Design Innovation and Fashion Cycles

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A model of fashion cycles is developed in which designs are used as a signaling device in a "dating game." A monopolist periodically creates a new design. Over time the price of the design falls as it spreads across the population. Once sufficiently many consumers own the design it is profitable to create a new design and thereby render the old design obsolete. The paper gives conditions under which all consumers would be better off by banning the use of fashion. Competition among designers may lead to less frequent changes in fashion and to higher prices than monopoly. (*JEL* D40, L10)

Appearance is an important component of most durable consumption goods. Large amounts of resources are devoted to the development of designs for clothing, cars, furniture, and electronic equipment. These resources are not primarily used to make those goods more functional; rather their goal is to let the product appear *fashionable*. By "fashion," one generally means the opaque process that identifies certain designs, products, or social behaviors as "in" for a limited period and which replaces them with infallible regularity by new designs, new products, and new forms of social behavior.

If the consumption of a fashionable item is removed from its specific social context, then changes in fashion do not entail any improvement in product quality. In his essay on fashion Georg Simmel (1957 p. 544) writes:

> Fashion is merely a product of social demands.... This is clearly proved by the fact that very frequently not the slightest reason can be found for the creations of fashion from the standpoint of an objective, aesthetic or other expediency. While in general our wearing apparel is really adapted to our needs, there is not a trace of expediency in the method by which fashion dictates. ... Judging from the ugly and repugnant things that are sometimes in vogue, it would seem as though fashion were desirous of exhibiting its power by getting us to adopt the most atrocious things for its sake alone.

Simmel goes on to argue that the lack of practical use is part of the definition of fashion. Thus fashion and fashion cycles can only be understood if consumption is considered as a social activity:

> [Fashion] satisfies the need of differentiation because fashions differ for different classes—the fashions of the upper stratum of society are never identical with those of the lower; in fact, they are abandoned by the former as soon as the latter prepares to appropriate them.
>
> (Simmel, 1957 p. 543)

Examples of fashion cycles can be found throughout history. Fernand Braudel (1981) notes that fashion resulted to a large extent from the desire of the privileged to distinguish themselves, whatever the cost, from the masses that followed them. Braudel quotes a Sicilian who passed through Paris in 1714: "nothing makes noble persons despise the gilded costume so much as to see

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it on the bodies of the lowest men in the world.... So the upper class had to invent new 'gilded costumes,' or new distinctive signs, whatever they might be, every time complaining that 'things have changed indeed, and the new clothes being worn by the bourgeois, both men and women, cannot be distinguished from those of persons of quality'" (M. de Paulmy, 1774 p. 220).[1] As a consequence, "observers reported, 'tailors have more trouble inventing than sewing'" (Braudel, 1981 p. 324).

The purpose of fashion is to facilitate differentiation of "types" in the process of social interaction. The demand for new designs is derived from the desire of agents to interact with the "right" people. At the same time, fashion is accompanied by a process of continuous innovation, in which new designs are developed at sometimes large cost only to be replaced by other designs. With the arrival of every new design, previous fashions become obsolete.

I propose a simple model that captures the described features of fashion. I consider a monopolist (the designer) who can create new designs for a product such as a dress. There is a fixed cost of redesigning the product. Buyers like dresses not for their own sake, but because dresses allow them to signal their own quality. Customers want to signal their own quality to other customers because they are involved in a matching game in which each person would like to match up with a high-quality person rather than a low-quality person (e.g., a dating game).

More precisely, I assume that there is a population of buyers each of whom can be one of two types, say, "high" or "low." There is a positive complementarity associated with date quality, so that a high type's loss from meeting a low type rather than a high type is greater than the corresponding loss for a low type. When a consumer wears the new dress, other consumers will observe this and draw inferences about her type. Thus, if the price of the dress is high enough, it will allow the high types to separate at least partially from the low types. Those who wear the new dress in equilibrium are members of the "in" group, which contains a relatively high fraction of high types. Those who do not wear the dress have a lower proportion of high types. An "in" person will insist on dating another "in" person. The dress therefore acts as a screening device of potential partners.

The product sold is a *durable good* of which the consumer can use exactly one unit at a time.[2] The production cost is zero, so the producer's only cost is designing the product. As with standard durable-goods monopolists, the designer lowers the price of the dress over time since he cannot commit to maintaining a high price. The dress is therefore sold to more and more low types, and consequently the compositions of the "in" and the "out" groups change over time. Eventually the "in" groups will be so large that it becomes worthwhile for the designer to create a new dress, which can be sold at the high price again. By innovating, the designer introduces a new signaling device and hence destroys the value of the previous design.

The model predicts deterministic fashion cycles of fixed length. For large fixed costs, fashion cycles are long. To recover the fixed cost, the designer has to sell the fashion at a high price, which in turn requires that the design stays fashionable for a long period of time, and hence sufficient time must pass between innovations. If the fixed costs are small then the cycle is short. In the limit, for zero fixed costs, the designer will create a new fashion every period.

There are two possible cases: the "egalitarian" case, in which fashion spreads over the whole population before a new innovation occurs, and the "elitist" case, in which the latest design is sold only to the high types. In the latter case, once all the high types have acquired a design, the designer

[1] As quoted in Braudel (1981 p. 324).

[2] While most clothing products are not perfectly durable, fashionable clothes are usually replaced long before they are worn out.

sells it at a zero price to the low types and at the same time introduces a new design. An elitist fashion cycle will be the equilibrium outcome if the benefit of meeting other high types is much larger for high types than for low types and if the period length (i.e., the time between possible price changes) is not too small. The first parameter can be interpreted as a measure of the inequality (e.g., in the human-capital endowment) between high and low types.

If periods are very short, fashion spreads very quickly so that in most periods the "in" group contains a large portion of the low types. In addition, short periods imply that the designer's profit is close to zero. Since the designer benefits from long periods, short periods reflect his inability to commit to a fixed time interval between price changes. However, even if such a commitment is not possible, long periods may arise if the designer has acquired a reputation for infrequent price changes.

I extend the analysis also to the case in which there is competition between designers. First, it is observed that even if potential competitors are free to enter the design market, *one* possible outcome is that one designer is chosen to be a fashion czar and behaves like a monopolist. If all consumers believe that only the fashion czar is capable of creating "fashion," then this will be the equilibrium outcome. Fashion czars are observed in the form of trademarks. As was pointed out by Gary Becker and Kevin M. Murphy (1993), a trademark is one method of "artificially" creating a monopoly over the production of a good.

Second, I show how competition may keep prices above marginal cost and may reduce the frequency at which innovations are introduced. This is possible since, in addition to the usual price competition, designers compete along an unusual dimension: the designer whose clients are more likely to be high types will be more attractive to future buyers. This effect puts pressure on designers to maintain high prices and may cause equilibrium prices to be higher than in the monopoly case.

I do not allow imitation of successful designs. Imitation would give designers an additional incentive to create new fashions periodically. Clearly imitation is an important force behind the creation of new designs. However, through the creation of brand names, designers can at least partially insulate themselves from competition with potential imitators. In this paper, I consider the case in which the designer has well-defined property rights over his innovations. It turns out that even in this case fashion cycles will occur.

I. Background

A. *Relation to the Literature*

In his analysis of static demand curves, Harvey Leibenstein (1950) distinguishes the "bandwagon" and the "snob" effect. The bandwagon effect describes the idea that demand for a commodity may increase if others are consuming it, while the snob effect refers to the extent to which demand for a commodity is decreased because others are consuming it. Similar consumption externalities have been studied by Thomas C. Schelling (1978), Stephen R. G. Jones (1984), Robert H. Frank (1985), and Becker (1991).

The demand for design commodities in the present model will display *both* the snob and the bandwagon effects, even though there is no direct consumption externality. If more high types purchase the design, it will be more valuable to all consumers, while if more low types purchase the design, it will be less valuable to all consumers. Since high types purchase the design commodity first, there is a bandwagon effect if few consumers buy the design, while there is a snob effect if many consumers buy the design.

Becker (1991) and Becker and Murphy (1993) derive bandwagon and snob effects by assuming that consumers care about who else consumes a particular good. Laurie Bagwell Simon and B. Douglas Bernheim (1993) consider a model in which consumers signal their wealth by purchasing conspicuous commodities. In Bagwell and Bernheim's model consumers can signal both with the quantity and with the type of good they consume. If the single-crossing property is satisfied, then consumers signal their wealth by consuming large amounts, rather than by choosing expensive brands. In contrast to Bagwell and Bernheim, I assume that only one unit of a conspicuous good can be consumed at a time. This assumption is satisfied for many conspicuous-consumption goods, like clothing or cars. My approach shares with Becker and Murphy (1993) and with Bagwell and Bernheim (1993) that a fashion is introduced by a price-setting producer. However, these authors consider a static model and therefore do not analyze fashion cycles.

Abhijit V. Banerjee (1992, 1993) and Sushil Bikhchandani et al. (1992) show how in a model of sequential choice rational consumers can be led to imitate the choice of consumers who move first. In Bikhchandani et al. it is a particular "fashion leader" who dictates a new fashion or social norm, and changes in fashion are explained by exogenous shocks.

Edi Karni and David Schmeidler (1990) consider a dynamic game played by two classes of individuals: the lower and the upper classes. Individuals choose among three different colors. Members of the upper class want to distinguish themselves from members of the lower class, while members of the lower class want to imitate the upper class. Karni and Schmeidler show that it is possible to get a cyclical variation of the colors adopted by individuals. Kiminori Matsuyama (1992) examines the dynamics of a random matching game between conformists and nonconformists. The author shows that there are equilibria with cyclical demand variations which can be interpreted as fashion cycles. In a related paper, John Conlisk (1980) considers the interaction between optimizers and imitators in a changing environment.

A central question that did not receive attention in the literature is why producers spend large amounts of resources on periodic changes in their design. The current paper addresses this question. Further, instead of assuming a consumption externality, I demonstrate how this externality can arise endogenously.[3] Finally, since I consider a dynamic model of price-setting firms, the model predicts price cycles for fashion commodities, which can be compared to actual price movements of fashion commodities.

The present paper is also related to the literature on durable-goods monopolies (see e.g., Ronald Coase, 1972; Faruk Gul et al., 1986). The price cycles predicted by the model are similar to the price cycles analyzed in Conlisk et al. (1984) and Joel Sobel (1984, 1991). The reason for a sale in their model is the periodic desire of the monopolist to sell to the large mass of low-valuing buyers that have accumulated on the market. In the present model, sales occur because design commodities go out of fashion, and buyers anticipate this.

B. *Examples*

Most major fashion houses fit into the described pattern of design innovation and price cycles. The fashion house Armani has three different "lines" of fashion products: Armani Via Borgo Nuovo, Armani, and Emporio Armani.[4] The three lines differ in prices and in designs, but not in the type of clothing they offer. New designs are introduced first in the top line (Armani Via Borgo Nuovo) at a very high price and later are passed on to the lower-priced lines. Currently, for example, the new jacket design will only be offered by Armani Via Borgo Nuovo, while Emporio Armani still offers the jackets that were fashionable in previous years. Armani is therefore an illustration of fashion cycles very similar to the ones predicted by the model. Similar patterns can be found for many other fashion houses.

An alternative interpretation of the described innovations is that they are improvements in product quality, for which there is

[3] See also Bagwell and Bernheim (1993) for a similar approach of endogenizing the consumption externality.

[4] This line is called Mani in the United States.

little value from the point of view of consumption. For example, one might think of some technical innovations in consumer electronics or cars as "useless" technical innovations. Nevertheless, if a class of goods is used as a signaling device in the process of social interaction, these seemingly "useless" innovations may be very valuable to consumers. Thus the current model predicts "overinvestment" in product quality, in the sense that the cost of the quality improvements may exceed the gain in "consumption value" if consumption is removed from its social context.

II. The Model

Consider a society of many consumers, each of whom is either a high type (type h) or a low type (type ℓ). Let $q \in [0,1]$ denote a generic consumer. If $q \leq \alpha$ then q is a high type, and if $q > \alpha$ then q is a low type. Depending on the interpretation, the type of an individual may refer to her education, entertainment skills, or human capital.

The purpose of a consumer in this model is to "date" another consumer. There is a matching mechanism, to be specified below, that matches consumers into pairs.[5]

The utility of a match to a consumer depends on the type of the partner she is assigned to and on her own type; $u(i,j)$ denotes the utility of a type-i consumer matched with a type-j consumer. Both types prefer to be matched with high types; that is, $u(i,\mathrm{h}) > u(i,\ell)$ for $i = \mathrm{h}, \ell$. Moreover, high types value a match with high types more than do low types. This idea is expressed in the following assumption of complementarity:

$$(1) \qquad u(\mathrm{h},\mathrm{h}) - u(\mathrm{h},\ell) > u(\ell,\mathrm{h}) - u(\ell,\ell).$$

Let $v^{\mathrm{h}} \equiv u(\mathrm{h},\mathrm{h}) - u(\mathrm{h},\ell)$ and $v^{\ell} \equiv u(\ell,\mathrm{h}) - u(\ell,\ell)$. Hence (1) is equivalent to $v^{\mathrm{h}} > v^{\ell}$.[6] Consumers are endowed with money that they can spend on a "design commodity." I assume quasi-linear utility functions; that is, if consumer type i is matched with a consumer type j and spends m units of money on a design, then her total utility is $u(i,j) - m$. Designs do not directly enter the utility function. This assumption captures the idea that design innovations do not provide any direct improvement in the quality of the product.

There is one type of firm, a designer, who can create designs $n \in \{1,2,\ldots\}$. To create a new design, a fixed cost of $c > 0$ must be paid. Once design n has been created, the designer can produce indivisible units of it at zero marginal cost. Consumers can purchase arbitrarily many units of a design but can only use one unit of it. The idea is that the design is attached to a commodity like a dress or a car of which at most one unit can be used at a time. All consumers observe which design an individual is using, and therefore designs can be used as a signaling device in the matching process.

A. *Matching*

Consumers who use the same design will be randomly matched into pairs. If a consumer is the only person to use a particular design, she is matched with a consumer who uses no design. In addition, I assume that there is always a small (measure-zero) group of low types who use no design.[7] A consumer who does not use any design will be described as using design $n = 0$. Let $\mu_i(n)$,

[5] Alternatively, one could assume that consumers are matched into groups of size N, $N \geq 2$. Groups of size 2 simplify the analysis, but the same results could be obtained for arbitrary N.

[6] An example of these preferences is a situation in which the type refers to a human-capital endowment. After a match is made, consumers engage in some form of production that involves complementarities. That is, let x_{h} and x_{ℓ} denote the high and low types' human-capital endowment and let $f(x^i, x^j)$ denote the payoff to i when she is matched with j. The assumption is that the two inputs are complements.

[7] Without this assumption, a consumer might stay without a match. This would complicate the notation but would not substantially change the results.

$i = \ell, \mathrm{h}$ denote the fraction of consumers of type i using design n. I make the following assumptions on the matching technology:

(i) If $\mu_\ell(n) + \mu_\mathrm{h}(n) > 0$, for $n = 0, 1, \ldots$, then the probability of meeting a high type for a consumer who uses n is given by $\mu_\mathrm{h}(n)/[\mu_\mathrm{h}(n) + \mu_\ell(n)]$.
(ii) If $\mu_\ell(0) + \mu_\mathrm{h}(0) = 0$, then a consumer who uses no design ($n = 0$) will meet a low type with probability 1.
(iii) If $\mu_\ell(n) + \mu_\mathrm{h}(n) = 0$, then the probability of meeting a high type for a consumer who uses design n is equal to her probability of meeting a high type when she uses no design ($n = 0$).

This specification of the matching technology ensures that, no matter which design a consumer uses, she will not stay without a match. The analysis below remains valid even if (ii) and (iii) are replaced by alternative conditions. The conditions chosen simplify the notation.

B. *The Demand for Fashion*

Suppose a new design n is offered and all consumers have the same endowment of old designs. Suppose further that individuals only care about their current utility (i.e., they do not take into account future uses of the design). What is the demand for the new design?

Complementarity implies that if q is willing to purchase the design then all consumers $q' < q$ are willing to purchase the design. If all consumers in $[0, q)$ use the design, then the maximum q is willing to pay is given by q's utility gain from meeting a high type times the increase in the probability of meeting a high type by using the new design. (Note that since all consumers have the same endowments of old designs, every old design used in equilibrium will lead to the same payoff.) Hence one can define the inverse demand for the new design at q as the maximum price that consumer q is willing to pay for the design if all consumers $q' \in [0, q]$ are using the design.

First suppose that $0 \le q \le \alpha$. Thus q is a high type, and if she purchases the design she is matched with a high type with probability 1. If she does not purchase the design then she finds herself in a pool of consumers with a $(\alpha - q)/(1 - q)$ fraction of high types. Hence the maximum consumer q is willing to pay for the design is

$$(2) \qquad v^\mathrm{h}\left(1 - \frac{\alpha - q}{1 - q}\right) = v^\mathrm{h}\left(\frac{1 - \alpha}{1 - q}\right).$$

Suppose that $\alpha < q \le 1$. Then consumer q is a low type, and purchasing the design gives her an α / q chance of meeting a high type. She will be matched with a low type with probability 1 if she does not purchase the design. Therefore the maximum consumer q is willing to pay is

$$(3) \qquad v^\ell \frac{\alpha}{q}.$$

The two cases are summarized by the function f (see Fig. 1):

$$(4) \quad f(q) = \begin{cases} \dfrac{1 - \alpha}{1 - q} v^\mathrm{h} & \text{if } 0 \le q \le \alpha \\ \dfrac{\alpha}{q} v^\ell & \text{if } 1 \ge q > \alpha. \end{cases}$$

The function $f(q)$ can be interpreted as the one-period inverse demand function for a new design.[8] That is, $f(q)$ gives the maxi-

[8]A similar demand function for fashion can be obtained by directly assuming that each person's utility depends on what the other people believe is the person's type. For example, let $u(i, p)$ be the utility of type i if she is believed to be a high type with probability p. The matching interpretation implies that $u(i, p)$ is linear in p, which simplifies the analysis. The pure signaling approach, however, ignores the screening role of fashion, which is highlighted in the matching game. If one adopts a standard refinement for signaling games (e.g., the "intuitive criterion" [see In-Koo Cho and David Kreps, 1987]), then if the price of the design is high enough the buyer will be identified as a high type in the pure signaling case and hence may benefit from her purchase, irrespective of whether other consumers buy the design. In the matching case, even if the person is identified as a high type, if no other consumers buy any design, she is unable to screen prospective partners and hence is at best matched with a random mate from the whole population. Thus, in the matching case the design must overcome a more severe coordination problem to be successful. This may explain why not every expensive and useless item is fashionable.

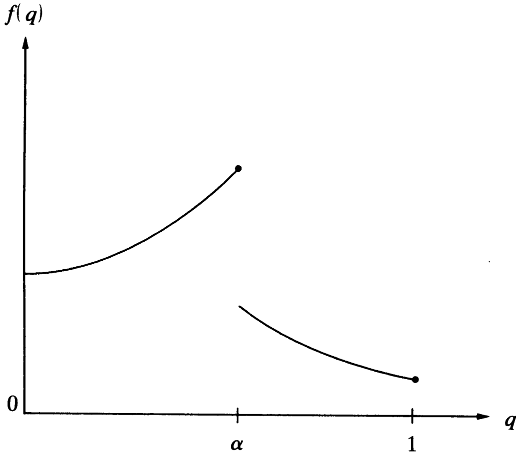

FIGURE 1. THE FUNCTION $f(q)$

mum amount consumer q is willing to pay for the benefits of the design in the current period, given that consumers $[0,q]$ are purchasing the design and consumers $(q,1]$ are not purchasing the design.

Note that for $q \leq \alpha$, the demand function has a positive slope. This is the case since the more high-type consumers purchase a new design, the smaller is the chance of meeting a high type without the new fashion. By purchasing the fashion, high types impose a negative externality on consumers who do not buy the new fashion, and this externality is responsible for the positive slope in the first part of the demand function. This effect can be interpreted as a "bandwagon effect" (Leibenstein, 1950).

At $q = \alpha$ the inverse demand function reaches a maximum. At this point all high types purchase and use the fashion, whereas low types do not. Thus the consequence of not purchasing the design is to be matched with a low type with probability 1.

For $q > \alpha$, the demand function has the usual negative slope since the more low types purchase the fashion, the less advantageous it is to wear the new fashion. In this case every additional purchase imposes a negative externality on the group of consumers who buy the new fashion, since the probability of meeting a high type conditional on using the design decreases. Hence in this range of the demand function there is a "snob effect" (Leibenstein, 1950).[9] Even if all consumers purchase the fashion, the utility from using the fashion is strictly positive; that is, $f(1) > 0$.

III. Fashion Cycles

To develop a model of fashion cycles I embed the static analysis of the previous section in a dynamic game. For this section I assume that there is one designer who can create at most one design in any period. Since consumers have no direct preferences for any specific design, one can assume without loss of generality that designs are created "in order"; that is, design n is created only if design $n-1$ has previously been innovated.

Every period is structured in the following way:

(i) First the designer decides whether to innovate and at what prices to offer his designs.
(ii) Then, each consumers decides which designs to buy and which (of the designs she already owns) to sell.[10] The designer meets the market excess demand in every period.
(iii) Finally, consumers decide which design to use, and pairs are formed according to the matching technology described

[9] In the simple two-type case analyzed here, the bandwagon and the snob effects are conveniently separated: for $q < \alpha$ there is no snob effect, whereas for $q > \alpha$ there is no bandwagon effect. In the general case with a continuum of different types, both effects are present simultaneously, since an increase of the "in" group will always imply a decrease in the average quality of both the "in" and the "out" group. Suppose the utility of consumer q from meeting q' is given by the function $u(q,q')$. The inverse demand function, $f(q)$, can be constructed also for this general case. The slope of f in the general case depends on the functions $u(q,\cdot)$. If $u(q,\cdot)$ is *convex* for all q, then $f(q)$ will be decreasing. If $u(q,\cdot)$ is "sufficiently" *concave*, then $f(q)$ will be increasing. If, for example, $u(q,q') = (1-q)^a(1-q')^a$, then $f(q)$ is increasing for small q if $a < 1/3$.

[10] All results are unchanged if consumers are not allowed to sell their designs.

above. At the end of every period, the pairs separate.

Implicit in the definition of the game is that histories of individuals are unobservable, and hence the matching technology cannot condition on past designs used by a consumer.

Let n_t be the number of designs that have been created up to period t; that is, in period t designs $n \leq n_t$ have been innovated, and the designs $n > n_t$ have not. The price of design n in period t is denoted by p_t^n; y_t^n is a consumer's purchase (or sale) of design n in period t and x_t^n is a consumer's endowment of design n at the end of period t. Thus $x_t^n = x_{t-1}^n + y_t^n$. I also define $\mathbf{x}_t = (x_t^1, x_t^2, \dots)$ as a consumer's endowments, $\mathbf{y}_t = (y_t^1, y_t^2, \dots)$ as a consumer's purchases, and $\mathbf{p}_t = (p_t^1, p_t^2, \dots)$ as the vector of prices in period t.[11] Every period, each consumer will choose the design that gives her the highest chance of meeting a high type. Let $\nu_t(\mathbf{x}_t)$ denote the probability of meeting a high type when the consumer owns $\mathbf{x}_t$ and she chooses the optimal design. Clearly, ν_t is not exogenous, but the result of equilibrium strategies.

The payoff of a consumer of type $i = \ell, \mathrm{h}$ in period t is then

$$(5) \quad v^i(\mathbf{x}_t, \mathbf{y}_t, \mathbf{p}_t, \nu_t) = (1-\delta)\{\nu_t(\mathbf{x}_t)u(i,\mathrm{h}) + [1-\nu_t(\mathbf{x}_t)]u(i,\ell)\} - \mathbf{p}_t \cdot \mathbf{y}_t.$$

The discount factor is denoted by δ, $0 < \delta < 1$. The utility of each match is normalized by $1-\delta$ which measures the length of one period. The overall payoff of the consumer is then given by the discounted sum of the period payoffs:

$$(6) \quad \sum_{t=1}^{\infty} \delta^{t-1} v^i(\mathbf{x}_t, \mathbf{y}_t, \mathbf{p}_t, \nu_t).$$

The payoff of the designer is the discounted sum of revenues from his designs minus the incurred fixed cost. If λ_t^n denotes the (excess) demand for design n in period t and $\boldsymbol{\lambda}_t = (\lambda_t^1, \lambda_t^2, \dots)$, then the payoff of the designer is

$$(7) \quad \sum_{t=1}^{\infty} \delta^{t-1}[\mathbf{p}_t \boldsymbol{\lambda}_t - c(n_t - n_{t-1})].$$

If a consumer is the only person to purchase a design, then she will be matched with a random consumer from the pool of individuals who use no design. The design does not improve the quality of the consumer's match in this case and therefore has no value. Thus a design is only valuable to consumers if a coordination problem is solved. I assume that the designer can coordinate demand for his latest design. Part of the innovation cost c should be interpreted as expenses for marketing and advertising to achieve the coordination of consumers to the largest demand. I also assume that whenever the designer creates a new design he cannot simultaneously advertise old designs, and hence the coordination of the demand for the old designs breaks down. Consequently, I restrict attention to equilibria in which designs other than the latest innovation are sold at a zero price.

The assumption that old designs are sold at a zero price greatly simplifies the analysis but clearly is not essential for the intuition of planned obsolescence in the model. If the designer could coordinate demand for old designs, then innovation might not lead to full obsolescence of old designs. The qualitative conclusion, however, would remain unchanged: since the new design is always sold to high types, innovation decreases the value of old designs.[12]

[11] Even though in period t at most t designs have been innovated, I define p_t^n for all n and set $p_t^n = \infty$ for $n > n_t$.

[12] If the new design is sold to both high and low types, then the old design must have a zero price. This follows from the fact that in this case no high type is using the old design (by complementarity).

I consider subgame-perfect equilibria that satisfy the following conditions:

(i) For consumers who do not already own the current design, n_t, the decision of whether or not to buy n_t is only a function of the current price of n_t.[13] Consumer demand for design n_t can therefore be characterized by an acceptance function $P(\cdot)$ such that consumer q will purchase exactly one unit if and only if $p \geq P(q)$.

(ii) For any design $n < n_t$ the equilibrium price is zero. For design n_t the realized demand in any period will be the maximal demand consistent with optimal behavior of consumers.

I will call equilibria that satisfy these two properties *weak Markov coordination* (*WMC*) *equilibria*.[14]

If the designer is committed to exactly one innovation, then the game can be interpreted as a standard durable-goods monopoly with the demand function $f(q)$ and common discount factor δ. Let $M(\delta)$ denote the present value of the revenues of the monopolist at the beginning of the game in the one-innovation model.[15]

THEOREM 1: *Under the maintained assumptions, there exists a WMC equilibrium. Moreover, in every WMC equilibrium, the designer innovates an infinite number of times if* $c < M(\delta)$.

(See the Appendix for the proof.)

The theorem says that there exists a subgame-perfect equilibrium of the dynamic game that satisfies the stationarity and coordination assumptions described above. Moreover, if costs of innovation are smaller than $M(\delta)$, then WMC equilibria capture a crucial feature of fashion cycles: design innovation never stops.

A. *Properties of Fashion Cycles*

In a WMC equilibrium the maximal demand will be realized for every price of the latest design. Therefore $P(\cdot)$ is a decreasing function.[16] By $R(q)$ I denote the net present value of profits of the monopolist when the consumers $q' \leq q$ have purchased the current design n_t. Consumer demand is stationary, and all previously innovated designs have an equilibrium price of zero. Therefore payoffs in the subgame following any innovation are identical to the payoffs after the first innovation, and q summarizes the payoff-relevant history.[17] Let π denote the probability of innovation. The designer will innovate ($\pi = 1$) whenever the payoff at the beginning of the game $[R(0) - c]$ exceeds the payoff from selling the design for one more period. When the designer innovates, he makes the old design obsolete by selling it at a zero price. If the designer does not innovate ($\pi = 0$) then he continues to sell the previously created design and chooses an optimal volume of sales $(y - q)$ for the current period. $R(q)$ therefore satisfies equation (8), on the following page.

If $P(q)$ is strictly decreasing, then q is the marginal consumer at $p = P(q)$. In this case $P(q)$ is equal to q's utility from using the design in the current period, $(1 - \delta)f(q)$, plus the design's discounted expected resale

[13] This assumption corresponds to the familiar notion of weak Markov equilibrium in the literature on bargaining with asymmetric information and the durable-goods monopoly (see Gul et al., 1986).

[14] For a formal definition of WMC equilibria see the Appendix.

[15] Since I restrict the analysis to WMC equilibria, one can apply theorem 1 in Gul et al. (1986) to establish existence and uniqueness of $M(\delta)$, even though $f(\cdot)$ is not monotone.

[16] The assumption of complementarity implies that high types have a strict incentive to purchase the design if a low-type consumer purchases the design. In addition, without loss of generality, one can rearrange consumers of each type so that $P(\cdot)$ is decreasing. I also assume that deviations by sets of consumers of measure zero do not affect the equilibrium, and hence one can assume (without loss of generality) that $P(\cdot)$ is a left-continuous, decreasing function.

[17] All designs $n < n_t$ have a price of zero, and therefore in equilibrium consumers are indifferent between any design $n < n_t$ used by a positive fraction of consumers. Thus, for characterizing payoffs, one can assume without loss of generality that all consumers who do not own n_t use design $n_t - 1$.

$$(8) \qquad R(q) = \max_{y \in [q,1];\ \pi \in [0,1]} \left\{ (1-\pi)[P(y)(y-q) + \delta R(y)] + \pi[R(0) - c] \right\}$$

value. If $P(q)$ is constant at q, then at the price $P(q)$ some additional consumers $q' > q$ will purchase, and therefore the current utility of owning the design may be larger than $(1-\delta)f(q)$. It is necessary to allow for this possibility since $f(q)$ is upward-sloping for $q \le \alpha$. More formally, let $t(q)$ and $\pi(q)$ be the solution to the optimization problem in (8). Consider a point q where $t(q)$ and $\pi(q)$ are single-valued.[18] For $q' = t(q)$, the following has to hold:

$$(9) \quad P(q) \ge (1-\delta)f(q) + \delta[1-\pi(q)]P(q')$$

$$P(q) = (1-\delta)f(q) + \delta[1-\pi(q)]P(q') \quad \text{if } P(q) \text{ is strictly decreasing at } q.$$

When $\pi(q), t(q)$ is multiple-valued the monopolist should play a possibly mixed strategy such that if p_{-1} was the price charged in the previous period then the expected price $\bar{p}$ and the innovation probability π satisfy

$$(10) \quad p_{-1} \ge (1-\delta)f(q) + \delta(1-\pi)\bar{p}$$

$$p_{-1} \le (1-\delta)f(q') + \delta(1-\pi)\bar{p} \qquad q' > q.$$

Such a mixed strategy justifies the decisions of q to purchase in the previous period and of all $q' > q$ not to purchase.

In equilibrium there is a sequence of prices $(p_1, \ldots, p_T)$ and demands $(q_1, \ldots, q_T)$ for every design. In the first period after innovation the monopolist charges the price p_1 and sells to the first q_1 consumers; in the second period after innovation the design is sold at a price p_2 to consumers in $(q_1, q_2]$; and so on. After the design has been sold for T periods, a new innovation occurs. The consumers who own the latest design form the "in-group." A fashion cycle is "elitist," if the low types are never part of the in-group. If low types are part of the in-group in some periods, the fashion cycle is "egalitarian."

PROPOSITION 1: *Suppose* $c < M(\delta)$. *Consider any new design along a WMC equilibrium path.*

(i) Over time the price of the design is strictly decreasing, and the size of the in-group is strictly increasing until the next innovation occurs. In the period prior to an innovation either all high types and no low types own the design (the elitist case), or all consumers own the design (the egalitarian case).

(ii) A lower bound for the number of periods between consecutive innovations is given by $\log(1 - c/\alpha f(\alpha))/\log(\delta)$. *If, for a fixed discount factor, the cost of innovation is sufficiently small, then a new design will be created every period.*

(iii) If, for a fixed discount factor and a fixed $\alpha > 0$, $v^{h} - v^{\ell}$ *is sufficiently large, then the fashion cycle will be elitist.*

(iv) The designer will never randomize between innovating and not innovating along the equilibrium path. Furthermore, except possibly in the initial period after innovation, there will be no randomization between prices along the equilibrium path.

(See the Appendix for the proof.)

Item (i) of Proposition 1 implies that, whenever the fashion cycle is longer than two periods, high types will sometimes be matched with low types. Therefore inefficient matches will be made in equilibrium.

The second part of the proposition is concerned with the length of fashion cycles. If innovation costs are large, the price of the design must be high to make an innovation worthwhile, and hence the design must stay fashionable for many periods. With small innovation costs the temptation of in-

[18] Since $t(\cdot)$ is monotone, it is single-valued except possibly at a countable set of q. Similarly, $\pi(\cdot)$ will be unique except for possibly one point q at which the designer may be indifferent between innovating and not innovating.

novation is too large to sustain sales over more than one period.[19] In this case the model is equivalent to the repeated selling of a perishable good, and the equilibrium outcome is simply the one-shot monopoly outcome: the good is sold to all the high types at a price of $f(\alpha)(1-\delta)$.

The third item of Proposition 1 suggests that if, for example, human capital is very unevenly distributed (and hence the difference between v^{h} and v^{ℓ} is large), then one should expect the fashions of the upper stratum of society to be different from those of the lower classes. On the other hand, in a society with a relatively even distribution of human capital, fashion cycles can be egalitarian (see Example 2 below).

B. *Two Examples of Fashion Cycles*

In this section I present two simple numerical examples of fashion cycles.

Example 1 (an elitist fashion cycle): In this example, the designer innovates every third period. The parameters for this example are: $\delta=0.9$; $c=5.71$; $\alpha=1/2$; $v^{h}=60$, $v^{\ell}=10$. A new design is created in periods $3t+1$, $t=0,1,\dots$. The price sequence is as follows:

$$p_{3t+1}=14.58,\ p_{3t+2}=10.54,\ p_{3t+3}=6.$$

The diffusion of the design is given by the following sequence:

$$q_{3t+1}=0.298,\ q_{3t+2}=0.4135,\ q_{3t+3}=0.5.$$

The design is sold to $\frac{3}{5}$ of the high types in the initial period after innovation and then spreads over the next two periods until after three periods all of the high types have purchased the design. Then the designer innovates and at the same time makes the old design freely available to all consumers, and the fashion cycle starts again with a new innovation.

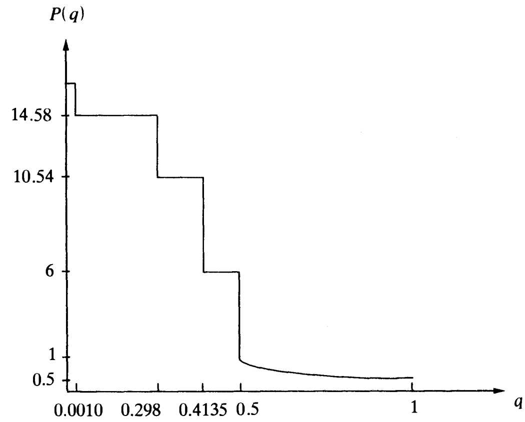

FIGURE 2. THE FUNCTION $P(q)$ FOR EXAMPLE 1

Figure 2 indicates the function $P(q)$ for this example. In the first and second period after innovation the design does not spread among all the high types. This is surprising since for $q\in[0,1/2]$, $(1-\delta)f(q)$ is increasing in q. Hence by selling to more high types the designer could increase the value of the fashion in the current period. The reason he decides not to do so is that there is an opposing effect: an increase in sales today implies that the designer will innovate sooner, and hence the design stays fashionable for fewer periods. Thus, larger sales today reduce the future value of the design.

In this example the low types never purchase the currently fashionable design. It is only when a design has gone "out of fashion" that the low types will purchase the design (at a zero price).

Example 2 (an egalitarian fashion cycle): In this example, the fashionable designs also spreads among the low types. The parameters of the example are: $\delta=0.9$; $c=2.44$; $\alpha=0.5$; $v^{h}=40$, $v^{\ell}=10$. Again there will be a three-period fashion cycle:

$$p_{3t+1}=7.6,\ p_{3t+2}=4.9,\ p_{3t+1}=1.$$

[19] If part of the innovation cost is the cost of coordinating consumers by means of advertising, then it is misleading to interpret c as a technological parameter of the fashionable good. In this interpretation the "innovation cost" cannot be reduced to zero by choosing a commodity for which design changes pose no technological problem.

A new design will be created every three periods, and the diffusion of the designs is given by the sequence:

$$q_{3t+1} = 0.3577,\ q_{3t+2} = 0.5,\ q_{3t+3} = 1.$$

After two periods, the design is sold to all the high types, and in the third period of the fashion cycle the design is sold to the low types. After that, a new design is created, and a new cycle starts.

C. *Universal Fashions*

Some fashionable products have the feature that after a short period of time almost everybody in the relevant group of consumers owns the fashionable item. In my model this implies that fashion does not significantly alter the social interaction (i.e., the matches that are made when consumers use the designs are almost identical to the matches that would be made if there were no fashion at all). In the following I show that this phenomenon is reproduced by the model if the periods are very short.[20]

PROPOSITION 2: *Suppose $f(1) \equiv \alpha v^{\ell} > c > 0$. For every $\varepsilon > 0$, if the period length is sufficiently small (i.e., δ is sufficiently close to 1), then*

- *(i) the payoff of the designer is smaller than ε;*
- *(ii) the fraction of consumers who own the currently fashionable design is larger than $1-\varepsilon$ in all but an ε fraction of periods; and*
- *(iii) all but an ε fraction of consumers purchase the design at prices between $c+\varepsilon$ and $c-\varepsilon$.*

(See the Appendix for the proof.)

[20]As the period length becomes small, the utility per period also shrinks. One can think of every period as consisting of a large number of short independent matches for every consumer. If the period size is small, then the number of interactions that take place in one period is also small. Thus, one can think of the number of interactions as going to zero, rather than the duration of each match going to zero.

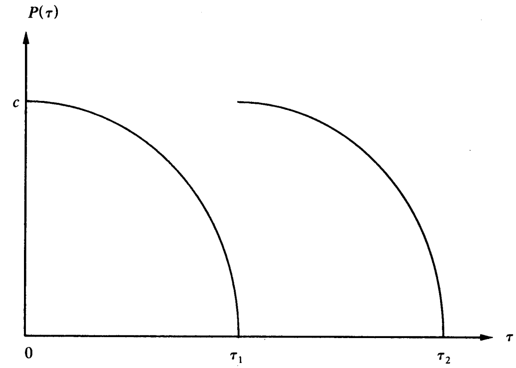

FIGURE 3. A TYPICAL PRICE CYCLE WHEN THE PERIOD LENGTH IS VERY SMALL

If periods are very short then the initial phase of a fashion cycle is similar to the predictions of the Coase conjecture for durable-goods monopolies. Most consumers buy within a short period after innovation, and most consumers pay essentially the same price for the new design. After this initial phase the sales volume of the design will be very small but positive for many periods. In particular, it will be just sufficient to keep the designer from creating a new design. Since the payoff of the designer is very small the sales volume can also be very small without giving the designer an incentive to innovate. The price for the design commodity decreases over time until it almost reaches zero. At this point the designer introduces a new design, and a new fashion cycle starts. Why do consumers purchase fashion in this case? Anybody who does not use the fashion is matched with a low type with probability 1. Hence even though fashion does not serve any social purpose, the *penalty* of not owning it is large.

Figure 3 describes a typical price cycle when the period length is very small. Note that τ indicates calendar time, rather than the number of periods. Innovations are assumed to occur at times τ_1 and τ_2. The welfare implications of a short period length are very different from the standard durable-goods monopoly. The logic of the dynamic design monopoly essentially precludes successful separation of types and therefore leads to inefficient matches.

The length of a period in the present model is the minimum amount of time that elapses before the designer can change the price of his design, and this amount of time is parameterized by δ.[21] Note that if the designer could commit at the beginning of the game to a period length he would optimally choose $\delta = 0$ (i.e., he would want to commit to an infinite interval between consecutive price changes). Assuming that such a commitment is not possible, one can imagine the designer attempting to establish a reputation for infrequent changes in the price.[22] While an explicit treatment of reputation is beyond the scope of this paper,[23] one can imagine that some designers have established a reputation for a relatively slow frequency of price changes while others have not. In particular, while established fashion designers may have acquired such a reputation, some newcomers might not. Casual observation suggests that fashions like pet rocks, cabbage-patch dolls, or hula hoops spread very fast and at the same time were not supplied by established designers.

IV. Competition

In this section I discuss outcomes that may arise if there are many potential designers. Suppose $j = 1, 2, \ldots$ denotes the designer and Z^j describes the collection of designs that j can innovate. I assume that designers cannot imitate each other's products (i.e., the sets Z^j are disjoint). The definition of the game is exactly as above with the exception that now many designers may sell their innovations simultaneously.

A. *A Fashion Czar*

Even in a situation of potential competition, monopoly may be the equilibrium outcome. Suppose that some random process designates one particular designer as a "fashion-czar" and that all consumers believe that only this designer is capable of creating "fashion." Such beliefs will be self-enforcing, and no consumer will have an incentive to purchase designs from any other designer. Suppose designer $\hat{j}$ is designated as a fashion czar. Suppose further that only designer $\hat{j}$ can coordinate the demand for fashion. In this case, profitable entry is not possible, irrespective of the price and innovation policy of $\hat{j}$. Therefore designer $\hat{j}$ is a monopolist, and the game reduces to the one analyzed in the previous section. Hence even though competition is possible, the fact that fashion always involves the coordination of many consumers may prevent competition from actually taking place.

B. *More Than One Successful Designer*

Here I describe equilibria in which true competition between designers occurs. In particular, I construct equilibria in which competition implies a *lower bound* on the price for designs. This lower bound will allow the high types to separate themselves from the low types. Competition will imply an increase in variety of the designs marketed. Hence two or more designers will simultaneously market designs that attract similar types of consumers. This increase in variety is without additional benefit to the consumers, and hence, from the point of view of efficiency, it is wasteful.

The following proposition describes a collection of subgame-perfect equilibria in

[21] Suppose that sales occur at times $\tau = 0, z, 2z, \ldots, tz, \ldots$. Let $\delta = e^{-rz}$ where z is the length of the period. Thus δ close to 1 corresponds to a small z, and δ close to 0 corresponds to a large z.

[22] While I focus on weak Markov equilibria in the analysis, there are equilibria that do not satisfy the weak Markov restriction in which the designer reduces the price less rapidly. By using the weak Markov equilibrium as a punishment one can sustain equilibria in which the designer does not change the price for several consecutive periods and hence effectively commits to a fixed period length.

[23] See Drew Fudenberg and David K. Levine (1989) for a model of reputation in repeated games, and see Marco Celentani and Pesendorfer (1992) for a model of reputation that can be applied to the present context.

which only the high types purchase the latest design, and innovation is accompanied by a sale of the previous design at a zero price. The interval between successive innovations is indeterminate. In particular, the interval may be infinite, so that only one innovation occurs by every designer in the market.

Recall that $(1-\delta)v^{\ell}$ is the one-period benefit of a design to a low type if all high types and no other low types are purchasing the design.

PROPOSITION 3: *Suppose that* $c < \alpha v^{\ell}/2$. *Let N be the number of active designers,* $2 \leq N < \alpha v^{\ell}/c$. *Given N, there is a* $\overline{T}$ *such that for* $T \geq \overline{T}$ *the following price and innovation sequence constitutes equilibrium play of a subgame-perfect equilibrium:*

(i) N designers create a new design every T periods.
(ii) The price of any design t periods after its creation is given by $v^{\ell}(1-\delta^{T+1-t})$ *if* $t \leq T$; *if* $t > T$ *then the price of the design is zero.*
(iii) In the period of an innovation, every high-type consumer purchases one of the new designs. Low types never purchase designs at a strictly positive price.

In this equilibrium, the designers innovate and sell to the high types in the period of innovation. Then, for $T-1$ periods no sales occur until in period T a new design is introduced, and the old design is sold at a zero price to the low types. New designs are sold at a price of $v^{\ell}(1-\delta^{T+1})$ to all high types. In this equilibrium high types always meet high types, and low types are always matched with low types. Hence from the point of view of matching, an efficient allocation is achieved.

How can the designers in this equilibrium resist the temptation to sell to the low types after having sold a new design to the high types? A reduction in the price below its equilibrium level is interpreted by high types as a sign that the design has gone "out of fashion" (i.e., it will no longer be used by high types as a signaling device). High types respond to the price reduction by selling the design and purchasing an alternative design. Since high types have abandoned the design, it can no longer guarantee a positive probability of meeting a high type. As a consequence, the design is of no value to the low types, and therefore low types do not purchase the design unless the price is zero. Thus, lowering the price will not generate any revenue for the designer.

If, instead of the equilibrium response to a reduction in the price, the high types continued to use the design, then low types would buy the design. This in turn would make the fashion less desirable and would give the high types a strict incentive to sell the design and purchase an alternative fashion.[24] Thus it cannot be equilibrium behavior for the high types to continue using a design after its price has been reduced below the equilibrium level.

The behavior of consumers after an attempt of a designer to attract "low" types is reminiscent of the behavior of clients of the Italian designer Fiorucci. Fiorucci started in the 1970's as a designer with a young upper-middle-class clientele. Around 1980 the designer tried to attract a broader group of customers by selling his fashion in department stores and by lowering the price. Shortly thereafter Fiorucci lost his fashion-

[24] In case the price reduction is "small," this follows since sufficiently many low types will purchase the design to make additional low-type consumers indifferent between buying and not buying. Complementarity then implies that every high type has a strict incentive to sell the cheap design and purchase a competing more expensive design. If the price reduction is "large," then high types will have an incentive to switch to an alternative design if $(v^{h}-v^{\ell})(1-\alpha) > v^{\ell}/N$, which is always satisfied if the number of designers operating in equilibrium is sufficiently large. However, note that even if this condition is violated, or if consumers cannot sell their designs, Proposition 3 is still true. If all high types switch to a new design, then every high type has an incentive to switch even if she cannot sell her design. Thus a coordinated switch of all high types after a price reduction by the designer can always sustain the equilibrium of Proposition 3.

able image and went out of business.[25] The present model suggests that the attempt of Fiorucci to increase revenue by lowering the price and selling in department stores may have been interpreted by the "high" types as indicating that Fiorucci was going out of fashion, and hence the high types switched to different designers. But this also implied that the design was of no value to the "low" types whom Fiorucci tried to attract.

Proposition 2 shows that in the monopoly case, for δ close to 1, the price of the design after innovation is approximately c. In the equilibrium of Proposition 3 this price is at least $2c/\alpha$. Moreover, since under competition there are no sales after the period of innovation, the price declines less rapidly than in the monopoly case. Hence if δ is sufficiently close to 1 the equilibrium price of the latest design is strictly larger under competition than under monopoly. If δ is close to 0 the equilibrium price under competition is smaller than in the monopoly case.[26]

V. Conclusions

This paper provides a model of fashion industries based on the idea that fashion is used as a signaling device in social interactions. A necessary condition for consumers to demand otherwise useless designs is that individuals do not know each other's characteristics and histories before they start a relationship. This suggests a connection between the likelihood of meeting an individual whose type is unknown and the importance of fashion in a community. Thus one would expect that fashion-conscious consumers are more common among inhabitants of large and densely populated cities than among inhabitants of small towns.[27] In addition, I assume complementarity in the unobservable characteristic for which the fashion provides a signal. This assumption is justified if the "type" of a consumer refers to a skill or to human capital and if one imagines the couple deriving pleasure or profit from some joint activity. It is less justified if the type of a consumer refers to her wealth and couples simply combine their wealth to provide for consumption goods.

The model reproduces several stylized facts associated with fashion industries. (i) A design is most desirable when it is new. Over time the price of any design declines. (ii) When a new fashion arrives, the old design becomes obsolete and sells at a very low price relative to its introductory price. (iii) Design innovations occur with deterministic regularity. The clothing industry, for example, "innovates" every year. Such design changes cannot be explained by the (necessarily stochastic) arrival of new ideas that improve previous products. In my model, design "innovations" are arbitrary changes to the look of a commodity. The new design does not improve the old in any dimension, and therefore, innovations can and will occur with precise regularity.

I examine two different market conditions (monopoly and free entry) and show that competition can have surprising effects when it applies to markets of fashion goods. First, competition enhances the fashion's ability to separate types. Under competitive conditions fashion cycles will be elitist, while under monopoly they may be egalitarian. Second, competition may reduce the frequency with which new products are introduced in the market. Finally, if the trading

[25] *The Wall Street Journal* remarks on the decline of Fiorucci in the beginning of the 1980's that "...the beautiful people went elsewhere for their clothes; the California store closed, [and] department stores shunned the stuff" (*Wall Street Journal*, 16 December 1986, p. 38). The same article notes that Fiorucci enjoyed some continued success in France and Germany; in Italy and in the United States, however, sales plummeted.

[26] If δ is 0 then the monopoly price is v^h, whereas the price in the equilibrium of Proposition 3 is v^ℓ. Moreover, in both cases prices change continuously as $\delta \to 0$.

[27] Simmel (1904) emphasized a similar relation between the observability of individual characteristics and the importance of fashion. In particular, he explained the greater importance of fashion for women by the fact that women tended to be restricted to nonpublic activities.

period is short, competition will lead to higher prices for consumers than monopoly, whereas the opposite conclusion holds if the trading period is very long.

A decisive factor in the competition between designers is the average "quality" of their customers. A designer whose clients are mostly low types will be less attractive to prospective buyers than a designer whose clients are mostly high types. If a designer tries to expand his clientele by catering to low types, the average quality of his clients may collapse, since high types switch to competing designs and leave him with a design that nobody wants. Concerns about the negative impact of price reductions on the "image" of a product are widespread among marketing managers (see e.g., *The Wall Street Journal*, 19 February 1992, p. B4). My model provides a theoretical foundation for these concerns.

From the point of view of efficiency, fashion cycles are wasteful. If a designer could commit to exactly one innovation and to a fixed price, then all agents could be made better off. This may explain the frequent attempts to regulate apparel. Sumptuary legislation, for example, which existed throughout Europe during the Middle Ages and early modern times, regulated the apparel that members of the lower classes were allowed to wear. Both in England and France velvets and silks were forbidden for certain classes, and limitations of expenditure for clothing according to rank, income, or both were in place (J. M. Vincent, 1934). Sumptuary laws were explicitly passed "to restrain extravagance, which was considered not only displeasing to God but economically ruinous to individuals" (Vincent, 1934 p. 465). Similarly, some school authorities are presently attempting to regulate the apparel of students. Excessive jewelry and particular fashions are prohibited in many U.S. high schools (see *The New York Times*, 15 November 1993, p. B1).

In the context of my model, sumptuary legislation can be interpreted as a way of avoiding wasteful fashion cycles. If the lawmaker can easily decide which social groups should interact, then sumptuary legislation will be efficient in the sense that the maximal gains from social interaction will be realized without waste of resources on design innovations.[28] Thus in societies with a well-defined class structure, one would expect sumptuary laws, while in a society for which it is impossible for the lawmaker to identify the efficient matches, one would not expect these laws.[29]

The analysis of this paper focuses on the simple case, in which designers all use the same material; that is, marginal cost is equal for all products. Suppose instead that there is a collection of potential materials which can be used by fashion designers. A high-quality material implies a high marginal cost of producing the design. Thus, by using high-cost materials, designers could effectively commit to keeping a high price, and this could eliminate fashion cycles.[30] Suppose, however, that in addition to the designers there is a second set of entrepreneurs, the *imitators*, who can imitate both designs and materials at a significant fixed cost and a low marginal cost. If the cost of imitating materials is low enough, then the only equilibrium outcome of such a model would be the use of either inexpensive materials or imitations of expensive materials.[31] Since designs are continuously changing, it is more costly to imitate an in-person who relies on designs than an in-person who exclusively relies on expensive materials. Thus, designs may still allow a partial separation of types, and fashion

[28] See Becker and Murphy (1993) for a similar interpretation of sumptuary legislation.

[29] "In Massachusetts the enactment of sumptuary laws extended from about 1634 to 1676, and at that time, in spite of repeated efforts at enforcement, the courts were already beset with widespread disobedience. The laws did not embody such detailed regulation of dress as did those in Europe, but they expressed a similar desire to maintain distinctions between an upper and a lower class" (Vincent, 1934 p. 466).

[30] I am grateful to an anonymous referee for pointing out the effect of materials with high marginal cost.

[31] This may be the reason why designers like Moschino almost exclusively use inexpensive materials like cotton or even plastic, while their products are among the most expensive designer clothes.

cycles similar to the ones analyzed in this paper would result. More generally, a model that includes imitation of both materials and designs could allow one to distinguish conditions under which designs will be the primary means of signaling a person's type, and conditions under which materials will be used for this purpose. An analysis of such a model is left for future research.

A second limitation of the present paper is that consumers can only be of two types. Moreover, the analyzed equilibrium has the designer marketing only one design at a time. In the example of Armani the designer markets at least three designs simultaneously and thereby provides more precise signaling devices than the designers in my model. Marketing several designs simultaneously will be important in a setting with a continuum of different types trying to interact. Such a framework would allow one to analyze the interaction between the distribution of types and the resulting fashion cycles.

APPENDIX

Strategies and Equilibrium

To simplify the definition of histories and strategies, I assume that all agents can observe each other's actions. However, strategies will be required to be anonymous (i.e., the deviations of a measure-zero set of agents do not affect equilibrium outcomes). Note that the interaction between consumers is entirely determined by the matching technology which determines matches using the currently displayed designs of consumers. Therefore, information about individual consumer histories is irrelevant for all agents, and one can interpret the game as one in which only the designer's action and total sales can be observed.

A history in period t is a sequence of prices, a sequence of innovations, a sequence of purchases by consumers, and a sequence of display decisions by consumers. Let $\mathcal{H}^t$ denote the set of histories in period t. A pure strategy σ_t^d for the designer in period t is a map from histories to prices and innovations, $\boldsymbol{\sigma}^{\mathrm{d}} = (\sigma_t^{\mathrm{d}})_{t=1}^{\infty}$. The consumer's action in every period consists of a purchase/sales decision $y_t^n \in \{-1,0,1\}$ for all n and a display decision $z_t \in \{0,1,\ldots\}$. A strategy in period t for consumer q, $\sigma_t(q)$, is a map from histories (including the actions taken by the designer in period t) to purchases and displays. To incorporate the feasibility restrictions into the payoff function I will assume that whenever the consumer chooses to sell more than x_t^n units of a design the payoff will correspond to the sale of x_t units, hence $x_t^n(q) = \max\{x_{t-1}^n(q) + y_{t-1}^n(q), 0\}$. Similarly, whenever a consumer chooses a design that she does not own, then this is equivalent to choosing no design. As a function of $q, \sigma_t(q)$ is assumed to be measurable with respect to the Borel σ-algebra on $[0,1]$. Finally, $\boldsymbol{\sigma}(\cdot) = (\sigma_t(\cdot))_{t=1}^{\infty}$.

Note that $(\boldsymbol{\sigma}(\cdot), \boldsymbol{\sigma}^{\mathrm{d}})$ induces a sequence $[\nu_t(\mathbf{x})]$, and hence one can define the payoff for consumer q as $V^q(\boldsymbol{\sigma}^{\mathrm{d}}, \boldsymbol{\sigma}(\cdot), \boldsymbol{\sigma}(q))$. Similarly $V^{\mathrm{d}}(\boldsymbol{\sigma}^{\mathrm{d}}, \boldsymbol{\sigma}(\cdot))$ is the payoff of the designer.

A *subgame-perfect equilibrium* is a strategy pair $(\boldsymbol{\sigma}^{\mathrm{d}}, \boldsymbol{\sigma}(q),\ q \in [0,1])$ such that for all t and for any history h_t,

$$V^{\mathrm{d}}\left(\boldsymbol{\sigma}^{\mathrm{d}}\big|_{h_t}, \boldsymbol{\sigma}(\cdot)\big|_{h_t}\right) \geq V^{\mathrm{d}}\left(\boldsymbol{\sigma}'^{\mathrm{d}}\big|_{h_t}, \boldsymbol{\sigma}(\cdot)\big|_{h_t}\right)$$

for all $\boldsymbol{\sigma}'^{\mathrm{d}}$. Furthermore,

$$V^q\left(\boldsymbol{\sigma}^{\mathrm{d}}\big|_{h_t}, \boldsymbol{\sigma}(\cdot)\big|_{h_t}, \boldsymbol{\sigma}(q)|_{h_t}\right) \geq V^q\left(\boldsymbol{\sigma}^{\mathrm{d}}\big|_{h_t}, \boldsymbol{\sigma}(\cdot)\big|_{h_t}, \boldsymbol{\sigma}'(q)|_{h_t}\right)$$

for all $\boldsymbol{\sigma}'(q)$. In order to ensure existence of an equilibrium the monopolist must be allowed to mix at any stage of the game. It should be clear to the reader how to extend the above definitions when mixed strategies are allowed.

In the following I show the existence of a subgame-perfect equilibrium with the following properties:

(i) Deviations of sets of consumers of measure zero do not affect equilibrium play.

(ii) Demand for the design n_t can be characterized by an acceptance function $P(\cdot)$. $P(\cdot)$ is a nonincreasing left-continuous function that satisfies equations (9) and (10).
(iii) Along the equilibrium path, for any $n < n_t$, $p_t^n = 0$.

Since old designs have a zero price the designer's behavior along the equilibrium path is a map from histories to prices for the latest design and innovations (i.e., $\boldsymbol{\sigma}_t^d$: $\mathcal{H}^{t-1} \to \{0,1\} \times \mathbb{R}_+$, Since equations (9) and (10) are satisfied, one can assume that $y_t \in \{0,1\}$ along the equilibrium path. Moreover, since (by the coordination assumption) design n_t always guarantees a better match than any design that was previously innovated one can eliminate the consumer's "display decision" and simply assume that any consumer who owns the currently fashionable design will use it. Any old design used in equilibrium will give consumers the same payoff. Hence one can assume that all consumers who do not own the latest innovation use design $n_t - 1$.

Proofs

PROOF OF THEOREM 1 (Outline):[32]

For $c \geq M(\delta)$, let the equilibrium strategy prescribe that no innovation occurs. If the designer deviates and innovates, no further innovation will occur, and the designer receives the payoff $M(\delta)$ by following the equilibrium strategy corresponding to a standard durable-goods monopoly with demand function $f(q)$ and the assumption that the monopolist can coordinate demand. Clearly the designer has no incentive to innovate.

For $c < M(\delta)$, the first step of the proof is to show that the system of equations given by (5), (6), and (7) has a solution. To this end, fix a continuation value (= payoff of the designer at the beginning of the game) and define the functions $R(\cdot\,|V)$ and $P(\cdot\,|V)$ where

$$R(q|V) = \max_{y \in [q,1];\ \pi \in [0,1]} \{(1-\pi)[P(y|V)(y-q) + \delta R(y|V)] + \pi V\}$$

and $P(\cdot\,|V)$ satisfies (9) and (10). For a given $V > 0$ this system has a solution. This follows from Gul et al. (1986 [theorem 1]). The function $R(0|V)$ is continuous in V, for all $V > 0$. In addition, if $c < M(\delta)$ and if V is sufficiently large, then $R(0|V) - c \leq V$, and if V is sufficiently small, then $R(0|V) - c > V$. (This part utilizes a generalization of the theorem of the maximum due to Lawrence M. Ausubel and Raymond Deneckere [1993]). As a consequence, there exists a $V^* > 0$ such that $R(0|V^*) - c = V^*$. Thus (8), (9), and (10) are satisfied for $R(\cdot) = R(\cdot\,|V^*)$, $P(\cdot) = P(\cdot\,|V^*)$, and hence R and P support a WMC equilibrium.

In the second step I show that in equilibrium designs $n \leq n_t$ can be assigned a price of zero. For all designs $n < n_t$, assume the following strategies. If $p_t^n = 0$ for all $n < n_t$, then all consumers who did not purchase design n_t purchase and use design $n_t - 1$. If $p_t^n > 0$ for some n, all consumers who own design n sell it to the designer and use design 0. All consumers who did not purchase the design n_t use design 0. Thus it is optimal for the designer to set $p_t^n = 0$ for all $n < n_t$. Consumer behavior is clearly optimal.

Since $V^* > 0$, a new design must be created at least every T periods for some $T < \infty$, since otherwise the discounted profits for the monopolist would be smaller than V^* for some t, and hence the second part of the theorem follows.

PROOF OF PROPOSITION 1:

(i) Equation (5) implies that payoffs in every period are strictly positive [if $c < M(\delta)$ and hence innovation occurs] since $R(0) > c \geq 0$. Thus sales are strictly positive in every period. If $p_t \leq p_{t+1}$, then by the coordination and the stationarity assumptions sales

[32] For a detailed proof, see Pesendorfer (1993).

in period $t+1$ are zero, contradicting strictly positive sales. For the second part, note that as a function of q, $(q-q')f(q)$ attains a maximum either at α (for "small" q') or at 1 (for "large" q'). Therefore in the period prior to an innovation the designer either sells to all consumers or to all high types.

(ii) If T denotes the number of periods between successive innovations, then by equations (9) and (10), $(1-\delta^T)\alpha f(\alpha)$ is the maximum revenue from the designs. This implies that $(1-\delta^T)\alpha f(\alpha)\geq c$, since otherwise it is optimal not to innovate. Hence the lower bound on the periods between successive innovations follows.

For $c=0$, $R(0)\geq \alpha f(a)$, Let $\bar{q}$ be such that for $q>\bar{q}$ the designer creates a new design and for $q\leq\bar{q}$ the designer continues to sell the old design. Then it must be that $\max_q(q-\bar{q})(1-\delta)f(q)\geq(1-\delta)R(0)$. Since $(q-\bar{q})f(q)\leq\alpha f(\alpha)$, this implies that $\bar{q}=0$. For c close to zero $\bar{q}$ is close to zero. But for small $\bar{q}$ and for $y\leq\bar{q}$, $P(y)\cdot y+\delta R(y)\leq R(y)$ since $R(y)$ is bounded below by $\alpha f(\alpha)-c/(1-\delta)$. Hence it is optimal for the designer to sell to all high types instead of restricting the sale to $[0,\bar{q}]$. But this implies that innovation must occur every period if c is sufficiently small.

(iii) Note that $R(0)-c\geq\alpha v^{\text{h}}-c/(1-\delta)=\alpha f(\alpha)-c/(1-\delta)$. Since v^{ℓ} is an upper bound for the per-period gains to selling to low types, one can choose a v^{h} sufficiently large, so that $(1-\delta)R(0)-c>v^{\ell}$, which implies that it can never be optimal to sell to low types.

(iv) First suppose that $0<\pi(q)<1$ along the equilibrium path. Then by choosing any $q'<q$ the designer will no longer be indifferent between innovating and not innovating; that is, $\pi(q')=0$, and therefore $P(q')>P(q)+\varepsilon$ for all $q'<q$. Thus q cannot be optimal. The fact that there will be no randomization among prices except in the initial period is a property of the equilibrium path of a durable-goods monopoly (see Ausubel and Deneckere, 1989).

PROOF OF PROPOSITION 2:

Since $c>0$, then for some $\gamma>0$ and for $T(\delta)$, the number of periods between successive innovations, $1-\delta^{T(\delta)}\geq\gamma>0$.

Claim 1: Let V^d denote the payoff to the designer when starting the game. As $\delta\to 0$, $V^d\to 0$.

To see this note that $(1-\delta)V^d\leq\max\{(1-q_{T-1})(1-\delta)f(1),(\alpha-q_{T-1})(1-\delta)f(\alpha)\}$. Further, optimality requires that along the equilibrium path

$$\text{(A1)}\quad p_t(q_t-q_{t-1})+\delta V_{t+1}^d \geq p_{t+1}(q_{t+1}-q_{t-1})+\delta V_{t+2}^d$$

where p_t, q_t, and V_t^d denote the price, the demand, and the expected payoff, t periods after an innovation; $t=1,\ldots T=T(\delta)$, $V_{T+1}\equiv V^d$. But this implies that

$$\text{(A2)}\quad (p_t-p_{t+1})(q_t-q_{t-1}) \geq(1-\delta)V_{t+1}^d$$

or

$$\text{(A3)}\quad q_t-q_{t-1} \geq\frac{(1-\delta)V_{t+1}^d}{(1-\delta)f(q_t)-(1-\delta)p_{t+1}}.$$

Note that $V^d\leq V_T^d$ and V_t^d is increasing in t, and therefore if V^d stays bounded away from zero as $\delta\to 1$, then there is a bounded number of periods in which the innovation is sold. This contradicts the observation that $1-\delta^{T(\delta)}\geq\gamma>0$. Hence $V^d\to 0$, and hence $q_{T-1}\to 1$.

Claim 2: For all $\varepsilon>0$ there is a $\bar{\delta}$ such that for $\delta>\bar{\delta}$ and for $t>\tau(\delta)$, $q_t>1-\varepsilon$, where $\tau(\delta)$ satisfies $\delta^{\tau(\delta)}=1-\varepsilon$.

Suppose the contrary. Then there is a sequence $\delta_k\to 1$ such that if t_k is the integer part of $\tau(\delta_k)+1$ then $q_{t_k}\leq 1-\varepsilon$ for all k. First I show that this implies that, for all k, $R^k(q_{t_k}^k)\geq\varepsilon'$ for some $\varepsilon'>0$. Note that along the equilibrium path $p_t\geq f(1)(1-\delta^{\tau})$, where τ is the number of remaining periods for which the design is purchased. Let $L(\delta,\eta)$ be such that $1-\delta^{L(\delta,\eta)}=\eta$. Then for $R^k(q^k_{t_k}) \to 0$ it must be that, for all $\eta > 0$,

$$\text{(A4)} \qquad \sum_{t=t_k}^{T(\delta)-L(\delta,\eta)} q_t^k \to 0$$

$$\sum_{t=T(\delta)-L(\delta,\eta)}^{T(\delta)} q_t^k \geq \varepsilon.$$

Hence, along the equilibrium path, all of the remaining sales from period t_k on must be crowded in the final $L(\delta,\eta)$ periods of the remaining "lifetime" of the design. Now observe that, for $q_{t+1}, q_t, q_{t-1} \neq \alpha$, equations (A1) and (A3) must hold with equality. If strict inequality were to hold, then by increasing q_{t+1} the designer could increase his profit. This is the case since

$$\frac{\partial}{\partial q}[(q-q')f(q)] > 0$$

for $q > q' > 0$, $q \neq \alpha$. But if inequality (A3) holds with equality, then $q_t - q_{t+1} \geq b(q_{t'} - q_{t'+1})$ for all $t < T(\delta) - L(\delta,\eta) < t'$ and for some constant $b > 0$.[33] But this contradicts (A4) if ε/γ is sufficiently small. Hence $R^k(q^k_{t_k}) > \varepsilon' > 0$.

To obtain a contradiction to $q^k_{t_k} \leq 1-\varepsilon$ for all k suppose that after innovation the designer charges the sequence of prices $\{\hat{p}_k\}$, with $p_k = f(\alpha)(m-k)/m$, $k = 0,1,\ldots,m-1$ and with $f(\alpha)/m \leq (\varepsilon\cdot\varepsilon')/4$. Since $\{\hat{p}_t\}$ comes within $(\varepsilon\cdot\varepsilon')/4$ of the available surplus, selling after τ with $\delta^\tau > 1-\varepsilon$ to more than ε consumers cannot be optimal, since more than ε' of the available surplus remains. Thus, Claim 2 follows.

The third part of the proposition now follows from the fact that for every ε there is a $\bar{\delta}$ such that for $\delta > \bar{\delta}$, $R(0) < c + \varepsilon$ (by Claim 1) and $P(0) - P(1-\varepsilon) < \varepsilon$ (by Claim 2).

[33]This follows since $f(q_t) - p_{t+1} \geq f(q_t)(1-\eta)$ for all $t \in \{T(\delta) - L(\delta,\eta),\ldots,T(\delta)\}$ and since V_t^d is decreasing in t.

Competition.—Histories and strategies are as in the monopoly case with the exception that now in every period all designers choose innovations and prices simultaneously. It should be clear to the reader how to extend the above definitions of strategies and of subgame-perfect equilibrium to this case. Let n_t^i denote the latest design innovated by designer i (i.e., all designs $n^i \in \mathbf{Z}^i$ such that $n^i \leq n_t^i$ have been innovated in period t).

PROOF OF PROPOSITION 3:

Let $\bar{T}$ be the smallest integer T that satisfies the inequality $(1-\delta^{T+1})\alpha v^\ell/N \geq c$. Since $c < \alpha v^\ell/N$, there is such a $\bar{T}$. The following strategies constitute a subgame-perfect equilibrium of the game:

(i) N designers create a design every T periods (i.e., in periods $kT+1$, $k = 0,1,2,\ldots$). For $t = kT + t'$, $t' < T$,

$$p_t^{n_t^i} = v^\ell(1-\delta^{T+1-t'})$$

and $p_t^{n^i} = 0$, $n^i < n_t^i$.

(ii) Every T periods, high types purchase a new design. Every designer sells to a fraction α/N of high types. Purchases occur only in periods 1, $T+1$, $2T+1,\ldots$.

i) If designer i deviates in period $t = kT + t'$, $t' < T$, to a price

$$p_t^{n_t^i} < v^\ell(1-\delta^{T+1-t'})$$

then all high types who own n_t^i purchase design n_t^j offered by some $j \neq i$ and sell the design n_t^i.

(iv) If designer i creates a new design in any period $t \neq kT+1$ for some $k = 0,1,\ldots$, then no purchases occur until period $t+\tau$, where τ is the smallest number such that $t + \tau = kT+1$ for some k.

(v) The strategy of all designers is constant and independent of the subgame they are in. In particular, after a price deviation of one designer, *all* designers return to the strategy played along the equilibrium path.

It is easily checked that the strategy outlined above constitutes a subgame-perfect equilibrium.

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