G

GAMBLER'S FALLACY

The Gambler's Fallacy refers to an incorrect belief about a sequence of independent random events. Someone falling prey to the fallacy believes that if a sequence of observed random events deviates from expected behavior, subsequent events will be biased in the opposite direction in order to move his observed sample towards a known population mean. A commonly overheard example is the expectation that something is "due"; a roulette ball is "due" to fall on a red number after a long series of black numbers.

Such beliefs have been demonstrated experimentally by Estes (1964), who asked subjects to observe a sequence of coin flips and predict outcomes. Subjects behave as if every segment of the sequence must reflect the true proportion of 50 percent, and expect corrective biases in the opposite direction of the observed sequence. This can also be seen by asking experimental subjects to generate a random sequence of hypothetical coin flips. Tune (1964) showed that subjects maintain the proportion in any short segment at much closer to 50 percent than the laws of chance would predict.

Tversky and Kahneman (1971) suggest that the Gambler's Fallacy is driven by belief in the Law of Small Numbers (the Law of Large Numbers applied to small samples). This can be described as the belief that a sample randomly drawn from a population is highly representative; thus each sample must be similar to each other sample and to the population. In surveys of professional psychology researchers, they demonstrate fundamental misunderstandings of interpreting replication studies. This includes overestimating the likelihood of replicating study findings, and underestimating the significance of successful replication with differing magnitudes. They suggest that across naïve subjects and trained scientists alike, there exist strong intuitions about random sampling that are fundamentally wrong. They argue that belief in the Law of Small Numbers (and thus the Gambler's Fallacy) is a result of the representativeness heuristic, a cognitive bias that operates regardless of motivational factors. This has been replicated in field experiments by Croson and Sundali (2005).

A related fallacy is known as the Hot-Hand Fallacy, where future outcomes are believed to be biased in the *same* direction as a previous sequence (this is sometimes also called the Gambler's Fallacy, as both fall into a general category of inference from previous independent results). There may be some validity to such beliefs in a human-generated outcome like the shot of a basketball, but it is just as misguided as the Gambler's Fallacy with respect to independent, randomly generated outcomes.

Correcting or avoiding the Gambler's Fallacy has proven to be difficult, as education about the nature of random events has been ineffective at reducing the prevalence of picking "with" the fallacy. Beach and Swensson (1967) tested how people predict draws of reshuffled cards with and without prior education about the Gambler's Fallacy and found that both groups made similar predictions that relied on the fallacy.

Roney and Trick (2003) have demonstrated that the effect of the Gambler's Fallacy can be reduced by "grouping" observations to make the next outcome appear as though it were the beginning of a sequence. Participants were shown the results of a sequence of six coin flips, with the last three all coming up heads. Those who were asked to predict the outcome of the seventh coin flip relied more heavily on the Gambler's Fallacy (by choosing tails), more so than those that were asked to predict the first flip for the next sequence of six. They thus argue for encouraging people to view each event as a beginning and not a continuation of events.

Kevin Laughren and Robert Oxoby

See also: Errors and Biases; Heuristics; Ignorance of Base Rates; Kahneman, Daniel; Tversky, Amos

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GAMBLING BEHAVIOR

Gambling refers to staking money on an outcome with a random element. Gambling takes many different forms, betting on races or sports events, card games, roulette, lotto, slot machines, scratch tickets, or online casinos. The acceptance of gambling varied in history and across societies, but current surveys in Western nations suggest that a large majority of adults gamble on a regular basis. From a profit-maximizing perspective, gambling represents a puzzle. For the individual, the expected value of gambling is often considerably smaller than the cost. This comes from the usual small probabilities of winning in combination with payout ratios being reduced by profit made by bookmakers, casinos, or lotto agencies. Different explanations have been suggested to explain why people gamble nevertheless, focusing on the subjective interpretations of probabilities, risk-seeking, self-deception, affect, and social factors.

Subjective interpretations of probabilities often differ from objective probabilities. People overweight low probabilities, as described by the weighting function of *prospect theory*. They use *heuristics* to judge probabilities, like the availability heuristic that is based on the ease of retrieval from memory. People often have a limited understanding of random processes, which in turn influences subjective probabilities. They often expect the outcome of a random process also to look random (representativeness heuristic), and therefore prefer to bet on seemingly unordered sequences. In the *Gambler's Fallacy*, random processes are misunderstood as self-correcting over time, and independent probabilities are perceived as depending on previous outcomes. For example, after the roulette wheel has shown red for five or more times in a row, people expect black to be more likely, and also bet accordingly. Observing a "near miss," only one symbol missing to win the jackpot on a slot machine, leads to continued gambling by reinforcing the gambler's fallacy.

Risk-seeking explains why the decision to engage in gambling can differ even when the same probabilities are involved. Individuals who are more risk-seeking are more likely to gamble, but situational factors also are important. The "house money effect" describes the phenomenon in which people are more careless about windfall gains (such as money won in the casino). But losses also can induce more risky behavior in line with the value function of prospect theory, particularly when there is a chance to "break even" and to recover the losses. This can result in "chasing," placing higher bets after losing, in the hope of making up for previous losses.

Self-deception describes that gamblers may have self-serving views related to gambling. Gamblers may show unrealistic optimism in the sense that they see themselves as more likely to win than other people. They may also be prone to illusion of control—they think they have more influence on outcomes than is the case. Some gamblers hold superstitious beliefs and use rituals or lucky charms, bet on significant numbers such as birthdays, or believe that a ticket they owned but gave up is more likely to win. For games that involve some skill elements, gamblers' overconfidence in their skills can be a driving factor.

Affect, mood, and emotions can influence how people perceive probabilities and their risk aversion. Gambling in itself is often arousing and exciting, and casinos and other gambling sites are often designed to add to the experience. Seeking positive emotions and avoiding negative emotions contributes to gambling beyond considerations of probabilities and outcomes. For example, people anticipate regret when not participating in a lottery designed to provide clear feedback (Dutch postcode lottery) and therefore are more likely to buy tickets.

Social factors can take various forms. Gambling is often heavily advertised and part of mainstream television, and some forms of gambling are more seen as a leisure activity than as betting money. On the level of social networks, gambling among peers and family members has been found to be related to gambling behavior. Finally, some forms of gambling are specifically done in groups or syndicates and provide a valued group membership.

In some cases, gambling develops a pattern similar to *addiction*. Pathological gambling is characterized by needing to bet higher amounts for excitement, by chasing losses, and by unsuccessful attempts to quit gambling. Pathological gambling can have severe economic, social, and psychological consequences, like bankruptcy, criminal behavior, relationship conflicts, or depression.

Erik Hölzl

See also: Addiction; Gambler's Fallacy; Heuristics; Prospect Theory; Regret

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GAME THEORY (BEHAVIORAL/COOPERATIVE)

Game theory is an interdisciplinary study of rational strategic behavior. The 2005 Nobel Laureates in Economics, Robert Aumann and Thomas Schelling, have both observed that game theory would be better described as interactive decision theory. As such, most of the literature of game theory is about "absolutely rational decision makers whose capabilities of reasoning and memorizing are unlimited" in the words of Reinhard Selten. Within game theory there are two major streams of thought, cooperative and noncooperative game theory, which can be thought of as corresponding to two different concepts of (equally perfect) rationality.

For cooperative game theory, which stems from the foundational book of von Neumann and Morgenstern, whenever rational agents can realize a mutual benefit from coordinating their strategies, they will find a way to do so. For noncooperative game theory, which originates from the work of John Nash, strategy choices are stable only if each individual chooses his best (or least bad) option at every stage of the game. Because of this limitation mutually beneficial strategy choices may not be realized. Of the two, noncooperative game theory has been the more widely influential. In noncooperative game theory, there is a fairly extensive literature that substitutes bounded rationality for the more common assumption of perfect rationality; and there is also an extensive literature of experimental studies. Some experimental studies of cooperative game theory have also been done.

Noncooperative game theory is often illustrated by an example called "The Prisoner's Dilemma"; it is one of a broader category of "social dilemmas." Another widely studied social dilemma arises in price strategies for a duopoly. This is illustrated in Table 1. Each of the two firms can choose between two strategies: maintain a monopoly price or cut the price to a more competitive level. These strategies are shown in the table as the bottom two rows, representing the two strategies for Firm 1, and the rightmost two columns, representing the two strategies for Firm 2. In each of the lower right four cells, two payoffs are shown: the profits to Firm 1 and Firm 2, respectively, in millions or tens of millions or on some other appropriate scale.

The payoffs in the table reflect the idea that if one firm chooses a lower price than the other, then the firm with the lower price will attract most of the customers; but if they both cut their prices, they will continue to split the market at the lower price. Assuming that each chooses his "best response" to the strategy chosen by the other, each will choose to cut prices, which is the "dominant strategy" for each firm. Thus, they will price competitively, even though both would do better charging the monopoly price. This is an instance of Nash equilibrium.

Table 1 A Pricing Dilemma

First payoff to Firm 1, second to Firm 2.		Firm 2	
		maintain price	cut
Firm 1	maintain price	5,5	0,8
	cut	8,0	1,1

The monopoly price would be the cooperative solution to this game. We should observe that the customers, who would benefit from lower prices, are not considered players in the game.

This is not quite conclusive, though, because the pricing game is likely to be played again and again. If, in each year, there is some probability that the game will be played again in the following year, then it is quite possible that the cooperative monopoly price will be realized. For example, if each firm chooses its strategy according to a tit-for-tat rule, cooperation may be realized. The tit-for-tat rule is this: Play cooperatively unless and until the other player plays noncooperatively, and at that point retaliate by playing noncooperatively in the next round. This rule may be a Nash equilibrium in some games. On the other hand, if both players know that their play will be terminated after a certain number of plays, then perfectly rational players will never cooperate.

This will serve to illustrate both experimental studies and the implications of bounded rationality. Experiments with repeated games have taken place from quite early in the history of game theory (Poundstone). Typical results are that some cooperation is realized in early repetitions of the game. That is, it appears that real human beings are rational enough to recognize the possibility of some mutual gain, but not rational enough to reason back from the last repetition and understand that cooperation is never a best response. In all, game theory has applications in any field in which outcomes depend simultaneously on the decisions of two or more persons.

Roger McCain

See also: Behavioral Economics; Golden Rule, Cooperation, and Productivity; Nash Equilibrium; Prisoner's Dilemma; Public Good Game; Tit-for-Tat; Trust Game

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GENDER DIFFERENCES

Testing for differences in preferences between genders has been a focus of economic research for many years, particularly in the areas of labor economics and the economics of the household. For example, early work by Gary Becker (1965) and Claudia Golden (1990) has delineated the ways in which incentives may vary across genders and how social institutions may shape these incentives and motivate different behaviors across genders. Many researchers (such as Daly and Wilson 1978, 1988) have taken an alternate approach to gender differences, focusing on evolutionary bases for the emergence of differences in contemporary behavior. Taking a more behavioral approach to identifying and understanding gender differences in behavior, Croson and Gneezy (2009) review findings from experimental economics regarding differences across risk preferences, social preferences, and preferences toward competition. While there are significant variations in specific findings, several stylized facts emerge from the experimental research on gender differences. For example, women are typically observed to be more risk-averse than men, though this difference disappears among professional managers and those with knowledge of financial investments. Women frequently respond less favorably to competitive environments than men. Finally, men and women frequently demonstrate different social preferences, though Croson and Gneezy make the case that such results could be a side-effect of women's overall greater propensity to react to contextual changes in experiments. These findings all shed light on the labor market, educational, and social differences identified by researchers such as Becker (1965, 1976), Daly and Wilson (1978, 1988) and Goldin (1990).

The difference in risk preference between men and women is the most widely demonstrated and robust gender difference in economic experiments. In almost all contexts, men show a greater incidence of risk taking than do women. With risk differences established, researchers have sought explanations for this behavior. Psychological research suggests that women experience emotions more strongly than men and that this can affect the utility of a risky choice. In experiments, women have reported more intense nervousness and fear in anticipation of negative outcomes than men, resulting in greater observed risk aversion among women. Similarly, experiments have demonstrated that identical situations can motivate anger in men and fear in women (Daly and Wilson 1978). When paired with findings that anger evaluates gambling behavior (risk taking), it is possible that men underestimate risk, leading to observed differences in risk preferences.

In economic experiments, women respond less favorably to competitive environments than do men. Researchers have observed improved performance from men when faced with a competitive incentive to perform a task rather than a piece-rate incentive but no similar improvement from women. This gender difference has also been observed in children, leading to the suggestion that the difference stems more from "nature" than from "nurture," as children are less likely to have assumed strong gender identities before puberty. This preference for competition is important in labor policy, where it has been suggested by some researchers that wage gaps are affected by women bargaining less competitively.

Experimental research has demonstrated important gender differences in social preferences, including inequality aversion, altruism, envy, trust, and reciprocity.

These findings have relied on observed differences in behavior between individuals in simple economic games (ultimatum, dictator, and trust games). However, the results are consistent across decision environments: women are typically more concerned with equality, while men demonstrate preferences for efficiency. Results on differences in levels of trust and contributions to public goods have been more mixed.

Croson and Gneezy (2009) offer evidence that women's choices are more sensitive to the experimental environment, insofar as their responses to contextual changes are larger than those of men. For example, in an ultimatum game where the gender of the proposer is known, men show less variation in their rejection rate by the gender of their opponent than do women. In dictator games, women increase the amount offered once they move from an anonymous opponent to one of known gender.

It is also important to note that gender differences in choices can also be affected by institutional parameters such as the power relationship (a point of significance to Herbert Simon's perspective on behavioral economics) between decision makers in terms of, for example, the number of children, household expenditure, and the division of labor. As well, the norms and social values instilled in the household, school, and work environment also can significantly affect the extent to which choices are gendered.

Kevin Laughren and Robert Oxoby

See also: Capabilities Approach; Experimental Economics; Feminist and Behavioral Economics; Household Decisions; Social Preferences within a Population

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GENOECONOMICS

Genoeconomics studies the effects of individual genetic variation and social environment on economic behaviors, preferences, or outcomes (economic phenotypes). It is a composite term based on genomics and economics defining an interdisciplinary research field where economists, behavioral geneticists, psychologists, and even physicians work closely together.

The foundation of the field was established in the mid-twentieth century, but emerged recently after the human genome sequencing was finalized in 2001 and when the collection of genetic data became affordable. Because the idea that behavior and beliefs are the product of environmental *and* biological factors had gained interest in other social sciences (psychology, political science), behavioral economics also started to use biological explanatory variables. The field is steadily growing in terms of number of studies and practitioners, having brought about intriguing findings such as the conjecture of a genetic component to individuals' preferences (fairness, risk) and economic outcomes (educational attainment, tendency to be an entrepreneur).

Why is genoeconomics relevant? Genoeconomics is expected to make important contributions to the study of human behavior. Although highly interdisciplinary in itself, genoeconomics strongly benefits from neuroeconomics, where neurological pathways are incorporated into explanations of economic decision making. Just recently, the assumption of a static brain was abandoned and replaced by the phenomenon of neuroplasticity. Neuroplasticity is based on the observation that the synapses change over the course of their lifetime, on the basis of environmental influences. When certain parts of the brain are injured, new neural connections are built to partly compensate for the old ones.

Genoeconomics and neuroeconomics together can identify causal effects for economic phenotypes. Furthermore, better theories and models of human behavior might be constructed when the relationships between economic phenotypes and genetic components become clearer. If genes do indeed play a role in explaining economic behavior, building models from an environmental, deterministic point of view would result in an omitted variable bias. Finally, genoeconomics might contribute to a better understanding of human evolution, if genes with respect to economic phenotypes are compared to our ancestors, such as with chimpanzees.

Heritability is a proportion of the variability for an economic phenotype that is contributed by a gene. It does not imply certain determinism based on genes. The basic foundations of genoeconomic studies are twin studies: if monozygotic twins are more similar to each other than dizygotic twins with respect to a particular phenotype, then this phenotype is assumed to be heritable. Then, we want to find particular genes. This process is called genetic association and has been made possible by cost-effective DNA collection methods. It recently became routine to ask respondents in standard household surveys to provide saliva from which DNA can be extracted. We differentiate between targeted and genomewide association studies. Targeted association studies use a predetermined number of genes (candidates) that are already known to be related to the concept under study, whereas genomewide association studies test all genetic variations along the human genome. While the first approach is driven by theoretical considerations, but might not be exhaustive, the second one generates a lot of false positive results due to its explorative nature. Nevertheless, multiple testing procedures are currently created to overcome these problems. Genetic association studies can particularly benefit from using economic experiments as (1) they offer a controlled environment, (2) economic phenotypes are studied in realistic settings, (3) noise is avoided to a great extent, and (4) replication studies are easy to conduct.

Eventually, once genoeconomics becomes a mature discipline, it may have practical implications. Genetically disadvantaged individuals could be supported by some affirmative action policy or educational support on the basis of equal human rights. In order to avoid discrimination based on genetic endowment, a regulatory framework needs to be in place when genes achieve a higher significance in scientific discourse and public debate. Despite its many caveats and misunderstandings, genoeconomics is a promising research area that can reveal new insights into the roots of individual preferences at the level of molecular genetics.

Vanessa Mertins and Manuel Hoffmann

See also: Amygdala and Behavioral Economics; Behavioral Economics; Brain Scans and Behavioral Economics; Experimental Economics; Neuroeconomics; Neuroplasticity

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GIGERENZER, GERD (1947–)

Gerd Gigerenzer is Director of the Max Planck Institute's Center for Adaptive Behavior and Cognition (ABC) and the Harding Center for Risk Literacy in Berlin. Gigerenzer's research on decision making, heuristics, and bounded rationality demonstrates that simple approaches (heuristics) to *complex* (uncertain, unstable, not well-defined) problems frequently outperform complex algorithms based on constrained optimization. But the rationality of heuristics depends on the context in which they are used. Gigerenzer's approach and findings challenge the widespread interpretation among behavioral economists and psychologists (associated with Daniel Kahneman's work) that heuristics are a form of irrationality, *arationality*, cognitive bias, or otherwise some form of predictable error.

Related to his research on heuristics, Gigerenzer shows that there are many conditions under which forecasters and decision makers perform better by using less information, as opposed to strict optimizing. This less-is-more effect is one of several that Gigerenzer has brought to light across various disciplines, including psychology, economics, finance, medicine, and public policy.

Gigerenzer views his research as building on the work of Herbert Simon and uses Simon's term, "bounded rationality," in a way that distinguishes it from common interpretations among many behavioral economists. In Gigerenzer's view, bounded rationality does not refer to second-best solutions to optimization problems after including cognitive biases and limits on memory in the decision maker's constraint set. Rather, Gigerenzer's program seeks empirical and theoretical descriptions of decision processes (*process models* rather than *as-if models*), motivated by his normative approach, which he refers to as *ecological rationality*. Gigerenzer investigates adaptive strategies that successful individuals and organizations use in the face of uncertainty and complexity.

In contrast to most decision models in psychology and economics, Gigerenzer's approach emphasizes that decision makers typically do not possess exhaustive knowledge of the feasible set of actions they choose from, the mapping from actions to associated outcomes, or the probabilities associated with those outcome. This perspective points to experimentation and innovation in exploring one's choice set as an important function that heuristics contribute to accomplishing.

With co-author Ulrich Hoffrage, Gigerenzer demonstrated that natural frequencies (which represent conditional probabilities as counts in relation to a constant base population instead of normalized by smaller counts on subpopulations as is the case with conditional probabilities) significantly improve people's performance (from children to medical doctors) when interpreting joint probabilistic information such as the sensitivity and specificity of mammography results used as a screening device for breast cancer. In *Simple Heuristics that Make us Smart*, Gigerenzer and ABC co-authors (1999) put forward a research program focused on "fast and frugal" heuristics (easy to use, quick and "frugal" in the sense of requiring very little information to arrive at a decision or action). The take-the-best (TTB) heuristic is one example of a fast and frugal heuristic.

The TTB heuristic makes a binary forecast (predicts whether turning left or right will result in higher-value foraging opportunities) based on multiple (a vector of) predictors. TTB makes a prediction on the basis of the single predictor with highest validity (conditional probability of making an accurate forecast) while ignoring the rest. The surprising accuracy of TTB has been validated in later replication and extension studies describing the characteristics of the joint probability distributions of predictors (referred to in this literature as *cues*) and binary outcomes for which the less-is-more effect—greater objective accuracy while using less information—can be expected to occur.

Gigerenzer's simple heuristics program has tackled challenging applied problems in medical decision making, financial decision making, and public policy, and has influenced public and private sector decision makers. Designing the decision-making environment to match the repertoire of heuristics that real-world decision makers actually use (based on evolved capacities and limitations) is sometimes referred to as environmental or institutional design.

The normative concept of ecological rationality is fundamental to Gigerenzer's research program. Ecological rationality requires an adequately successful match between the decision procedures used and the environments in which they are used. In contrast to standard definitions of rationality in economics and psychology based solely on the internal consistency of the decision maker's choice rule, ecological rationality follows Herbert Simon's observation that the rationality of a decision procedure depends on the structure of the environment. This observation leads Gigerenzer to a pluralistic "toolbox" approach to understanding the repertoire of decision rules that successful individuals and organizations require. Rather than applying rationality as a universal (context-free) set of criteria in isolation from the situations in which they are used, ecological rationality interprets rationality not as an inherent characteristic of the decision procedure but as a characteristic of the *match* between decision procedures and the structure of the environment.

Gigerenzer's ecological rationality is rooted in Herbert Simon's notion of *satisficing*. Ecological rationality as a design principle suggests that optimality is a generally unhelpful goal. Instead, good-enough (satisficing) heuristics and institutions (sets of rules) describe what successful individuals and durable or long-lived organizations and institutions typically achieve. Simplicity, transparency, and decentralization are three characteristics of successful and durable (good-enough) institutions in Gigerenzer's analysis. Having observed those characteristics across numerous decision domains, Gigerenzer argues against paternalistic policies where experts attempt to centrally engineer favored outcome based on social welfare maximization.

Gigerenzer has criticized behavioral economics for relying on neoclassical *as-if* methodology while contradictorily claiming its methodology to be based upon realistic assumptions. Gigerenzer argues that many behavioral models, including Kahneman and Tversky's prospect theory, are better understood as neoclassical optimization models to which "psychological" parameters (nonlinear transformation of probabilities into decision weights) have been added to more easily fit—but not explain—observational data. In contrast, Gigerenzer's theoretical work eschews constrained optimization and argues for decision trees that specify the process by which decisions are made without relying on free parameters. Gigerenzer's decision tree models lexicographically evaluate cues so that decisions follow simply from a single reason, which Gigerenzer refers to as "one-reason decision making." Although decision tree models can be more challenging to characterize in closed-form algebraic expressions than compensatory models, his work uses analytic, computational, and experimental data to reveal new insights about the decision process.

Nathan Berg

See also: Behavioral Economics; Bounded Rationality; Ecological Rationality; Fast and Frugal Heuristics; Fast and Frugal Decision Trees; Kahneman, Daniel; Prospect Theory; Simon, Herbert; Tversky, Amos

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GOLDEN RULE, COOPERATION, AND PRODUCTIVITY

One important finding in game theory is that rational or smart people with common knowledge and expectations of the other individual's preferences will behave strategically such that a Prisoner's Dilemma outcome arises—the worst possible outcome for both individuals. In the original manifestation of this narrative, two individuals are arrested for a crime and interrogated in separated rooms. There is no communication between these two people. If no one confesses, both individuals are sent to prison for a short spell, given the evidence. If both persons confess, they each receive a lengthy sentence. If one person confesses and the other doesn't, the silent one get the shortest possible sentence or is released, while the other person gets the longest possible sentence. If you anticipate that the other person will confess, it is in your interest to confess, because if you don't and the other person does, you'll end up with the worst possible outcome. Rational strategic behavior results in the worst possible outcome given common knowledge of the other's behavior and no communication. Moreover, this Prisoner's Dilemma outcome is considered to be a stable equilibrium outcome.

This modeling can be imported into the realm of production. When groups of firm members such as workers and management are characterized by conflicting preferences, this can result in a Prisoner's Dilemma solution to the productivity problem, yielding a minimal level of productivity and high level of X-inefficiency (a form of economic inefficiency). If workers and managers maximize their efforts in a cooperative fashion, in the interest of the firm's productivity, firm productivity is maximized. This is sometimes referred to as the Golden Rule outcome. This occurs when workers and firm managers and owners treat each other as they each would want to be treated, bounded by the constraints of remaining competitive and earning normal profits. On the other hand, if workers and managers each minimize their effort inputs in a narrowly self-interested manner, hoping that the other party will maximize their effort inputs, one arrives at a Prisoner's Dilemma, with X-efficiency and productivity being minimized.

In this narrative, unlike in the traditional Prisoner's Dilemma game, the different members of the firm can communicate with each other. But the Prisoner's

Dilemma arises because each party does not trust each other to maximize their effort inputs. Only joint effort maximization results in a Golden Rule productivity and X-efficient outcomes. In this narrative economic incentives and behavioral norms and conventions determine whether and the extent to which a Prisoner's Dilemma outcome arises. Appropriate incentives and behavioral norms or conventions can resolve the Prisoner's Dilemma problem.

Unions, for example, can serve to enforce conventions that result in X-efficient behavior, providing workers with a trust mechanism in larger firms and providing managers with an efficient means to monitor and achieve X-efficiency amongst workers. Worker cooperatives have the same effect. So can norms of fairness and trust among firm members. Critical to achieve Golden Rule solutions are incentives, such as higher wages and/or competitive pressures. If workers feel poorly treated, they will not produce X-efficiently. Also, if managers or firm owners see no benefit from increasing the level of X-efficiency—if all benefits accrue to workers—they might oppose mechanisms to achieve Golden Rule outcomes. It is possible for the Golden Rule option to generate the same benefits to managers and owners as the Prisoner's Dilemma option. But even if managers and owners don't benefit from increasing X-efficiency in production, this Golden Rule can still be achieved if their preferences include improvements to the well-being of their employees or if higher wages are constraints that must be overcome, by increasing the level of X-efficiency for the firm to remain competitive. But in the absence of appropriate incentives, norms, and conventions, given absence of trust amongst firm members or groups of members, a Prisoner's Dilemma is the natural consequence of strategic behavior among rational individuals.

Morris Altman

See also: Behavioral Economics; Game Theory (Behavioral/Cooperative); Golden Rule, Cooperation, and Productivity; Nash Equilibrium; Reciprocity; X-Efficiency/X-Inefficiency

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GREENWALD-STIGLITZ THEOREM AND BEHAVIORAL ECONOMICS

Behavioral economics finds its origins in several strands of twentieth-century economic thought. One of those strands is the economics of information of which the Greenwald-Stiglitz Theorem, named after Economic Nobel Laureate Joseph E. Stiglitz (1943–) and his co-author Bruce C. N. Greenwald (1946–), represents a key result. The Theorem establishes that an economy that is subject to imperfect information or incomplete markets is generally inefficient. This has given rise to a tradition of economic analysis that proceeds from the recognition that all economic institutions, including markets themselves, have real-world limitations that need to be recognized, and in this sense the Greenwald-Stiglitz Theorem intersects with many of the underlying assumptions of behavioral economics.

Modern economic thought finds its roots in Adam Smith's metaphor of the "invisible hand" of the market, which ensures that the pursuit of individual self-interest on the part of economic agents is in the interest of society as a whole. For this to work, prices would have to be such that they direct economic resources to their highest valued uses from a social point of view. In economics, this question is considered in terms of "Pareto" efficiency. An economic allocation is efficient if it is not possible to reallocate resources such that at least one agent is made better off while nobody else is worse off as a result. If Pareto efficiency holds, then a government, for example, could not improve the market outcome, even if it wanted to, unless income distribution is of consequence.

One of the key results of welfare economics states that a perfectly competitive economy is in equilibrium Pareto efficient. However, this result rests on a number of strong assumptions regarding the degree of perfection of such an economy, including free availability of relevant information to all parties and the absence of side-effects ("externalities") between economic agents that are not reflected in market prices. Somebody buying a used car, for example, would be assumed to have full information of all defects that the car may be suffering from, and a factory discharging greenhouse gases into the atmosphere would need to pay the full cost reflecting the effect of these emissions on the economy as a whole.

Realistically speaking, these assumptions are rarely satisfied. However, the underlying imperfections that prevent the perfect market outcome might also stand in the way of the government rectifying the situation. Compared to the "first best" outcome of a perfect competitive economy, an economy subject to such imperfections would be in a less preferred state. But neither market transactions nor government intervention could improve on this. Economists therefore call such an economy constrained Pareto efficient.

The Greenwald-Stiglitz theorem states that there are certain kinds of imperfections that imply that even constrained Pareto efficiency may be violated. In the used car example, if buyers cannot distinguish high-quality from low-quality cars, then the price they are prepared to pay for used cars will depend on average quality in the market. If there is a high proportion of low-quality cars or "lemons," buyers will offer less compared to a situation where there are only a few lemons. According to a crucial insight at the heart of the Greenwald-Stiglitz theorem, it is possible to treat the imperfect information of buyers technically as a form of externality. If the quality of lemons increases, this means a decrease in the average quality of cars and hence a positive externality on buyers. This leaves scope for Pareto-improving government measures. For example, it may be possible for the government to collect a tax that is used to fund measures that increase the quality of lemons.

The Greenwald-Stiglitz results do pave the way toward a kind of economic analysis that aims for greater empirical adequacy, and have led to a more realistic treatment of information effects in economics. Nevertheless, they rest on a more conventional approach that does not fully embrace the behavioral perspective given that it continues to rely on standard rationality assumptions.

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See also: Efficient Market Hypothesis; Inefficient Markets; Moral Hazard and Behavioral Economics; Rationality (Process and Neoclassical); Smith, Adam, and Moral Sentiments; Stiglitz, Joseph; Transaction Costs and Behavioral Economics

Further Reading

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