c(b)=C_1f_1(b)$ and $f_a(b)=C_2f_2(b)$. In this case the transforms become $C_1\mathcal{F}_1(k)$ and $C_2\mathcal{F}_2(k)$. Substituting the functional family description of f_c and f_a we get

$$\mathcal{F}(k)=C_1\int_{-\infty}^{\infty}2\cos(bk)f_1(b)db+C_2\int_{-\infty}^{\infty}-2i\sin f_2(b)db.$$

The Dirichelet conditions (which have been assumed to hold) ensure that the integrals are finite. Thus C_1 and C_2 are scaling parameters that will, jointly with α, determine the sign of $\alpha-\mathcal{F}(k)$. The stronger are the externalities, the faster the system diverges; similarly the smaller is α, that is the smaller the proportion of works that come onto the market each period, the faster the divergence. If externalities are weak enough, or enough works come onto the market each period, then the system converges.

5. Simulation of the model

To illustrate some of the results, showing both dynamics and long run properties, we simulate the model of art prices developed above. An initial problem is the space in which painters exist. In a Lancasterian world, paintings obviously exist in a very high dimensional space—they have many types of qualities that can vary from one painter to another. To what extent the dimension of the space can be reduced without doing extreme violence is as yet unknown. Peter Swann explores this issue in his contribution to these proceedings. He finds that it is indeed possible to reduce the dimension dramatically. Exactly how far this can be done, and the nature of the space itself (linear, periodic, spherical or toroidal and so on) is something he is currently exploring I believe. Because these details, which are essentially empirical matters, are still being explored we can use this opportunity to implement the model in a variety of spaces.

We create a world of 600 painters, each at a fixed location in space. Proximity in this space indicates that painters (or more properly their outputs) are “like” each other in the eyes of their beholders. Consumers gain utility from consuming art works, and there are externalities in that consumption. Painters, and schools of painters become fashionable, that is, a consumer will gain utility from owning the works of a painter who is like other painters who are widely appreciated. This is the conformity effect, though it could be described as the effect of having concerns and ideas common with other consumers. This we model as an even function. On the other hand, there is an avant garde effect. There are some consumers who are ahead of the pack in terms of ideas and concerns, and are thus looking for “new” painters to express those concerns. In general, this effect is to seek “unfashionable” parts of the space in which painters reside. There is, though, a difference between yesterday and tomorrow, so this is modelled as an odd function. It is this effect that gives direction (rather than just change) to art prices.

5.1 One Dimension

The analytic results developed above were in the context of a one dimensional linear space. They apply directly to a (1-D) periodic space, making allowances for the fact that in this space if a wave travels forever in one direction, it is actually travelling around a circle. One caveat is that the externality functions must go to zero (in distance) at a distance less than the circumference of the circle. This seems entirely reasonable in this case. For completeness we explore both linear and periodic spaces.

5.1.1 Linear Space

Six hundred painters are arrayed along the whole line. Every period 1 percent of each painters paintings comes up for auction. Prices of those paintings are set as in equation 2. Two types of externalities exist: the conformity effect is modelled as $f_1(b) = c/|b|$. The avant garde effect is modelled as $f_2(b) = \mathrm{sgn}(b)a(1 - 1/|b|)$. The dynamic pattern can be seen in Figure 1. This figure should be read as a relief map. Darker colours indicate higher prices, and thus higher popularity. What can be observed here is a main wave of popularity. Initially the painter located at 550 on the horizontal axis is the painter of the day. His popularity fades, though, and popularity moves to painters to his left. This is driven by the avant grade effect. What is noteworthy, however, is that painters “re-appear”. There is a second and third wave. An echo if you will, in which prices rise again, to be followed by a decline. What is interesting here is that this occurs without the introduction of new painters, which is clearly one source of new waves in the actual world of art and artists. Here the simple dynamics are alone enough to produce a main wave and subsequent resurgence of formerly popular painters.

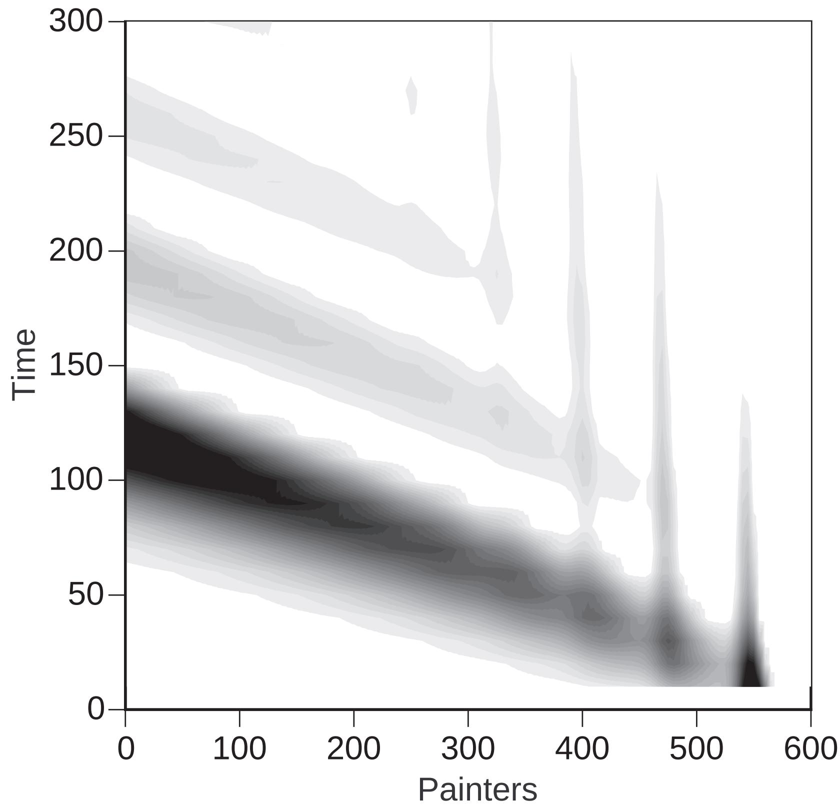

Figure 1: Prices of Painters over Time: Linear Space

5.1.2 Periodic Space

The interpretation of the dimensions of "painter-space" is unclear. Fine art has a variety of attributes, precisely which of them should appear as major axes is unclear. Further, some of these properties seem naturally modelled as extending indefinitely, while others seem naturally periodic (consider a colour wheel for example). In this section we implement the same simulation but in a periodic space. Painters are arrayed around a circle rather than on a line. This is consistent with some of the empirical results of Peter Swann. The periodicity of the space permits a painter to re-appear if there are waves in consumption. A wave travels in one direction, and eventually returns to its original position, travelling round and round. Again, cycles emerge without the introduction of new painters. Figure 2 shows a typical pattern, using the same representation as Figure 1. Darker grey indicates higher popularity (and prices). Notice that with these parameters prices are secularly increasing, as the waves shown by the diagonal patches get darker and darker as time passes.

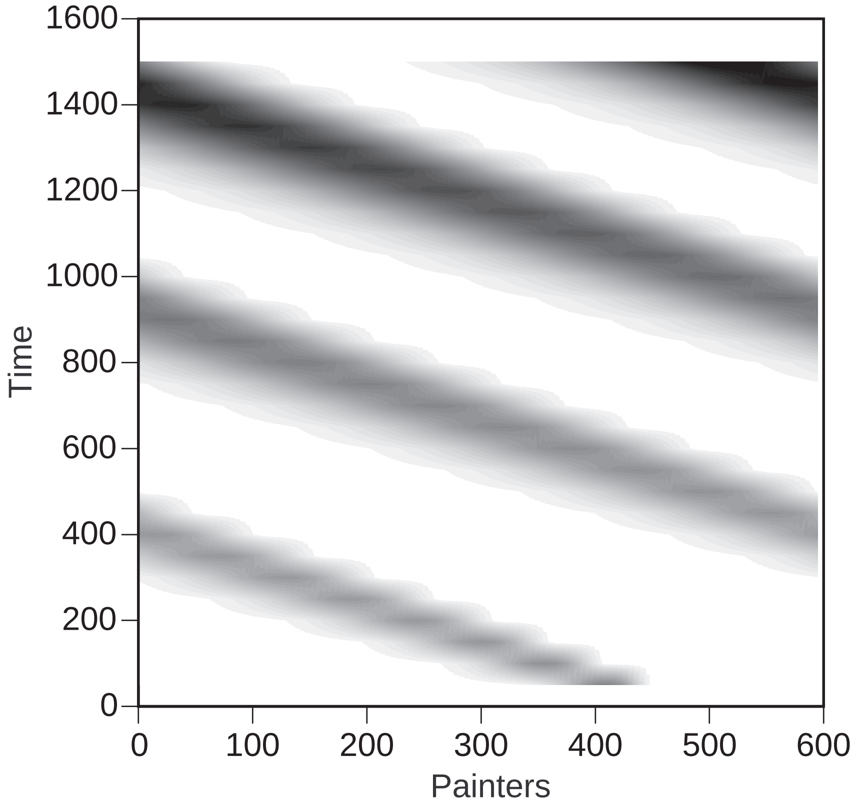

Figure 2: Prices of Painters over Time: Periodic Space

5.1.3 Inherently Good Painters

In the previous illustrations of the model, no painter was any better, inherently, than any other. Thus the dynamics were driven purely by externalities or fashion effects. It may be, though, that some painters or schools *are* inherently better than others in providing consumers with higher utility regardless of fashion. The analytic results included this aspect; here we illustrate it. Figure 3 shows the same dynamics as Figure 2 (a periodic space with secularly increasing prices) but with the painter located at position 100 having inherent value. His inherent value spreads a short distance to include those nearby above and below.[5] As can be seen in the figure, the gradual darkening of the graph as time passes indicates general increases in prices. Repeated waves occur—the diagonal stripes running north-west/south-east. We can see though, that relative to figure 2, those waves are distorted by the price of painter 100. His inherent, persistent value creates a vacuum of low prices to his right, caused by the avant garde shunning him and those like him. (Reading horizontally from left to right just to the right of 100 the graph becomes lighter "than it should be" relative to the over-riding wave pattern.) This effect gains extent in that as time passes more and more painters are affected. This can be seen by the changing shape of the wave—the

[5] Specifically there is a scaled normal distribution with variance 10, and mean 100 describing inherent value.

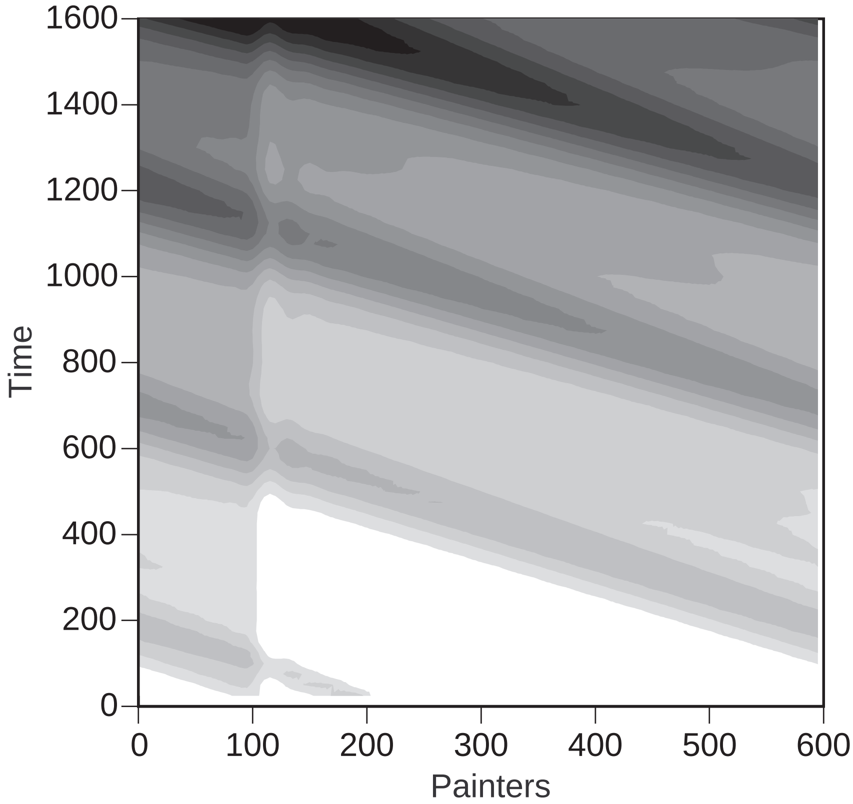

Figure 3: Prices of Painters over Time:
Periodic Space with One Inherently Valuable Painter

stripes are not of uniform width, and have odd patterns emerging between the waves. Similar effects exist in the one-dimensional linear space.

5.2 Two Dimensions

Reducing the dimension to one is a dramatic simplification of the space in which fine art must exist. Nonetheless it does lend insights into cycles in pricing. A higher dimension space adds realism, but raises an in principle problem: How does the avant garde effect operate? In a single dimension this was relatively simple, in that the temporal aspect of avant garde-ism had to be equated with a spatial aspect, and this determined the direction of motion. In higher dimensions, however, at any time the avant garde effect operates, it could be pulling the art world in more than one direction, depending on what the avant garde consumer (or artist) is attempting to express. To assume at the outset that this motion always occurs in the same direction (the avant garde effect favours painters to the right, as in the one dimensional case, for example) will simply reproduce the effects of the one dimensional model, the other dimensions not interacting very much with the motion. A more interesting, and probably more realistic, notion is that from time to time one point, currently “ignored” in the space becomes very popular. The avant garde effect would be to pull popularity from the current mode towards and beyond this newly popular artist. This implies that popularity would follow a more random path around the space, but tending to move from "old" to "new" ideas.

Ignoring the possibility that new painters enter, thereby disturbing exiting market structures and dynamics, the same dynamic patterns observed in the single dimension cases are observed in two dimensions, whether the space is a plane or a torus. There are waves of popularity as painters' prices rise, fall, and then rise again as the fashion is pulled by the avant garde away from the currently popular painters. Using the same framework it is possible to introduce entirely new fashions, by creating a small island of high prices in a part of the space that is currently out of fashion. Doing this in an ad hoc way indicates that the motion of prices is as expected. The island of high prices creates immediate conformity and distinction effects, and changes the direction in which art fashion was moving. It is difficult to perform this experiment in a systematic way, (and it is equally difficult to present the results graphically and concisely) so we leave that discussion at this point as part of the agenda for future work.

5.3 Planes and Circles

One of the fascinating results of Peter Swann's contribution to these proceedings is that even when painters are constrained to exist in a two- or three-dimensional space, neither the planar nor the spherical projection is full. In fact, in both cases the painters are (statistically) located around a circle. This suggests that the one-dimensional *periodic* space may be a good representation in which to analyse the dynamics of prices or fashion in the fine art world. Swann's analytic results show that in this representation correlations of prices are proportional to the cosine of the angle between the painters. Thus a test of the suitability of modelling a high dimensional space as a circle is whether the dynamics of the model can be parameterized in such a way that the price correlations satisfy the cosine relationship. Figure 4 is a scatter plot of price correlations versus the cosine of the angle between painters on the circle. In this implementation there are 600 painters, avant garde and conformity effects that increase with distance, but are truncated at a distance of 25.[6] As is clear in the figure, this parameterization comes very close to satisfying the cosine relationship exactly. It departs from this relationship when the cosine is near -1, that is, between painters who are located on opposite sides of the circle. There are three explanatory factors: 1) here the externality effects, which are key to determining price relationships, are weakest; 2) in general the model places no bounds on prices, but for reasons of realism prices have been bounded

[6] Because the circle is translation invariant, many pairs of painters are separated by the same angle—painters 0 and 10 are separated by the same angle as 1 and 11, and so on. The data in the figure are not averages for an angle but rather are the correlations between each pair of painters plotted against the cosine of the angle between them.

below by zero, which will interfere with the inter-painter price relationships, and will "distort" this relationship most for distant painters; and 3) under the parameters used in this implementation there is a secular increase in prices which is a source of positive correlation among prices of all painters, which pulls the correlation "up" most where the pattern created by externalities is weakest.

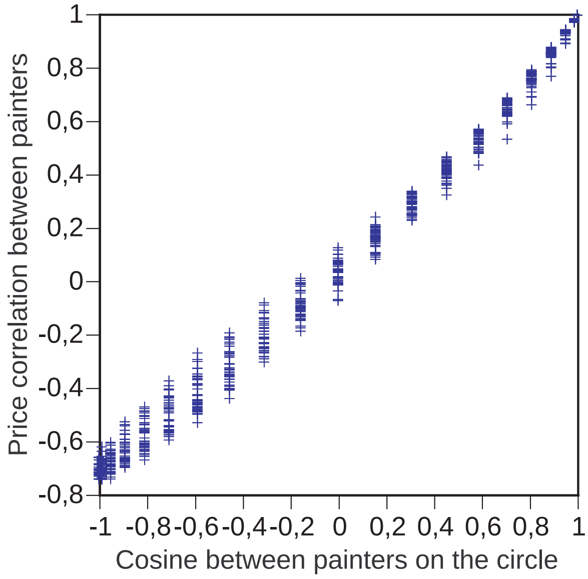

Figure 4: Correlations between Prices versus Cosine of the Angle between Painters

6. Discussion

The rise and fall of painters' popularity is striking over a period of several hundred years. This is a phenomenon that has been felt intuitively by many observers of modern culture, but is also evident from the hard economic measure, namely prices. It is a commonplace that the art world goes through fads and fashions, so a tempting explanation for the rise and fall of a painter is something like sunspots. But to explain the rise and fall of *groups* of painters implies that there are qualitative similarities between the members of any group. This suggests that something more stable is going on (unless one simply invokes sunspots that operate on groups rather than on individuals, but this begs the question why members of a group fetch different prices from each other.) An economist is tempted to point to stable preferences at least in explaining the grouping phenomenon. But stable preferences can be used for a more general explanation, provided one is willing to abandon inter-agent independence in preferences. That has been the approach here. Stable preferences in a stable world are enough to generate waves in which painters emerge, disappear and emerge again. And a very simple model has produced a rich set of dynamics which can be treated analytically and numerically to help understand the dynamics of the art market.

One of the observations made by Swann regarding the price time series is that there appear to be cycles of different period. This can in principle be reproduced in this simple model, by introducing more complex externality functions. Every function used here was monotonic. But a non monotonic function, with more than one maximum or minimum will produce strong reactions at wherever there is an optimum. If there are optima at several distances, this implies that waves of different frequencies will form.

The stablility of the world of the model, in the sense that no new painters are suddenly appearing to upset existing dynamic patterns, is both a strength and a weakness. It shows the power of externalities in creating interesting dynamics, but it departs somewhat from reality. Introducing new painters in a non ad hoc way remains a research challenge.

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