A Model of Positive Self-Image in Subjective Assessments

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Abstract

This paper suggests a mechanism that describes individuals' positive self image in subjective assessments of their relative abilities. The mechanism assumes individuals have heterogeneous production functions that determine ability as a function of multiple skills, individuals make skill-enhancing investments with the goal of maximizing their ability, and make ability comparisons using their own production function. Within this framework, the paper formulates and proves propositions consistent with experimental findings. It provides conditions under which there is a positive self image effect: more than half of the population views itself as above the median in ability. The positive self image effect is increasing in the ease of the task, the number of different skills needed for the task, and the variability of production technologies in the population. We provide conditions under which positive self image is decreasing in objective ability.

1 Introduction

Many have noted that people tend to have overly positive assessments of their relative abilities. Adam Smith [40, page 124] wrote that "the over-weening conceit which the greater part of men have of their own abilities, is an ancient evil remarked by the philosophers and moralists of all ages." Contemporary psychologists agree that "on nearly any dimension that is both *subjective* and *socially desirable*, most people see themselves as better than average."[1]

Positive self image may influence behavior in economically relevant situations. Smith suggests that people's overly positive view of their own abilities explains gambling behavior and the decision of individuals to become soldiers. Myers points out that merit pay may lead to low morale when 90 % or more of employees rates themselves as above average.[2]

Taking the evidence at face value has led to interesting research that modifies standard economic models to provide reasons for the existence of positive self image and to study its implications for economic applications. We discuss some of this work in Section 13. We argue instead that much of the evidence fits comfortably in the standard model that we describe.

Ability is a function of a vector of skills. There is a subjective component to the definition of ability, in that different individuals can hold different opinions about how skills combine to determine an ability level. We capture this ambiguity in our model by assuming that ability is an increasing function of skills, but that different agents use different functions to evaluate ability. The fact that we permit different measures of ability is what makes our comparisons subjective. Individuals begin with an initial endowment of skills and make an investment to improve their ability. We assume that when an individual responds to questions about relative standing, he responds egocentrically: He uses his own production function to compare his final skills to those of others in the population.

As an example, driving is an ability that depends on several individual skills: knowledge of laws; ability to merge into freeway traffic; parallel parking; controlling a vehicle on icy roads; and so on. Different individuals disagree about how much each of these skills contributes to good driving. Parking skill is a significant part of ability for urban driver. For someone in

[1]The quotation is from Myers [37, page 54], a textbook on social psychology. The book presents a several examples of positive self image.

[2]Myers [37, page 63] cites studies by Cross [12] of the relative self image of college professors.

a cold climate, how well he can control a car in a snow storm is an important factor in driving ability. These differences will lead different drivers to augment their skills in different ways.

Individuals in our model have complete information about their own skills and the skills of other members of the population. They have different production functions that describe how skills determine ability. They are egocentric in that they evaluate the abilities of others using their own production function. An individual's self image is the fraction of the population that, in his opinion, has a lower ability level. A strong form of positive self image arises when the fraction of individuals who view themselves to be in the bottom p percent of the population is less than p for all p. In this case, more than 10% of the individuals in the population view their ability as greater than 90% of others in the population; half of the population would claim to be above the median; and so on.

Our basic model generates this kind of positive self image. Without the ability to add to skills, the population would typically be well calibrated: precisely p % of the population would claim to be better than $1 - p$ % of the others. Positive self image arises because individuals tailor their skill augmentation to their own production technology. The driver who values parking will work to improve her parking skills and ultimately rate her ability more highly than that of someone with an identical initial endowment who chooses to improve his freeway driving.[3] In Section 3 we state this result formally.

Subsequent sections of the paper discuss factors that influence positive self image. We consider several findings from the psychology literature, formulate them in terms of our model, and present propositions stating assumptions that imply the psychological findings. We give conditions under which positive self image increases with the variability of technologies or with the number of skills relevant to the ability. We explain how our model gives insight into the finding that positive self image is more pronounced among individuals who are (objectively) less skilled and for abilities that are viewed to be more under the control of the individual.

We are convinced by the evidence that positive self image is real, although our results do suggest conditions that will lesson or reverse its appearance. Nonetheless, we argue that there is a parsimonious way to organize the findings that does not depend on assuming that individuals process information

[3]Svenson [42] identifies positive self image in drivers.

irrationally or that self esteem enters directly into their utility functions.

We know of two papers that offer descriptions of positive self image effects without assuming that beliefs enter directly into preferences or technologies or that individuals make systematic mistakes is information processing. The most closely related work is the paper of Van den Steen [43]. Van den Steen provides a model of rational decision making in which agents have different priors. In his basic model, an agent must choose from a finite number of actions. Agents have heterogeneous beliefs about the quality of each action. Specifically, the probability that a given action succeeds is an independent draw from an identical distribution. Since each agent selects the action that (in his view) is most likely to succeed, each agent believes that his choice is at least as good as the choices made by others in the population, and everyone believes that the other agents overestimate their probability of succeeding. While we formulate our model in terms of heterogeneous technologies, in Section 2 we show that formally Van den Steen's basic model is a special case of the model we use in most of the paper.

Van den Steen's model contains the two basic elements of our approach. Individuals are heterogeneous (evaluating their situation using different criteria heterogeneous beliefs, technologies, or preferences) and they make choices (of project or investment). Given the similarity of the basic structure, it is not surprising that Van den Steen's paper contains versions of several of the results in this paper. In addition to demonstrating the existence of excessive optimism, he demonstrates that excessive optimism increases with the riskiness of the distribution of beliefs (comparable to Proposition 3) and with number of projects (comparable to Proposition 5). He also presents asymptotic results that strengthen the finding of over optimism when there are many projects. In our model individuals have different technologies and different endowments. Adding the possibility of different endowments adds minor complications to results and allows us to state propositions that are not available in Van den Steen's framework (for example, Proposition 13). Sections 5, 6, and 7 have no parallels in Van den Steen's work.

Some examples of positive self image are easily seen to be consistent with unbiased information processing and rational decision making. For example, if drivers are either good or bad, and the only informative signal about driving ability is whether a driver is involved in a serious accident, then (provided serious accidents are rare) most drivers will never be involved in an accident and correctly view their ability as above average. Zábojník [46] presents a dynamic model in which utility maximizing individuals with unbiased priors have an opportunity to learn about their abilities through costly experimentation. Experimentation has the potential advantage of providing information that individuals can use to make a better decision, which leads to a positive payoff; it has the cost of postponing the time of the decision and (due to discounting) reducing the value of the payoff. The payoff is an increasing function of ability. Consequently, the opportunity cost of experimentation is higher for agents with who have higher priors on their ability. Zábojník shows that only individuals with low self assessments continue experimenting, which creates a bias in the distribution of posterior beliefs. An implication of the bias is that (under appropriate conditions) the fraction of agents who believe their ability to exceed a cutoff value is larger than the objective fraction. This paper presents a plausible rational mechanism through which a population's beliefs may become skewed over time. It will not be the case in Zábojník's model (or in the simple model of drivers) that the fraction of people who place themselves in the top p % of the population exceeds p for all p. That is, the positive self image effect is weaker than the one we identify in Proposition 1.

Since our approach requires subjective measurement of ability, it does not apply directly to situations in which there are well-understood incentives or objective measures of ability. We devote Section 8 to evidence suggesting positive self image even when ability has an unambiguous definition. Our model is relevant to the understanding of these results because it leads us to look for ambiguity and subjectivity, for example in the choice of comparison group, even in objectively defined tasks. In addition, Section 8 contains a result, independent from our basic model, that provides conditions under which we would expect to find positive self image even when subjects answer unambiguous questions about their abilities. This result also provides conditions under which negative self image would arise.

The next section of the paper introduces the model. Section 3 demonstrates the existence of positive self image. Proposition 1 not only guarantees that at least half of the population views itself to be above the median, but extends the "above-median" effect to all percentiles. Section 4 contains results on how positive self image is influenced by the variability of production technologies in the population. Informally, we show that the amount of positive self image in the population grows with the ambiguity of the ability being assessed. Section 5 gives conditions under which positive self image is more pronounced for easy tasks than for hard ones. Section 6 investigates the finding that people tend to claim that important skills are the ones that they possess in largest quantities. Section 7 models the tendency for positive self image to be more pronounced in individuals with lower objective skill levels. Section 8 introduces a model in which final ability is unambiguously measured. Noisy observations of the abilities of others can lead to either positive or negative self image (depending on the difficulty of the task). Section 9 discusses the connection between our model of positive self image and evidence that people tend to be optimistic. Section 10 discusses evidence of positive self image in situations where agents have explicit incentives. Section 11 suggests some implications of our model that have not, to our knowledge, been subject to detailed empirical investigation. In particular, we discuss environments that would lead to negative self image. Section 12 briefly mentions alternate interpretations of our model. Section 13 reviews some related research. Section 14 concludes the paper. The Appendix contains the proofs of propositions.

2 The Model

There is a large population of individuals. Individuals are born with a vector of (initial) skills, $\kappa \in \mathbf{R}^{\mathbf{n}}_{+}$. These individuals choose a final vector of skills ($k \in \mathbf{R}^{\mathbf{n}}_{+}$) to maximize their ability. An individual's initial skill level determines the set $A(\kappa)$ of final skills that he may acquire. We assume that the definition of ability is subjective, so that different individuals have different ideas about how skills combine to produce ability. The technologies that transform skills into ability are heterogeneous, parameterized by $\lambda \in \mathbf{R}^{\mathbf{n}}_{+}$, so that $T(k;\lambda)$ is the ability level that an individual of type λ associates with a skill vector k. The assumption that $\lambda \in \mathbf{R}^{\mathbf{n}}_{+}$ is not necessary for our basic result, but makes sense for the linear model (introduced below) for which we conduct most of our analysis. An individual's behavior is completely determined by his initial skills and his technology. We let $\zeta = (\kappa, \lambda)$ denote these characteristics. We assume that $T(\cdot)$ is continuous and that $A(\kappa)$ is compact for all κ, so the optimization problem that determines an individual's investment,

$$\max \; T(k;\lambda) \text{ subject to } k \in A(\kappa), \tag{1}$$

has a solution. Denote by $K(\zeta)$ the set of solutions to (1). We assume that there is a measure μ defined on (Borel) subsets of $\mathbf{R}^{\mathbf{n}}_{+} \times \mathbf{R}^{\mathbf{n}}_{+}$ and interpret $\mu(X)$ as the fraction of the population with characteristics in X. We further assume initial endowments and technologies are independently distributed.

For convenience, assume that μ can be described by a continuous density function.

The paper investigates how individuals in the population rank themselves relative to other members of the population. We next introduce notation that allows us to express answers to questions of the form: "What fraction of the population has ability greater than yours?"

Given any $\zeta' = (\kappa', \lambda')$, let

$$T^*(\zeta'; \lambda) = \max_{k' \in K(\zeta')} T(k'; \lambda)$$

be the (highest) ability a type λ individual could obtain if he had the skill of an individual with characteristic ζ'. Let

$$W(u; \lambda) = \{\zeta' : T^*(\zeta'; \lambda) \leq u\}.$$

From the perspective of an individual of type λ, u is at least as good as the ability of an individual with characteristic $\zeta' \in W(u; \lambda)$. Finally, let $B_p = \{\zeta : \mu(W(T^*(\zeta; \lambda); \lambda)) \geq p\}$ be the set of individuals who prefer their skills to the fraction p of the population. A population exhibits **positive self image** if

$$\mu(B_p) \geq 1 - p \text{ for all } p \in (0, 1). \tag{2}$$

Positive self image is strict if the inequality in (2) is strict for all $p \in (0, 1)$. When the population exhibits positive self image, then at least the fraction $1-p$ of the population believes that its skills are in the top p of the population.

We describe positive self image at the individual level by examining an agent's subjective ranking of his own ability. Let

$$R^*(\zeta) = \mu(W(T^*(\zeta; \lambda); \lambda)) \tag{3}$$

be the fraction of the population that a ζ individual ranks lower than himself. In a population without positive self image, the expected value of $R^*(\cdot)$ is $\frac{1}{2}$.[4] Many of our results discuss how $R^*(\zeta)$ or the expected value of R^* changes with changes in the composition of the comparison group or the nature of the ability.

[4]Strictly speaking, this assertion requires a non-degeneracy assumption. If all agents had identical technologies, that is, if λ had a degenerate distribution, then $R^*(\zeta) \equiv 1$.

Results from social psychology justify our modeling approach. Dunning and Hayes [14] and Dunning, Perie, and Story [16] are representative of papers which demonstrate that individuals make egocentric comparisons when evaluating the abilities of others. That is, in order to evaluate the behavior of others, they apply the standards that they use on themselves.

Our basic result on the existence of positive self image holds for the general model. In order to state and prove propositions describing how different environments influence relative self image, we frequently limit attention to a special case of the model in which technologies are linear. Assume that $\lambda \in \mathbf{R}^{\mathbf{n}}_{+}$, $T(k; \lambda) = \lambda \cdot k$, and $A(\kappa) = \{k : k \geq \kappa \text{ and } \sum_{i=1}^{n}(k_i - \kappa_i) \leq c\}$, for $c > 0$. In this formulation, the individual can increase his skills by a total of c units. The linear objective function is essential for most of our results. The precise form of the constraint set is less important. We will modify the formulation at times to discuss situations in which it is not possible to augment some of the skills.

Let $\bar{\lambda}$ be the largest component of an individual's type vector λ. In the solution to (1), this individual will increase his ability by $c\bar{\lambda}$ (by augmenting only the skill that makes the highest contribution to ability). Compared to an individual whose maximal component of λ is λ_i, he prefers his own final skill level to any skill level in the set

$$L(\kappa, \lambda) = \{\kappa' : \kappa \cdot \lambda + c\bar{\lambda} > \kappa' \cdot \lambda + c\lambda_i\}. \tag{4}$$

In the special case where all initial endowments are zero, our linear model with $c = 1$ reduces to Van den Steen's model: interpret the n skills as projects and λ_i as the probability that the i^{th} project succeeds. Individuals then invest in the project that they believe is most likely to succeed. What we call ability Van den Steen interpretes as the probability of success.

3 A Basic Result

This section presents a formulation of the basic result on positive self image. Positive self image exists in our model due to heterogeneity of technologies and the opportunity to make individual skill-augmenting investments.

Proposition 1 *The population exhibits positive self image.*

The appendix contains the proof of Proposition 1 (and all other propositions that need proof). The proposition follows from a simple variation of a revealed preference argument. Imagine first that technologies in the population are homogeneous. Agents will then agree about which skill levels lead to higher abilities and the population will be well calibrated. When technologies are heterogeneous, individuals will generally solve their skill augmentation problem differently than individuals with different technologies. If this happens, one obtains strict positive self image. Proposition 2 states this result precisely. In order to do so, we need to describe what it means for individuals to have different technologies. We say that the technologies in the population are **distinct** if for each $\zeta = (\lambda, \kappa)$ there exists λ' such that $K(\zeta) \bigcap K(\lambda', \kappa) = \emptyset$.

Proposition 2 *The population exhibits strict positive self image if technologies are distinct.*

The assumption that initial skills and production technologies are independently distributed is necessary for the conclusion. Consider a simple example in which there are two skills and the population has a technology of the form $\lambda \cdot k$, where $\lambda = (\lambda_1, \lambda_2)$. Suppose that half of the population heavily values only the first skill ($\frac{\lambda_1}{\lambda_2}$ is large) and the other places high relative weight on the second ($\frac{\lambda_1}{\lambda_2}$ is small). If people are endowed with only the skills that are less productive for their technology and have little opportunity to augment their skills, then essentially everyone would have a negative self image.

It is apparent that one individual could believe another has superior abilities for only two reasons: either the second individual begins with a superior initial endowment or has greater opportunity to augment his skills.[5]

Proposition 1 guarantees that in our model the expected value of $R(\cdot)$ is greater than or equal to $\frac{1}{2}$. The next result, for which we supply no further proof, asserts that if individuals differ only in their technologies, every individual believes his own skills are as good as the best in the population.

Corollary 1 *If the initial distribution of skills is degenerate, then $R^*(\zeta) \equiv 1$, that is everyone think his ability is at least as good as the ability of everyone else in the population.*

Corollary 1 holds in Van den Steen [43]'s model, where people differ only in their beliefs.

[5]In this paper we assume that the resources available to add to skills (measured by c) do not vary in the population. So a person acknowledges that another has superior final ability only when the other began with a more attractive endowment.

4 Positive Self Image and Ambiguity

There has been a lot of work done to identify factors that influence positive self image. The most critical feature leading to positive self image is how easy it is for individuals to apply egocentric interpretations of the ability under study. Empirical studies can gain insight into how the definition of ability influences self appraisals by controlling the number of skills that subjects can count as relevant to an ability. For example, Dunning, Meyerowitz, and Holzberg [15] manipulated the number of attributes that subjects could use to describe a specific trait. Some subjects were given a list of six potential attributes to construct their trait definitions, others were given two or four attributes, and a control group was given none. They found that the more restrictive the menu of attributes, the lower were students' above-median effects. Felson [18] and Dunning, Meyerowitz, and Holzberg [15] compare subjects' ratings on different abilities, and conclude that the more ambiguous the trait, the greater the evidence of positive self image.[6] Allison, Messick, and Goethals [5, page 277] summarize the relevant literature by stating that "the less ambiguous, private, or subjective the attribute is, the less subject it is to self serving exaggeration."

In this section, we propose several ways to study the effect of a change in the ambiguity of a skill and study what our model predicts about how these changes influence relative self image.

In our formulation, ambiguity is measured by the extent to which different people can interpret the same question in different ways. If subjects have similar technologies, then they will have similar interpretations of the importance of skills, which will reduce the extent of positive self image. First consider the effect of changing the degree to which technologies vary within the population.

Proposition 3 *In the linear model, a mean-preserving spread in the distribution of technologies increases the number of individuals inferior to each individual in the population.*

Proposition 3 does not show that the fraction of the population that believes it is in the top fraction increases following a mean preserving spread

[6] The studies use intuitive notions of ambiguity. Felson [18] compares an athlete's assessment of relative speed to football sense. Dunning, Meyerowitz, and Holzberg [15] compared a student's reported punctuality to their sensitivity.

in the distribution of technologies. Indeed, this result need not be true. Compare the situation in which λ is equally likely to take on the values 1 and 3 to the one in which 1, 2, and 3 are equally likely.[7] Technologies in the first case are obtained from the second distribution via a mean-preserving spread. In the first case, the gap between the biggest component and the other component is equally likely to be 0 and 2. In the second case, it is 2 with probability $\frac{2}{9}$, 1 with probability $\frac{4}{9}$ and 0 otherwise. If $\lambda \cdot \kappa$ is equally likely to be 1 or 2, then with the three-point distribution $\frac{2}{3}$ of the population believes that it is at least as good as $\frac{3}{4}$ of the population, while in the two-point distribution only $\frac{1}{2}$ of the population believes this. Proposition 3 states that when one holds the production technology fixed, a mean-preserving spread of the distribution of technologies increases positive self image. However, changing the distribution of technologies changes how likely the marginal technology may be and therefore need not uniformly increase positive self image.

A different sort of transformation does lead to a uniform increase in positive self image. In the linear model we say that a transformation **stretches** the distribution of technologies if there exists a function $g(\cdot)$ with $g'(\cdot) > 1$ such that the probability that $\lambda_i \leq x$ is equal to $G(g(x))$ (instead of $G(x)$).

Proposition 4 *In the linear model, any transformation that stretches technologies increases positive self image in that the fraction of the population in the top p-cile increases for all p.*

These results study the implications of changes in the variation of technologies. Another approach to the problem is to try to see what happens to positive self image when the number of skills that contribute to an ability increases. In our model, there is no positive self image in a one-skill world, so increasing the number of dimensions initially must increase the prevalence of positive self image.

We cannot show that increasing the number of dimensions increases the fraction of the population that is better than at least p for each p. Consider the following example. To simplify, imagine that individuals receive initial incomes rather than endowments. Specifically, assume income I is equally likely to be 0 or 1.9, so that individuals are born either poor or rich, and that income can purchase either skill (at unit price). Individuals therefore select investments to solve: $\max \lambda \cdot k$ subject to $\sum_{i=1}^{n} k_i = I + c$ and $k \geq 0$. Assume

[7] Assuming discrete distributions is not necessary, but simplifies the exposition.

that λ_i is equally likely to be 1 or 3 and that individuals can augment one skill by one unit. If there are two skills, then a poor individual with $\lambda_1 \neq \lambda_2$ is at least as good as rich individuals who invest in the other skill. This means that the fraction $\frac{3}{4}$ of the population views itself to be in the top $\frac{3}{8}$ of the population. On the other hand, if there are three skills, then only the rich individuals and those poor individuals who strictly prefer one skill to the other two ($\lambda_i = 3$ for precisely one i) rank themselves in the top $\frac{3}{8}$ of the population.[8] Only $\frac{1}{2} + (\frac{1}{2})(\frac{3}{8}) = \frac{11}{16}$ are in this group.

To study the question in general, we need to be careful about making the comparison. Changing the number of dimensions changes the domains of endowments of skills and technologies. The linear model provides a convenient way to talk about how technologies change. We simply add another dimension to λ and assume that this component is selected independently and with an identical distribution to all of the other components. When we do this, we change the distribution of initial endowments. We point out in Section 11.5 (Proposition 13) that the dispersion of endowments plays a role in the amount of positive self image. It may be possible that some increases in the number of skills also increase the variability of endowments, reducing positive self image. We wish to isolate changes that do not increase variability of endowments. For the next proposition we take what is perhaps the simplest approach.

We assume that when a dimension is added, there is no variation in the endowment of that dimension. Under this assumption, surely, increasing dimensions does not chance the variability of the initial distribution of endowments.

In the next proposition we consider the effect of adding a dimension on the average value of positive self image in the economy. We start with an ability that depends on $n - 1$ skills. We then add another skill, under the assumption that both the endowment in the new skill is constant throughout the population and the weight in the technology is distributed independently and identically from weights of other skills. We compare the average positive self image in both situations and find that it is larger when there are more skills.

[8]In order for a poor individual to prefer his final skills to those of a rich individual, the rich individual must make an "incorrect" investment in skill augmentation; this is more likely when the poor individual has $\lambda = (3, 1, 1)$ than $\lambda = (3, 3, 1)$.

Proposition 5 *In the linear model, increasing the number of skills increases the expected positive self image provided that all members of the population receive the same endowment in newly created skills.*

Increasing the number of dimensions tends to increase positive self image for two reasons. First, when there are more dimensions, it is more likely that other individuals will choose to augment different skills. Second, an individual's favorite skill will become more valuable (the expected largest component of λ will increase with n).

Proposition 5 states only that the positive self image averaged across the population increases when the number of dimensions increases, while the example demonstrates that a stronger result is not possible.

5 Control and Difficulty of Tasks

There is substantial evidence that positive self image is more pronounced when tasks are easy than when tasks are hard.[9] For example, Kruger [33] asked students to make self assessments of four abilities where the threshold for successful performance is low (using a mouse to operate a computer, driving, riding a bicycle, and saving money) and of four abilities where the threshold for successful performance is high (telling jokes, playing chess, juggling, and computer programming). Each student was asked to rank himself in a percentile for each ability. Students exhibited positive self image with respect to the first set of abilities and negative self image for the second set.

This section presents one formulation of the idea that easier tasks tend to create more positive self image. Section 8.2 contains other results consistent with these empirical findings.

In this section we take the position that easy tasks are those for which it is less difficult to turn investment into abilities. That is, we associate the difficulty of a task with the control an individual has in developing expertise. The simplest way to model this is to measure difficulty with c, the amount that an individual can invest in skill augmentation in the linear model. One can be sure that a few hours of practice will lead to competence in an easy

[9] This observation is restricted to *relative* comparisons. It is generally agreed that absolute overconfidence is increasing in the difficulty of the task. See Lichtenstein, Fischhoff, and Phillips [34] for a review. Note that there is more opportunity to overestimate one's absolute ability when performance is low, which we expect in hard tasks.

task, while there is no guarantee that one can become an expert chess player even with work.

Proposition 6 *In the linear model, increasing the level of control increases positive self image.*

Proposition 6 is true more generally than the linear model. If the technologies are homogeneous of degree one and individuals differ in their initial (random) wealth, then increasing wealth to everyone increases the positive self image effect.[10]

Proposition 6 is a statement about how positive self image relates to the amount individuals can augment their skill. We argued that there is a relationship between the formal result and the experimental finding that positive self image is more pronounced for easy tasks than for hard ones. The connection between the proposition and the qualitative property may not be convincing. In fact, changing the nature of the task could involve changing the domain and form of technologies. In Section 8.2 we offer another way to distinguish between easy and hard tasks.

Of course, Proposition 6 can also be interpreted more directly as a statement that says that positive self image increases when individuals have more control over their ability. This finding is consistent with the results of several studies.[11]

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[10]This footnote sketches a proof. If wealth is originally w and if the amount available for augmenting skills increases from c to c', then the total budget increases from $c + w$ to $c' + w$. By homogeneity, final skills are scaled up by $\frac{c'+w}{c+w}$. If an individual were originally indifferent to the final skill level of someone with different technologies, then that other person must have started with a higher initial wealth, w', so the effect of an increase in c is a smaller proportional increase in final skills. The discussion relies on homogeneity, since in general increases in wealth create possibilities for substitution. The analysis also fails when people differ in their initial skills (not wealth). Here boundary conditions could cause problems. Take a Cobb-Douglas technology in which weights are equal $(.5, .5)$. If the initial endowment is $(1, 1)$ and you have nothing to invest in augmenting skills, then the individual prefers his endowment to $(10, 0)$. If both individuals can augment skills by 10, however, the individual's final skill level of $(6, 6)$ may will be worse than will not be as good as the other individual's $(10 + a, 10 - a)$ provided that $0 < a < 8$.

[11]Alicke [2] and Dunning [13] present evidence that positive self image increases with the degree to which people claim to be able to control the trait.

6 Subjective Importance of Skills

Dunning, Perie, and Story [16] found that the extent to which individuals consider a skill to be important to describing a specific ability is positively related to the extent that they perceive themselves as having the skill. That is, individuals tend to claim that the skills that they possess are valuable.[12] For example, subjects first received a list of attributes associated with intelligence (vocabulary, logical reasoning) and asked: "Which of the following are the best examples of intelligence?" A week later the same subjects were asked to rate how descriptive these attributes were of themselves. The correlations between productive attributes and perceived attributes were found to be positive.

Our linear model predicts a relationship between skills and abilities consistent with the empirical findings. There are several ways to state the result.

Proposition 7 *In the linear model, the expected level of the most productive skill is greater than the expected value of any other skill.*

Proposition 7 is a simple consequence of the linear optimization problem. In the linear model, individuals augment their most productive skill (and only that skill). Since endowments are identically distributed, the expected value of the most productive skill will be c units greater than the expected value of any other skill.

Proposition 8 *In the linear model, the expected level of the most productive skill is greater than the population's expected value of the skill.*

Proposition 8 follows for essentially the same reason as Proposition 7, but it compares individuals holding the skill fixed, rather than skills holding the individual fixed. Since technologies are randomly distributed, different members of the population will invest in different skills. An individual who choose to augment a particular skill will gain (in that skill) relative to the population, because there will be individuals who prefer to augment different skills.

Propositions 7 and 8 are direct consequences of the linear optimization problem and need no proof. The next result is more delicate. Just as it is

[12]The empirical findings identify a correlation between possessing a skill and claiming that the skill is important. It is not clear whether individuals acquire the skill because they think it is important or think the skill is important because they have it.

possible to evaluate an individual's relative positive self image in ability, it is possible to compute the individual's self image with respect to a particular skill. For a given skill i, let

$$R_i(\zeta) = \mu\{\zeta' : k_i' \leq k_i\}$$

be fraction of the population that has no more than k_i of the i^{th} skill. If $\lambda_{i^*} = \max_{i=1,\ldots,n} \lambda_i$, then $\bar{R}(\zeta) = R_{i^*}(\zeta)$. The next proposition states that the expected value of $\bar{R}(\zeta)$ exceeds the expected positive self image.

Proposition 9 *In the linear model, relative positive self image is higher with respect to an individual's most productive skill than it is overall.*

Proposition 9 states that if an individual were asked to rank himself only on the basis of the skill that he feels is most important, then positive self image would increase. Two factors contribute to this. Suppose that the first skill in the most productive skill of a given individual. The investment of other individuals whose most productive skill is different will still improve their total ability, but leave unchanged their endowment in the first skill. Second, randomness in skills tends to reduce positive self image (see Proposition 13) and there is greater uncertainty about all skills than about just the favorite skill.

Our linearity assumption made it possible to formulate the results on changing the number of dimensions in Section 4. In one sense, it plays an even more important role here. If one interprets the most preferred skill as the one that has the highest marginal productivity, Proposition 9 depends strongly on the linearity assumption. If the technology was strictly concave and the marginal cost of adding to a skill was constant and equal across skills, then individuals equate the marginal benefit of investment across skills at interior solutions.

If skills are complements and increasing λ_i leads to an increase in the marginal productivity of skill i, then (under mild regularity conditions) it is possible to show that increasing λ_i leads to an increase in k_i. Loosely speaking, making a skill more important leads to an increase in the final quantity of the skill.[13]

[13] The formal argument is an application of Edlin and Shannon [17, Theorem 5].

7 Objective Baselines and Self Image

Many experiments demonstrate that people who perform the worst at tasks are the most likely to overestimate their ability. This finding is a statement about an individual's self appraisal relative to an objective baseline. Since comparisons in our model are subjective, we need to establish an objective standard.

One possibility is to assume that initial endowments are of the form $\kappa = Ie$, where $e = (1, 1, \ldots, 1)$. With this specification, there is no disagreement that initial endowments improve as I increases. It is natural to measure one's self image relative to the initial endowment. Denote by $F(\cdot)$ the cumulative distribution function describing the distribution of initial incomes in the population.[14] Therefore we define the relative self image of an individual with characteristic $\zeta = (\lambda; I)$ to be $R(\zeta) = R^*(\zeta) - F(I)$.

The revealed-preference argument used to establish Proposition 1 demonstrates that

$$R(\zeta) > 0, \qquad (5)$$

so that all individuals have a positive relative self image. We wish to investigate when $R(\cdot)$ is decreasing in I so that relative self image is declining in ability. Since $R^*(\zeta) \leq 1$ and $\lim_{I \to \infty} F(I) = 1$, it follows from (5), that $\lim_{I \to \infty} R(\zeta) = 0$. Consequently, using $F(0) = 0$ and (5), the relative self image of the lowest ability individuals must exceed that of the highest ability individuals. Formally, we have shown:

Proposition 10 *There exists $\bar{I} > \underline{I} > 0$ such that for all I' and I'' with $I' < \underline{I}$ and $I'' > \bar{I}$, $R(I') > R(I'')$.*

Proposition 10 is a straightforward result. The ability to make investments permits all individuals to enhance their subjective relative standing. For those individuals with large initial endowments, however, there is not much room for improvement. These individuals have objective reasons for viewing themselves as better than most of the population. Agents with lower initial abilities stand to gain more from their investment.

One can obtain a stronger result by making stronger assumptions.

[14] The notation applies to this section only.

Proposition 11 *In the linear model, if $F(\cdot)$ is concave, then an individual's subjective assessment of relative standing is decreasing in the initial endowment.*

An alternative modeling approach is to assume that there is an objective technology $T_0(\cdot)$. It is straightforward to obtain relative rankings by comparing $R^*(\zeta)$ to the ranking ζ would obtain using the technology T_0. By analogy with Proposition 10, we can show that individuals who rank near the top of the population with respect to the objective technology have lower positive self image than individuals who rank near the bottom of the population.[15] This approach may capture another experimental finding. Kruger and Dunning [31] find evidence that the self-image of high-performing individuals is lower than their objective performance. This finding is consistent with the approach of using an objective benchmark. Agents who have high ability relative to the objective standard T_0 must have initial endowments of skills that produce high ability according to T_0. These skills may be less highly valued by the individual's own production function.

Krueger and Mueller [30] argue that the observation that positive self image is decreasing in ability can be explained as a regression effect, an observation that is consistent with our analysis. On the other hand, Kruger and Dunning ([31] and [32]) claim that individuals who have low-ability in a task also lack the ability to assess performance in others a finding that is inconsistent with the spirit of our approach. When subjects receive evaluations on their performance (in tasks that have objective measures), high-performing individuals tend to become better calibrated while those who perform more poorly do not. Hodges, Regehr, and Martin [22] present a related finding.[16]

Section 8.2 provides another explanation for a qualitative difference between self image in easy versus hard tasks.

[15]Formally, let $R_{T_0}(\zeta) = \mu\{\zeta' : \max_{k\in K(\zeta)} T_0(k) \geq \max_{k'\in K(\zeta')} T_0(k')\}$ be the ranking with respect to an arbitrary technology T_0 . It is straightforward to show that there exists $\epsilon > 0$ such that for all $\bar{\zeta}$ and $\underline{\zeta}$ with $R_{T_0}(\bar{\zeta}) > 1-\epsilon$ and $R_{T_0}(\underline{\zeta}) < \epsilon$, $R^*(\bar{\zeta}) - R_{T_0}(\bar{\zeta}) < R^*(\underline{\zeta}) - R_{T_0}(\underline{\zeta})$.

[16]Hodges, Regehr, and Martin [22], Krueger and Mueller [30], and Kruger and Dunning ([31] and [32]) studied objective abilities.

8 Unambiguous Assessments

Our explanation of positive self image, which assumes that technologies are heterogeneous, requires that different individuals can hold different views about how skills determine ability. Individuals show positive self image even when asked unambiguous questions about abilities or achievements. While this kind of positive self image is formally outside of the descriptive power of our model, we cannot ignore it. If positive self image exists even when ability has an unambiguous definition, then one would hope to have a description of the phenomenon that does not rely on ambiguity.

In Section 8.1 we discuss in detail an example that identifies positive self image with respect to an objectively defined criterion. Section 8.2 gives conditions for the existence of positive (and negative) self image in a model motivated by the example.

8.1 Magistrate Judges

Guthrie, Rachlinski, and Wistrich [19] asked United States magistrate judges who attended a workshop to respond to the following question:

> United States magistrate judges are rarely overturned on appeal, but it does occur. If we were to rank all of the magistrate judges currently in this room according to the rate at which their decisions have been overturned during their careers, [what] would your rate be?[17]

The judges were asked to place themselves into an appropriate quartile. Responses were striking: 56.1% of the judges placed themselves in the highest quartile (therefore claiming that their decisions were turned down on appeal less often than 75% of the magistrate judges in the room); 31.6% of the judges placed themselves in the second highest quartile; 7.7% of the judges placed themselves in the third quartile; and only 4.6% of the judges placed themselves in the lowest quartile.

The judges are trained decision makers. They were asked an unambiguous question about a subject familiar to them. There is little doubt that all judges prefer their decisions not to be overturned. Yet the judges seem to exhibit positive self image.

[17] Guthrie, Rachlinski, and Wistrich [19, page 815].

Close reflection suggests that the result be evaluated with caution. We offer several ways to look at the judges' responses.

First, the experiment did not elicit responses using economic incentives. One imagines that if the stakes were high enough, the judges would provide more careful answers. The criticism is a cheap shot, since we have taken seriously other experimental findings without incentives.

Second, there is a possibility that different judges did interpret the question differently. For example, "rate" might refer to the average rate over a judge's tenure or over a more recent interval.[18] Alternatively, some decisions may be partially overturned, leading to different interpretation of the question. While different readings of the question could play a role (and would lead to an analysis consistent with our model), this does not strike us as an important factor.

Third, there is a possibility of selection bias. The article reports that there are 519 magistrate court judges of which approximately 200 were in the room, 167 responded to the questionnaire, and 155 responded to the question quoted above. It is possible that the judges who have been overturned most were more likely not to return the questionnaire. Selection bias, even if it existed, would only moderate the extreme results of the survey.

Finally, and most importantly, the question suggests that the distribution of rulings that are successfully appealed is small. The authors point out (Guthrie, Rachlinski, and Wistrich [19, page 816]) that "it is possible that the 56.1% of the judges who placed themselves in the lowest quartile have never been overturned on appeal." If the distribution is highly skewed, then the responses become less surprising.[19]

The possibility of skewed distributions suggests an alternative theoretical explanation for an apparent bias in self image. The next subsection describes a result that may be relevant.

8.2 Skewed Distributions

In this subsection, assume that all individuals have an attribute x that takes on non-negative integer values. The cumulative distribution function $H(\cdot)$ describes the distribution of x in the population. For example, in the case of magistrate judges, x would be the number of verdicts overturned on appeal,

[18]The term of magistrate judge is typically eight years.

[19]We have been unable to find the actual distribution of reversals.

and $H(x)$ is the fraction of the population who have had x or fewer judgments overturned.[20]

In this environment, an individual is well calibrated if he believes that $H(\cdot)$ accurately describes the distribution of x. In keeping with the example involving judges, we will assume that lower values of x are more desirable than higher values. An individual with attribute x will believe that he ranks better than the fraction $1 - H(x)$ of the population.

Suppose that $H(\cdot)$ is supported on the set $\{0, \ldots, M\}$ and has density h_x. Suppose that individuals observe the valuations of others, but with an error. Specifically, assume that if the true value is x, then with probability $e(t)$ the observed value is $x + t$, provided that $0 \leq x + t \leq M$, and x otherwise. We assume that the distribution of errors is symmetric, $e(t) = e(-t)$. A simple version of this type of noise is when the error is either plus or minus one. In this case, $e(t) = 0$ whenever $|t| > 1$, and the error distribution is such that for $0 < x < M$, there is a probability that the value will be incorrectly observed as either $x - 1$ or $x + 1$, while if x takes on a boundary value, then the error is biased due to the finite support.

Reconsider the example of the magistrate judges. Here x is the number of cases overturned on appeal. We assume that an individual judge does not know the number of cases another judge has had overturned with certainty. His information is a noisy version of the truth that respects the condition that the number is non negative. The next result shows that the noisy observation will tend to be biased: If most of the judges are never overturned, then the error in observation will lead judges to overestimate the rate that other judges are overturned. If one has a mistaken impression of the quality of a judge that has never been overturned, the mistake can only be in the direction of overestimating the judge's overturn rate. There may be a similar bias associated with judges with the highest possible overturn rate, but if the distribution of overturns is skewed, then the first effect will dominate the second one.[21]

If $\tilde{h}_x$ and $\tilde{H}(x)$ represent the perceived density and cumulative distribu-

[20]In the language of our basic model, there is a univariate skill and all individual's agree on the mapping that transforms skill into ability, x.

[21]Our arguments still hold if the distribution $H(\cdot)$ has unbounded support in one direction. If h_x is monotonically decreasing, then the distribution must have a finite lower bound; if the density is monotonically increasing, then the distribution must have a finite upper bound.

tion of attributes. Formally we have

$$\tilde{h}_x = h_x + \sum_{t=-x}^{M-x} e(t)(h_{t+x} - h_x) \tag{6}$$

$$\tilde{H}(x^*) = H(x^*) + \sum_{x=0}^{x^*} \sum_{t=-x}^{M-x} e(t)(h_{t+x} - h_x) \tag{7}$$

Proposition 12 *If h_x is decreasing, then $\tilde{H}(x) \leq H(x)$ for all x. If h_x is increasing, then $\tilde{H}(x) \geq H(x)$ for all x. If h_x is strictly monotonic in x for $x \in \{0, \ldots, M\}$, then the inequalities are strict for $x \in \{0, \ldots, M-1\}$.*

It is appropriate to associate $\tilde{H}(x) \leq H(x)$ with positive self image. In this case, individuals perceive that there are fewer members of the population with attribute less than a given amount than there truly are. (Recall that lower values of x, like lower overturn rates, are more desirable than higher values.) With this interpretation, the proposition states that (when individuals observe the attributes of others with symmetric errors) positive self image arises when the density of attributes increases with the quality of the attribute. It seems natural to associate a decreasing density with an easy task. The assumption fits the distribution of decisions by magistrate court judges that are overturned on appeal.

Proposition 12 also asserts that negative self image holds for hard tasks (when the density of attributes is increasing in x – that is, when less desirable attributes are more likely than more desirable ones).[22]

9 Relative Optimism

According to Armor and Taylor [6, page 336], "results from hundreds of empirical investigations have shown that, on average, people tend to view themselves as more likely to experience positive outcomes, and less likely

[22]An alternative specification would be to assume that if the additive error takes the observation outside of the feasible range of values (for example, if $x + t < 0$), then observation is the boundary value (0). This specification is identical to the one we use when errors are either plus or minus one. For more general noise distributions, mass will concentrate on the endpoints of the interval under the alternative specification and Proposition 12 will not hold.

to experience negative ones, than the average members of the group from which they have been drawn." We call this kind of positive outlook relative optimism. The crucial difference between positive self image and optimism is that optimism concerns expectations about future events while positive self image stems from comparisons of abilities at a fixed time.

Many of the studies of relative optimism investigate subjects' attitudes towards future health risks. Studies claim that individuals underestimate their relative risks of contracting or dying from various diseases (heart attack, cancer, alcoholism, and AIDS, for example).[23] These studies, the focus of our discussion in this section, are important because they suggest that individuals might make suboptimal investments in prevention activities. A good understanding of the reasons for the experimental findings may provide useful guidelines about how to encourage people to make the right level of investments in health care.

In terms of our model, relative optimism can be viewed as positive self image about the ability to avoid disease. Our model identifies how positive self image arises when different agents use systematically different scales to respond to questions about relative performance. The same mechanism may generate at least some of the apparent bias that arises in responses to questions about health outcomes.

Rather than assuming that individuals maximize ability given a production function, let us reinterpret their optimization problem as maximizing an expected payoff. Under this interpretation, individuals have different beliefs (parameterized by λ) of future health outcomes and they make investments to maximize their expected well being. If we assume, following Van den Steen [43], that beliefs are heterogeneous, Propositions 1 and 2 explain why individuals would think that their health risks are low relative to comparable individuals.

The health studies also demonstrate that relative optimism about vulnerability to disease is strongest when individuals feel that they can exercise the most control. The more individuals believe that a condition is preventable, the more strongly they exhibit confidence that they are relatively less likely to get the condition.[24] Proposition 6 demonstrates that positive self image is

[23]Representative examples of this kind of research are: Bauman and Siegel [7], Klar, Medding, and Sarel [25], and Weinstein [45].

[24]Klein [26, page 121] states that people show less optimism about health hazards for genetic – uncontrollable – events and more unrealistic optimism when they believe that they have more control than others do. The literature classifies heart attacks and (ex-

related to control. Results on health outcomes (and in other areas) suggest that individuals may exaggerate the degree to which they control outcomes.

We have separated the study of positive self image from optimism. Studies that identify relative optimism typically ask questions about future events. In these studies subjects' beliefs about their degree of control necessarily influence their answers. While our model may explain positive self image without appealing to motivational arguments, we leave open the possibility that there are important motivational reason for people to overestimate the degree to which they have control of their environment.[25]

Some survey responses about relative risks are not captured by our model. Klein and Kunda [27] and Klein [26] find that people tend to overestimate the rate at which their peers participate in risky forms of behavior. When supplied with information about their peers, people tend to underestimate their own risky behavior.[26] These results are more consistent with theories that assume individuals obtain utility directly from their beliefs. Section 13 briefly discusses some work by economic theorists in this area.

10 Incentives

There are a small number of studies that investigate positive self image or related biases using economic incentives. If subjects seek to maximize their monetary payoff and understand what determines their monetary reward, then all subjects should have the same production function. In this case, our

cessive) drinking as controllable problems, but mugging and high-blood pressure as less controllable. See, for example, Bauman and Siegal [7], Klar, Medding, and Sarel [25], or Weinstein [45].

[25]Van den Steen [43], using an approach similar to ours, does provide a link between optimism and an exaggerated sense of control. Van den Steen discusses a variation of his model that provides a rational foundation for findings that individuals overestimate their sense of control. He considers a situation in which nature moves prior to the decision maker. Nature's move determines whether the outcome is determined by chance (with the probability of success independent of the decision maker's action) or skill (with the probability of success determined by the decision maker's action). Van den Steen shows that if the decision maker overestimates his probability of success, then he will also overestimate the probability that success is due to skill (being in control) and failure to chance.

[26]In a study that makes a related point, Alicke, Klotz, Breitenbecher, Yurak, and Vredenburg [3] ask people to rate themselves on a variety of traits. Six weeks later the people were given their own ratings and told that they come from average percentage estimates of peers. The subjects claimed that they performed better than these "average" estimates.

model suggests that positive self image will not be present. Some experimental findings support this prediction, while others do not.

Moore [35] and Moore and Kim [36] conduct experiments with incentives that identify a bias in beliefs individuals hold about their relative standing. These papers use a 2×2 experimental design in which subjects were asked to wager a fraction of the money they were paid to participate in an experiment on their performance on an exam. Some subjects were told that they would take a hard test; others an easy test. (They were given sample questions.) Some subjects were told that their bet would be doubled if they received the highest score of five; others were told that they would win their bet if their score was higher than the lowest score. After placing their bets, subjects actually took the test.[27] The papers contain two results. First, participants taking the easy test wagered significantly more than those taking the hard test. Second, whether a subject needed to be the best or just better than the worst in order to win the wager did not have a statistically significant impact on the wager.

Since there is an objective criterion that determines payoffs, our basic model only applies to the extent that different subjects have different opinions about the nature of the test. The qualitative relationship between betting behavior on hard versus easy tasks is consistent with Proposition 12, however. The second result is especially surprising. One would expect subjects to bet more when payoffs go to four of the five players than when only the highest score wins. The results are consistent with the hypothesis that subjects believed that answering all of the questions guaranteed that they would win and answering none of the questions guaranteed that they would lose regardless of the relative ranking needed for success. This reading is only a small departure from the instructions. The error structure described in Section 8.2 also generates some of the experimentally observed bias in bidding.

Hoelzl and Rustichini [23] conduct another study with incentives. Subjects are told the difficulty of the task (and are also asked to assess difficulty). Payments (when they were given) were either given to a randomly selected half of the subjects or to the half of the population that scored best on the test. Subjects voted on whether to receive payments based on performance

[27] The test contained a question whose answer was a real number. Ties were broken by taking the distance to the correct answer. The article does not report how frequently tie breakers determined the outcome.

or on the basis of a random assignment. The authors interpreted a vote for performance-based payment as evidence that the subject viewed himself as better than the median. More people voted for performance-based payment for easier tasks than for hard ones. Monetary payments significantly reduced positive self imagine. The first result is consistent with the findings of Moore [35] and Moore and Kim [36]. The second result is consistent with our approach, which attributes positive self imagine to flexibility in the definition of what constitutes success.

Camerer and Lovallo [10] study an entry game. Payoffs in the game are based on rank, which is determined either randomly or through a test of skill. There is more entry when relative skill determines payoffs, which suggests that individuals overestimated their ability to do well on the test relative to others. As with the papers of Moore [35] and Moore and Kim [36] our model can explain these findings only to the extent that different subjects disagree about what skills contribute to success on the test and that subjects have made investments appropriate to the test. Since subjects made entry decisions prior to taking the test, it is plausible to assume that different subjects had different notions of what ability was being tested. It is harder to see why subjects would believe that the skills that they had chosen to improve were relevant to the experimental task. Camerer and Lovallo argue that subjects fail to take into account the strategic behavior of their opponents – in particular, subjects neglect that self selection leads only the most highly skilled subjects to enter when payments are based on skill.

In all of the papers discussed in this section, players must make decisions based on their assessment of their relative standing and on their beliefs about the actions of their opponents. One of the common findings, that positive self image decreases with the difficulty of the task, is consistent with other work and with Proposition 12.[28] It is likely that the results are also influenced by the inability of agents to accurately forecast the actions of others. A careful investigation of the extent to which individuals fail to take into account how their opponents' actions depend on their information or characteristics is outside the scope of our paper.

[28]There are other explanations for the result. Hoelzl and Rustichini [23] point out that ambiguity aversion may discourage subjects from voting for performance-based payoffs. Hoelzl and Rustichini [23] and Moore [35] point out that subjects may not accurately distinguish absolute from relative performance.

11 Implications and Tests of the Model

This paper presents a model that organizes some findings on positive self image. We demonstrate the extent to which the model's predictions are consistent with some observations and point out some aspects of positive self image that are not consistent with the model. This section describes several implications of our model that could be tested and that could distinguish the model from alternative descriptions of behavior.

11.1 Awareness of the Positive Self-Image in Others

In our model, people know they have positive self images, but they also can accurately compute the self image of others. Consequently our assumptions permit individuals to be aware that positive self image holds throughout the population.[29] While explanations of positive self images based on the need to boost self esteem are consistent with an awareness of positive self image in others, awareness might reduce the ability to maintain unrealistically high self estimates.

11.2 Negative Self Image

A full understanding of any behavioral property enables the scientist to know what causes it. To the extent that our model explains positive self image, it should also indicate situations in which positive self imagine is unlikely to arise. Experiments identify the causes of positive self image by varying experimental design. Theorists change assumptions. Positive self image must arise in our model, but we make assumptions to obtain the result. Relax the assumptions and other possibilities arise.

Our model suggests situations in which we would expect to see negative self image. This subsection discusses some of these situations.

We assume that every individual in the population has the same ability to augment his skills. In our model, it is this ability to augment skills that generates positive self image. Our model predicts that individuals who are relatively less able to improve their skills have lower self assessments. There is evidence (Alloy and Abramson [4]) that individuals who claim to have less control have lower self images.

[29] Krueger [29] presents evidence that suggests that people expect others to have positive self images.

We assume that initial skills are distributed independently of technologies. If skills were distributed so that people had relatively low endowments of the skills that they thought were most productive, then negative self imagine would be common in the population. We see no reason why endowments should be negatively correlated with productivity, so we do not think that this is a compelling reason for negative self images. It does suggest that one could induce negative self image effects in the laboratory by selecting individuals whose endowments do not match their productivity, by asking individuals to rate themselves on the basis of attributes selected by others,[30] or by asking individuals to base ability rankings on dimensions that they earlier described as unimportant.

Proposition 12 demonstrates that positive self image should be expected for easy tasks (those in which high skill is more likely than low skill) and that negative self image should be expected for hard tasks. Qualitatively, this result is consistent with experimental findings that we discussed in Section 5. While we have not investigated the result in controlled settings, we ask the reader to consider the following questions, which are parallel to the questions asked of magistrate court judges:

> Students in this university rarely receive the final grade of A+, but it does occur. If we were to rank all of the students currently enrolled in this course according to the number of classes on their transcript from this university in which they received a final grade of A+, what would your rank be?

Motivational models of egocentric bias would predict that students overestimate their ranking. Assuming that most students never receive A+ grades, an explanation of apparent bias based on the skewness of distributions would predict that students underestimate their ranking.

For an academic audience, consisting of a mix of graduate students and researchers, the following question may elicit the same kind of negative self image:

> *American Economic Review*, *Econometrica*, *Journal of Political Economy*, and *Quarterly Journal of Economics* are the most prestigious economics journals. If we were to rank all of the people

[30]Dunning, Meyerowitz, and Holzberg [15] show that self image goes down when people evaluate themselves using lists of skills created by others rather than themselves.

in this audience according to the number of publications in these journals, what would your rank be?

11.3 Fixed Versus Variable Characteristics

Some attributes can be changed, others are fixed. For example, a basketball player can practice taking free throws, passing, or dribbling, but has less control over his height. If you ask basketball players how important height is to the game, a theory of positive self image based on self-serving biases would predict that the taller players view height as relatively more important factor than do smaller players. In our model, positive self image arises because agents can select which traits to augment. Assuming that technologies are independent of fixed traits, individuals' positive self image will come from the investments that they make in flexible traits, but not from fixed ones.

There are some physical traits that can be adjusted, at varying costs. Our model predicts that bleached blondes are more likely to claim that their hair color contributes strongly to their beauty than natural blondes. Similarly, we predict that, on average, not wearing glasses is viewed as a more significant positive attribute by laser surgery patients than by people who wear contact lenses, who in turn rate it more highly than people with no need for glasses.

11.4 Positive Self Image Over Time

In our model positive self image arises because individuals use different criteria to evaluate the value of skills and because they are able to tailor their investments to their own criteria. To the extent that investments take place over time, this suggests that self image may vary systematically over a lifetime.

One could imagine asking college students to rate their ability to study efficiently relative to people in the same entering class or asking teachers to rate themselves relative to others with the same experience. Our model predicts that positive self image should increase with experience.[31]

If individuals overestimate the degree to which they can exercise control, relative optimism regarding future events may decline as the event ap-

[31] Camerer and Lovallo [10] suggest that successful people will become increasingly overconfident in their ability relative to workers at a similar rank over time because while they attribute their own promotion to skill, they fail to take into account that only the best of their co-workers advance.

proaches. For example, college students may underestimate their relative probability of becoming overweight by age 50, but become better calibrated as their fiftieth birthday approaches (and there are fewer opportunities to believe that they can control their weight).[32]

11.5 Composition of Comparision Group

Proposition 3 suggests that positive self image will be stronger when subjects are asked to compare themselves with more heterogeneous groups. Surveys that carefully vary the comparison group should (according to our model) generate systematic changes in the degree of positive self image, with positive self image decreasing the more homogeneous the comparison group.

Proposition 3 measures heterogeneity through differences in individual technologies. We can also measure heterogeneity through differences in the endowments. Heterogeneity of initial skills leads to a reduction in positive self image, in contrast to heterogeneity of production functions.

Since we assume that agents have the same capacity to augment their skills, we know from Corollary 1 that when there is no variation in initial endowment, the strongest possible positive self image effect exists. In general, there is a sense in which greater variability decreases positive self image. The idea is that skill augmentation allows individuals to "become" better than others by making an appropriate investment. The investment has only limited ability to improve one's subjective ranking. It only permits an agent to get better than individuals who have similar endowments. By making endowments more variable, the chance of moving up in relative rankings through investment decreases.

Proposition 13 *In the linear model, a mean-preserving spread in the distribution of initial skills decreases the average positive self image.*

The different qualitative conclusions of Propositions 3 and Proposition 13 may provide a useful way to test our model and classify observational findings.

[32]Shepperd, Ouellete, and Fernandez [39] asked 29 college seniors to provide estimates for their starting salary after graduation four months prior to graduation and again two weeks prior to graduation. The average starting salary estimated four months prior to graduation was $23,544; at two weeks prior to graduation the estimate was $21,638.

11.6 Self Image versus Appearance

In our model, people tend to see themselves more positively than others see them. When initial endowments are identical, this effect is most striking: Each individual believes that he is better than everyone else. When initial endowments differ, then it is possible for one individual's subjective ranking to be lower than the ranking that individual would receive from another.[33]

We'll say that an individual's external ranking is the average of rankings across all technologies in the population. External rankings differ from self rankings because different scales are used to evaluate the final vector of characteristics. Investment will always be tailored to an individual's technology, leading one's self ranking to exceed his external ranking, but when technologies and initial endowments are independently distributed, there will be no relationship between initial external and self rankings. This argument suggests how an individual's self ranking varies with his external ranking: The higher his pre-investment self ranking and the greater the possibility of making investments, the more likely a self ranking will exceed the external ranking.

12 Alternative Interpretations of the Model

In our model positive self image arises because agents make choices and have different objectives. We interpret the objective as maximization of an ability derived from a production technology, but have already mentioned that, like Van den Steen [43] we could also interpret the objective as maximizing the probability of success. Under this interpretation, heterogeneity arises when people have different beliefs.[34] Similarly, one can interpret the production function as a utility function and attribute heterogeneity to differences in preferences. In this section, we briefly discuss other interpretations of the model.

Imagine that individuals have identical objectives, but the best way to achieve their objective depends on their environment. Return to the driving example and assume that all drivers have the same goal, say to minimize the

[33] For a simple example, assume in the linear model that $\lambda = (2, 1, 0)$, $\kappa = (0, 0, 1)$, and $\lambda' = (2, 0, 1)$. Assuming that the components of the initial endowment are independently and identically distributed across the population, an individual with type λ' will rank the (λ, κ) individual more highly than he ranks himself.

[34] See Van den Steen [43] and his references for discussions of this assumption.

probability of being involved in an accident. Safe driving requires different skills in different climates, however. Drivers who live in different places will acquire the appropriate skills for their environment. As long as individuals evaluate safe driving egocentrically – using the appropriate definition for their environment – our model applies without modification. We need only interpret λ as the description of the environment.

Story and Dunning [41] discuss another interpretation. They speculate that different strategies can lead to success, but that an individual may underestimate the effectiveness of strategies that he did not use. A successful teacher who relies on well prepared formal lectures may be skeptical of the ability of someone using a more interactive approach to convey course material. A doctor who actively intervenes and successfully treats a medical condition may not be willing to believe that the condition would have gone away on its own. A complete formulation of this idea is beyond the scope of our paper, but here is a possible way to approach the problem that is quite similar to our basic model. Assume that individuals receive a monetary payoff of the form

$$v(k;\lambda) = \begin{cases} 0 & \text{if } k < \lambda, \\ 1 & \text{otherwise.} \end{cases}$$

An interpretation of $v(\cdot)$ is that individuals either succeed (earn \$1) or fail (earn 0). Success requires that at least one skill k_i exceeds a threshold value λ_i. Individuals pick k to maximize an increasing concave function of $v(\cdot)$. Now, in contrast to the approach we took in this paper, assume that individuals have limited, and different, information about λ. Individuals will make different choices depending on their information and, because of risk aversion, will tend to prefer their choice to choices made by others.

13 Related Literature

Several papers have presented theoretical models involving optimism or positive self image. We now briefly discuss some of this research.

If one accepts that individuals have systematically biased beliefs, then it is hard to resist the conclusion that individuals will make suboptimal decisions.[35] If positive self image leads to incorrect decisions, it is natural to

[35]According to our approach, the appearance of positive self image need not be associ-

ask why decision makers do not learn to correct their biases. One branch of the literature points out that there are strategic advantages to maintaining optimistic beliefs. Hvide [24] introduces a model in which individuals choose beliefs about their own ability, and demonstrates that there are conditions under which there is a strategic advantage for selecting beliefs that over estimate true ability. The advantage arises through commitment effects. An individual's bargaining position is an increasing function of his own opinion of his skill level because high self image leads to high reservation wages, so an individual gains from having a positive self image. For similar reasons, Heifetz and Spiegel [21] show in a class of environments having optimistic beliefs is beneficial in a class of strategic environments. Heifetz and Spiegel provide conditions under which overconfident beliefs will have a selective advantage.

Others posit that a positive self image is desirable even in non-strategic contexts. Psychologists interpret much of the evidence on positive self image in this way, arguing that people are motivated to maintain a positive self image. A straightforward way to model this is to assume that individuals have preferences that are defined directly on beliefs.[36] Akerlof and Dickens [1] is perhaps the first such model in the economics literature.

While we believe that our approach parsimoniously organizes much of the evidence on positive self image, we have described work that does not easily fit into our framework. Motivated by this evidence, several insightful recent papers explicitly insert beliefs into preferences. When beliefs enter directly into preferences, agents obtain a direct compensation for biased beliefs that counteracts the cost of the bias. There may also be strategic reasons for maintaining biased beliefs. Benabou and Tirole ([8] and [9]), and Weinberg [44] are examples of models that explain why agents could maintain systematically biased beliefs.[37] These papers and the work of Köszegi [28] and Rabin [38] demonstrate how including beliefs directly into preferences provides ways to explain strategies individuals use to learn about themselves and their environment.

ated with biased decision making.

[36] This specification can often be viewed as a convenient reduced form derived of a more complicated model.

[37] Compte and Postlewaite [11] assume that confident people are more likely to succeed. In their model, beliefs influence a production process so that biased beliefs may enhance performance.

14 Conclusion

We demonstrate that, in the presence of skill enhancement, egocentric comparisons lead to positive self image. We do not explain why individuals make egocentric comparisons.[38] Our model organizes a range of observations under the assumption that people make egocentric comparisons.

We are in agreement with Dunning [13, page 99] when he writes "the central tenet guiding the discussion is that people are often not referring to the same actions and characteristics when invoking the same word or concept" and are convinced by the finding that optimism and positive self image are widespread. This paper provides a descriptive model and suggests that positive self image may not be a compelling reason to change modeling approaches.

While our conventional model captures much of what has been classified as biased behavior, we have discussed some observations that are not consistent with our model. Moreover, two biases that are difficult to separate from positive self image are widespread but not explained by our model. It would be valuable to pursue the extent and implications of the finding that (non-depressed) individuals have an exaggerated estimate of their ability to control events and also the inability to take into account strategic behavior of others (as identified in the papers discussed in Section 10).

We discussed in Section 11.2 how relaxing our assumptions indicates situations in which negative self image might arise. All of our results require strong assumptions. By investigating environments were the conditions in our propositions fail, we are led to situations where the commonly observed qualitative properties of relative self image are unlikely to hold.

[38]Psychologists present two reasons for egocentric comparisons. Motivational arguments posit that individuals get utility directly from maintaining positive feelings about themselves. Our work explains why egocentric comparisons supply positive feelings. Cognitive theories assume that it is easier to categorize behavior according to something familiar (personal preferences) than something less familiar (the preferences of another) and so egocentric comparisons conserve scarce information-processing costs.

Appendix

Proof of Proposition 1 For fixed λ, define $u_p(\zeta)$ to be the ability level that a type λ individual views as being as good as the fraction p of the population with technology parameter λ. That is, $u_p(\lambda)$ is defined by

$$u_p(\lambda) = \inf\{u : \mu(\{W(u;\lambda)|\lambda' = \lambda\}) \geq p\}. \tag{8}$$

At least $1 - p$ of the population with technology λ must have final ability as big as $u_p(\lambda)$.

It follows from the definition of $T^*(\cdot)$ that

$$T^*((\kappa', \lambda'); \lambda) \leq T^*((\kappa', \lambda); \lambda). \tag{9}$$

Consequently,

$$T^*((\kappa', \lambda); \lambda) \leq u \text{ implies } T^*((\kappa', \lambda'); \lambda) \leq u$$

and because κ and λ are independently distributed, for all λ',

$$\mu(\{\zeta' : T^*(\zeta'; \lambda) \leq u_p(\lambda)|\lambda'\}) \geq p.$$

Hence anyone with ability greater than $u_p(\lambda)$ is in the top part of the skill distribution in his own estimation, which is the desired result. *Q.E.D.*

Proof of Proposition 2 When technologies are distinct, for each λ there exists λ' such that inequality (9) holds strictly. The proof follows along the lines of the proof of Proposition 1. *Q.E.D.*

Proof of Proposition 3 If $\bar{\lambda} = \max \lambda_i$, then $v(\lambda) = \bar{\lambda} - \lambda_i$ is a convex function. It follows from (4) that a mean-preserving spread in the distribution of technologies increases the fraction of individuals that any individual beats. *Q.E.D.*

Proof of Proposition 4 $g(\bar{\lambda}) - g(\lambda_i) \geq \bar{\lambda} - \lambda_i$ and so, by (4) the set $L(\cdot)$ prior to the transformation is contained in $L(\cdot)$. *Q.E.D.*

Proof of Proposition 5 Let c denote the amount available to augment skills. When there are $n - 1$ skills, a type λ individual augments the same skill as $\frac{1}{n-1}$ of the population and, on average, is better than exactly one half of that fraction of the population. With probability $\frac{n-2}{n-1}$ the individual invests in a different skill. Expected self image when the individual invests in his favorite skill, which receives weight $\bar{\lambda}$, relative to an agent who invests in a different skill i is

$$F_\lambda\{c(\bar{\lambda} - \lambda_i) \geq \Delta_{n-1}\}, \tag{10}$$

where $\Delta_h = \sum_{i=1}^{h} \lambda \cdot (\kappa' - \kappa)$ and $F_\lambda(X)$ is the conditional probability (given λ) of $\{(\kappa, \kappa') \in X\}$. Denote the expected value (with respect to λ_i given $\lambda_i \leq \bar{\lambda}$) of the quantity in expression (10) by S. By symmetry, S does not depend on i and, since $\bar{\lambda} > \lambda_i$, $S > \frac{1}{2}$.

When there are $n-1$ skills, the expected self image of an individual is therefore

$$\frac{1}{2(n-1)} + \frac{n-2}{n-1} S. \tag{11}$$

Now add one component and consider the expected fraction of the population that is below the individual.

$$\frac{n-1}{n}\Big(\frac{1}{2n} + \frac{n-1}{n} S\Big) + \frac{1}{n}\Big(\frac{1}{2n} + \frac{1}{n}\sum_{i=1}^{n-1} F_\lambda\{c(\lambda_n - \lambda_i) \geq \Delta_{n-1}\}\Big). \tag{12}$$

The first sum contains the terms corresponding to when $\bar{\lambda} \geq \lambda_n$, while the second sum contains the terms where $\bar{\lambda} < \lambda_n$. To prove the proposition, we must show that (12) is greater than or equal to (11). Conditional on $\lambda_n \geq \bar{\lambda}$ the expected value of $F_\lambda\{c(\lambda_n - \lambda_i) \geq \Delta_{n-1}\}$ must be greater than or equal to S. It follows that (12) is greater than or equal to

$$\frac{n-1}{n}\Big(\frac{1}{2n} + \frac{n-1}{n} S\Big) + \frac{1}{n}\Big(\frac{1}{2n} + \frac{n-1}{n} S\Big) = \frac{1}{2n} + \frac{n-1}{n} S. \tag{13}$$

Since $S \geq \frac{1}{2}$, (13) is greater than or equal to (11), which is the desired result. *Q.E.D.*

Proof of Proposition 6 The proposition follows because the set

$$L(\kappa, \lambda) = \{\kappa' : \frac{1}{n}\sum_{i=1}^{n} \kappa \cdot \lambda + c\bar{\lambda} > \kappa' \cdot \lambda + c\lambda_i\}$$

increases when c increases. *Q.E.D.*

Proof of Proposition 9 For concreteness, let $\lambda_1 = \bar{\lambda}$ be the largest component of λ. Compared to other individuals in the population whose favorite skill is 1, the individual's expected ranking is $\frac{1}{2}$ both with respect to skill one and with respect to the ability. We will show that for all other skills, the individual has a higher expected ranking with respect to his favorite skill than with respect to the ability.

Take a skill $i \neq 1$. An individual with initial endowment κ and favorite skill one is better than an individual with endowment κ' in the $(\frac{1}{n})^{th}$ of the population who prefers i provided that

$$c(\bar{\lambda} - \lambda_i) > \lambda \cdot (\kappa' - \kappa), \tag{14}$$

Let $\rho_i = \frac{\lambda_i}{\bar{\lambda}-\lambda_i}$ and rewrite (14) as

$$c > \rho_1(\kappa'_1 - \kappa_1) + \rho_{-i} \cdot (\kappa'_{-i} - \kappa_{-i}). \tag{15}$$

It suffices to show that the probability that inequality (15) holds is less than the probability that $c > \kappa'_1 - \kappa_1$, with is the probability that

$$k_1 = \kappa_1 + c > \kappa'_1 = k'_1. \tag{16}$$

First note that $\rho_{-i} \cdot (\kappa'_{-i} - \kappa_{-i})$ is a symmetrically distributed mean-zero random variable that is uncorrelated with $\rho_1(\kappa'_1 - \kappa_1)$. It must add weight to the tails of the distribution of the right-hand side of inequality (15) and therefore (since $c > 0$) lowers the probability that (15) holds. Second note that since $\rho_1 > 1$ and $c > 0$, $c > \kappa'_1 - \kappa_1$ whenever $c > \rho_1(\kappa'_1 - \kappa_1)$. *Q.E.D.*

Proof of Proposition 11 In the linear model, the relative standing of an individual with income I^* and type λ is

$$\sum_{i=1}^{n} \frac{1}{n}\{F(I^* + \bar{\lambda} - \lambda_i) - F(I^*)\}. \tag{17}$$

Concavity of $F(\cdot)$ guarantees that (17) is decreasing in I^* for λ fixed. *Q.E.D.*

Proof of Proposition 12 The proposition follows from the next relationship.

$$\sum_{s=0}^{s^*} \sum_{t=-s}^{M-s} e(t)(h_{t+s} - h_s) = \sum_{s=0}^{s^*} \sum_{t=s^*-s+1}^{M-s} e(t)(h_{t+s} - h_s) \tag{18}$$

The right-hand side of equation (18) is equal to zero when $s^* = M$. Otherwise, the right-hand side of (18) is a non-negatively weighted average of terms of the form $h_{t+s} - h_s$, for $t > 0$. Consequently, if h_t is strictly increasing (non decreasing), then the sum is positive (non negative) and if h_t is strictly decreasing (non increasing), then the sum in negative (non positive).

To establish equation (18) write

$$\sum_{t=-s}^{M-s} e(t)(h_{t+s} - h_s) = \sum_{t=1}^{M-s} e(t)(h_{t+s} - h_s) - \sum_{t=1}^{s} e(t)(h_s - h_{s-t}), \tag{19}$$

where the second term uses the symmetry of $e(\cdot)$. Now observe that

$$\sum_{s=0}^{s^*} \sum_{t=1}^{s} e(t)(h_s - h_{s-t}) = \sum_{s=0}^{s^*-1} \sum_{t=1}^{s^*-s} e(t)(h_{t+s} - h_s). \tag{20}$$

To obtain equation (20) change the order of summation of the left-hand side of (20) to obtain

$$\sum_{s=0}^{s^*} \sum_{t=1}^{s} e(t)(h_s - h_{s-t}) = \sum_{t=1}^{s^*} \sum_{s=t}^{s^*} e(t)(h_s - h_{s-t}), \tag{21}$$

substituting $u = s - t$ in the right-hand side of equation (21) yields

$$\sum_{s=0}^{s^*} \sum_{t=1}^{s} e(t)(h_s - h_{s-t}) = \sum_{t=1}^{s^*} \sum_{u=0}^{s^*-t} e(t)(h_{u+t} - h_u), \tag{22}$$

and changing back the order of summation in the right-hand side of (22) yields

$$\sum_{s=0}^{s^*} \sum_{t=1}^{s} e(t)(h_s - h_{s-t}) = \sum_{u=0}^{s^*-1} \sum_{t=1}^{s^*-u} e(t)(h_{t+u} - h_u) = \sum_{u=0}^{s^*} \sum_{t=1}^{s^*-u} e(t)(h_{t+u} - h_u), \tag{23}$$

which is equivalent to (20) (the second equation in (23) follows because $\sum_{t=1}^{s^*-u} e(t)(h_{t+u} - h_u) = 0$ when $u = s^*$.

Equation (18) follows by summing both sides of (19) from $s = 0$ to $s = s^*$, substituting the right-hand side of equation (20), and simple algebraic manipulation. *Q.E.D.*

Proof of Proposition 13 The average positive-self image is the probability that a symmetric mean-zero random variable is no greater than a positive constant. An increase in the randomness of the initial distribution makes the random variable more variable, which decreases average positive self image. *Q.E.D.*

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