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Abstract

We introduce loss aversion into a model of conspicuous consumption in networks. Agents allocate their income between a standard good and a status good to maximize a Cobb-Douglas utility. Agents interact over a connected network and compare their status consumption to their neighbors' average consumption. Loss aversion has a profound impact. If loss aversion is large enough relative to income heterogeneity, a continuum of Nash equilibria appears and all agents consume the same quantity of status good. Otherwise, there is a unique Nash equilibrium and richest agents earn strict status gains while poorest agents earn strict status losses.

Keywords: Loss Aversion, Conspicuous Consumption, Social Networks.

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1 Introduction

We often compare ourselves to others. Following Veblen (1899), a vast literature has documented the importance of conspicuous consumption. The consumption of goods like clothing and cars, appears to be driven, in part, by considerations of social status.[1] Comparisons are rooted in the social structure. People generally have different reference groups, which may include family, friends, and colleagues. Consumption in our reference group defines a reference level to which we compare our own consumption. Do we then react in symmetric ways to status gains and losses? The literature on loss aversion stresses the importance of asymmetries in the response to deviations from reference points. People appear to place more weight on relative losses than on relative gains.[2] The literature on conspicuous consumption has largely ignored loss aversion, however.

In this paper, we introduce loss aversion into the network model of conspicuous consumption of Ghiglino and Goyal (2010). Agents allocate their income between a standard good and a status good to maximize a Cobb-Douglas utility. Agents are embedded in a social network and compare their own status consumption to the average consumption among their network neighbors. Under loss aversion, status losses from a negative difference to the reference level are larger in magnitude than status gains from a positive difference of the same size. We analyze the network game induced by these social preferences.

We find that loss aversion has a profound impact on outcomes. Our main result establishes the existence of two mutually exclusive domains. In the conformism domain, there is a continuum of Nash equilibria where all agents consume the same quantity of status good. This domain only appears under loss aversion. In the differentiated domain, there is a unique Nash equilibrium where agents consume different quantities of the status good. We provide a simple, explicit condition characterizing the boundary between these two domains and valid for any connected network. Indeterminate, conformist equilibria appear if and only if loss aversion is large enough relative to income heterogeneity.

[1] See, e.g., Charles, Hurst, and Roussanov (2009).

[2] Kahneman and Tversky (1979) introduced prospect theory to help explain decisions under risk, see also Tversky and Kahneman (1992). A key ingredient in prospect theory is loss aversion with respect to a given reference point. Loss aversion also appears to play an important role in explaining riskless choices, see Thaler (1980) and Barberis (2013) for a survey.

Intuitively, the kink in the utility functions induced by loss aversion means that agents are extra motivated to avoid status losses. They really want not to consume less than the average consumption of their network neighbors. When the comparison network is connected and income heterogeneity is not too high, the interplay of these motives across the network leads all agents to consume the same amount of status good. This pure conformism becomes untenable, however, when incomes are too different. In that case, we show that consumption of the status good for the richest agents always lies strictly above their reference levels, while it lies strictly below for the poorest agents.

An important first step in our analysis is to compute agents' best responses. Without loss aversion, the best response is linear in the average consumption among network neighbors with slope strictly lower than 1, see Ghiglino and Goyal (2010). By contrast, we show that with loss aversion, the best response is piecewise linear with three pieces. Crucially, we show the emergence of an intermediate domain where the best response is precisely equal to the reference level - and hence with a slope equal to 1. The best response is also continuous and strictly increasing overall, implying that the consumption game is supermodular.

In a last step, we assess the robustness of our results. We show that our main result extends to a setup with heterogeneity in concerns for status and in loss aversion. This heterogeneity tends to reduce the emergence of conformism. We then provide preliminary results, and conditions under which the emergence of a continuum of conformist equilibria is guaranteed, when agents maximize some general increasing and quasi-concave utility function. We find that agents may still act as pure conformists over some intermediate range.

Our analysis contributes to the literature on conspicuous consumption. Our model builds on the early literature on status games, as formalized by Frank (1985) and developed by Hopkins and Kornienko (2004). As in these papers, we assume that agents allocate expenditures between two goods, a standard good and a status good. Frank (1985) and Hopkins and Kornienko (2004) assume that an agent cares about their rank in the overall consumption distribution, i.e., about the proportion of agents with a status consumption lying below own consumption. By contrast and following the literature on keeping up with the Joneses, we assume that utilities depend on a reference level of consumption.[3] We further assume that

[3]See, e.g., Abel (1990), Clark and Oswald (1998), Ljungqvist and Uhlig (2000).

each agent may have a different reference group, defining a network of comparisons as in Ghiglino and Goyal (2010). We provide the first analysis of the impact of loss aversion and find that it can lead to pure conformism in status good consumption.

Closer to our work, Friedman and Ostrov (2008) consider a continuum of identical consumers also allocating income between a standard good and a status good. In their framework, an agent cares about the difference between their status consumption and the status consumption of everyone else, with possibly different weights on positive and negative differences. By contrast, we tackle the more realistic - and more technically challenging - case of a finite society, where the action of one agent may have non-negligible impacts on others. Further, we characterize outcomes for any distribution of incomes and any connected network, without imposing the network to be complete. We show that pure conformism on status consumption only emerges when loss aversion is large enough relative to income heterogeneity.

Our analysis also contributes to the literature on games played on networks, surveyed in Bramoullé and Kranton (2016) and Jackson and Zenou (2015). To our knowledge, the only papers looking at status games on networks are Ghiglino and Goyal (2010) and Immorlica et al. (2017). Immorlica et al. (2017) consider a game where agents take a costly action which confers both private benefits and social status. The utility depends on a weighted sum of the differences between own action and the actions of neighbors taking a higher action. There is no weight on positive differences, an assumption akin to extreme loss aversion.[4] By contrast, we analyze the choices of consumers allocating income across two categories of goods. The relative weights on positive and negative differences can vary, covering situations of no loss aversion (equal weights), extreme loss aversion (zero weights on positive differences), and intermediate cases. We uncover the existence of two domains: one with a continuum of conformist equilibria, and one with a unique differentiated equilibrium.

As described above, we introduce loss aversion in the model of Ghiglino and Goyal (2010).[5]

[4] Immorlica et al. (2017) assume that an agent compares their action with the action of every other agent and then aggregates these pairwise comparisons by premultiplying with exogenous network weights. By contrast, comparisons operate through an network-based reference level in our framework.

[5] Ghiglino and Goyal (2010) develop a general equilibrium analysis with exchange, endogenizing the price of the goods. By contrast, we consider exogenous prices, as in Frank (1985) and Hopkins and Kornienko (2004). Leaving the offer unspecified allows the results to be relevant for general market structures. For example, production of the goods could be competitive, monopolistic, or include rigidities or incompleteness.

In the absence of loss aversion, best responses are linear and the equilibrium is unique. A remarkable implication of our main result is that equilibrium uniqueness is non-generic. Even an arbitrarily small wedge between the weights on negative and positive differences gives rise to a continuum of equilibria, and this holds even with arbitrarily small concerns about others' consumption. Loss aversion can lead to pure conformism in status consumption, a feature absent from Ghiglino and Goyal (2010).

Finally, our analysis contributes to the literature on loss aversion. Introduced by Kahneman and Tversky (1979) to analyze decisions under risk, loss aversion has also been proved useful to help explain riskless choices, see Thaler (1980) and Barberis (2013) for a survey. A central challenge in this literature is to develop a better understanding of the formation of reference points.[6] In a context of relative concerns, the ideas that agents have different reference groups and that an agent's reference level is built from consumption in their reference groups are very natural, and have empirical support. Across different contexts, people appear to compare themselves to their neighbors, family, and colleagues.[7] We provide the first analysis of the impact of loss aversion on conspicuous consumption in a network context.

2 The Model

We introduce loss aversion into a network model of conspicuous consumption. We consider a society of n consumers. Each agent i allocates her budget $w_i > 0$ between the consumption of a standard good, $x_i \geq 0$, and of a status good, $y_i \geq 0$. The price of the standard good is normalized to 1 and let p denote the relative price of the status good. The budget constraint is $x_i + py_i \leq w_i$.

Agents are embedded in a directed social network, describing comparison relationships. Denote by N_i the comparison group of agent i, of size $|N_i|$. We consider a connected network; any agent can be reached from any other agent through an indirect path in the network. This

[6]"The central idea in prospect theory is that people derive utility from "gains" and "losses" measured relative to a reference point. But in any given context, it is often unclear how to define precisely what a gain or loss is, not least because Kahneman and Tversky offered relatively little guidance on how the reference point is determined.", see Barberis (2013), p.178. For decisions under risk, Kőszegi and Rabin (2006) propose a framework where an agent's reference point is their expectation held in the recent past about outcomes.

[7]See, e.g., Clark and Senik (2010), Luttmer (2005), Neumark and Postlewaite (1998).

implies that no agent is socially isolated, $\forall i, N_i \neq \emptyset$. Each agent compares his consumption of the status good, y_i, to the average consumption in her comparison group, $\bar{y}_i = \frac{\sum_{j \in N_i} y_j}{|N_i|}$. Denote by $\mathbf{G}$ the interaction matrix such that $g_{ij} = \frac{1}{|N_i|}$ if $j \in N_i$ and $g_{ij} = 0$ if $j \notin N_i$. Thus, $\bar{y}_i = \sum_j g_{ij} y_j$.

Agents' preferences are described by the following Cobb-Douglas utility function, which depends on own consumption of the standard good and of own and peers' consumption of the status good.

$$u_i(x_i, y_i, \mathbf{y}_{-i}) = x_i^{\sigma} \varphi(y_i, \mathbf{y}_{-i})^{1-\sigma}$$

with

$$\varphi(y_i, \mathbf{y}_{-i}) = y_i + \alpha^+(y_i - \bar{y}_i) \text{ if } y_i \geq \bar{y}_i$$

$$\varphi(y_i, \mathbf{y}_{-i}) = y_i + \alpha^-(y_i - \bar{y}_i) \text{ if } y_i \leq \bar{y}_i$$

where $\sigma \in (0, 1)$ represents the consumption elasticity of the standard good and $\alpha^- \geq \alpha^+ \geq 0$ capture how much agents compare their consumption of the status good to others' consumption. Note that this utility function is well-defined, and greater than or equal to zero, when $\varphi(y_i, \mathbf{y}_{-i}) \geq 0$. For completeness, we assume that $u_i = -L < 0$ when $\varphi(y_i, \mathbf{y}_{-i}) < 0$. This means that agent i wants to consume at least $\frac{\alpha^-}{1+\alpha^-}\bar{y}_i$ units of status good before starting to consume the standard good.

This formulation nests well-known cases. When $\alpha^- = \alpha^+ = 0$, there is no social comparison. Agents have standard Cobb-Douglas preferences and $x_i = \sigma w_i$ and $y_i = (1-\sigma)\frac{w_i}{p}$.

When $\alpha^- = \alpha^+ = \alpha > 0$, there is social comparison without loss aversion. This is the benchmark case analyzed in Ghiglino and Goyal (2010). An agent's consumption depends on her peers' consumption, defining a simultaneous, complete information network game. The budget constraint binds, implying $x_i = w_i - py_i$. The utility as a function of status consumption only is $u_i(y_i, \mathbf{y}_{-i}) = (w_i - py_i)^{\sigma}((1+\alpha)y_i - \alpha\bar{y}_i)^{1-\sigma}$ with $y_i \in [0, \frac{w_i}{p}]$. This yields, $\frac{\partial u_i}{\partial y_i} = (-\frac{p\sigma}{w_i - py_i} + \frac{(1+\alpha)(1-\sigma)}{(1+\alpha)y_i - \alpha\bar{y}_i})u_i$. And $\frac{\partial u_i}{\partial y_i} = 0 \Leftrightarrow y_i = \sigma\frac{\alpha}{1+\alpha}\bar{y}_i + (1-\sigma)\frac{w_i}{p}$ when $u_i > 0$.

When α is not too high, individual best response is linear and there exists a unique Nash equilibrium to the consumption game. Denote by $\mathbf{I}$ the identity matrix. The unique equilibrium is interior and equal to

$$\mathbf{y} = \frac{1-\sigma}{p}(\mathbf{I} - \sigma\frac{\alpha}{1+\alpha}\mathbf{G})^{-1}\mathbf{w}$$

Under income homogeneity, in particular, this reduces to $y_i = \frac{1-\sigma}{1-\sigma\frac{\alpha}{1+\alpha}}\frac{w}{p}$. An increase in the importance of social comparison, as measured by α, unambiguously increases the consumption of the status good and decreases the consumption of the standard good.

Our main contribution is to introduce the possibility of loss aversion in status seeking. When $\alpha^- > \alpha^+$, the social losses from having a consumption level of the status good below peers' average are larger in absolute value than the social gains from having a status consumption above peers' average. This introduces a kink in the utility function, which is not differentiable around the reference level $y_i = \bar{y}_i$. Our main objectives are then to characterize the Nash equilibria of the consumption game under social comparison and loss aversion, and to understand how loss aversion affects equilibrium behavior.

3 Results

We develop our analysis in several steps. We first derive the individual best response of an agent under loss aversion. We show that the best response is an increasing, piecewise linear function with three pieces. A key implication of loss aversion is to induce pure conformist behavior over an intermediate range. We then present our main result on Nash equilibria. We uncover the existence of two mutually exclusive and qualitatively different domains. In a first domain, every agent plays the same action and there is a continuum of Nash equilibria. In a second domain, there is a unique Nash equilibrium and agents play different actions.

3.1 Individual best response

As a preliminary remark, note that the budget constraint implies that $y_i \in [0, \frac{w_i}{p}]$ and hence that $\bar{y}_i \in [0, \frac{\bar{w}_i}{p}]$. Therefore, an agent can afford the minimal level of consumption of status good for every possible consumption levels of her peers if and only if $w_i \geq \frac{\alpha^-}{1+\alpha^-}\bar{w}_i$ and we maintain this assumption in what follows.

We next derive the individual best response in the consumption game. Denote by $f_i(\mathbf{y}_{-i})$ the best response of agent i, i.e., the solution to the problem of maximizing $u_i(y_i, \mathbf{y}_{-i}) = (w_i - py_i)^\sigma \varphi(y_i, \mathbf{y}_{-i})^{1-\sigma}$ under the constraint that $y_i \in [0, \frac{w_i}{p}]$. Note that u_i is continuous, and hence admits a maximum on the compact interval $[0, \frac{w_i}{p}]$. Further, we show that $ln(u_i)$ is strictly concave on this interval's interior, and hence u_i admits a unique maximum. Let $a^- = \frac{\alpha^-}{1+\alpha^-}$ and $a^+ = \frac{\alpha^+}{1+\alpha^+}$, such that $0 \leq a^+ \leq a^- \leq 1$.

Proposition 1. *The individual best response of agent i in the consumption game is equal to:*

$f_i(\mathbf{y}_{-i}) = \sigma a^+ \bar{y}_i + (1-\sigma)\frac{w_i}{p}$ *if* $\bar{y}_i \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p}$

$f_i(\mathbf{y}_{-i}) = \bar{y}_i$ *if* $\frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p} \leq \bar{y}_i \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}$

$f_i(\mathbf{y}_{-i}) = \sigma a^- \bar{y}_i + (1-\sigma)\frac{w_i}{p}$ *if* $\bar{y}_i \geq \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}$

Proof. We first show that $ln(u_i)$ is strictly concave over $]0, \frac{w_i}{p}[$. When i consumes at least the minimal amount of status good, we have:
$ln(u_i) = \sigma ln(w_i - py_i) + (1-\sigma)ln((1+\alpha^-)y_i - \alpha^-\bar{y}_i)$ if $y_i \leq \bar{y}_i$ and $ln(u_i) = \sigma ln(w_i - py_i) + (1-\sigma)ln((1+\alpha^+)y_i - \alpha^+\bar{y}_i)$ if $y_i \geq \bar{y}_i$. This yields $\frac{\partial ln(u_i)}{\partial y_i} = -\frac{p\sigma}{w_i - py_i} + \frac{(1-\sigma)(1+\alpha^-)}{(1+\alpha^-)y_i - \alpha^-\bar{y}_i}$ if $y_i \leq \bar{y}_i$ and $\frac{\partial ln(u_i)}{\partial y_i} = -\frac{p\sigma}{w_i - py_i} + \frac{(1-\sigma)(1+\alpha^+)}{(1+\alpha^+)y_i - \alpha^+\bar{y}_i}$ if $y_i \geq \bar{y}_i$.

Therefore, $\frac{\partial ln(u_i)}{\partial y_i}$ is continuous and strictly decreasing until y_i reaches $\bar{y}_i$ from the left and then, again, continuous and strictly decreasing when y_i increases from $\bar{y}_i^+$. Moreover, $ln(u_i)$ is left and right differenntiable at $y_i = \bar{y}_i$ and

$$\frac{\partial ln(u_i)}{\partial y_i}(\bar{y}_i^-) = -\frac{p\sigma}{w_i - p\bar{y}_i} + \frac{(1-\sigma)(1+\alpha^-)}{\bar{y}_i} > \frac{\partial ln(u_i)}{\partial y_i}(\bar{y}_i^+) = -\frac{p\sigma}{w_i - p\bar{y}_i} + \frac{(1-\sigma)(1+\alpha^+)}{\bar{y}_i}$$

The left-derivative at $y_i = \bar{y}_i$ is larger than the right-derivative, and hence $ln(u_i)$ is strictly concave.

Since $ln(u_i)$ is a strictly concave function over $]0, \frac{w_i}{p}[$, tends to $-\infty$ at both extremes, and has a kink at $\bar{y}_i$, it has a unique interior maximum and there are two possible cases. Either $\frac{\partial ln(u_i)}{\partial y_i} = 0$ and $y_i \neq \bar{y}_i$. Or $\frac{\partial ln(u_i)}{\partial y_i}(\bar{y}_i^-) \geq 0$ and $\frac{\partial ln(u_i)}{\partial y_i}(\bar{y}_i^+) \leq 0$, and the maximum lies precisely at the kink, $y_i = \bar{y}_i$.

If $y_i < \bar{y}_i$, then $\frac{\partial ln(u_i)}{\partial y_i} = 0 \Rightarrow y_i = \sigma a^- \bar{y}_i + (1-\sigma)\frac{w_i}{p}$. This is a valid solution only if $\sigma a^- \bar{y}_i + (1-\sigma)\frac{w_i}{p} < \bar{y}_i$. If $y_i > \bar{y}_i$, then $\frac{\partial ln(u_i)}{\partial y_i} = 0 \Rightarrow y_i = \sigma a^+ \bar{y}_i + (1-\sigma)\frac{w_i}{p}$. This is a valid

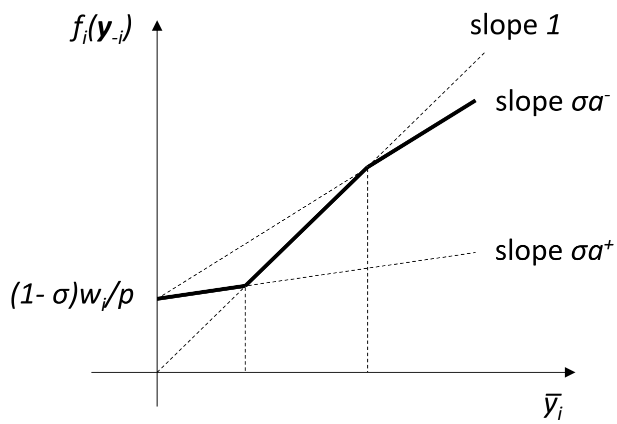


Figure 1: Individual best response under loss aversion

solution only if $\sigma a^+ \bar{y}_i + (1-\sigma)\frac{w_i}{p} > \bar{y}_i$. Otherwise, the maximum lies at the kink $y_i = \bar{y}_i$.

□

We illustrate Proposition 1 in Figure 1. We depict how agent i's consumption of the status good y_i depends on the average consumption among her peers, $\bar{y}_i$. Three domains appear. When the social reference level is low, the agent is in a domain of status gains. Her consumption level is linear in $\bar{y}_i$ with slope $\sigma a^+ < 1$. When the social reference level is high, the agent is in a domain of status losses. Her consumption level is also linear in $\bar{y}_i$ with slope $\sigma a^- < 1$. The slope in the loss domain is higher than in the gain domain due to loss aversion, $a^- > a^+$. Note, also, that these two straight lines have the same intercept, $(1-\sigma)\frac{w_i}{p}$. Crucially, we see the emergence of an intermediate domain, when $\bar{y}_i \in [\frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p}, \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}]$. In this domain, the agent behaves as a pure conformist and sets her consumption level equal to the social reference level, $y_i = \bar{y}_i$. Intuitively, the agent in this domain can avoid social losses, but cannot afford social gains. This conformism domain only appears under loss aversion when $\alpha^- > \alpha^+$ and its size increases when the wedge between social gains and social losses expands.

An important implication of Proposition 1 is that the best response of an agent is strictly increasing over her strategy space. This implies that the consumption game is supermodular.[8]

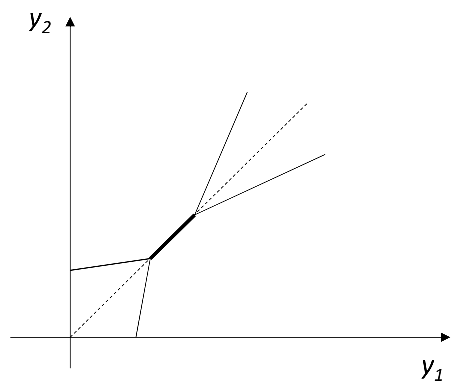
[8]See e.g. Milgrom and Roberts (1990) and Vives (1990) for classical references on supermodular games.

A well-known consequence is that there exist a lowest and a highest Nash equilibrium, $\mathbf{y}^{min}$ and $\mathbf{y}^{max}$, such that for any Nash equilibrium $\mathbf{y}$, $\forall i, y_i^{min} \leq y_i \leq y_i^{max}$. In addition, an increase in w_i leads to a weak increase in the best response of agent i, and hence to a weak increase in the action of every agent in both the lowest and highest Nash equilibrium. We will be using these properties in the proof of our main Theorem below.

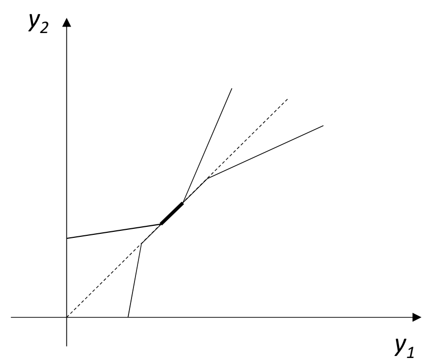
3.2 Nash equilibria

To provide some intuition for our main result, we show how to determine Nash equilibria graphically with two agents. We depict the best responses of the two agents in the same graph and under three scenarios in Figure 2. A profile is a Nash equilibrium iff it lies at the intersection of the two curves. In the upper panel, the two agents have equal incomes, $w_1 = w_2$. We see that there is a continuum of Nash equilibrium, where both agents choose the same level of status good, and this continuum corresponds precisely to the conformist portions of the best-responses. In the middle panel, we assume that agent 2 is now richer than agent 1, $w_2 > w_1$, and that the income difference is not too high. Agent 2's best response is now shifted upwards. We see that there is still a continuum of conformist Nash equilibria, corresponding to the portion of the 45 degree line which is common to both best-responses. In the lower panel, we depict a case where agent 2 is now much richer than agent 1. Agent 2 best response is shifted upwards even further. There is now a unique Nash equilibrium, at the intersection of the domain of status gains for agent 2 and of status losses for agent 1. In this equilibrium, $y_2 > y_1$, the richer agent earns strict status gains while the poorer agent earns strict status losses.

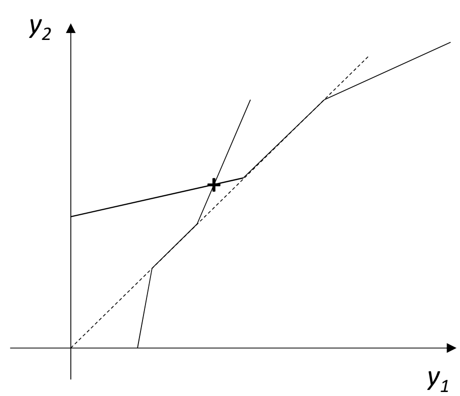
We can now state our main Theorem, which shows that the logic of this example extends to any connected network among n agents. Let w_{min} and w_{max} denote the minimal and maximal wealth levels among agents. A richest agent is an agent with wealth w_{max} while a poorest agent has wealth w_{min}. Say that agent i earns strict satus gains in Nash equilibrium $\mathbf{y}$ when $\bar{y}_i < \frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p}$, and hence by Proposition 1, $y_i = \sigma a^+ \bar{y}_i + (1-\sigma)\frac{w_i}{p} > \bar{y}_i$. She earns status gains if $\bar{y}_i \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p}$, and hence $y_i \geq \bar{y}_i$. Similarly, agent i earns strict status losses when $\bar{y}_i > \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}$ and $y_i = \sigma a^- \bar{y}_i + (1-\sigma)\frac{w_i}{p} < \bar{y}_i$. She earns status losses when $\bar{y}_i \geq \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}$, and $y_i \leq \bar{y}_i$.



(a) Equal incomes



(b) Low income inequality



(c) High income inequality

Figure 2: Nash equilibria with two agents

Theorem 1. *Consider any connected comparison network.*

(Conformism and Indeterminacy) If $\frac{w_{max}}{1-\sigma a^+} \leq \frac{w_{min}}{1-\sigma a^-}$*, then a profile* $\mathbf{y}$ *is a Nash equilibrium if and only if* $\mathbf{y} = (y, y, ..., y)$ *with* $y \in [\frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}, \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}]$.

(Differences and Uniqueness) If $\frac{w_{max}}{1-\sigma a^+} > \frac{w_{min}}{1-\sigma a^-}$*, then there is a unique Nash equilibrium* $\mathbf{y}$ *and* $\forall i, \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p} \leq y_i \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}$*. Richest agents earns strict status gains while poorest agents earn strict status losses.*

Proof. (1) Assume first that $\frac{w_{max}}{1-\sigma a^+} \leq \frac{w_{min}}{1-\sigma a^-}$.

(1.1) Consider a profile $\mathbf{y} = (y, y, ..., y)$ where everyone plays the same action and $y \in [\frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}, \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}]$. For every i, $\bar{y}_i = y$. By Proposition 1, playing $y_i = y = \bar{y}_i$ is a best response when $\frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p} \leq y \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}$. These inequalities hold since

$$\frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p} \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p} \leq y \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p} \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}$$

This shows that the conformist profiles described in the first part of the Theorem are indeed Nash equilibria.

(1.2) Let us show that these are the only Nash equilibria in this domain. Recall, $\mathbf{y}^{min}$ and $\mathbf{y}^{max}$ denote the lowest and highest Nash equilibria of the game. By (1.1) we know that $\forall i, y_i^{min} \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}$. This implies that $\bar{y}_i^{min} \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}$. Since by assumption $\frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p} \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$, we have $\bar{y}_i^{min} \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}$. By Proposition 1, this implies that no agent is in the domain of strict social losses and hence $\forall i, y_i^{min} \geq \bar{y}_i^{min}$. We can then invoke the following elementary graph-theoretic property. Consider a directed, connected network such that $\forall i, y_i \geq \bar{y}_i$. Then $\forall i, y_i = y$.

To see why, let i_0 be an agent with lowest value of y_i. By assumption, $y_{i_0} \geq \bar{y}_{i_0}$. However, $\bar{y}_{i_0} = \frac{\sum_{j \in N_{i_0}} y_j}{|N_{i_0}|}$ and since $y_j \geq y_{i_0}$, $\bar{y}_{i_0} \geq y_{i_0}$. Therefore, $y_j = y_{i_0}$, for every $j \in N_{i_0}$. Apply the same argument to the neighbors of the neighbors of i_0. Then, repeat until the whole network is covered, which is possible since the network is connected.

Therefore, everyone must play the same action in the lowest equilibrium. By (1.1), this implies that $y_i^{min} = \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}$. Similarly, since $\mathbf{y}^{max}$ is the highest Nash equilibrium, $\forall i, y_i^{max} \geq \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$. This implies that $\bar{y}_i^{max} \geq \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$, and hence $\bar{y}_i^{max} \geq \frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p}$. By Proposition 1, no agent is in the domain of strict social gains and $\forall i, y_i^{max} \leq \bar{y}_i^{max}$. Since the network is connected, all agents also play the same action in the largest equilibrium and $y_i^{max} = \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$.

To conclude, note that any other Nash equilibrium $\mathbf{y}$ must satisfy $y_i^{min} \leq y_i \leq y_i^{max}$. This implies that $\frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p} \leq y_i \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$ and hence $\frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p} \leq y_i \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}$. By Proposition 1, every agent is then in the conformist range: $y_i = \bar{y}_i$, implying that everyone plays the same action.

(2) Assume now that $\frac{w_{max}}{1-\sigma a^+} > \frac{w_{min}}{1-\sigma a^-}$ and let $S = \{\mathbf{y} : \forall i, \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p} \leq y_i \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}\}$.

(2.1). Let us first show that all Nash equilibria belong to S and, moreover, that $\mathbf{f}(S) \subset S$. Consider a decrease in incomes $\mathbf{w}'$ such that $\frac{w'_{max}}{1-\sigma a^+} = \frac{w_{min}}{1-\sigma a^-}$ and $w'_{min} = w_{min}$. From the first part of the Theorem, we know that at incomes $\mathbf{w}'$, there is a unique Nash equilibrium where every agent plays $y = \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$. Since the lowest equilibrium decreases weakly when incomes decrease, this implies that $\forall i, y_i^{min} \geq \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$. In particular if i is a poorest agent, $\bar{y}_i^{min} \geq \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}$ and i earns status losses.

Similarly, consider an increase in incomes $\mathbf{w}''$ such that $\frac{w''_{min}}{1-\sigma a^-} = \frac{w_{max}}{1-\sigma a^+}$ and $w''_{max} = w_{max}$. At incomes $\mathbf{w}''$, there is a unique Nash equilibrium where all agents play $y = \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}$. Since the highest equilibrium increases weakly following an increase in incomes, this implies that $\forall i, y_i^{max} \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}$. If i is a richest agent, $\bar{y}_i^{max} \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p}$ and i earns status gains.

Therefore, for any Nash equilibrum $\mathbf{y}$, $\frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p} \leq y_i^{min} \leq y_i \leq y_i^{max} \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}$. Any Nash equilibrium thus belongs to S.

Next, consider $\mathbf{y} \in S$. We have: $\frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p} \leq y_i \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}$. Therefore, since i's best response is increasing, $f_i(\frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}) \leq f_i(y_i) \leq f_i(\frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p})$. Since $\frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p} \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}$, $\frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$ lies in the domain where f_i lies weakly above the 45 degree line. Therefore, $f_i(\frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}) \geq \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$. Similarly, since $\frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p} \geq \frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p}$, $\frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}$ lies in the domain where f_i lies weakly below the 45 degree line and hence $f_i(\frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}) \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}$. This implies that $\frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p} \leq f_i(y_i) \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p}$, and hence $f_i(\mathbf{y}) \in S$.

(2.2) We now show that the overall best response $\mathbf{f}$ is contracting over S. Let i_0 be a richest agent, $w_{i_0} = w_{max}$, and j_0 be a poorest agent, $w_{j_0} = w_{min}$. For any $\mathbf{y} \in S$, $\bar{y}_{i_0} \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p} = \frac{1-\sigma}{1-\sigma a^+}\frac{w_{i_0}}{p}$. By Proposition 1, this implies that $f_{i_0}(\mathbf{y}) = \sigma a^+ \bar{y}_{i_0} + (1-\sigma)\frac{w_{i_0}}{p}$. Similarly, $\bar{y}_{j_0} \geq \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p} = \frac{1-\sigma}{1-\sigma a^-}\frac{w_{j_0}}{p}$ and hence $f_{j_0}(\mathbf{y}) = \sigma a^- \bar{y}_{j_0} + (1-\sigma)\frac{w_{j_0}}{p}$.

Next, observe that for any i, $\mathbf{y}$, $\mathbf{y}'$, $|f_i(\mathbf{y}) - f_i(\mathbf{y}')| \leq |\bar{y}_i - \bar{y}'_i|$. This holds by Proposition

1 when $\bar{y}_i$ and $\bar{y}'_i$ belong to the same domain. In these cases, f_i is a linear function of $\bar{y}_i$ with slope lower than or equal to 1. This also holds when $\bar{y}_i$ and $\bar{y}'_i$ belong to different domains. For instance, if $\bar{y}_i \leq \frac{1-\sigma}{1-\sigma a^+}\frac{w_i}{p}$ and $\bar{y}'_i \geq \frac{1-\sigma}{1-\sigma a^-}\frac{w_i}{p}$, then $f_i(\mathbf{y}) \geq \bar{y}_i$ while $f_i(\mathbf{y}') \leq \bar{y}'_i$. Thus, $0 \leq f_i(\mathbf{y}') - f_i(\mathbf{y}) \leq \bar{y}'_i - \bar{y}_i$.

Introduce h the linear function that $h_i(\mathbf{y}) = \bar{y}_i$ if $i \neq i_0, j_0$, $h_i(\mathbf{y}) = \sigma a^+ \bar{y}_i$ if $i = i_0$ and $h_i(\mathbf{y}) = \sigma a^- \bar{y}_i$ if $i = j_0$. This function is represented by the matrix $\mathbf{H}$ built from $\mathbf{G}$ by multiplying row i_0 by $\sigma a^+ < 1$, row j_0 by $\sigma a^- < 1$ and leaving other rows unchanged. Since $\mathbf{G}$ is row-normalized with non-negative entries, the spectral radius of $\mathbf{G}$ is 1. From Corollary 2.6 in Azimzadeh (2019), we know that the spectral radius of $\mathbf{H}$ is strictly lower than 1 if and only if there is a walk connecting every $i \neq i_0, j_0$ to i_0 or to j_0. Since the network is connected, this property holds.

Finally, let $||.||_2$ denote the Euclidean norm. Then, for any $\mathbf{y}, \mathbf{y}' \in S$,

$$||f(\mathbf{y}) - f(\mathbf{y}')||_2^2 = (f_{i_0}(\mathbf{y}) - f_{i_0}(\mathbf{y}'))^2 + (f_{j_0}(\mathbf{y}) - f_{j_0}(\mathbf{y}'))^2 + \sum_{i \neq i_0, j_0} (f_i(\mathbf{y}) - f_i(\mathbf{y}'))^2$$

$$||f(\mathbf{y}) - f(\mathbf{y}')||_2^2 \leq (\sigma a^+(\bar{y}_{i_0} - \bar{y}'_{i_0}))^2 + (\sigma a^-(\bar{y}_{j_0} - \bar{y}'_{j_0}))^2 + \sum_{i \neq i_0, j_0} (\bar{y}_i - \bar{y}'_i)^2$$

$$||f(\mathbf{y}) - f(\mathbf{y}')||_2^2 \leq ||h(\mathbf{y}) - h(\mathbf{y}')||_2^2 \leq \rho(H)||\mathbf{y} - \mathbf{y}'||_2^2$$

Therefore, the best response f is contracting with respect to the Euclidean norm on S, and hence has a unique fixed point.

(2.3) Finally, let us show that status losses (gains) earned by poorest (richest) agents are strict. Let i be a poorest agent, $w_i = w_{min}$. Suppose that i's status losses are not strict, $y_i = \bar{y}_i = \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$. Since $\bar{y}_i = \frac{\sum_{j \in N_i} y_j}{|N_i|}$ and $y_j \geq \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$, $y_j = \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$ for every $j \in N_i$. Therefore, $y_j \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_j}{p}$ and hence by Proposition 1, $y_j \geq \bar{y}_j$. Thus, $\bar{y}_j \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$ and hence for every $k \in N_j$, $y_k = \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$. Repeating the argument and since the network is connected, $\forall k, y_k = \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$. By (1.1), $\frac{1-\sigma}{1-\sigma a^+}\frac{w_{max}}{p} \leq \frac{1-\sigma}{1-\sigma a^-}\frac{w_{min}}{p}$, a contradiction. Therefore, poorest agents earn strict status losses and, through similar arguments, richest agents earn strict status gains.

□

Theorem 1 uncovers the existence of a conformism domain, where all agents consume the same level of status good even when they have different incomes. Interestingly, conformism emerges even though agents do not have a direct preference for conformism. Rather, they display loss aversion with respect to the social reference level. In other words, agents have an extra incentive not to fall below the reference level. Theorem 1 shows that the interplay of loss averse social comparisons over a connected network yields full conformism in status good consumption when income heterogeneity is not too high.

How does consumption varies with incomes across agents? In the absence of social comparison, when $\alpha^- = \alpha^+ = 0$, consumption of the status good varies linearly with income with slope $(1-\sigma)/p$ while consumption of the standard good varies linearly with income with slope σ. In the conformism domain, consumption of the status good does not depend on income. By contrast and since $x_i = w_i - py_i$, consumption of the standard good varies linearly with income across agents and with slope 1. An income difference between two agents is passed on one-to-one into a difference in the consumption of the standard good. Thus, conformism on the consumption of the status good is associated with excess variation with income on the consumption of the standard good.

A continuum of conformist Nash equilibria appears when $\frac{w_{max}}{1-\sigma a^+} < \frac{w_{min}}{1-\sigma a^-}$. This key condition is always satisfied under loss aversion and income homogeneity, when $w_{max} = w_{min}$. This implies, in particular, that under income homogeneity, equilibrium uniqueness is non-generic in the parameter space. Even an arbitrarily small departure from no loss aversion $\alpha^- = \alpha^+$ leads to a continuum of equilibria, and this holds even when the interaction parameters α^- and α^+ are arbitrarily small.[9] For a given magnitude of loss aversion, this condition is satisfied when income heterogeneity, as measured by the ratio of the highest to lowest income, is not too high. Formally, $\frac{w_{max}}{w_{min}} < \frac{1-\sigma a^+}{1-\sigma a^-}$. Conversely, for a given level of income heterogeneity, a continuum of conformist equilibria appears when loss aversion is large enough. Formally, $a^- - a^+ > \frac{w_{max}-w_{min}}{w_{max}}(\frac{1}{\sigma} - a^+)$.

By contrast when $\frac{w_{max}}{1-\sigma a^+} > \frac{w_{min}}{1-\sigma a^-}$, the consumption game has a unique Nash equilibrium where agents do not all consume the same level of status good. This holds when incomes

[9]The length of the interval of possible equilibrium values converges towards zero when $\alpha^- - \alpha^+$ converges to zero.

are heterogeneous, $w_{max} > w_{min}$, and when loss aversion is absent (as in Ghiglino and Goyal (2010)) or small enough. In this domain, whether an agent earns status gains or status losses generally depends on incomes and on agents' positions in the comparison network. For a given income profile $\mathbf{w}$, if $w_{min} < w_i < w_{max}$ there exist networks where i earns status gains and others where i earns status losses.[10] Thus in the uniqueness domain, the relative position with respect to the reference level is independent on the network only for poorest and richest agents. Note that conditional on which agent lies in which domain, consumption levels in equilibrium solve a linear system of equations. While there is no simple explicit formula to determine which agent lies in which domain, we can leverage algorithmic results from the literature on supermodular games to compute the Nash equilibrium. We know, in particular, that a process of synchronous, iterated best responses starting at $\mathbf{y} = \mathbf{0}$ converges quickly, and via an increasing sequence, to the unique Nash equilibrium.

We can also leverage standard results of comparative statics for supermodulare games. Note that the whole best response of agent i increases weakly following an increase in w_i, α^-, α^+ or a decrease in p. Therefore, the actions of all agents in the lowest and in the highest Nash equilibrium also increase weakly following an increase in w_i, α^-, α^+ or a decrease in p.

Corollary 1. *Let $\hat{\mathbf{w}} \geq \mathbf{w}$, $\hat{\alpha}^- \geq \alpha^-$, $\hat{\alpha}^+ \geq \alpha^+$ and $\hat{p} \leq p$. Assume $\frac{\hat{w}_{max}}{1-\sigma\hat{a}^+} > \frac{\hat{w}_{min}}{1-\sigma\hat{a}^-}$ and $\frac{w_{max}}{1-\sigma a^+} > \frac{w_{min}}{1-\sigma a^-}$. The consumption game has a unique Nash equilibrium $\hat{\mathbf{y}}$ for parameters $\hat{\mathbf{w}}$, $\hat{\alpha}^-$, $\hat{\alpha}^+$, $\hat{p}$ and $\mathbf{y}$ for parameters $\mathbf{w}$, α^-, α^+, p, and $\forall i, \hat{y}_i \geq y_i$.*

In the uniqueness domain, all agents weakly increase their consumption of the status good when agents' incomes increase, interaction parameters increase, or the relative price of the status good decreases.

4 Extensions

4.1 Heterogeneity

In our benchmark analysis, agents may only differ in their income levels. We now show that our main result extends to a setup where agents may also differ in how much they care about

[10] Agent i earns status gains when she compares herself to poorest agents and status losses when she compares herself to richest agents.

status and in their level of loss aversion. Formally, assume that agent i has individual specific interaction parameters α_i^-, α_i^+ with $0 \leq \alpha_i^+ \leq \alpha_i^-$ and $w_i \geq \frac{\alpha_i^-}{1+\alpha_i^-}\bar{w}_i$. Let $a_i^- = \frac{\alpha_i^-}{1+\alpha_i^-}$ and $a_i^+ = \frac{\alpha_i^+}{1+\alpha_i^+}$ and introduce

$$\omega_{max}^+ = \max_i \frac{w_i}{1-\sigma a_i^+} \text{ and } \omega_{min}^- = \min_i \frac{w_i}{1-\sigma a_i^-}$$

Theorem 1 then extends as follows.[11]

Theorem 2. *Consider any connected comparison network and heterogeneous interaction parameters. If $\omega_{max}^+ \leq \omega_{min}^-$, then a profile $\mathbf{y}$ is a Nash equilibrium if and only if $\mathbf{y} = (y, y, ..., y)$ with $y \in [\omega_{max}^+, \omega_{min}^-]$. If $\omega_{max}^+ > \omega_{min}^-$, then there is a unique Nash equilibrium $\mathbf{y}$ such that $\forall i, \omega_{min}^- \leq y_i \leq \omega_{max}^+$ and not all agents play the same action.*

Theorem 2 shows that the emergence of two mutually exclusive domains - one with a continuum of conformist equilibria and another one with a unique equilibrium with different actions - is robust to the introduction of heterogeneity in status concerns and loss aversion. This heterogeneity affects the equilibria and tends to reduce the emergence of conformism. For instance under homogeneous incomes, the key condition $\omega_{max}^+ \leq \omega_{min}^-$ is equivalent to $\alpha_{max}^+ \leq \alpha_{min}^-$ with $\alpha_{max}^+ = \max_i \alpha_i^+$ and $\alpha_{min}^- = \min_i \alpha_i^-$. A continuum of conformist equilibria then appears when the heterogeneity in interaction parameters is not too high.

This setup notably covers the specifications of peer effects in Ghiglino and Goyal (2010) where the strength of interaction depends on the number of neighbors, through increasing function $S(.)$. In that case, $\alpha_i^- = S(|N_i|)\alpha^-$ and $\alpha_i^+ = S(|N_i|)\alpha^+$, and a continuum of conformist equilibria appears when the dispersion in degrees and in incomes is not too high.

4.2 Utility functions

Our benchmark analysis relies on the assumption that agents have Cobb-Douglas utility. Providing a full-fledged analysis of the consumption game under status concerns and loss aversion and for arbitrary networks and utility functions is an interesting - and challenging - direction of future research. We present some preliminary results here and conditions under which the emergence of a continuum of conformist equilibria is guaranteed.

[11] The proof of Theorem 2 follows the same steps as the proof of Theorem 1, we omit it for brevity.

Consider some utility function $u(x, y)$, increasing and quasi-concave in both arguments. Denote by $x(p, w)$ and $y(p, w)$ the usual Walrasian demands in the absence of relative comparisons, i.e., the solutions to the consumer problem $\max_{x,y\geq 0} u(x, y)$ under $x+py \leq w$. With status concerns, assume that agent i seeks to maximize $u(x_i, \varphi(y_i, \mathbf{y}_{-i}))$ under the budget constraint $x_i + py_i \leq w_i$. An important first step of the analysis is to determine an agent's best response under status concerns but without loss aversion, i.e., when $\alpha^- = \alpha^+ = \alpha$. In that case, the best reponse $f_i(\mathbf{y}_{-i}, \alpha)$ is equal to[12]

$$f_i(\mathbf{y}_{-i}, \alpha) = \frac{1}{1+\alpha} y(\frac{p}{1+\alpha}, w_i - \frac{p\alpha}{1+\alpha}\bar{y}_i) + \frac{\alpha}{1+\alpha}\bar{y}_i$$

and hence crucially depends on properties of the Walrasian demand. For instance, the best response is linear in $\bar{y}_i$ iff the Walrasian demand is linear in income, which covers both the Cobb-Douglas and CES cases.

In general, the best response without loss aversion may be non-linear, in which case the best response with loss aversion is not piecewise linear. However, the best response under loss aversion can still have an intermediate range with pure conformist behavior. This notably happens when f_i is increasing in $\bar{y}_i$ and in α and, for a given α, crosses the 45 degree line only once from above. We illustrate a situation where f_i is concave in $\bar{y}_i$ in Figure 3. As in Proposition 1, the best response under loss aversion is continuous, increasing and formed of three pieces. It is first equal to $f_i(., \alpha^+)$ until it crosses the 45 degree line; it is then equal to the 45 degree line until $f_i(., \alpha^-)$ crosses it, above which it is equal to $f_i(., \alpha^-)$. Therefore, even with general utility functions the kink induced by loss aversion may lead agents to act as pure conformists.

[12]To see why, express the budget constraint as a function of x_i and $\varphi = (1 + \alpha)y_i - \alpha\bar{y}_i$.

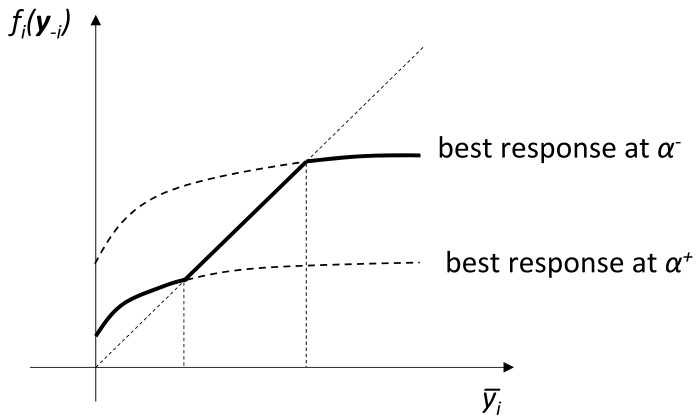


Figure 3: Non linear best response with loss aversion

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