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consumer good innovation*

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Social norms and equality of opportunity in conspicuous consumption: on the diffusion of consumer good innovation.

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Abstract

This paper presents a simple evolutionary model to study the diffusion patterns of product innovations for consumer goods. Following a Veblenian theme, we interpret consumption as a social activity constrained by social norms and equality of opportunity. Societies that allow for more behavioral variety will experience faster adoption of new consumer goods. We also find that the speed of diffusion as well as the saturation levels reached highly depend on the equality of opportunity. Combining these two effects, we conclude that a social structure displaying behavioral variety and equal opportunities dominates any other social set-up in terms of the speed of adoption of product innovations.

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1 Introduction

Early economists and contemporary economic historians alike have identified conspicuous consumption as an important determinant in the expansion of markets and technological innovations in the Western world in the 18th century and later. The acquisition and diffusion of consumer goods is driven by “the recognition and admiration of our fellow human beings”, as “to deserve, to acquire, and to enjoy, the respect and admiration of mankind, are the great objects of ambition and emulation”, (A.Smith, cited in Rosenberg [26, p.365]). This was particularly the case for semi-durable consumer goods, such as ornaments of building, dress, or household furniture, (see e.g. McKendrick et al. [21], Bianchi [3, p.6]). There is interdependence in the choices of the different populations of adopters. Members of different social groups observe the consumption patterns of other members in society. In the absence of more direct social contact consumption patterns reveal the social status of people. This is a process in which consumers compare, evaluate and imitate or reject the choices of relevant others. Furthermore, socio-economic attributes such as disposable income or more pervasive value systems have an influence on the choice and the subsequent legitimization of an innovation in consumer goods. The diffusion of consumer good innovation does not just involve the dissemination of information as the diffusion literature typically would suggest (for an overview see Geroski [16]), but is determined by a social process of persuasion and depends on the extent of consumer heterogeneity in an economy.

Over the years the interest in the study of consumer behavior under the presence of externalities amongst consumers has steadily increased. Many contributions have drawn on ideas set out in the classic works of John Rae [24] and Thorstein Veblen [35] on conspicuous consumption as well as on ideas by sociologists such as Georg Simmel [31] or Pierre Bourdieu [4]. Most of this literature has addressed the allocational aspect of interdependent preferences and studied the adoption of pure luxury goods, such as fine art, holiday resorts, luxury cars or fashion goods (see e.g. Pesendorfer [22] or Swann [32]), but was not so much interested in the diffusion of positional goods.

The paper studies the diffusion paths resulting under different parameter settings capturing the social structure of an economy in a simple evolutionary model. By social structure we mean equality of opportunity and social norms determining group cohesiveness. The first is an indicator for the class structure and reflects the probability of an individual of being member of any of the two classes, and the second is a measure for freedom of choice. These two parameters constrain consumer behavior and hence affect the diffusion patterns of new semi-durable consumer goods. We model two populations of agents that differ in their income, in their behavior towards their peers and in their social position. Agents in the leading high income group seek

distinction from members of the lower social class and draw well-being from the fact to be similar or dissimilar to their peers. The extent to which behavioral variety within a social group exists is determined by social norms, which may be thought of as social mechanisms sanctioning deviations from group behavior. The lower class in turn behaves differently. As in the upper class, there is a behavioral pattern which supports the cohesion of the group. People draw utility from either conformist or snobbish behavior. But unlike members of the upper class lower class types aspire to the lifestyle of people in the upper class. They want to conform with the social elite. This is a typical setting of conspicuous consumption. The leading class shows the way, while the lower class follows. Depending on the social norms and equality of opportunity in society, very different diffusion patterns result, which we characterize in terms of market penetration time and speed of substitution.

In the next section we review relevant literature and give an overview on the framework guiding our formal analysis. We then advance the evolutionary model to study the diffusion patterns resulting from different social settings. In the fourth section we discuss our results and relate them to the history of consumerism. Final comments conclude our paper.

2 Background

2.1 Previous work

The classical contributions of Duesenberry [11], Leibenstein [20] or Venieris and Hayakawa [17] have tried to endogenize preferences through introduction of social or cultural propensities into the consumer's choice problem or the incorporation of Veblenian topics into utility functions. The work of these authors implies that preferences for conspicuous or status goods are driven by comparison of individuals with social reference groups. People may react positively to the consumption pattern of some groups and adversely to others. Accordingly, wants are shown not to be randomly distributed throughout the society, but to cluster for specific social groups.

On this Veblenian line of thought several authors have developed status game models to study the property of demand schedules under conspicuous consumption and implications for taxation (see Corneo and Jeanne [7], [8]), as well as possible market failure resulting from it and conditions under which it can be avoided (see Pesendorfer [22] and Bagwell and Bernheim [2]). The diffusion of new products is not an explicit aim of the analysis of these papers.

Other work has partly addressed this question. Some authors have shown that if the behavioral patterns of an individual are alternately enforced or dampened by the behavior of significant others chaotic demand patterns may emerge (see for instance Congleton [6], Iannaccone [18] or Rauscher [25]). Similarly Cowan, Cowan and Swann [9] have devised a stochastic model

whose dynamic is based on aspiration-, bandwagon- and Veblen effects. They show that if certain consumer groups seek distinction and others aspire to their behavior cyclical consumption patterns and consumption waves may emerge. In a similar fashion Janssen and Jager [19] explain market dynamics with lock-in, fashions or unstable renewal. They posit that it is dominated by the behavioral rules of consumers reflecting preference for distinction or conformity.

Cowan et al. and Janssen and Jager identify consumption norms as an emergent property of systems of single agents interacting with others. While we believe that social norms do indeed emerge from social interaction of individuals, it is also the case that individuals act embedded in some given social structure. Social norms for instance lead often to institutions, which have a semi-permanent character, and change only slowly as norms change. Individuals are also part of different social groups whose members show similar behavior against each other and members of other social groups. We believe that these are factors that should not be neglected. Therefore, instead of taking an agent based view, we pursue a population approach and study adoption patterns and the speed of diffusion in relation to a given social structure.

2.2 Consumption as a social activity: the relation to social structure

Commodities do not only have an intrinsic value in use, they have also a social meaning. Sociologists have long stressed that individuals value goods because they define their social position in relation to associates in lower or higher status positions. This comparison enters in the assessment of their well-being (see Bourdieu [4]). In a similar line Amartya Sen [27, p.7] has argued that commodities have functionings, which allow people *to do* something or *to be* something. These functionings are different from having a good or from having utility. They depend on the evaluation of the circumstances of life of a person, and are also determined through interpersonal comparison. This points to the fact that preferences of individuals are interrelated.

An early example for the recognition of interrelatedness of preferences was Duesenberry's [11] analysis of the consumption patterns of households, which led to the formulation of his relative income hypothesis. It states that families reduce their savings in order to keep up with the standard of living to which they have become accustomed in case their income falls. For Easterlin [12] this corresponds to a model in which the well-being of an individual varies with his or her income, but is inversely related to the income of others. He shows in a series of papers that people do not feel better off with increasing affluence unless their relative position in regard to other members of the society improves. One of the possible reasons

for this is that when consumers interact and learn from each other they do not only exchange information on the technical characteristics of the products they own, but also on their social symbols or meanings, which are the result of social interaction. These meanings are constituted by the way in which people interact in distinct social contexts. Commodities and their functionings affect the perception people have about themselves and create identity via social differentiation.

Veblen [35] has suggested that individuals compare themselves to significant others in terms of the status that comes with the wealth displayed through consumption. The comparison of the achievements of a person and the ones of its social reference group is a major force in creating desires and aspiration. The command over commodities is a mean to these ends. In a capitalistic society achieved money wealth is an important criterion for social achievement, but as direct personal interactions are less common this becomes obvious to others only through the consumption pattern of relevant others. Accordingly the functionings a person is able to attain through the acquisition and consumption of commodities act as important signalling devices for status. The differences in achievable functionings are a source for aspiration. As people desire to live up to “standards of decency” [35, p.88] in a society that is hierarchically structured the social elites are obvious examples to follow. People thus tend to seek consumption patterns associated with the lifestyles of higher income groups. As Frey and Stutzer [15, p. 411] put it, “people look upward when making comparisons. Aspirations thus tend to be above the level reached.”

The discussion so far shows that the consumption of commodities does not only signal what people actually are, but also how they would like to be considered. Veblen’s theory of conspicuous consumption is based on the assumption that leading classes tend to seek distinction from other social groups in order to show their status as social elite. As over time commodities lose their ability to confer status, members of these social group tend to continuously acquire new consumption goods. They are the resources with which the competition of individuals for the scarce resource “status” takes place (Campbell [5, p.104]). In this way the material norms on which judgements of well-being are based change continuously.

A possible reason for this is that the members of the leading groups of society draw part of their identity and well-being from what they consume. Nevertheless, over time the income of the lower social groups increases, and they acquire the capability of imitating the social elite. As a consequence its members will change their patterns of consumption in order to defend their relative position of well-being. The dialectic tension between aspiration and distinction gives rise to a never ending race, as commodities that at one time may confer status lose their significance once the other classes have caught up. In this way tastes do “trickle down” from the higher classes to lower social strata (see Trigg [34, p. 106]). This is a powerful engine of

social and economic change. Its effect will be more pronounced in an equal society, where the chances of an individual to become a member of the upper class are high. Under these circumstances it is more likely that lower class individuals encounter upper class individuals and induce aspiration effects.

There are different forces at work within social groups that govern group cohesion or rejection. Social norms establish behavioral regularities to which the members of a group are supposed to adhere. As consumption is a signalling device for social status, it is naturally constrained by them as well. Posner [23] defines social norms as a rule that is based on some socially shared belief on how people ought to behave, but is not promulgated by any official or legal source. They are sometimes self-enforcing, sometimes enforced by expressions of disapproval, ridicule, ostracism or codes of honor and related actions. Social norms are a sort of behavioral public good, to which every member should make a positive contribution. If that happens the behavior is reciprocated while deviations from established patterns of behavior are likely to be heavily punished (see e.g. Fehr and Gächter [13, p.166]). These mechanisms determine the pressure toward uniformity in groups. People cannot easily avoid them due to their inherited position in social space, as repeated social interactions are socially localized. Accordingly people tend to choose similar commodities than their peers, because “joining the ‘herd’ makes their choice act less assertive and perspicuous” (Sen [28, p. 751]). Social norms determine the bandwidth within which discrepancies in behavior are allowed, and hence the ease to break with the closer social environment. An example in case is the medieval society with its “God given” order discussed later. Any break with the social group assigned by birth was impossible and could happen only at the danger of being marginalized by society. In more subtle ways such norms exist still today and are a defining moment of any society.

As Akerlof [1] has stressed interactions in a social group are not only synergetic, but very often they are also conflictual. People tend to move out of a group, which does not share their basic values, and the group in turn supports their exit in order to maintain its inner cohesion (see Simon [30]). Economic success or educational achievement may endow members of a social group with some upper-class power or attributes so that in their aspiration to a higher standard of living they break with their social environment. People who have already a high status in turn may feel the need to overcome their inherited social past, as they resent the social eminence of their peers and search for alternative means of expression. These forces give rise to behavioral variety within groups, which consists of compliance with and rejection of given lifestyles.

This discussion suggests that the social factors influencing the adoption of a positional good may be condensed to effects existing between members of different social classes, namely aspiration and distinction, and intra-group effects consisting of snobbism or individualistic behavior and conformism

or bandwagon behavior. In the model that follows, we take into account these two characteristics of the social structure in which an individual is embedded to study their influence on the speed of market penetration of the new commodity. These social characteristics are the engine driving the dynamics in the model. As will be shown, different constellations of social coherence in the leading group and equality of opportunity give rise to different patterns of diffusion.

3 The model

We formalize the considerations put forward in the previous section as an evolutionary game with two groups of individuals.¹ As such our model is concerned with the frequency evolution of consumption strategies in the economic system. In this model the members of each population are heterogeneous. The perceived utility derived from consumption is based on the individuals characteristics and the characteristics of the population as a whole, i.e. the individuals in the game derive their utility of consumption from the interaction with the members of their own groups, as well as from the interaction with members of the other social group.

We derive the equilibria of the model analytically and establish their local stability, but unlike most theoretical work in evolutionary games the focus of our model does not lie on the investigation of the application of the evolutionary stable strategy solution concept to the dynamic stability of the replicator dynamic. We focus on the study of the adjustment process towards a new equilibrium once a new commodity is introduced into the economy. For this purpose we simulate the behavior of the model for some limit scenarios and analyze the resulting diffusion patterns.

3.1 Players and Strategies

There are two social classes in our model. Each class i ($i=1,2$) is characterized by an “average” available consumption budget per unit of time and individual w_i , $w_1 < w_2$, and its share in the total population q_i , $q_1 > q_2$ with $q_1 + q_2 = 1$. Equality of opportunity is captured by these population shares. The share of the lower class, q_1 may be thought of as a measure of equality: if $q_1 = 0.5$ we have a perfectly equal class structure, as each agent has an equal probability of being member in one of the two cohorts. Population shares and available income (w_1, w_2, q_1, q_2) are exogenously given and are assumed to be constant over time.

We assume that each unit of time an individual of a population chooses a consumption basket consisting of two parts: a luxury good, and a basic

¹See Taylor [33], as well as Cressman [10] and Weibull [36] and the classic references cited there.

good. The utility of consuming a basket is the sum of the utilities from consuming its parts. In choosing a luxury good an individual has the choice between two alternatives: good X with price p_x , or good Y with price p_y . We assume that the endowment of each individual is large enough to consume any of the two commodities, $(w_i > p_y, p_x)$; $i = 1, 2$. The luxury goods are indivisible. For simplicity we also assume that they have no other value than a social one. In other words, individuals derive utility from owning the good or not as this conveys social status, and not from its intrinsic value in use. Consumption of the basic good has no particular social meaning, and has decreasing marginal utility. The basic good is perfectly divisible. We assume that prices reflect marginal costs, and that they do not change over time.²

The share of the lower class consuming good X at time t is given by x_1 . The remaining share of the population consuming good Y is $y_1 = 1 - x_1$. Similarly, x_2 and $y_2 = 1 - x_2$ are the shares of the upper class of individuals consuming X and Y , respectively. Thus, individuals in both classes play pure strategies, where the strategies are denoted as e_x when she chooses the basket with good X , and e_y when he goes for the basket with good Y . The population states for the two classes are then defined by $\mathbf{s}_1 = (x_1, y_1)$ for the lower class, and by $\mathbf{s}_2 = (x_2, y_2)$ for the upper class.

3.2 Payoffs

Goods with social meaning Capturing some of the considerations advanced in the previous section, we assume that consumption of goods X and Y is driven purely by social factors. We analyze two important behavioral motives described before: *aspiration* and *distinction*. The lower class aspires to the standards of decency demonstrated by the upper class, the social elite. Members of this group would like to signal status similar to that of the upper class. In terms of our model this means that they want to buy what the upper class buys. On the other hand the upper class seeks distinction to preserve their status as social elite.

As for the behavior within the two social groups we will examine a spectrum of different “social norms” ranging from a society forcing strict behavioral compliance on their members, to a “non-conformist” society, where it is important for any individual to emphasize his own identity and individuality from the others. In a conformist society mechanisms of retaliation will sanction deviant behavior. Conversely in a “non-conformist” society individuals “aping” others will be perceived as a nuisance and accordingly retaliatory mechanisms will ensure that this does not happen too frequently.

We assume that an individual is engaged into two contests per unit of time against a randomly drawn opponent from the total population. The

²This is done for analytical clarity. The results do not change if we assume falling prices (due to scale or learning economies) for the new good.

utility given by a specific consumption profile depends on his expected payoff in this matching. We choose the following specification of the payoff matrix to formalize the “distinction”-effect.

	e_x	e_y
e_x , (basket with good X)	-1	1
e_y , (basket with good Y)	1	-1

Table 1: Payoff matrix \mathbf{D} (distinction)

An agent perceives a positive utility whenever his choice is different from his opponent’s choice, and nuisance (of the same magnitude) when the choices coincide. In the same way, matrix \mathbf{C} enables us to capture conformist behavior. Here, conversely as in the case of “distinction” behavior, an agent gets positive payoff if he chooses the same basket as his opponent, and negative outcome otherwise.

	e_x	e_y
e_x , (basket with good X)	1	-1
e_y , (basket with good Y)	-1	1

Table 2: Payoff matrix \mathbf{C} (conformity)

Basic good Consumption of the basic good has no particular social meaning and does not depend on the choice of the others. Every part of income that is not spent on the luxury is spent on these “basics”. The marginal utility of consuming $w - p$ of the basic good is decreasing, i.e. the utility of the income not spent on the luxury falls on the margin for higher incomes. To capture this standard assumption we use - without loss of generality - a concave function given by $\sqrt{w - p}$.

A basket An individual consuming a basket that contains basic and luxury goods gets a payoff which is given by the sum of the utility from the consumption of the basic good and the expected payoff from consuming a luxury good with social meaning. For an agent out of the low income group playing strategy e_k , $k = x, y$ the expected payoff is given by

$$u_1(e_k; \mathbf{s}_1, \mathbf{s}_2) = q_1 \left[\mathbf{e}_k (\omega \mathbf{C} + (1 - \omega) \mathbf{D}) \mathbf{s}_1 \right] + q_2 \left[\mathbf{e}_k \cdot \mathbf{C} \mathbf{s}_2 \right] + \mathbf{e}_k \cdot \mathbf{w}_1, \quad (1)$$

where \mathbf{e}_k is a unit vector in \mathbb{R}^2 , and \mathbf{w}_i is the vector of utilities of the basic goods

$$\mathbf{w}_i = \begin{pmatrix} \sqrt{w_i - p_x} \\ \sqrt{w_i - p_y} \end{pmatrix},$$

with $i = 1, 2$. The first term in equation (1) describes interactions within the lower class. Here the parameter $\omega \in [0, 1]$ captures the “social norms” in place in a society. We assume that $\omega = 0$ for a perfectly “non-conformist” set-up, while $\omega = 1$ in the case of strictly conservative social norms. All the values within these limits represent the more realistic intermediate cases, expressing a tendency to conformity if $\omega > 1/2$ or to individualism if $\omega < 1/2$. A special case worth mentioning is where $\omega = 1/2$. Here the intergroup heterogeneity of each population vanishes and the game transforms into a contest between two homogeneous populations. The second term in equation (1) arises from the *aspiration* effects present in the social class, and, finally the third term is just the utility derived from consumption of the basic good.

From equation (1) we derive the average payoff for the lower class, which is given by

$$u_1(\mathbf{s}_1; \mathbf{s}_1, \mathbf{s}_2) = q_1 \left[\mathbf{s}_1 \cdot (\omega \mathbf{C} + (1 - \omega) \mathbf{D}) \mathbf{s}_1 \right] + q_2 \left[\mathbf{s}_1 \cdot \mathbf{C} \mathbf{s}_2 \right] + \mathbf{s}_1 \cdot \mathbf{w}_1. \quad (2)$$

The utility of individuals of the upper class is derived in a similar fashion. In analogy to equation (1) equation (3) defines the pay off for an individual playing strategy e_k , which is

$$u_2(e_k; \mathbf{s}_1, \mathbf{s}_2) = q_1 \left[\mathbf{e}_k \cdot \mathbf{D} \mathbf{s}_1 \right] + q_2 \left[\mathbf{e}_k \cdot (\omega \mathbf{C} + (1 - \omega) \mathbf{D}) \mathbf{s}_2 \right] + \mathbf{e}_k \cdot \mathbf{w}_2. \quad (3)$$

Given equation (3) the average payoff in the upper class is

$$u_2(\mathbf{s}_2; \mathbf{s}_1, \mathbf{s}_2) = q_1 \left[\mathbf{s}_2 \cdot \mathbf{D} \mathbf{s}_1 \right] + q_2 \left[\mathbf{s}_2 \cdot (\omega \mathbf{C} + (1 - \omega) \mathbf{D}) \mathbf{s}_2 \right] + \mathbf{s}_2 \cdot \mathbf{w}_2. \quad (4)$$

The second and third terms of equation (3) are similar to the ones in equation (1) for the lower class. The difference is the first term, which captures the wish of the upper class to distinguish themselves from members of the lower class.

3.3 Replicator Dynamics

We use the standard two-population replicator dynamics introduced by Taylor [33] to analyze our model. The dynamics is defined by the system of four differential equations

$$\begin{aligned} \dot{x}_i &= x_i \cdot \left[u_i(e_x; \mathbf{s}_1, \mathbf{s}_2) - u_i(\mathbf{s}_i; \mathbf{s}_1, \mathbf{s}_2) \right] \\ \dot{y}_i &= y_i \cdot \left[u_i(e_y; \mathbf{s}_1, \mathbf{s}_2) - u_i(\mathbf{s}_i; \mathbf{s}_1, \mathbf{s}_2) \right] \end{aligned} \quad (5)$$

with initial conditions $x_i(0) = 1 - \varepsilon$, $y_i(0) = \varepsilon$, $i=1,2$. In the appendix to this paper we examine the local stability of the replicator dynamics for the equilibria towards which the model converges under different parameter settings. The model is not stable in a small domain of the parameter space, as shown in figure 1. This is discussed in detail later.

3.4 Equilibria of the model

There are four types of possible equilibria in the model: two in pure strategies (pooling and separating), one in mixed strategies, and one where the upper class plays pure (consuming the new good), while the lower class plays mixed strategies. In what follows this is denoted as partially mixed strategy. Furthermore we determine under which parameter values for equality of opportunity ($q_1 > 0.5$) and social norms (ω) a given equilibrium exists and is locally stable in the replicator dynamics (5). In the appendix we show that they are (locally) stable. For all parameters other than q_i and ω we use the same values as we employ for our simulations, i.e. $w_1 = 1, w_2 = 2, p_x = 0.5, p_y = 1$.

3.4.1 Pooling (no penetration) equilibrium: $y_1 = 0, y_2 = 0$.

This is an equilibrium where there is no diffusion of the new good at all. The equilibrium requires

$$\Delta u_1(0, 0) < 0, \quad \text{and} \quad \Delta u_2(0, 0) < 0.$$

where $\Delta u_i = u_i(e_y; \mathbf{s}_1, \mathbf{s}_2) - u_i(e_x; \mathbf{s}_1, \mathbf{s}_2)$, $i = 1, 2$ represent gains or losses in utility for each of the classes from consuming the new or the old good. According to (1) and (3) $\Delta u_i(y_1, y_2)$ is then defined as

$$\begin{aligned} \Delta u_1(y_1, y_2) &= 4\alpha q_1 y_1 + 4q_2 y_2 - \Delta w_1 - 2\alpha q_1 - 2q_2, \\ \Delta u_2(y_1, y_2) &= -4q_1 y_1 + 4\alpha q_2 y_2 - \Delta w_2 + 2q_1 - 2\alpha q_2, \end{aligned} \quad (6)$$

where $\alpha \equiv 2\omega - 1$ and $\Delta w_i \equiv \sqrt{w_i - p_x} - \sqrt{w_i - p_y} > 0$. Substituting expressions for Δu_i from (6) we get

$$q_1(1 - \alpha) < 1 + \frac{\Delta w_1}{2}, \quad \text{and} \quad q_1(1 + \alpha) < \alpha + \frac{\Delta w_2}{2}. \quad (7)$$

When these inequalities hold, there is no diffusion. Accordingly, the share of the new good in equilibrium will be zero,

$$Y^* = 0. \quad (8)$$

3.4.2 Separating equilibrium: $y_1 = 0, y_2 = 1$.

In separating equilibrium only the upper class adopts the new good, while the lower class uses the old one. The conditions for the equilibrium are

$$\Delta u_1(0, 1) < 0, \quad \text{and} \quad \Delta u_2(0, 1) > 0.$$

or by substituting as before

$$q_1(1 + \alpha) > 1 - \frac{\Delta w_1}{2}, \quad \text{and} \quad q_1(1 - \alpha) < \frac{\Delta w_2}{2} - \alpha. \quad (9)$$

The equilibrium market share of the new good when inequalities (9) hold is given by

$$Y^* \equiv q_1 y_1 + q_2 y_2 = q_2. \quad (10)$$

3.4.3 Partially mixed equilibrium: $0 \leq y_1 \leq 1$, $y_2 = 1$.

The third possible equilibrium is a partially mixed equilibrium, where the upper class uses only the new good, while the lower class uses both. The conditions for the equilibrium are

$$\Delta u_1(y_1^*, 1) = 0, \quad \text{and} \quad \Delta u_2(y_1^*, 1) > 0. \quad (11)$$

Accordingly, from the first equation in (11) we can find the equilibrium market share for the lower class y_1^* :

$$y_1^* = \frac{1}{2} + \frac{\Delta w_1 - 2q_2}{4\alpha q_1} \quad \text{for } \alpha \neq 0. \quad (12)$$

The equilibrium market share for the upper class if condition (11) is to hold, is $y_2^* = q_2$. From this together with (12) the market share of the new good in equilibrium is given by

$$Y^* = q_1 y_1^* + q_2 = 1 - \frac{q_1}{2} + \frac{\Delta w_1 - 2q_2}{4\alpha} \quad \text{for } \alpha \neq 0 \quad (13)$$

To determine the domain of q_1 and ω , where the equilibrium exists we substitute y_1^* into inequality (11), and in addition we require $0 < y_1^* < 1$. It gives us

$$\begin{aligned} (1 - q_1)(1 + \alpha^2) &> (<) \frac{\Delta w_1 + \alpha \Delta w_2}{2}, \\ (1 - \alpha)q_1 &< (>) 1 - \frac{\Delta w_1}{2}, \\ (1 + \alpha)q_1 &> (<) 1 - \frac{\Delta w_1}{2}, \end{aligned} \quad (14)$$

for $\alpha > 0$ ($\alpha < 0$).

3.4.4 Equilibrium in mixed strategies: $0 \leq y_1 \leq 1$, $0 \leq y_2 \leq 1$.

Finally, there is an equilibrium in the model, where individuals from both classes use the old and the new good. It must hold that $u_{1x} = u_{1y}$ and $u_{1x} = u_{1y}$. This implies that the following conditions hold,

$$\Delta u_1(y_1^*, y_2^*) = 0, \quad \text{and} \quad \Delta u_2(y_1^*, y_2^*) = 0.$$

The solution to the system of equations is

$$\begin{aligned} y_1^* &= \frac{1}{2} + \frac{\alpha\Delta w_1 - \Delta w_2}{4(1 + \alpha^2)q_1}, \\ y_2^* &= \frac{1}{2} + \frac{\Delta w_1 + \alpha\Delta w_2}{4(1 + \alpha^2)q_2}. \end{aligned}$$

Therefore the market share of the new good is

$$Y^* = q_1 y_1^* + q_2 y_2^* = \frac{1}{2} + \frac{(1 + \alpha)\Delta w_1 - (1 - \alpha)\Delta w_2}{4(1 + \alpha^2)} \quad (15)$$

The solutions of the system must be in the range (0,1). From this follows that equilibrium (15) exists in the area in parameter space delimited by the following conditions

$$\begin{aligned} q_1 &> \frac{\alpha\Delta w_1 - \Delta w_2}{2(1 + \alpha^2)}, & q_1 &< 1 + \frac{\Delta w_1 + \alpha\Delta w_2}{2(1 + \alpha^2)}, \\ q_1 &> -\frac{\alpha\Delta w_1 - \Delta w_2}{2(1 + \alpha^2)}, & q_1 &< 1 - \frac{\Delta w_1 + \alpha\Delta w_2}{2(1 + \alpha^2)}. \end{aligned} \quad (16)$$

3.4.5 Domains of the equilibrium and stability

The domain of the parameters for social norms and equality of opportunity (ω, q_1) ($0 \leq \omega \leq 1$, $0.5 \leq q_1 \leq 1$) for which the different equilibria exist and are locally stable can be divided into five parts by inequalities (7), (9), (14), (16) and the stability conditions given in the appendix. This is depicted in the figure 1.

(**Figure 1 about here.**)

For combinations (ω, q_1) enclosed by area 4 only mixed equilibria exist and are stable. For an increase in inequality we move to area 3, where the new good Y is consumed by all individuals from the upper class, and by some individuals of the lower class. Here we observe partially mixed equilibria. If the social norms change towards conformism, we step into the domain with separating equilibria 2, which are stable all over 2. The no penetration (pooling) equilibrium domain 1 is located in the bottom-right corner of figure 1. In 1 both no penetration and separating equilibrium exist and are stable, therefore the replicator dynamics (5) may converge to any of them depending on the initial conditions. For the initial conditions used in our model we observe convergence to the pooling equilibrium. A mixed strategy equilibrium exists for the parameter values enclosed by area 5, however it is not stable and shows limit cycles oscillating between on

the boundary (i.e. $Y^* = 0$ and $Y^* = 1$). The reason for this is that at $\omega = 0.5$ the intra-group effect of the game vanishes and becomes a game between homogeneous populations. A glance at matrices **C** and **D** shows that matching strategies are of opposite sign. Thus, independent of the consumption strategy a member of the distinction group chooses *a-priori* she has always an incentive to switch to the alternative strategy if she is matched with a member of the conformist group playing the same strategy. For these solutions an analysis of the diffusion patterns is not meaningful.

3.5 Analysis of the diffusion paths for some limit cases

We use our model for the analysis of the role of equality of opportunity and social norms in the process of diffusion of a new good. We start with simulations over some limit cases capturing perfect conformity $\omega = 1$ and total non-conformity $\omega = 0$, as well as set-ups for a society with perfectly equal opportunity and with strongly unequal opportunity, i.e. for parameter values $q_1 = 0.5$ and $q_1 = 0.9$ respectively. We assume that the consumption prior to a date $t = 0$ is limited to only one basket with good X . At that moment in time a new product Y is introduced with an initial market share ε (for both classes). The price of the new product, p_y , is higher than the price of the old one, p_x . We examine the model for $p_x = 0.5, p_y = 1$ and consumption budgets $w_1 = 1, w_2 = 2$. The initial market share of Y for both social groups is set to $\varepsilon = 0.01$.

We use standard measures to describe the diffusion paths resulting from our simulations. Technological forecasters commonly characterize the diffusion speed of new commodities as the length of the time interval elapsing between the diffusion path reaching 10% and 90% of the final saturation level of the commodity. This measure is denoted as $\Delta t := t_{90\%} - t_{10\%}$. As Δt ignores the time interval elapsing between the initial introduction of the commodity and it reaching 10% of the final equilibrium market share, we will use the $t_{10\%}$ measure separately to capture the time it takes a commodity to take off and penetrate the market. The results from these calculations together with the absolute saturation levels is depicted in figure 3. In our discussion we ignore the Δt measure, as it is very similar for all runs and does not add much information. Alternatively, we use the Fisher-Pry substitution rate [14], which captures the speed at which an old commodity is driven out of the market. This model suggests a logistic substitution trajectory

$$\frac{y}{1-y} = \exp(a + bt).$$

In its linear transform $\ln(\frac{y}{1-y})$ the slope b of a fitted straight line captures the learning or substitution speed, while the intercept a measures the adoption delay. The steeper this line is, the faster substitution takes place, the larger the intercept (in absolute terms), the higher is the adoption delay. The

Fisher-Pry substitution rate is depicted in figure 4, while the intercepts and slopes of fitted curves are presented in figure 5.

3.5.1 Effect of inequality

We first examine two polar cases of social norms and analyze how changing equality of opportunity influences the diffusion pattern of the new consumer good introduced at time $t = 0$. The paths our model generates for these constellations are shown in the upper quadrants of figure 2.

(**Figure 2 about here.**)

Conservative social norms, $\omega = 1$ Under perfect conformity the intra-class distinction effect is not present, i.e. the \mathbf{D} matrices in the terms capturing inner-group interaction in our equations (1) and (3) disappear. In this case people of the same social class who are randomly matched play a coordination game given by pay-off matrix \mathbf{C} . The top left quadrant of figure 2 shows the diffusion curves resulting for a parameter range $0.5 \leq q_1 \leq 0.95$. The effect of growing equality is twofold: on one hand it speeds up diffusion, and on the other hand, the level of saturation falls.

With the given initial conditions at $q_1 = q_2$ the members of the lower class derive the same expected utility from being equal to their peers as well as from being equal to the upper class. There is no incentive for members of the lower class to switch to the new commodity, as given the initial market shares of the new commodity in the two groups, utility is already almost at its maximum. We observe at first a pooling equilibrium given by equation (8). The few initial adopters will switch back to the old luxury due to existing peer pressure.

A change in equality has the effect on the upper class to increase disutility from being equal than the lower class. It starts paying upper class individuals to adopt the new good. The model settles on separating equilibria given by equation (10). Due to the pressure towards conformity adoption is very slow. Diffusion takes longest under near-equality conditions (see figure 2), but eventually the whole upper class will adopt the new commodity.

Non-conformist society, $\omega = 0$ The top right quadrant of figure 2 indicates that the diffusion paths resulting in a non-conformist society are quite different. In a perfectly non-conformist social constellation the matrix \mathbf{C} capturing intra-group interaction in equations (1) and (3) vanishes. In this case people of the same social class who are randomly matched play a “hawk-dove” game given by pay-off matrix \mathbf{D} . Each individual seeks to be different from its peers. This means that over the parameter range of q_1 up to the value of $q_1 = 0.9$ the model settles on a mixed strategy equilibrium given by equation (15) for both social classes, and to a partially mixed equilibrium

as in equation (13) at that value and beyond. This implies that under the “individualistic” setting of this run the equilibrium reflects an economy with maximum variety on the market for most equality of opportunity parameters. With fixed ω the market share for the new good gravitates around 0.45, and falls in the partially mixed equilibrium range.

The inter-group effects are responsible for short fashion waves visible as an overshooting over the final saturation level. As the frequency of adopters of the new good in the lower class increases, the upper class starts perceiving disutility from buying it, while utility for the lower class increases, so that there is an incentive to adopt more of it. This triggers some members of the upper class to revert to the old commodity. With the frequency of adopters of the new good in the upper class decreasing, utility of the new good falls for individuals of the lower class as well and the model settles on the mixed equilibrium. When the opportunity parameter is changed towards values capturing inequality, the upper class will restrict consumption of Y earlier as lower class members are encountered at higher frequency, thus causing the overshooting to appear earlier. Rising inequality has the effect to dampen out fashion waves as the parameter range for partially mixed equilibria is approached.

3.5.2 Effect of conformity

While in the first set of runs we examined the diffusion path along the vertical parameter axis in figure 1, we now change parameters to move along its horizontal parameter axis, examining how changes in social norms influence the process of diffusion for any given equality of opportunity. The diffusion curves are shown in the quadrants at the bottom of figure 2. The diffusion paths resulting from these model runs are hybrids of the first two cases studied so far.

Inequality, $q_1 = 0.9$ In this case we observe partially mixed Nash equilibria and separating equilibria, as the parameter for conformity is changed from 0 to 1. At low conformism players in both populations would tend to use both goods, but as inequality is high and the probability for upper class types to encounter similar lower class types is high, it pays them to play a pure strategy, even though it may cause disutility in playing against peers. The shift of ω towards conformity leads to a fall in the adoption of the new good in the lower class as the utility of individuals being equal to their peers starts outweighing snobbism and aspiration effects. The saturation level shifts downwards and the speed of diffusion decreases. The upper class on the other hand continues to have an incentive to adopt the new commodity due to the high frequency of members of the lower class in the total population. The market share drops to the share of the upper class.

Equality, $q_1 = 0.5$ In changing the parameter ω over its parameter range, the model settles on four possible equilibria. Under non-conformity we observe mixed strategy equilibria, in the parameter range of $0.5 \leq \omega < 0.6$ the model exhibits a cyclical behavior, beyond that separating equilibria and close to perfect conformism there is a pooling equilibrium. Whether the model settles on the latter depends on the initial conditions chosen, and this is the case for the parameter value for ϵ we use.

Fashion cycles emerge as the intra-group effects vanish. Members of the lower class start deriving more utility from being equal to members of the upper class, while the latter's disutility increases through this development. In approaching the critical value dampened cycles appear, which converge to a stable saturation level after some time. At $\omega = 0.5$ nevertheless, intra-group effects completely vanish and fast cycles emerge. The upper class has a continued incentive to change its consumption pattern, as the lower class catches up. Only after conformity becomes stronger it pays better for members of the lower social class to stick on the same consumption pattern as their peers and forgo utility from imitating the upper classes.

3.5.3 Market penetration time and diffusion speed

Figure 3 shows in the top row the market share achieved under the four different scenarios. The graphs in the second row instead display the market penetration time $t_{10\%}$ for each run. The diffusion time Δt is not reported as it appears to be similar for most scenarios. A better measure for the diffusion speed are the Fisher-Pry substitution rates and the parameters of fitted substitution curves, which are reported in figures 4 and 5.

(**Figure 3 about here.**)

Figure 3 reveals that the final market shares are highest for the runs simulating non-conformity and equal populations, while they are lowest for the conformist scenarios. Equilibria in mixed and partially mixed strategies tend to settle on higher market shares than separating equilibria. The market penetration times are in general slowest under conformist set-ups.

(**Figure 4 about here.**)

The analysis of the Fisher-Pry substitution rates gives a clearer picture. Figure 4 shows (see top-left quadrant) that the substitution rate is highest under inequality with perfect conformism, while the picture is reversed under non-conformism, as displayed in the subplot in the top-right quadrant. The two subplots in the lower half of figure 4 show that non-conformism in general leads to faster adoption than conformism. If substitution curves are fitted to the substitution rates displayed in figure 4, then the picture becomes even more telling.

(**Figure 5** about here.)

The right part of figure 5 shows the intercept values and slope of the fitted linear substitution curves for the runs with changing equality. They reflect the adoption delay and substitution speed. The first is clearly higher for conformism than for non-conformism and tends to increase with increasing inequality, while the latter is faster under conformism and is falling with increasing inequality. Over the parameter range of ω instead the adoption delay is practically equal for parameter values capturing non-conformism, but while it levels out in the equality scenario, it increases steadily in the inequality scenario. This picture is reversed for the substitution speed. In the part of the parameter space where the adoption delays are equal for the equality and inequality scenarios, it is faster for the equality scenario but falling as parameters are set to capture conformism.

These results are summarized in table 3. The market penetration and diffusion time is slowest under a conformist setting with equality. A social set up with conformism and inequality fares better. These two set-ups in turn are dominated by non-conformist ones. The sign between the non-conformist setting with equality and the one with inequality is ambiguous in terms of the adoption delay or the $t_{10\%}$ measure, but under the first the substitution speed is clearly faster. Hence we say that the social set-up with non-conformism and equality dominates all other social constellations.

	Equality	Inequality
Conformist	\prec	\prec
Non-conformist	\succ	\succ

Table 3: Summary of the results

4 Social norms and the rise of consumerism: a reasoned history

The sustained growth in the 19th and 20th century is normally associated with the adoption and diffusion of path-breaking technologies, such as the steam engine, or the railways and a myriad of other minor yet significant, productivity increasing innovations. The increasing wealth generated through them induced consumerist interest. Historians have related the rise of consumerism in the late 18th, 19th and 20th century to conspicuous consumption (see e.g. McKendrick [21]). Technological improvement was thus accompanied by an increasing willingness of consumers to absorb novelty, which opened up new markets and fostered growth even further. The historical record shows that such a relationship existed well before modern

times. Aristocracies tended to define their class lines through the consumption of luxury goods and by fancying extensive mansions. As the group of merchants grew in size and wealth, they tended to imitate their lifestyles, yet consumerism and high class status were not automatic companions (see Stearns [29]). The causes were twofold. First, before modern times new products were not continuously generated, so that there was a limitation in terms to conspicuous behavior in consumption. The second and in relation to our model more important reason is that social norms built around traditional values and religious interest limited consumerism even when the means were available.

Our results summarized in table 3 suggest that social norms can play an inhibiting role, if they do not allow for too much behavioral variety in the social classes. These social norms have normally emerged and stabilized over time. Certainly the most important and most influential ones in relation to consumption were those associated with religion. The pervasive value systems established around major religions urged their members to seek spiritual goals and to be suspicious of material ones. This holds true for Buddhism, Christianity or Islam. The display of riches and success was thus inappropriate in terms of religious norms. A telling example is Christ's statement that it would be easier for a camel to pass through the eye of a needle than for a rich man to gain entry to heaven. This maxim was conveniently used by the leading classes to cement the given social order. They used religion to induce lower classes too stick to their "God given" position in society and thus not to deviate in their consumption from that of their social class. As the rules they set were disguised as God's will, they could easily develop into a social norm, which was no longer perceived as imposed from outside, but as a matter of decency. Considering the importance of religious belief such norms constrained consumer behavior not only in medieval times, but were actually present also during the first and second industrial revolution. Stearns [29, p.52-3] reports Protestant ministers in the United States to have rallied as late as 1853 against the parade of luxury and demanding from lower class believers to aspire to more durable riches than that offered by the material world. Such reservations were often related to the fact that conspicuous consumption blurred class lines. In complaining about deteriorating popular moral middle- and upper-class observers and their ministers pointed to the fact that it was increasingly difficult to tell a person's status from the dress. This was of course not completely true, as the differences in quality remained remarkable. But the increasing importance of urban life caused a shift in mainstream Protestantism. Consumer goods were now considered to be God's gifts to mankind. Our model suggests that the relaxation of such norms would ease the diffusion of new goods, as it indeed did.

The reasons for the increase in behavioral variety in the different social classes in history were manifold, and their discussion will also shed some light

on the relation between equality of opportunity and social norms, which in our model were assumed to be exogenous. The historical record suggests that commercialization setting in with the age of Enlightenment was a major driving force in disrupting strict social norms inhibiting consumption. The new rationality in science led to the development of new productivity enhancing tools and machines, which increased wealth. Besides the old aristocracy new wealthy merchant classes emerged. This rise in equality was accompanied by a quest for a similar lifestyle as the established classes. The merchants resented aristocratic eminence and tried to challenge their social status. In turn during the period of the First and Second Industrial Revolution many traditional lifestyles and the associated social status were disrupted. The urbanization and the rapid population growth furthered the process of status change. Consumption increasingly gained importance in order to demonstrate social achievement. Commodities served as badges of identity in such a rapidly changing social climate (see Stearns [29, p. 27-32]). This was even more the case as in the late 19th century workers started their quest for higher wages. The importance of work changed from being a goal in itself. More and more people considered it an instrument for other gains and this translated into consumerist interest (ibid. p. 56). This summary discussion suggests that an increase in wealth and an increasingly equal equality of opportunity disrupted social conventions that exerted an inhibiting influence on behavioral variety in consumption. A more accurate enquiry into the precise relationship between the two factors is an issue for further research, but imitation and conspicuous consumption seem to have gained increasing importance over time. Our model is able to account for all these factors reasonably well.

The model allows to engage into an exercise of periodizing economic history over the last two centuries in Europe and the United States. The social conventions over this period have developed in such a way that in terms of table 3 a gradual move from the north-eastern to the south-western quadrant took place. The north-eastern quadrant captures the social set-up of antique or medieval societies, with their strict adherence to a given social order and an accentuated inequality. In the aftermath of the period of Enlightenment wealth shifted increasingly away from the land-owning aristocracy to merchants. Inequality decreased, but remained high. This historical development nevertheless disrupted the given social order enshrined in the guild system and increased non-conformity in the society. This happened first in the upper class where rich merchants competed in innovating new lifestyles to show their position in society. The two Industrial Revolutions increased freedom of choice also in the lower social classes, and the rise of democratic institutions, the rise of public schools as well as the increasing activity of industrial action through trade unions supported the development of equality of opportunity. This is the set-up of the south-western quadrant, which, as our results show, dominates all other social set-ups. This underscores again

the main result of the paper.

5 Conclusions

This paper develops a simple model of conspicuous consumption to study the influence of parameters reflecting social structure on the diffusion paths of product innovations of consumer goods. We used the set-up of an evolutionary multi-population model with two populations. The first population is the upper class, whose members act as innovating force in consumption. The second population is the lower class, which imitates the consumption behavior of the higher class. We assumed that in both classes there are social norms exerting pressure on their members not to innovate or imitate, i.e. to develop an “individualistic” consumption behavior. We explored the influence of changes in equality of opportunity between the two classes, as well as the effect of social norms on the speed of diffusion of new products their take-off time and the market saturation level. The main finding of the paper is that novelty diffuses most rapidly in a social setting where equality of opportunity is equal and behavioral variety is high. This social set-up dominates all other constellations. In other words, societies allowing for more behavioral variety and ensuring equal equality of opportunity should experience a more dynamic consumer behavior than otherwise. Our model has potentially a wide range of implications, and could be extended in various directions. Furthermore we offered a theoretical interpretation of the historical record on the rise of consumerism. We found that our model was able to capture this development reasonably well.

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A Local stability of the equilibria of the model

Each Nash-equilibrium of our model gives the saturation level the new positional good will reach for a specific parameter constellation after having been introduced in the economy. To investigate their stability we rewrite the replicator dynamics (5) as

$$\begin{aligned}\dot{y}_1 &= y_1(1 - y_1)\Delta u_1, \\ \dot{y}_2 &= y_2(1 - y_2)\Delta u_2,\end{aligned}\tag{17}$$

where the Δu_i is defined as in equation (6).

A.1 Pooling (no penetration) equilibrium: $y_1 = 0, y_2 = 0$.

To check if this equilibrium is (locally) stable we examine the Jacobian of the replicator dynamics (17) at $y_1^* = 0, y_2^* = 0$

$$\mathcal{J}(0, 0) = \begin{pmatrix} \Delta u_1(0, 0) & 0 \\ 0 & \Delta u_2(0, 0) \end{pmatrix}.$$

Since $\Delta u_i(0, 0) < 0, i = 1, 2$ the determinant of the Jacobian is positive, $\det \mathcal{J}(0, 0) > 0$, while the trace is negative, $\text{tr } \mathcal{J}(0, 0) < 0$. Thus, we can conclude that for all values of q_1 and ω for which this equilibrium exists it is a stable stationary point of the system (17).

A.2 Separating equilibrium: $y_1 = 0, y_2 = 1$.

At $y_1^* = 0, y_2^* = 1$ the Jacobian of (17) has form

$$\mathcal{J}(0, 1) = \begin{pmatrix} \Delta u_1(0, 1) & 0 \\ 0 & -\Delta u_2(0, 1) \end{pmatrix}.$$

The determinant is positive for all q_1 and ω . The sign of the trace is

$$\begin{aligned}\text{sign}(\text{tr } \mathcal{J}) &= \text{sign}(\Delta u_1(0, 1) - \Delta u_1(0, 2)) = \\ &= \text{sign}(2(1 - \alpha) - 4q_1 - (\Delta w_1 - \Delta w_2)).\end{aligned}$$

For the parameters (w_i, p_i) we have chosen, once the condition for this equilibrium (9) hold, the sign of the trace is negative. In combination with the positive deter-

minant it implies that the equilibrium is stable for all values of parameters q_1 and ω satisfying (9).

A.3 Partially mixed equilibrium: $0 \leq y_1 \leq 1, y_2 = 1$.

The Jacobian at the point of the equilibrium is

$$\mathcal{J}(y_1^*, 1) = \begin{pmatrix} 4\alpha q_1 y_1^*(1 - y_1^*) & 4q_2 y_1^*(1 - y_1^*) \\ 0 & -\Delta u_2(y_1^*, 1) \end{pmatrix}.$$

The sign of the determinant is determined by the sign of α :

$$\text{sign}(\det \mathcal{J}) = -\text{sign}(\alpha).$$

Sign of the trace of the Jacobian is

$$\text{sign}(\text{tr } \mathcal{J}) = \text{sign}(4\alpha q_1 y_1^*(1 - y_1^*) + 4q_1 y_1^* - 2\alpha q_2 + \Delta w_2 - 2q_1).$$

For q_1 and ω satisfying (14) the trace of the Jacobian for $\omega < 0.5$ ($\alpha < 0$) is negative, while for $\omega > 0.5$ ($\alpha > 0$) it is positive. Taking into account that $\text{tr}(\mathcal{J})^2 > 4 \det(\mathcal{J})$ we can conclude that the equilibrium is a stable node of the replicator dynamics (17) if $\omega < 0.5$, For $\omega > 0.5$ the equilibrium is a saddle point of the replicator dynamics, and therefore it would depend on the initial conditions whether the system would move towards the equilibrium or away from it.

A.4 Equilibrium in mixed strategies: $0 \leq y_1 \leq 1, 0 \leq y_2 \leq 1$.

The Jacobian at the point of the equilibrium is

$$\mathcal{J}(y_1^*, y_2^*) = \begin{pmatrix} 4\alpha q_1 y_1^*(1 - y_1^*) & 4q_2 y_1^*(1 - y_1^*) \\ -4q_1 y_2^*(1 - y_2^*) & 4\alpha q_2 y_2^*(1 - y_2^*) \end{pmatrix}.$$

The determinante and the trace of the Jacobian at (y_1^*, y_2^*) are

$$\det \mathcal{J} = 16q_1 q_2 y_1^*(1 - y_1^*) y_2^*(1 - y_2^*) (1 + \alpha^2) > 0,$$

$$\text{sign}(\text{tr } \mathcal{J}) = \text{sign}(4\alpha(q_1 y_1^*(1 - y_1^*) + q_2 y_2^*(1 - y_2^*))) = \text{sign}(\alpha).$$

Thus, equilibrium in the mixed strategies is stable for $\omega < 0.5$ ($\alpha < 0$) and unstable for $\omega > 0.5$ ($\alpha > 0$).

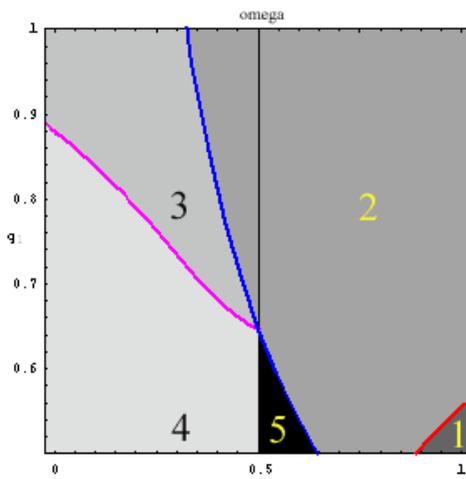


Figure 1: Domains of the stable equilibria of the model. (1) Pooling (no-penetration) equilibrium ($y_1 = 0, y_2 = 0$), (2) separating equilibrium ($y_1 = 0, y_2 = 1$), (3) partially mixed strategy equilibrium ($0 \leq y_1 \leq 1, y_2 = 1$), (4) mixed strategy equilibrium ($0 \leq y_1 \leq 1, 0 \leq y_2 \leq 1$), (5) unstable equilibrium.

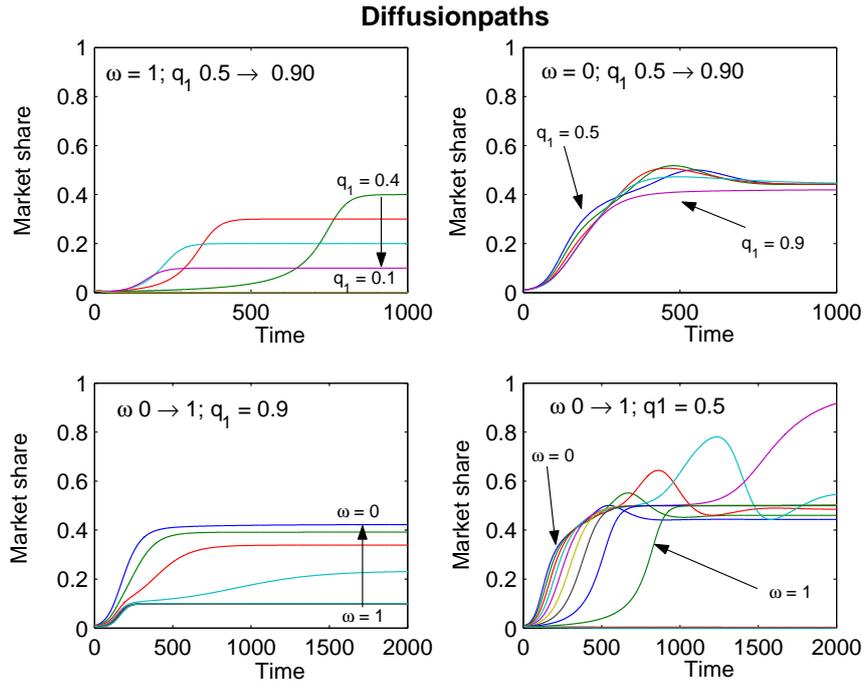


Figure 2: Diffusion paths, examples of limit cases. Upper left quadrant: perfect conformity, a change in class structure (towards inequality) shifts the saturation level down and decreases absolute adoption time. Upper right quadrant: non-conformity, changes in class structure speed up diffusion (outer curves are for more equal values), saturation level is the same for all set-ups. Inequality causes the overshooting to happen earlier and flattens it out for high inequality. Lower left quadrant: unequal class structure, changes in conformity shift the equilibrium up and accelerate absolute diffusion time. Lower right quadrant: equality, changes in social norms accelerate absolute diffusion time, final market shares are in a close bond, some solutions with $\omega \approx 0.5$ give rise to oscillations (fashion cycles).

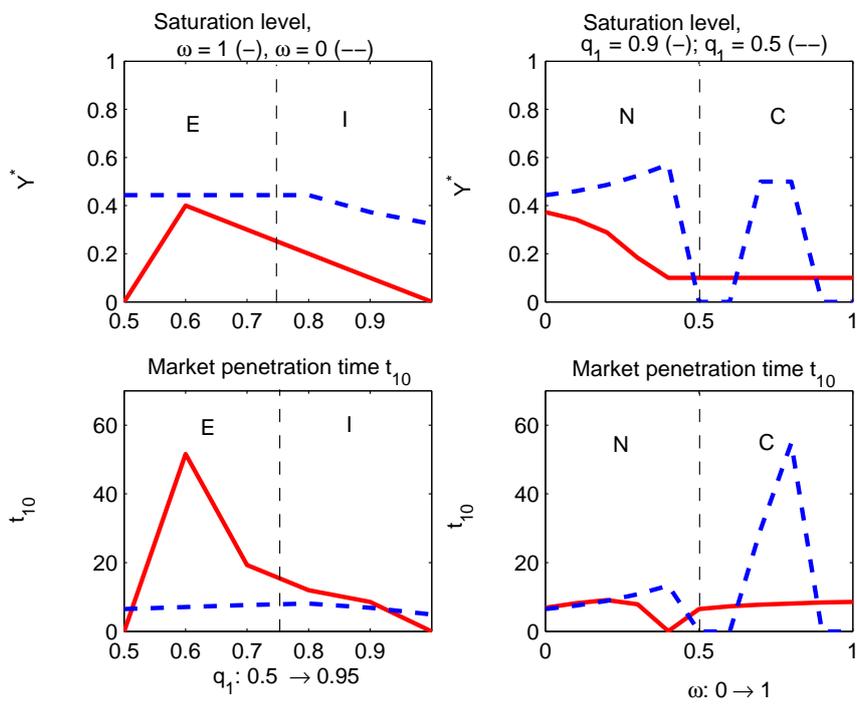


Figure 3: Diffusion statistics: results from the analysis of the limit cases. N: non-conformity, C: conformity, E: equality; I: inequality.

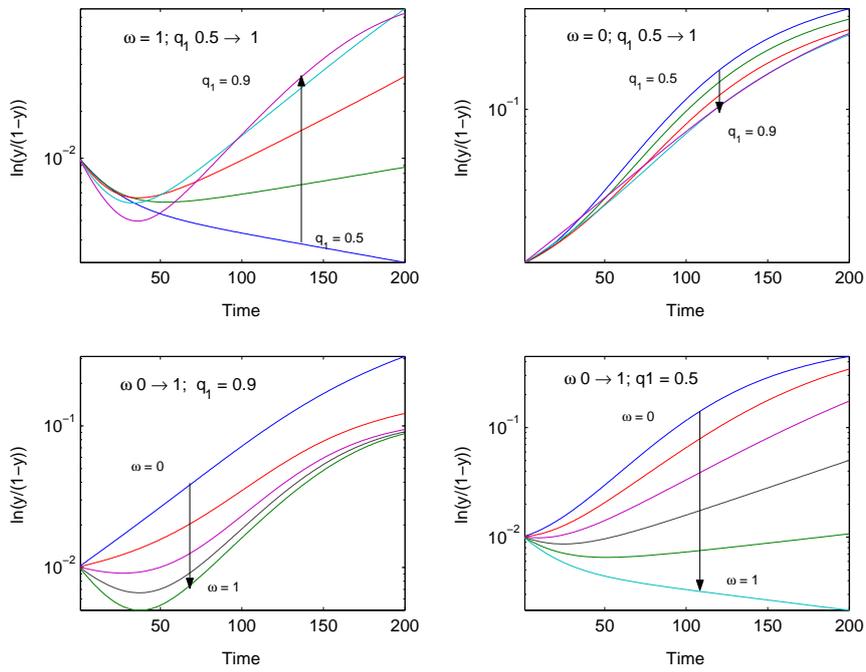


Figure 4: Fisher-Pry substitution rates: steeper slopes indicate faster adoption. The arrows indicate the direction of change of the parameters.

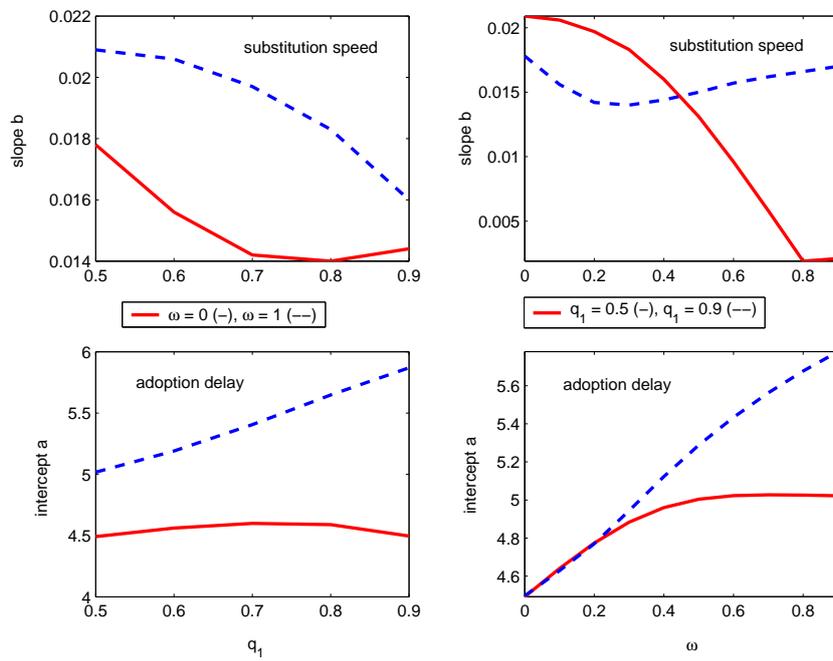


Figure 5: Parameters of fitted Fisher-Pry substitution curves: $\ln\left(\frac{y}{1-y}\right) = a + bt$. The intercept a captures the adoption delay, while the parameter b captures the learning or substitution speed.