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Visibility Bias in the Transmission of Consumption Norms and Undersaving

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We study the spread of social norms for time preferences, and the effect of the transmission process on equilibrium consumption and interest rates. In the model, consumption is more salient than non-consumption. Owing to visibility bias and the availability heuristic, people infer that low saving is normative and increase their own discount rates accordingly. This effect is self-reinforcing at the societal level, resulting in overconsumption and high interest rates. In contrast with Veblen effects, which imply greater overconsumption when there is greater information asymmetry about the wealth of others (as occurs when wealth dispersion is high), in our setting greater information asymmetry dilutes the inference from high observed consumption that the discount rate of others is high. In consequence, equilibrium consumption is *lower*, the opposite prediction.

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1 Introduction

People are heavily influenced by those around them, and their cultural milieu, in acquiring attitudes of all sorts, including those pertaining to economic decisions. This applies, for example, to time preference. Rather than knowing perfectly their own preferences, people seem to 'grasp at straws' in making major savings decisions. The difficulty that people have in deciding how heavily to discount the future was emphasized by Akerlof and Shiller (2009). Allen and Carroll (2001) point out that "...the consumer cannot directly perceive the value function associated with a given consumption rule, but instead must evaluate the consumption rule by living with it for long enough to get a good idea of its performance. ... it takes a very large amount of experience ... to get an accurate sense of how good or bad that rule is."[1]

The phenomenon of 'grasping at straws' seems to apply to investment decisions more generally. Investors are very heavily influenced by default choices in various features of their retirement investment decisions (the status quo bias; Samuelson and Zeckhauser (1988), Madrian and Shea (2001), Beshears et al. (2008)). Furthermore, small shifts in cues have substantial affects on retirement savings (Choi et al. (2013)), and simplified presentation of savings options have very large effects on the amount invested (Beshears et al. (2012)). Another indication that people do not have a good sense of how much they want to discount the future is that economically meaningless mental accounts affect their willingness to consume out of their investment portfolio (**?**)).

Evidence of low financial literacy of individual investors around the world (Lusardi and Mitchell (2011), van Rooij, Lusardi, and Alessie (2011)) suggests that investors may perceive that they can gain useful insight by observing the behaviors of those around them. Individual investment decisions are influenced by social interactions with other non-experts (see the evidence reviewed in Hirshleifer and Teoh (2009)). These include the decisions of how much to contribute to retirement plans (Duflo and Saez (2002, 2003)), market participation (Hong, Kubik, and Stein (2004), Brown, Ivkovich, Smith, and Weisbenner (2008), Kaustia and Knüpfer (2012)), and the decisions of households of whether to borrow for consumer and other loans (Georgarakos, Haliassos, and Pasini (2013)). Similarly, there is social influence in consumption decisions such as car purchases (Grinblatt, Keloharju, and Ikäheimo (2008), Kuhn et al. (2011), **?**), and Shemesh and Zapatero (2011)).

[1] They go on to argue: "The question of how consumers come by their consumption rules therefore remains. Perhaps the most plausible answer involves 'social learning': rather than relying solely on their own (insufficient) experience, people observe the experiences of others and can learn from such observation and direct social communication." Their point applies to social influence more broadly.

So on both conceptual and empirical grounds, it is important to understand how social interaction affects the consumption/saving decision. But surprisingly, there has been very little formal modeling of how social processes determine equilibrium levels of time preference in society.[2]

In our model, social influence on this decision is biased by the fact that consumption is more salient than non-consumption. For example, it is more noticeable if a neighbor has a boat parked in his driveway than if not. Similarly, it is comparatively noticeable and memorable when friends and acquaintances wear designer apparel or report taking expensive trips. We call this effect of differential salience on attention *visibility bias*.

In the availability heuristic (Kahneman and Tversky (1973)), people estimate population frequencies based on ease of mentally retrieving examples. Visibility bias makes consumption more available than non-consumption for later retrieval and cognitive processing. In consequence, people infer high consumption and low savings rates by others, and conclude that a high discount rate is normative. Observers therefore increase their own subjective discount rates accordingly, which increases actual consumption.

Frederick (2012) provides field evidence of the high salience of consumption, and for resulting overestimation by observers of how much other individuals value certain consumer products. With respect to salience, Frederick concludes that "purchasing and consumption are more conspicuous than forbearance and thrift." He explains the difference in salience between consumption and non-consumption in the context of two well-known consumer products: "Customers in the queue at Starbucks are more visible than those hidden away in their offices unwilling to spend $4 on coffee. We are repeatedly exposed to commercials of people enthusiastically gulping soda and gyrating to their iPods, but the large segment of nonusers is not so memorably depicted."

At the social level, overestimation of the consumption of others is self-reinforcing, as each individual becomes an overconsuming model for others. So in our model, misperceptions of consumption norms can result in severe undersaving in society as a whole. A corollary of this reluctance of individuals to save is a higher equilibrium interest rate.

There are notable cultural differences in savings rates (e.g., Statman and Weng (2010)) across countries and ethnic groups. An implication of the visibility bias approach to time preference is that relatively modest differences in inherent discount rates can be amplified through social influence. This can help explain the extremity of cross-cultural differences.

The reasoning we have described suggests that advertising and media biases can further

[2] As Allen and Carroll (2001) remark "...there has been remarkably little work on the role of learning in the realm of intertemporal choice problems ... [such as] consumption/saving and investment decisions."

reinforce overconsumption. Advertisers have an incentive to depict consumers using their products heavily (as implicitly alluded to in the quotation from Frederick above). News media serve their clientele by highlighting interesting consumption of high-end products or of consumption events (consider, e.g., the "Travel" section of newspapers). These further contribute to the higher visibility of consumption than nonconsumption.

A plausible alternative theory of overconsumption and undersaving is that people are present-biased (i.e., subject to hyperbolic discounting, Laibson (1997)). Such effects can be empirically identified by documenting inconsistencies in consumption plans or decisions over time. In contrast, in our approach there need not be any time inconsistency in savings and consumption decisions. More importantly, hyperbolic discounting is an individual-level bias, whereas the visibility bias approach is based upon social observation and/or interaction. The visibility bias approach therefore has the distinctive implications that the intensity of social interactions, shifts in the technology for observing the consumption of others, and wealth dispersion affect the extent of overconsumption.

Another appealing approach to overconsumption is based on Veblen effects (Cole, Mailath, and Postlewaite (1995), Bagwell and Bernheim (1996), Corneo and Jeanne (1997), Charles, Hurst, and Roussanov (2009)), wherein people overconsume to signal high wealth to others. The visibility approach has distinct implications. For example, if all wealths were equal, Veblen effects would be eliminated, but the effects in our approach still apply. So in a visibility bias approach we expect to see overconsumption even within peer groups with low wealth inequality.

More generally, an intuitive implication of the Veblen approach is that the incentive to signal is stronger when observers face greater information asymmetry about the wealth of others, as occurs with high wealth dispersion.[3] In contrast, in the visibility bias approach,

[3] A compatible intuition is that when dispersion increases, the lower support of the wealth distribution decreases, so the signalling schedule needs to start increasing from an earlier start (a lower wealth level). As a result, for any given wealth level the signaling schedule will tend to be higher. In their Veblen-style model Charles, Hurst, and Roussanov (2009) show that an increase in the dispersion of the wealth distribution that derives from a reduction in the lower support (making the poorest poorer) causes greater conspicuous consumption. Their explanation is essentially the same: "The intuition is that as poorer people are added to a population, persons of every level of income must now signal more to distinguish themselves from those immediately poorer, because those people are themselves now compelled to spend more to distinguish themselves from persons who are even poorer still." However, Charles, Hurst, and Roussanov (2009) further show that the effect of a more general increase in wealth dispersion is theoretically ambiguous. Their model involves complexities that go beyond the basic intuition here, as it includes a non-observable as well as an observable consumption good; the ambiguity in their setting derives from the effect of curvature in conspicuous consumption as a function of wealth. However, what is inescapable in a wide range of Veblen-style models is that when wealth dispersion is zero, wealth-signaling through consumption vanishes. So such models reflect a general tendency for greater wealth dispersion to induce

greater information asymmetry dilutes the inference that can be drawn from (perceived) high consumption of others that their discount rates are high. In consequence, under high information asymmetry about wealth, equilibrium consumption is lower, the opposite of the Veblen-style prediction. The distinctive implications of the visibility bias theory are as yet untested.

2 Basic Model: Pure Exchange, No Uncertainty

We first consider the effects of visibility bias in learning about the consumption of others in a pure exchange setting with no uncertainty. Each individual consumes at two dates. In the basic model, there is no uncertainty in income and no risky asset, and no production. We start by assuming that the riskfree interest rate is exogenous.

2.1 Optimal consumption of individuals

Consider a two-date consumption problem. At date 0, the individual consumes, and borrows or lends at the riskfree interest rate r. Each individual i solves

$$\max_{c_{i0},c_{i1}} U(c_{i0}) + \delta_i U(c_{i1})$$

subject to the intertemporal budget constraint

$$c_{i0} + \frac{c_{i1}}{1+r} = y_{i0} + \frac{y_{i1}}{1+r}, \tag{1}$$

where the y_i's are endowed levels of the consumption good at the two dates.[4] The first order condition is

$$u'(c_{i0}) = \delta_i(1+r)u'(c_{i1}). \tag{2}$$

For most of the paper we assume logarithmic utility, $U(c) = \log(c)$. Then optimal consumptions c_{i0} and c_{i1} satisfy

$$\frac{c_{i1}}{c_{i0}} = \delta_i(1+r). \tag{3}$$

Define wealth as

$$W_i = y_{i0} + \frac{y_{i1}}{1+r}.$$

greater overconsumption, though not necessarily monotonically.

[4]The subjective discount factor δ_i should be distinguished from the subjective discount rate, which can be defined as $(1/\delta_i) - 1$. It is more common to refer to discount rates than discount factors in intuitive discussions; we do so at several points in the paper.

Combining (3) with the budget constraint (1) gives the individual's optimal consumption

$$c_{i0} = \frac{W_i}{1+\delta_i}. \tag{4}$$

So current consumption depends upon the subjectively discounted value of lifetime income.

In the rest of this section, our focus is on the determination of date 0 consumption c_{i0}. For ease of notation, we omit the time subscript 0.

2.2 Visibility bias in learning about others' consumption

Suppose that there are N potential publicly observable consumption activities. Let the consumption intensity c be the propensity to consume each of the N available activities, where the probability that he undertakes any given activity is increasing in c. Each activity costs $K = \kappa/N$, $\kappa > 0$. For any given activity, the probability that it is selected is $p(c) = c/\kappa$, where $0 \leq c \leq \kappa$. (Having a different multiplied constant here would not qualitatively affect the results.) So the total expected consumption expenditure is

$$Np(c)K = \frac{Nc\kappa}{N\kappa} = c, \tag{5}$$

As N become large, the expenditure on consumption is close to its expectation c almost surely. We therefore refer to c henceforth as 'consumption' rather than 'consumption intensity.'

An observer draws a sample of these potential activities and observes whether the individual did or did not undertake each. Crucially, he draws inferences based upon a biased sample, owing to what we call *visibility bias*. Under visibility bias, people are more likely to notice and recall events that are vivid and salient. Visibility bias combines with the availability heuristic of Kahneman and Tversky (1973) to cause people to overestimate the frequency of activities in which consumption occurred.

According to the availability heuristic, people overestimate the frequency of events that come to mind more easily, such as events that are highly memorable and salient. We assume that engaging in a consumption activity tends to be more salient to others than the event of not engaging in that activity. This leads to overestimation by observers of the consumption of others.

Many consumption activities are social, such as eating at restaurants, wearing stylish clothing to work or parties, and travelling. Furthermore, physical shopping for consumption goods is itself a social activity (although electronic shopping is not always so) and an engaging topic of conversation. In contrast, saving is often a private activity between an individual and his banker or broker. There are exceptions of course (investment clubs), but overall, consumption tends to be more socially salient than saving.

Henceforth, for brevity we refer to the observer as observing a biased sample of target activities. However, the algebra of the updating process in our model can equally be interpreted as deriving from a setting in which observers draw unbiased random samples of observations, but where there is a bias in the ability to retrieve different observations for cognitive processing and the formation of beliefs.

In the model, each observer randomly selects an individual from the population and observes a sample of the target's consumption activities, with a bias toward activities in which consumption did occur. (In the basic model, we will assume identical individuals, so that it would make no difference if an individual were to observe a sample from several targets.) The probability that the observer samples any given potential activity is q^H if the individual did undertake the consumption activity and q^L, if the individual did not, where $q^H > q^L$. The observer does not compensate for this selection bias.[5] Letting $f(c)$ be the fraction of the activities sampled by the observer in which consumption occurs, the expected fraction is therefore

$$E[f(c)] = \frac{p(c)q^H}{p(c)q^H + [1 - p(c)]q^L} > p(c). \tag{6}$$

In other words, visibility bias causes the observer to overestimate the fraction of the time that the target engages in consumption activity. As the number of activities observed $N \to \infty$, $E[f(c)] = f(c)$, so that the fraction of activities sampled in which consumption occurs, as given by (6), is nonstochastic.

The observer therefore inverts and infers the individual's consumption from this fraction.

[5]The availability heuristic can be viewed as a failure to adjust for the selection bias in information brought to attention–information that is stored into memory or easy to retrieve from it. In this case, this is information about consumption activities engaged in rather than not engaged in. There is evidence from both psychology, experimental economics, and field studies that observers do not fully discount for data selection biases, a phenomenon called selection neglect (see, e.g., Nisbett and Ross (1980) and Brenner, Koehler, and Tversky (1996)). People often naively accept sample data at face value (Fiedler (2008)). Koehler and Mercer (2009) find that mutual fund families advertise their better-performing funds, and find experimentally that both novice investors and financial professionals suffer from selection neglect. Auction bidders in economic experiments tend to suffer from a winner's curse (neglect of the selection bias inherent in winning), and hence tend to lose money on average (Parlour, Prasnikar, and Rajan (2007)). Selection neglect is not surprising given the need to process information quickly, and since adjusting for selection bias requires cognitive effort. Selection bias is especially hard for people to correct for because adjustment requires attending to the *non-occurrences* that shape a sample. Non-occurrences are less salient and are harder to process than occurrences (see, e.g., Neisser (1963), Healy (1981), and the review of Hearst (1991)).

When the true consumption of others is c, the inferred consumption is

$$\hat{c} = h(c) \equiv p^{-1}(f(c)) = \frac{cq^H \kappa}{cq^H + (\kappa - c)q^L} > c. \tag{7}$$

So owing to visibility bias, individuals overestimate their neighbors' consumption levels.

2.3 Updating Discount Rates Based upon Observation of Others

Let $\hat{c_{\bar{i}}}$ denote individual i's inference about the level of other individuals' consumptions. Suppose that all individuals have the same wealth, $W_i = W$ for all i. Then by (4), the time preference parameter $\hat{\delta}_{\bar{i}}$ inferred by observing consumption activities satisfies

$$\hat{c_{\bar{i}}} = \frac{W}{1 + \hat{\delta}_{\bar{i}}},$$

so

$$\hat{\delta}_{\bar{i}} = \frac{W}{\hat{c_{\bar{i}}}} - 1. \tag{8}$$

Let δ be the common *inherent* time preference parameter for all individuals. We do not impose the 'rational expectations' condition that individuals understand that others have the same inherent time preference. Indeed, when thinking about others, the individual does not draw inferences about inherent time preference, he simply updates based upon what he infers about their actual time preference. Such simplified reasoning by observers is broadly consistent with various models and experimental studies of limited cognition in economic settings (e.g., Hirshleifer and Teoh (2003), Camerer, Ho, and Chong (2004) and Eyster and Rabin (2005)).

After learning about others' consumption and time preference, the individual updates his own time preference parameter to δ_i by taking a weighted average of his inherent time preference, δ, and the inferred time preference of others, $\hat{\delta}_{\bar{i}}$:

$$\delta_i = g(\hat{\delta}_{\bar{i}}) \equiv (1 - \gamma)\delta + \gamma\hat{\delta}_{\bar{i}}, \tag{9}$$

where $0 \leq \gamma < 1$, and where γ depends on the degree of social interactiveness/observability.

This updating rule is based on the idea that when an individual believes that others are consuming a lot, he infers that consuming a lot is a good idea. This inference could be moralistic, i.e., learning about whether being a good person demands providing for the future (as with Aesop's fable of the ant and the grasshopper). Alternatively, the individual may simply be trying, from a hedonic perspective, to gain information from others about how much he will enjoy consumption now versus in the future. This in turn could involve implicitly learning from others how long one is likely to live, how one's needs will change in retirement, and so forth.

The updating rule (9), together with (4), implies that individual i's current consumption is

$$c_i = \frac{W}{1 + g(\hat{\delta}_{\bar{i}})}. \tag{10}$$

2.4 The Symmetric Equilibrium

Assume all individuals are identical. We seek a symmetric equilbrium, i.e., a fixed point in consumption and discount factor, for given wealth W and model parameters: $0 < \delta < 1$ (endowed discount factor), γ (weight on the inferred discount factor of others); and r riskfree rate.

We define (symmetric) equilibrium as follows.

Definition of Equilibrium *In an equilibrium, for all i, $c_i = c$, $\hat{\delta}_{\bar{i}} = \hat{\delta}$ satisfy the following:*

$$(1 + g(\hat{\delta}))c = W \tag{11}$$

$$(1 + \hat{\delta})h(c) = W, \tag{12}$$

with the functions g and h defined as

$$g(\hat{\delta}) \stackrel{def}{=} (1 - \gamma)\delta + \gamma\hat{\delta},$$

and

$$h(c) \stackrel{def}{=} p^{-1}(f(c)).$$

In this definition of equilibrium, (11) is the requirement that the individual optimize as in (10), and (12) is the requirement that the individual perceives others to be optimizing in their consumption choices, i.e., follow the solution as given in (4) with δ replaced with $\hat{\delta}$.

Proposition 1 *In a partial equilibrium setting with visibility bias, under log utility and the other assumptions of the model:*

1. *There exists a unique symmetric equilibrium.*

2. *The consumption level c is higher than that without visibility bias.*

Proof: From (12), $\hat{\delta} = W/h(c) - 1$. Substituting this into (11), equilibrium consumption c satisfies

$$[1 + (1-\gamma)\delta]\, c + \gamma \left(\frac{W}{h(c)} - 1 \right) c = W. \tag{13}$$

Let c_δ denotes the optimal consumption level corresponding to the inherent time preference δ,

$$c_\delta = \frac{W}{1+\delta}. \tag{14}$$

Let

$$F(x) \stackrel{def}{=} [1 + (1-\gamma)\delta]\, x + \gamma \left(\frac{W}{h(x)} - 1 \right) x - W \tag{15}$$

be the difference between the LHS and RHS of (13) as a function of possible consumption values x. F is a continuous function with the properties that

$$F(c_\delta) = \frac{\gamma W}{1+\delta} \left(-\delta + \frac{W}{h(c_\delta)} - 1 \right) = \frac{\gamma W^2}{1+\delta} \left(\frac{1}{h(c_\delta)} - \frac{1}{c_\delta} \right) < 0,$$

because $h(c_\delta) > c_\delta$; and $F(W) = g(\hat{\delta})W > 0$. Therefore, there exists at least one $c \in (c_\delta, W)$ satisfying $F(c) = 0$. Hence, the equilibrium exists, i.e., there exists a fixed point in consumption c and discount factor $\hat{\delta}$ satisfying (11) and (12).

Uniqueness of the equilibrium follows from the fact that F is monotonically increasing, so that there can be at most one solution to $F(c) = 0$. To verify monotonicity, differentiate F to get

$$F'(c) = (1-\gamma)(1+\delta) + \gamma W \frac{h(c) - ch'(c)}{h^2(c)}.$$

By (7),

$$h(c) - ch'(c) = \frac{c^2 q^H (q^H - q^L)\kappa}{[cq^H + (\kappa - c)q^L]^2} > 0,$$

so $F' > 0$.

To verify Part 2, observe that $\hat{c} = h(c) > c$. Substituting for $h(c)$ and c from (11) and (12), it follows that

$$\hat{\delta} < g(\hat{\delta}) = (1-\gamma)\delta + \gamma\hat{\delta}.$$

So $\hat{\delta} < \delta$, and hence $g(\hat{\delta}) < \delta$. By (11) and (14), we conclude that $c > c_\delta$. ‖

Intuitively, owing to visibility bias in what is observed, and availability bias in assessing frequences, people overestimate others' consumption, and therefore to overestimate others' discount rates. Based on a misperception that the social norm is less thrifty than it really is, people update their own time preferences toward current consumption.

The assumption that everyone is identical, yet individuals misperceive the attitudes of others, is rather stark. However, similar findings would apply in settings with heterogeneous individuals. Furthermore, such mismatches between beliefs and social reality are consistent with the phenomenon of *pluralistic ignorance* from social psychology, wherein everyone may individually reject a norm, yet believe that others favor it (Katz and Allport (1931)). For example, several studies find that college students overestimate how much other students engage in and approve of heavy alcohol use (Prentice and Miller (1993)) and uncommitted or unprotected sexual practices (Lambert, Kahn, and Apple (2003)), and suggest that this encourages such behaviors.

2.5 Comparative statics on varying endowments

Omitting i subscripts, let y_0 and y_1 be dates 0 and 1 endowed income. We now consider the comparative statics on varying y_0, the individual's date 0 income endowment. We will examine how comparative statics differ in settings with and without visibility bias.

Without visibility bias, an increase in the current income y_0 or future income y_1 increases current consumption:

$$\frac{\partial c_0}{\partial y_0} = \frac{1}{1+\delta}. \tag{16}$$

With visibility bias, the sample of others' consumption activities, and hence overestimation of their consumption levels, does not depend on y_0 or y_1. An increase in current income y_0 still increases current consumption:

$$\frac{\partial c_0}{\partial y_0} = \frac{1}{1+g(\hat{\delta})}. \tag{17}$$

Since $g(\hat{\delta}) < \delta$, it follows that visibility bias and resulting misperceptions of social norms cause the individual's current consumption c_0 to be more sensitive to changes in income than without visibility bias.

Proposition 2 *Under log utility, visibility bias increases the marginal propensity to consume from current income.*

This comparative statics is based upon an exogenous interest rate r, because the marginal propensity to consume is defined by varying one individual's income.

Intuitively, higher wealth tends to increase both current and future consumption, and with homothetic preferences (in this case log utility), the ratio between the two is constant.

Social influence and visibility bias in our setting increase the ratio of current to future consumption, and therefore also the marginal propensity to consume out of income (or wealth).

3 The Equilibrium Interest Rate

The above reasoning takes the riskfree rate r as given. We next solve for r by clearing the bond market. Intuitively, since visibility bias in social observation results in too low a time discount factor (δ), the equilibrium interest rate (r) is too high.

In a pure exchange economy, not everyone can consume more today. In such a setting, the pro-consumption effects of visibility bias on δ are offset by a corresponding rise in r, so that the representative individual consumes the (exogenous) per capita income (although each individual thinks that his neighbors consume more than himself). In Section 5, allowing for intertemporl production reinstates the result that visibility bias increases current consumption, as individuals are able to satisfy their amplified preferences for current consumption by investing less.

From the first order optimization condition (3) and the budget constraint (1), we obtain that the optimal consumption of the representative individual at date 0,

$$c_0(1+\delta) = y_0 + \frac{y_1}{1+r}.$$

In the symmetric equilibrium, each individual perceives that others use a time discount parameter $\hat{\delta}$, and updates his own belief of a proper time discount to be $g(\hat{\delta}) = (1-\gamma)\delta + \gamma\hat{\delta}$. By (11), equilibrium satisfies

$$c_0(1+g(\hat{\delta})) = y_0 + \frac{y_1}{1+r}. \tag{18}$$

The interest rate r is set so that there is no borrowing or lending (identical individuals), which implies that $y_0 = c_0$, so by (18),

$$1+r = \frac{y_1}{y_0 g(\hat{\delta})}. \tag{19}$$

Since all individuals are identical, in equilibrium there is no borrowing, so $c_0^* = y_0$.

Since $\hat{\delta} < \delta$, $g(\hat{\delta}) < \delta$. So comparing the cases with and without visibility bias (where without visibility bias $\hat{\delta} = \delta$, it is evident from (19) that visibility bias raises the interest rate.

Proposition 3 *Under pure exchange and log utility, the equilibrium riskfree interest rate is higher when individuals are subject to visibility bias in social observation than when they are not.*

This of course implies that when there are no social interactions or social observation, the interest rate is lower.

4 General utility function and income uncertainty

There is no uncertainty in the model of previous sections, and the results relied on log utility. The result that visibility bias causes overconsumption generalizes to a setting with uncertainty about future income and to any utility function $U(c)$ that satisfies $U'(c) > 0$ and $U''(c) < 0$. We examine this issue in a partial equilibrium with exogenous interest rate r. In such a setting, as an individual becomes more impatient (δ becomes smaller), he consumes more today:

$$\frac{\partial c_0}{\partial \delta} < 0. \tag{20}$$

Once this is established, it is straightforward to show that the optimal consumption c_0 with biased social transmission is higher than the case without visibility bias, because in the former case, the individual uses an updated discount factor $g(\hat{\delta})$ that is lower than the discount factor δ that obtains without visibility bias.

Now assume at date 0, y_1 is uncertain. Each individual solves the following problem

$$\max_{c_0} \; U(c_0) + \delta \mathrm{E}[U(c_1)]$$

subject to the intertemporal budget constraint

$$c_0 + \frac{c_1}{1+r} = y_0 + \frac{y_1}{1+r}. \tag{21}$$

Optimal consumption satisfies

$$u'(c_0) = \delta(1+r)\mathrm{E}[u'(c_1)]. \tag{22}$$

Parametrically differentiating both sides of this equation with respect to δ gives

$$u''(c_0)\frac{\partial c_0}{\partial \delta} = (1+r)\mathrm{E}[u'(c_1)] + \delta(1+r)\mathrm{E}[u''(c_1)]\frac{\partial c_1}{\partial \delta}. \tag{23}$$

The budget constraint (1) implies that

$$\frac{\partial c_1}{\partial \delta} = -(1+r)\frac{\partial c_0}{\partial \delta}.$$

Substituting this into (23) yields

$$\left(u''(c_0) + \delta(1+r)^2\mathrm{E}[u''(c_1)]\right)\frac{\partial c_0}{\partial \delta} = (1+r)\mathrm{E}[u'(c_1)]. \tag{24}$$

The RHS of (24) is positive because $u' > 0$; the coefficient on $\partial c_0/\partial\delta$ on the LHS is negative because $u'' < 0$. Hence (20) follows.

Denote the optimal date 0 consumption $c_0 = C(\delta)$, where we have supressed the dependence of c_0 on the other model parameters. Each individual observes a sample of another individual's activities biased toward consumption, from which he infers others' consumption level, and back out others' time discount parameter; then he updates his own time preference, and uses it in determining own consumption level.

Without visibility bias, the equilibrium consumption at date 0 is

$$c_0^R = C(\delta),$$

where R denotes 'rational', and δ is the individual's inherent discount factor.

In a symmetric equilibrium, with visibility bias, the consumption at date 0 is $c_0^B = C(g(\hat{\delta}))$, where B denotes 'biased', $g(\hat{\delta})$ is as defined in (9), $\hat{\delta} = C^{-1}(\hat{c}_0)$, and where $\hat{c}_0$ is the inferred consumption level of others. By (20), $C(\delta)$ is decreasing function of δ. Since $\hat{c}_0 > c_0^B$, $\hat{\delta} < g(\hat{\delta})$, and thus $\hat{\delta} < \delta$, and also

$$g(\hat{\delta}) < \delta. \tag{25}$$

This in turn implies that

$$c_0^B = C(g(\hat{\delta})) > c_0^R = C(\delta).$$

So visibility bias and social influence increases equilibrium consumption.

Proposition 4 *In a partial equilibrium setting with general von-Neumann Morgenstern risk averse utility and uncertain future income y_1, visibility bias increases consumption relative to a setting with no visibility bias.*

5 The Model with Production

We now extend the basic model to allow for productive transformation between current and future consumption. In addition to the riskfree asset, individuals can invest some of their savings in a production technology which produces Y_1 units of future consumption goods using I units of investment. At date 0, each individual chooses the amount of consumption

(c_0), allocates a positive or negative amount to riskfree bonds (b) and to real investment (I). Each individual is endowed with exogenous incomes y_0 and y_1 at the two dates.

Individual i solves the optimization problem

$$\max_{c_0, c_1} U(c_0) + \delta U(c_1)$$

subject to the productive technology constraint

$$Y_1 = H(I) \stackrel{def}{=} AI^\alpha, \quad 0 < \alpha < 1, \tag{26}$$

and the budget constraints

$$c_0 = y_0 - I - b \tag{27}$$

$$c_1 = Y_1 + y_1 + b(1+r). \tag{28}$$

The optimization can be done over two controls c_0 and b. Once these two are chosen, by (27), the initial investment in the production technology is

$$I = y_0 - c_0 - b.$$

Together with (26) and (28), this implies that the date 1 consumption is

$$c_1 = H(y_0 - c_0 - b) + y_1 + b(1+r). \tag{29}$$

Substituting (29) into the objective function $L = U(c_0) + \delta U(c_1)$ of the maximization problem, we obtain the first order conditions with respect to c_0 and b:

$$\frac{\partial L}{\partial c_0} = U'(c_0) - \delta U'(c_1)H(I) = 0 \tag{30}$$

$$\frac{\partial L}{\partial b} = \delta U'(c_1)[-H'(I) + 1 + r] = 0. \tag{31}$$

Equation (31) and the definition of $H(I) = A(I)^\alpha$ imply that

$$\alpha A I^{\alpha-1} = 1 + r, \quad \text{or} \tag{32}$$

$$I = \left(\frac{1+r}{\alpha A}\right)^{\frac{1}{\alpha-1}}. \tag{33}$$

The log utility function $U(c) = \log(c)$ and (30) imply that

$$c_1 = \delta H'(I) c_0 = \delta(1+r)c_0. \tag{34}$$

By (27), it follows that

$$c_0 + b = y_0 - \left(\frac{1+r}{\alpha A}\right)^{\frac{1}{\alpha-1}} = y_0 - I. \tag{35}$$

By (28) and (34),

$$\delta c_0 = \frac{y_1 + H(I)}{1+r} + b. \tag{36}$$

We can solve for date 0 optimal consumption c_0 and allocation to riskfree asset b from (35) and (36).

Let W be the individual's wealth, defined as the discounted value of the sum of present and future endowment y's and of production of future consumption $Y = H(I)$, net of expenditure on investment:

$$W = y_0 + \frac{y_1 + H(I)}{1+r} - I.$$

Adding (35) and (36), and cancelling b from both sides gives

$$c_0 = \frac{W}{1+\delta}. \tag{37}$$

By (35) and (37), the optimal bond investment is

$$b = \frac{\delta}{1+\delta}(y_0 - I) - \frac{1}{1+\delta}\frac{y_1 + H(I)}{1+r}. \tag{38}$$

In equilibrium, the bond market clears, $b = 0$, so the equilibrium interest rate satisfies

$$1 + r = \frac{y_1 + H(I)}{\delta(y_0 - I)}. \tag{39}$$

Corresponding to this interest rate, the optimal consumption is $c_0 = y_0 - I$. Since a log utility investor will never consume a negative amount, the equilibrium condition that $b = 0$ implies that $I < y_0$.

Combining (33) and (39), the equilibrium level of investment I satisfies

$$G(I; \delta) = 0, \tag{40}$$

where the function G is given by

$$G(I; \delta) = AI^{\alpha}(1 + \alpha\delta) - \alpha\delta A y_0 I^{\alpha-1} + y_1. \tag{41}$$

Differentiating shows that

$$\frac{\partial G}{\partial \delta} = \alpha A I^{\alpha-1}(I - y_0) < 0 \tag{42}$$

$$\frac{\partial G}{\partial I} = \alpha A I^{\alpha-2}[(1 + \alpha\delta)I - (\alpha - 1)\delta y_0] > 0 \tag{43}$$

because $I < y_0$ and $0 < \alpha < 1$. To see that this implies a solution for I within its support $(0, y_0)$, observe that $\lim_{I \to 0} G(I; \delta) = -\infty$, that $G(y_0; \delta) > 0$, and that $\partial G / \partial I > 0$.

By (42), (43), and the implicit function theorem, $\partial I / \partial \delta > 0$. Since visibility bias reduces δ by (25), the equilibrium investment I is lower, and hence the consumption level $c_0 = y_0 - I$ is higher.

The following proposition summarizes these results.

Proposition 5 *In an equilibrium setting with log utility, visibility bias and intertemporal production: (1) There exists a unique symmetric equilibrium. At date 0 all individuals invest*

$$I = \left(\frac{1 + r}{\alpha A} \right)^{\frac{1}{\alpha - 1}}.$$

Each individual's date 0 consumption c_0 and his inference of others' time preference $\hat{\delta}$ satisfy

$$\begin{aligned} (1 + g(\hat{\delta}))c_0 &= W & (44) \\ (1 + \hat{\delta})h(c_0) &= W, & (45) \end{aligned}$$

with the function g given by

$$g(\hat{\delta}) \stackrel{def}{=} (1 - \gamma)\delta + \gamma\hat{\delta},$$

and the inferred consumption of others $h(c)$ by

$$h(c) \stackrel{def}{=} p^{-1}(f(c)) > c.$$

Each individual invests b in the riskfree asset at date 0, where

$$b = \frac{g(\hat{\delta})}{1 + g(\hat{\delta})}(y_0 - I) - \frac{1}{1 + g(\hat{\delta})} \frac{y_1 + AI^\alpha}{1 + r},$$

and where the riskfree rate r is

$$1 + r = \frac{y_1 + A(I)^\alpha}{g(\hat{\delta})(y_0 - I)}.$$

(2) With visibility bias, the equilibrium consumption level c_0 is higher and investment I is lower, than in the absence of visibility bias.

So as in the basic partial equilibrium model of Section 1, visibility bias increases consumption, and as in the general equilibrium model of Section 3 (in which the pure exchange setting precluded an effect on equilibrium consumption), visibility bias increases interest rates. Here visibility bias also decreases saving and real investment.

6 Information Asymmetry

We now generalize to allow for wealth dispersion in the population, and where individuals do not know the wealths of others. Intuitively, the inference an individual draws about the discount rate of others based on observation of another's consumption is weaker rate if he does not know the individual's wealth, because of a confounding between the possibilities that the discount rate is high or that wealth is high. In consequence, the effect of wealth dispersion is to reduce the equilibrium degree of overconsumption. This contrasts sharply with the Veblen wealth-signaling approach, in which it is precisely the fact that there is uncertainty about wealth that motivates overconsumption as a signal.

To model this tractably, we need to grant individuals enough rationality to understand that when they see indications of high consumption, this could come from either a high discount rate or high wealth. But we will continue to assume that people are subject to visibility bias and the availability heuristic.

So we allow for a degree of rationality, but we do not impose the rational expectations condition that, in equilibrium, people correctly assess the distribution of types (wealth and discount rates) in the population. Furthermore, and as before, even though each individual updates his discount rate away from his inherent discount rate based on social influence, in observing others people do not distinguish the inherent versus the updated discount rate of others. An individual takes the consumption decisions of others as indicative of their wealth and inherent preferences, views the inferred discount rate as normative, and updates his own discount rates accordingly.

Apart from allowing for wealth dispersion, we return to the pure exchange setting of Section 2, and focus on the effects of unobservable wealth on discount factors. Let $f_\delta(\delta)$ be the prior probability density that each individual has about the discount factor of other individuals. This prior concerning all possible targets of observation is identical for all observers, and this density matches the true underlying density. Similarly, let $g_W(W)$ be the priority density for individuals' wealths, where true wealth and discount factors are independently distributed, and everyone correctly perceives this to be the case.

By (4) and independence of δ and W, an individual who infers that another individual's consumption is c for sure updates his belief about δ to

$$\begin{aligned} f_\delta(\delta|c) &= \frac{f_{\delta,c}(\delta,c)}{f_c(c)} \\ &= \frac{f_\delta(\delta)g_W((1+\delta)c)}{\int_\delta f_\delta(\delta)g_W((1+\delta)c)d\delta}. \end{aligned} \tag{46}$$

In this example, assume that $\delta \sim U[0,1]$ and $W \sim U[1,2]$. By (4), $c \in [0.5, 2]$. In the numerator of the RHS of (46), $f_\delta(\delta) = 1$ on the support of δ, and $g_W((1+\delta)c) = 1$ iff $(1+\delta)c \in [1,2]$, and otherwise is zero.

The condition that $W \geq 1$ implies that $(1+\delta)c \geq 1$, so

$$\delta \geq \max\left(0, \frac{1}{c} - 1\right) \stackrel{def}{=} \underline{\delta}. \tag{47}$$

The condition that $W \leq 2$ implies that $(1+\delta)c \leq 2$, so

$$\delta \leq \min\left(\frac{2}{c} - 1, 1\right) \stackrel{def}{=} \overline{\delta}. \tag{48}$$

We can therefore calculate the expected discount factor as perceived by an observer who believes he has observed another individual with consumption c, as

$$E[\delta|c] = \frac{\int_{\underline{\delta} \leq \delta \leq \overline{\delta}} \delta d\delta}{\int_{\underline{\delta} \leq \delta \leq \overline{\delta}} d\delta}. \tag{49}$$

We consider two cases.

Case 1: $c \leq 1$.

Then the range of the integrals becomes $\delta \in [\frac{1}{c} - 1, 1]$, so

$$\begin{aligned} E[\delta|c] &= \frac{\int_{\frac{1}{c}-1}^{1} \delta d\delta}{\int_{\frac{1}{c}-1}^{1} d\delta} \\ &= \frac{1}{2c}. \end{aligned} \tag{50}$$

We will compare the sensitivity of this expectation to c to the sensitivity of inferred δ to c in the model without wealth dispersion, so we differentiate with respect to c:

$$\frac{dE[\delta|c]}{dc} = -\frac{1}{2c^2}. \tag{51}$$

Case 2: $1 < c \leq 2$.

Then the range of the integrals becomes $\delta \in [0, \frac{2}{c} - 1]$, so

$$\begin{aligned} E[\delta|c] &= \frac{\int_0^{\frac{2}{c}-1} \delta d\delta}{\int_0^{\frac{2}{c}-1} d\delta} \\ &= \frac{1}{c} - \frac{1}{2}. \end{aligned} \tag{52}$$

Differentiating with respect to c gives

$$\frac{dE[\delta|c]}{dc} = -c^{-2}. \tag{53}$$

As a benchmark for comparison, suppose that there is no wealth dispersion, and that the known level of wealth $\bar{W}$ is equal to the expected value of wealth in the model with wealth dispersion, $\bar{W} = 1.5$. In the model without wealth dispersion, by (4), the inferred value of δ is

$$\hat{\delta}(c) = \frac{\bar{W}}{c} - 1 = \frac{3}{2c} - 1, \tag{54}$$

so

$$\hat{\delta}'(c) = -\frac{3}{2}c^{-2}. \tag{55}$$

Then it is evident by direct comparison that in both Case 1 and Case 2,

$$\hat{\delta}'(c) < \frac{dE[\delta|c]}{dc} < 0. \tag{56}$$

In other words, with wealth dispersion, the discount factor that the observer perceives about the target does not decrease as rapidly with perceived target consumption as in the model without wealth dispersion.

Proposition 6 *Comparing the setting with wealth dispersion with a setting with constant wealth equal to the expected wealth in the other setting, the discount factor that the observer perceives about the target is less sensitive to perceived target consumption than when there is no wealth dispersion.*

Empirically, Proposition 6 predicts that savings rates increase with wealth dispersion. This is the opposite of what is expected based upon Veblen wealth-signaling considerations. In the Veblen approach to overconsumption, people consume more in order to signal the level of wealth to others (Bagwell and Bernheim (1996)). Greater information asymmetry about wealth intensifies the effect, by increasing the potential improvement in wealth perceptions that can be achieved by signaling.

For example, in the limiting case of no information asymmetry, the Veblen effect would disappear and people would consume only for their direct utility benefits. More generally, in a simple setting in which the upper bound of the support of the wealth distribution becomes higher, then the range of possible equilibrium consumption signal levels is higher, so there will be more overconsumption on average.

The effects of wealth dispersion here derive from the unobservability of others' wealths rather than dispersion per se. The model therefore predicts that when the wealth of neighbors is harder to observe directly, there is less overconsumption.

An additional distinction between the Veblen approach and the social norm transmission approach is that consumption reacts differently to the degree of materialism of the society, and the incentives to obtain high reputation. In the Veblen approach, the greater the extent to which prestige is linked to perceptions of wealth, the stronger the incentive to signal and hence the greater the overconsumption. In contrast, in the social norm transmission approach this parameter is not relevant for overconsumption.[6]

7 Concluding Remarks

We examine how social influence shapes equilibrium levels of time preferences. In our model, consumption is more salient than non-consumption, and this visibility bias makes episodes of high consumption by others easier to retrieve from memory than examples of low consumption. Owing to availability heuristic, people therefore infer that low savings is normative and increase their own discount rates accordingly. This effect is self-reinforcing at the social level, resulting in overconsumption and high interest rates.

In contrast with the present-bias (hyperbolic discounting) theory of overconsumption, the effects here are induced by social observation and interaction. Our approach can therefore be distinguished from present bias using proxies for social interaction and observability, such as urban versus rural, and survey questions about sociability (see, e.g., Hong, Kubik, and Stein (2004) Christelis, Georgarakos, and Haliassos (2011), and Georgarakos and Pasini (2011)).

In contrast with Veblen effects, which imply greater wealth-signaling effects when there is greater information asymmetry about the wealth of others (as occurs with high wealth dispersion), in our setting greater information asymmetry dilutes the inference from high observed consumption that the discount rate of others is high. In consequence, equilibrium consumption is *lower*, the opposite prediction. Furthermore, the visibility bias theory also helps explain the strong differences in savings rates across countries and ethnic groups, because even modest differences in inherent discount rates can be amplified through social influence.

[6] Although the Veblen approach captures an important aspect of reality, in practice, people do not always seek to signal high wealth by consuming heavily. Olson and Rick (2013) report that individuals seeking to attract romantic partners exaggerate their *saving* behavior when completing dating profiles to enhance the impression of self-control, and that high saving enhances romantic appeal.

In addition to providing insight about undersaving in general, the social interaction approach to consumption/saving norms potentially can contribute to our understanding of dynamic macroeconomic phenomena as well. For example, suppose that there are lags between people observing others and updating their own consumption plans, or lags between their consumption plans and actual consumption. Suppose in addition that there are shocks to the system that encourage high or low spending. Then the response lags can create momentum into shifts in consumption and consumption norms. This can potentially cause patterns of overshooting and correction, which might provide the basis for an overconsumption theory of business cycles.

More generally, our approach to understanding the evolution of consumption and saving attitudes is based upon *misperception of norms*. This approach is potentially applicable to various other settings, which suggests a rich direction for future research.

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