NOBEL-PRIZE WINNERS IN ECONOMICS

Part I: Winners of 2001 and 2002

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CHAPTER ONE

The Markets with Asymmetric Information – Nobel Prize 2001

The Royal Swedish Academy of Sciences awarded the Bank of Sweden Prize in Economics in Memory of Alfred Nobel in 2001 jointly to three U.S. citizens: George A. Akerlof of the University of California at Berkeley, A. Michael Spence of Stanford University, and Joseph E. Stiglitz of Columbia University "for their analyses of markets with asymmetric information."

Markets are often characterized by asymmetric information, i.e. agents on one side of the market have much better information than those on the other. Sellers know more than buyers about their products, prospective clients know more than insurance companies about their accident risk, job applicants typically know more about their abilities than potential employers, borrowers know more than lenders about their repayment prospects, managers know more than shareholders about the firm's profitability. The three Nobel-Prize winners provided foundation for a general theory of markets with asymmetric information. Their contributions constitute the core of modern information economics.

1.1. Adverse selection as a result of asymmetric information

The existence of asymmetric information gives rise to a number of questions. First of all, what happens to the prices, traded quantities and the quality of goods, if agents on one side of the market are better informed than those on the other? What can better-informed agents do to improve their individual market outcome? What can less-informed agents do?

G. Akerlof demonstrated how a market where sellers have more information than the buyers about the product quality can lead to an adverse selection of low-quality products. His paper "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism" is probably the single most important contribution to the economics of information. He analyzes the market for used cars where sellers are better informed than buyers about the quality of the good. "Lemons" (a colloquialism for defective cars) became a well-known metaphor in every economist's vocabulary.

Consider a good sold in indivisible units and available in two qualities, low and high, in fixed shares λ and $(1 - \lambda)$. Each buyer is interested in purchasing at most one unit of the good, but cannot observe the difference between the two qualities at the time of purchase. The low-quality good is valued at w^L by all buyers, and the high-quality good is valued at w^H, where $w^L < w^H$. The quality of the good is known to the seller, and low-quality is worth v^L ($v^L < w^L$) and high quality is worth v^H ($v^H < w^H$). If there was perfect information about the quality (separate markets for low and high quality), every price in the interval $[v^L, w^L]$ would support beneficial transactions for both parties in the market for low quality, and every price in the interval $[v^H, w^H]$ would generate beneficial exchange for both agents in the market for high quality. A socially efficient outcome would be achieved, i.e. all potential gains from trade would be realized. In the case of no market regulations and under nonobservability of quality by buyers, selfish sellers of low-quality products would choose to trade on the market for high quality. In practice, there would be a single market with the same price for all goods. Suppose that the sellers' valuation of high quality exceeds the buyers' average (i.e. expected) valuation. Algebraically, we have:

$$\overline{w} < v^H ,$$

where the average valuation $\overline{w}$ is given by $\overline{w} = \lambda w^L + (1 - \lambda) w^H$. Buyers are willing to pay at most $\overline{w}$, but it falls short of v^H, the minimum price at which sellers of high-quality goods are willing to offer their goods. Therefore, the high-quality goods are not offered, and only low-quality units, the lemons, remain for sale in the market. Thus, the beliefs in invisible hand are put in doubt by the above example.

Akerlof's paper explained how private information may lead to the malfunctioning of markets. Among the consequences of informational asymmetries we may name social segregation in labour market and difficulties for elderly people in buying individual medical insurance. Adverse selection takes place in credit markets of developing countries, where local moneylenders charge interest rates twice as high as rates in large cities. However, any attempt to arbitrage between these markets, without knowing the local borrowers' creditworthiness, may attract clients with poor standing, and cause heavy losses.

1.2. The trap of undesirable equilibria

In another paper, "The Economics of Caste and the Rat-Race and Other Woeful Tales" (less famous than the one discussed above), Akerlof stresses the significance of informational asymmetries in the context of the caste system, factory working conditions and sharecropping. An important result of these analyses is an illustration how certain variables, called "indicators," not only provide crucial efficiency-enhancing information, but may also lead the economy to become trapped in an undesirable equilibrium.

In the case of sharecropping, where the payment for the use of land (tenancy) is made by a fixed share of the harvest, a volume of production serves as an indicator of tenant's work effort on the farm. In another case, on the assembly line in a factory, the speed of conveyor belt serves as an indicator of workers' ability, and can be used as a tool to distinguish between workers of different types.

If an employer cannot distinguish between high- and low-productivity labour when hiring new workers, the labour market might collapse into a market where only those with low productivity are hired at low wage – this is another example of undesirable equilibria where adverse selection occurs.

Asymmetric information may even cause markets to disappear like in the umbrella story presented by Varian (2006, pp. 697–698). Suppose that producers can choose the quality of umbrella to be manufactured, and the cost to produce high quality is $11.50 and to produce low quality is $11. In the case of asymmetric information about the quality, each producer in a market with many suppliers would always prefer to manufacture low quality. In the case of consumers willing to pay less than $11 for a low-quality umbrella, there would be no price at which trade takes place, i.e. the production level of umbrellas would be zero. Thus, the possibility of low-quality production destroyed the market for both qualities of the good.

1.3. Signalling to counteract the effects of adverse selection

Another fundamental insight brought by Akerlof was that economic agents attempt to avoid the adverse consequences of informational asymmetries. These attempts explain the existence of many economic institutions. One of many examples are guarantees offered by professional dealers in the used-car market.

M. Spence demonstrated how agents in a market can use signalling to counteract the effects of adverse selection. Signalling refers to observable actions taken by economic agents to convince the other party of the value or quality of their products. Spence developed and formalized this idea as well as demonstrated and analyzed its implications. It is worth mentioning that informal

version of this idea existed in the sociological literature; see, for example Berg (1970). A fundamental rule is that signalling can succeed only if its cost differs sufficiently among the "senders".

The most famous works by Spence deal with education as a signal in the labour market.[1] How signalling may provide a way out of adverse-selection problem can be illustrated by a simple example analogous to Akerlof's model. Suppose that job applicants can acquire education before entering the labour market. The productivity of low-quality workers, w^L is assumed to be below the productivity of high-quality workers, w^H, and the population shares of the two groups are λ and $(1 - \lambda)$, respectively. Employers cannot observe directly the workers' productivity, but they can observe the workers' educational level. Education level is measured on a continuous scale and denoted by $s \geq 0$, and the cost (in terms of effort, money or time) necessary to reach each level is lower for high-quality individuals. In this simple model, it is assumed that education does not affect a worker's productivity, and has no consumption value for the worker. Thus, *ceteris paribus*, the job applicant chooses as little education as possible. In the case of perfect competition (including perfect information and constant returns to scale), all applicants would choose the minimal educational level $s = 0$, and they would be paid according to their individual productivity. In the case of asymmetric information, however, high-quality workers may acquire education as a signal of their ability.

Assume that all employers expect every job applicant with at least educational level s^H to have high productivity, but all others to have low abilities. Under perfect competition (with constant returns to scale), all applicants with educational level at least equal to s^H are offered a wage equal to their expected productivity, w^H, whereas those with a lower educational level are offered a wage w^L. This case is shown in Figure 1 by the stepwise schedule. Thus each job applicant will choose either the lowest possible education $s^L = 0$ and obtain the low wage w^L, or the higher educational level s^H and the higher wage w^H.

The preferences of job applicants are represented by two indifference curves in Figure 1, which capture the assumption that education is less costly for high-quality agents. The flatter indifference curve passing through point *A* represents combinations of education level and wage, (s, w), that high-productivity workers value equally good as (s^H, w^H). Every point northwest of this curve is regarded as better than this alternative, while every combination to the southeast is regarded as worse. Similarly, the steeper curve passing through point *B* represents education-wage combinations that low-quality agents find equally valuable as the minimum educational level $(s^L=0, w^L)$.[2]

[1] See Spence (1973 and 1974).

[2] This is so called single-crossing condition, and is often referred to as the Mirrlees-Spence condition.

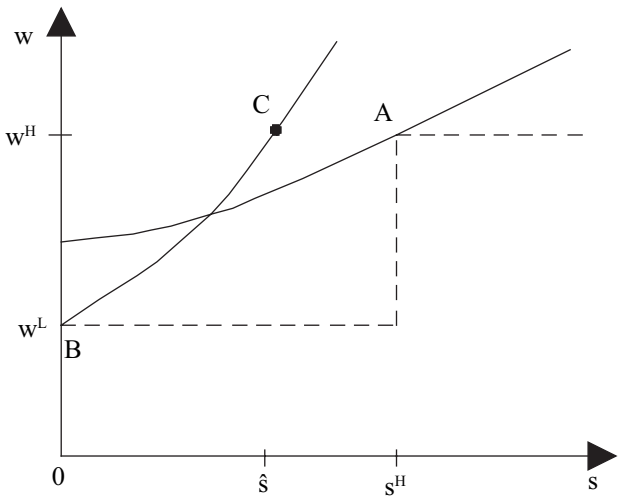

Fig. 1. Indifference curves of job applicants

Under the above assumptions, high-productivity individuals choose educational level s^H and receive the higher wage w^H (point *A*), and low-productivity workers optimally choose the minimum educational level $s^L = 0$ and receive the lower wage w^L (point *B*). Observe that low-quality applicants are worse off with choice *A*, because the higher wage does not compensate for their high cost of education. Therefore, employers' expectations that individuals with different productivity choose different levels of education are indeed correct in this signalling equilibrium. Thus, the market failure in which high-quality workers remain outside of the market has been eliminated. The high-quality individuals acquire a costly education in order to distinguish themselves from low-quality job applicants, and participate in the labour market.

1.4. Multiplicity and social efficiency of signalling equilibria

It is important to point out that there is a whole continuum of signalling equilibria.[3] However, in each of them, incentive compatibility condition must be satisfied. Spence indicated that a certain signalling equilibrium is socially most efficient. In this equilibrium, high-quality workers acquire the minimum education to distinguish themselves from those with low productivity and employers expect that to happen. In Figure 1, high-productivity individuals choose the combination given by point *C*. Low-productivity workers are then indifferent between the combination of education and wage $(\hat{s}, w^H)$ given by point *C* and the combination

[3] An interesting presentation of a variety of equilibria can be found in Lőfgren, Persson and Weibull (2002).

$(0, w^L)$ at their chosen point *B*. Riley (1975) showed that this is the only signalling equilibrium which is robust to wage experimentation by employers.

Since a continuum of equilibria implies that the model has little predictive power, economists typically try to reduce the number of equilibria by applying an equilibrium refinement. Spence's signalling model induced the development of various refinements of the Nash equilibrium concept.[4] Many of these refinements select the socially most efficient signalling equilibrium. The simplest refinement is the intuitive criterion of Cho and Kreps (1987). The idea is to apply a credibility test to out-of-equilibrium choice.[5]

Spence also demonstrated the existence of an equilibrium where no applicant acquires education. Assume that employers expect all job applicants, regardless of education to have average productivity, i.e. education is not a productivity signal, $\overline{w} = \lambda w^L + (1-\lambda) w^H$. Employers then offer this wage to all applicants, and their expectations are self-fulfilling, i.e. it is optimal for every job applicant to choose the minimum level of education $s^L = 0$.

Another interesting type of equilibria is the possibility that different groups of applicants have different educational incentives even in the absence of innate differences between groups. For example, high-productivity men (or blacks) may be expected to acquire another level of education than equally productive women (or whites). In such equilibria, the returns to education differ between men and women, or blacks and whites, as do their investments in education.

1.5. Extracting information from the better informed agents – the insurance market

A natural complement to the analyses on adverse selection provided by G. Akerlof and M. Spence was the paper by J. Stiglitz and M. Rothschild, "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information." The key question to be answered here is what uninformed agents can do to improve their outcome in a market with asymmetric information. Stiglitz and Rothschild consider an insurance market where companies do not have information on individual customers' risk level. The uninformed insurance companies offer their informed clients different combinations of premiums and deductibles and under certain conditions clients choose the policy preferred by the companies. Thus we deal here with screening through self-selection. Such

[4] Apart from his work on job market signaling, Spence has made important contributions to the so-called new industrial organization (based on the game-theoretical approach). He studied monopolistic competition (Spence, 1976) and market entry (Spence, 1977). His works in IO have also influenced other fields, such as the growth theory and international trade.

[5] An alternative refinement to be applied here was proposed by Grossman and Perry (1986a and 1986b).

screening is closely related to Vickrey (1945) and Mirrlees (1971) who analyzed optimal income taxation, where tax authority – unaware of private productivities and preferences – gives wage earners incentives to choose the "right" amount of work effort.[6]

Consider an example, where all individuals in an insurance market differ only by the probability of damage. Initially, all individuals have the same income y. A high-risk individual can lose an amount of d ($d < y$) with probability p^H and a low-risk individual could suffer a loss of d with the lower probability p^L, where $0 < p^L < p^H < 1$. The insurance companies cannot observe the individual policyholders' risk. The competition in the insurance market is assumed to be perfect and the companies in this industry are risk neutral.

An insurance contract (a, b) specifies a premium a and an amount of compensation b in the case of income loss d. In the case of perfect information, high-risk individuals pay the actuarially fair premium $a^H = p^H d$, low-risk clients pay the actuarially fair premium $a^L = p^L d$, and both groups receive full compensation in case of damage, $b = d$.

Under asymmetric information, Rotschild and Stiglitz found that equilibria may be divided into two main types: pooling and separating. In a pooling equilibrium, all individuals buy the same insurance, and in a separating equilibrium the contracts differ among individuals. One result of this model was that no pure-strategy pooling equilibrium exists. The reason is that in such an equilibrium an insurance company could instead profitably offer a contract that is better for low-risk individuals but worse for high-risk ones. Here, the equilibrium premium became too high for low-risk individuals, whereas in the used-car-market model the price was too low for high quality sellers.

The only potential equilibrium point in the Rothschild-Stiglitz model is a unique separating equilibrium. In the unique equilibrium two distinct contracts are sold: one contract (a^H, b^H) is purchased by all high-risk clients, and the other contract (a^L, b^L) is acquired by all low-risk individuals. The contract for high-risk individuals is relatively more expensive, i.e., $a^H > a^L$ and provides full coverage, i.e., $b^H = d$. The contract for low-risk individuals is less expensive, but at the same time provides only partial coverage, i.e., $b^L < d$. In equilibrium, the partial coverage (a deductable) barely scares away the high-risk clients.

The unique separating equilibrium corresponds to the socially most efficient signalling equilibrium analogously to point C of Figure 1 in the Spence's model. It is worth noting that in both models, it is costly for "good types" to signal quality in equilibrium. High-productivity workers have to obtain higher level of education than the low-quality individuals, and low-risk individuals have to accept some costs of damage in the form of a deductable.

Rothschild and Stiglitz identified conditions under which no pure-strategy equilibrium exists. Such situation does not take place in the job-market-signalling

[6] Actually, in his 1975 paper, Stiglitz used the word "screening" in the sense of signaling.

model of Spence. The fact that at most one equilibrium exists is typical of screening models.

1.6. Pooling and separating equilibria – standard concepts in microeconomic theory

The classification of equilibria offered by Rothschild and Stiglitz has become standard concepts in microeconomic theory in general and especially in information economics. Stiglitz has probably been the most cited researcher within information economics literature. His main point was that economic models may be quite misleading if they neglect asymmetries of information. Several of his papers have laid major foundation for further research.

Credit markets are analyzed in Stiglitz and Weiss (1981 and 1983). It is shown that to reduce losses from bad loans, it may be optimal for imperfectly informed banks to introduce rationing of the volume of loans rather than to raise the lending rate, as suggested by classical economic analysis. Given the wide practice of credit rationing in bank lending, the insights provided by Stiglitz and Weiss constitute an important contribution to a more realistic theory of credit markets. They have had a significant role in changing the fields of corporate finance and macroeconomics.

A widely cited paper by Shapiro and Stiglitz (1984) developed a labour-market model with so-called efficiency wages. An efficiency wage exceeds a worker's reservation wage (the wage level which makes him indifferent between remaining on the job and quitting) and thus gives workers incentives to perform well (more efficiently) to keep their jobs. An employer carries out random surveys among his employees to observe their work effort. A worker caught shirking is fired and ends up with his reservation wage. Optimal behaviour of both employers and employees results in equilibrium unemployment. It is an information-based explanation of involuntary unemployment, and constitutes an important contribution to modern labour economics and macroeconomics.

The works of Akerlof, Spence and Stiglitz on markets and informational asymmetries are fundamental to modern microeconomic theory. Their research has been of great help to understand market phenomena, which it was not possible to fully capture by the methods of traditional neoclassical approach. Also the emergence of many social institutions that counteract the negative consequences of asymmetric information can be explained in the framework of the models developed by them.

Over the last couple of decades many researchers continued works jumpstarted by Akerlof, Spence and Stiglitz.[7] In financial economics, for example, Myers and Majluf (1984) have shown how shareholders can become victims of adverse

[7] Riley (2001) gives a detailed survey of economic analyses of markets with asymmetric information.

selection among firms. Under asymmetric information, "the low-quality" firms (with low future profitability) tend to grow faster than "high-quality" companies, what leads to gradual domination of the market by "lemons." When uninformed investors eventually discover this, stock prices fall, i.e. the bubble bursts.

Another example is work by John and Williams (1985) who explain why some firms choose to distribute dividends to their shareholders, even though dividends are more heavily taxed (due to double taxation) than capital gains. They show that under asymmetric information, dividends can act as a credible signal for a "high-profitability" firm on the stock market. Under certain conditions, the stock price raises enough to compensate shareholders for the extra tax they have to pay on dividends, i.e., a separating equilibrium is in place.

In labour economics, Waldman analyzed the case of firms competing for labour by using job assignment of a rival's employee as a signal of his capacity. Employers try to avoid signalling the true ability of a good employee to potential competitors by assigning employees to tasks that do not necessarily maximize their contribution to the firm's profit. Such allocations of labour might be optimal from the viewpoint of an individual firm, but lead to socially inefficient outcomes.

This line of analysis has been continued by Bernhardt (1995), who explains why low-educated employees promoted to high positions turn out to be usually extraordinarily capable. A low-educated worker must compensate for the high wage the firm is forced to pay to retain a worker whose competence is revealed to potential rivals. In this framework, it is also possible to justify wage discrimination. Such discrimination is shown by Milgrom and Oster (1987) to lead to social inefficiency when employees are assigned to wrong duties or are not given sufficient incentives to obtain higher level of education.

Theoretical research on economics of information has been at least partially tested empirically. Riley (1979) tested Spence's signalling model. It could be expected that signalling would be most important when employee's productivity is difficult to measure. In such cases, wages and education could be expected to be strongly correlated at the beginning of an individual's career, and the correlation should be weaker when productivity is more easily observed. As firms get know their employees over time, the correlation between wages and education should become weaker, especially when productivity is hard to measure. These effects were confirmed empirically.

Lang and Kropp (1986) and Bedard (2001) showed that high-school enrolment and dropout rates are consistent with Spence's signalling model, but inconsistent with a pure-capital model.

The relevance of adverse selection and signalling to firing on labour market with asymmetric information was positively tested by Gibbons and Katz (1991).

Farber and Gibbons (1996) developed the Spence's framework by allowing employers to obtain information on worker productivity by observing their ca-

reers. Their model predicts that the wage effect of education is independent of the length of time an individual has been on the labour market, but the wage effect of unobserved characteristics, which are positively related with worker ability, increases with the length of employment. These predictions are consistent with data regarding young people on the U.S. labour market.

Applying the framework developed by Waldman (1984) and Gibbons and Katz (1991), Acemoglu and Pischke (1998) showed that asymmetric information about employee ability can explain on-the-job training in firms. Data from the German apprentice system confirm that informational asymmetries concerning a trained worker's productivity generate a monopsony on the local labour market, implying that the firm can pay for training by a wage that is somewhat below competitive wage.

It is important to mention that there were also some ambiguous results of empirical testing for the predicted effects of asymmetric information. For example, Bond (1982) found that data from a market for second-hand small trucks do not support the asymmetric information hypothesis. On the other hand Dahlby (1983 and 1992) found support for adverse selection using data on Canadian car insurance. Data from car insurance allowed Puelz and Snow (1994) to find support for adverse selection as well as signalling. Chiappori and Salanie (2000a) were not able to find statistical correlation between purchases of car insurance with better coverage and a larger number of accidents.

The main difficulty with testing asymmetric information models is how to distinguish in practice between adverse selection and moral hazard. Also, the fact that screening and signalling partially eliminate the effects of informational asymmetries makes the testing more complicated.[8]

[8] For a survey of empirical work on asymmetric information see for example Chiappori and Salanie (2000b).

CHAPTER TWO

The Psychological and Experimental Economics – Nobel Prize 2002

In 2002, the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel was awarded to Daniel Kahneman of Princeton University (U.S. and Israeli citizen), and Vernon L. Smith (U.S. citizen) of George Mason University. D. Kahneman was recognized ''for having integrated insights from psychological research into economic science, especially concerning human judgment and decision-making under uncertainty.'' V. Smith was distinguished ''for having established laboratory experiments as a tool in empirical economic analysis, especially in the study of alternative market mechanisms.''

Traditionally, the research in economics has relied on the assumption of agents known as ''homo oeconomicus'' who are motivated by self-interest and capable of rational decision-making. Economics has also been generally considered a non-experimental science. Nowadays, however, a growing body of research is devoted to modifying and testing basic economic assumptions. Moreover, economic research relies increasingly on data collected not only in the field, but in the laboratory experiments. This research has its roots in two distinct, but currently converging, areas: the analysis of human judgment and decision-making by cognitive psychologists, and the empirical testing of predictions from economic theory by experimental economists. The 2002 Nobel-Prize laureates are the pioneers in these two research areas.

2.1. Heuristics and biases in judgment under uncertainty

Economists have traditionally assumed that people's decisions are based on subjective probabilistic assessments about the state of the world based

on the laws of probability. Tversky and Kahneman (1974) documented many departures from rationality in judgment and decision-making under uncertainty. They pointed out that people rely on a limited number of heuristic principles that reduce the complexity of decision-making problems to simpler judgmental operations. Often, the heuristics are quite useful, but occasionally they lead to severe and systematic errors.

Kahneman made an analogy to visual perception in order to show how economists should react to research on judgmental biases. Optical imperfections and illusions are a fact about human beings and they should be studied as a matter of normal science.

Kahneman and Tversky's research on judgmental biases is an especially useful approach to bounded rationality. The heuristics-and-biases paradigm stresses the predictable nature of judgmental biases and acknowledges that people are intelligent and purposive in their decision-making.

One of the most important biases identified by Kahneman and Tversky could be generally called "the representativeness heuristic." They demonstrated that people over-use "representativeness" in assessing probabilities, i.e. Bayesian updating. One implication of this is the tendency to discount or even neglect base rates. For example, if we see somebody who looks like a criminal (shifty eyes, etc.), our assessment of the probability that he is a criminal tends to under-use knowledge about the percentage of people who are criminals.

Experiments confirmed biases of the type described above. In one of them subjects were shown various personality descriptions, and asked to judge the probability that each describes an engineer rather than a lawyer. Some subjects were told that the person was chosen at random from a group of 70 engineers and 30 lawyers, and other subjects were told a group of 30 engineers and 70 lawyers. Bayes' rule allows to conclude that the chance that any particular description belongs to an engineer rather than to a lawyer should be $(0.7/0.3)^2 = 5.44$ times higher for the first group than for the second group. In the experiments, however, the two groups of subjects produced basically the same probability judgments, evaluating the probability mostly by the degree to which the description matched the stereotype of a lawyer or engineer. The population proportion had far smaller effect than the magnitude derived by Bayes' law.

Another striking neglect of the base rate is the common violation of the conjunction rule:

The probability that somebody belongs to both Categories A and B is not bigger than the probability that this person belongs to Category B.

Experiments conducted by Tversky and Kahneman (1992) demonstrated the so-called conjunction effect:

When a description is representative of a person in Category A but not of a person in category B, people often judge it more likely that the description matches somebody who falls into both Categories A and B than into Category B alone.

Tversky and Kahneman (1971) point out another case of representativeness heuristic called "The Law of Small Numbers":

People exaggerate how often a small sample closely resembles the parent population or underlying probability distribution that generates the sample.

Belief in the Law of Small Numbers together with the common lack of belief in the Law of Large numbers leads people to expect almost the same probability distribution of types in small groups and in large groups.

All that leads to a range of errors that are important for economics. The tendency for people to over-infer from short sequences leads to misperception of regression to the mean. Our focus on the deviation from the norm makes us not to anticipate that further observations will look less deviant.

In addition to representativeness, Tversky and Kahneman (1973) identified other heuristic biases. People tend to disproportionately weight salient, memorable, or vivid evidence even when they have better sources of information. We may talk about people employing the availability heuristic. The over-use of salient information is likely to be extremely important in many economic settings; for example, in the context of the social-learning models.

Research on cognitive biases has been slow to penetrate economics, but it has begun and is likely to provide insight in many domains where economic agents are subject to judgmental bias.

2.2. Reference-based preferences and loss aversion

Kahneman and Tversky (1979) pointed out that people are typically more sensitive to changes in outcome from reference points than to the absolute levels of the outcome itself. In the context of utility theory it means that utility at time t, u_t, should not be assumed to depend solely on present consumption, c_t, but it may also depend on a "reference level," r_t, determined by factors such as past consumption or expectations of future consumption. Hence, instead of the form $u_t(c_t)$, utility should be represented in a more general form, i.e., $u_t(r_t, c_t)$.

Reference levels influence preferences and choice in at least two pervasive ways identified by Tversky and Kahneman (1991):

- loss aversion, i.e., people are more averse to losses relative to their reference level than they are attracted to same-sized gains.
- diminishing sensitivity, i.e., the marginal change in perceived well-being is greater for changes that are close to reference level than for changes that are further away.

The concepts of loss aversion and diminishing sensitivity were first introduced by Kahneman and Tversky (1971) in the context of preference over risky financial prospects. The difference between loss aversion and conventional risk aversion (represented by a concave utility-of-wealth function) is that the value function abruptly changes slope at the reference level, so that people are significantly "risk averse" for even small amounts of money. Graphically, it means that there is a "kink" in the utility function presented in Figure 2.

Diminishing sensitivity in the context of risk preferences over monetary outcomes implies that people, who are likely to be risk averse over gains, are often risk-loving over losses. Figure 2 illustrates the utility function for gains and losses that incorporates loss aversion and diminishing sensitivity.

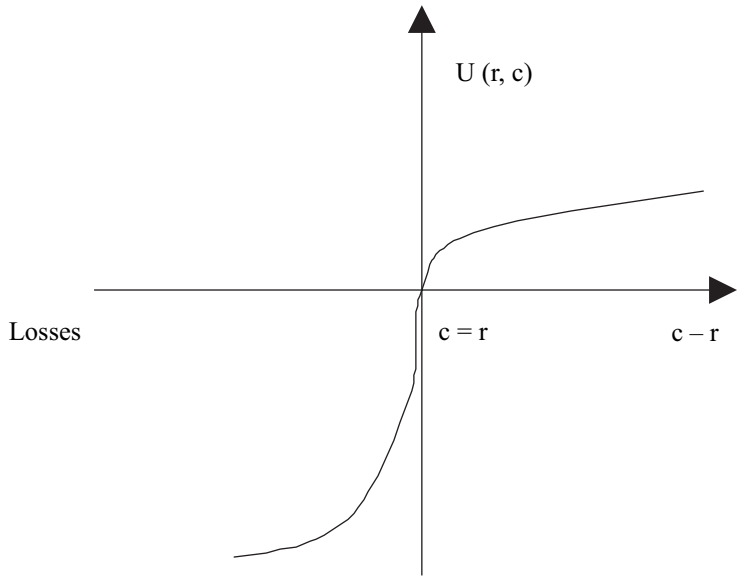

Fig. 2. Utility function of money

Notation: *c* – the wealth level
r – the reference wealth level

Another important consequence of loss aversion stressed in the literature is the endowment effect identified by Thaler (1980, and 1985) and subsequently analysed by Kahneman, Knetsch and Thaler (1990). A person who comes to a possession of a good immediately values it more than before the possession of it. Such an endowment effect is conceptualized as a case of loss aversion. People treat the endowed mugs as part of their reference levels, and consider subsequently not having a mug as a loss, whereas individuals without mugs consider not having a mug as remaining at their reference point. The endowment effect is qualitatively similar to models of habit persistence developed for example by Ryder and Heal (1973).

Besides the analysis of loss aversion and diminishing sensitivity in the valuation of monetary gains and losses, the second element of multi-facet prospect theory presented by Kahneman and Tversky (1979) was that individuals do not evaluate uncertainty as a linear function of the probabilities of different outcomes.[9] They argue that people ignore very low probability events, but among the events they do not ignore, low probabilities are overweighted, moderate and high probabilities are underweighted, and the latter effect is more pronounced than the former. As a consequence, individuals maximize with respect to a monotonic non-linear function of probabilities. Tversky and Kahneman (1992) conclude that there is a fourfold pattern of risk attitudes: risk aversion for gains and risk seeking for losses of high probability; risk seeking for gains and risk aversion for losses of low probability.

Another component of choice under uncertainty brought into finer focus by Kahneman and Lovallo (1993) is an observation that people take their attitudes towards different risky prospects in isolation rather than by assessing the aggregate effects of their choices. It was labelled "isolation errors." Consider an example based on Tversky and Kahneman (1986), who presented subjects with the experiment below.[10]

Imagine that you face the following pair of concurrent decisions.

Choose between:

A: $240 for sure

B: (*0.25, +$1,000; 0.75, $0*)

Choose between:

C: – $750 for sure

D: (*0.75, – $1,000; 0.25, $0*)

First examine both decisions, then indicate the options you prefer.

Choice *A* over *B* was made in 87 percent of cases, and 87 percent chose *D* over *C*, which is consistent with the principle of diminishing sensitivity. But combined choices for both decisions were: 73 percent chose *AD*, 11 percent chose *AC*, 14 percent chose *BD*, and 3 percent chose *BC*. Observe, however, that *AD* is in fact a 75 percent chance of losing $760 and a 25 percent chance of no change, whereas *BC* is a 75 percent chance of losing $750 and 25 percent chance of no change. Thus *BC* is clearly better than *AD*, and when people are asked to choose directly between *BC* and *AD*, they all go for the former. This example shows that people do not integrate the decisions, despite the use of the word "concurrent" in the instructions, and the request to first examine both decisions. It could also be viewed as a form of framing effects, where two logically equivalent statements of a problem lead decision-makers to choose different options.

Isolation errors are central for explaining risk aversion over modest stakes. On the one hand, expected utility theory avoided to explain several important

[9] This is similar to the „Allais paradox;" see Allais (1953).

[10] See Rabin (2003).

phenomena, like the pervasiveness of de facto small scale insurance policies. For example, many people buy extended warranties on consumer products costing $50 to $500, and buy insurance against having to pay for telephone repairs, where these warranties are significantly overpriced. Hence they should be declined. On the other hand, some explanations in the framework of expected utility theory were incorrect, like in the case of the famous equity-premium puzzle – that (risky) stocks earn persistently higher returns than lower risk bonds, where the degree of risk aversion needed to explain the lower demand for stocks seems to be implausibly high. Benartzi and Thaler (1995) used a very simple calibration of the prospect-theory utility function to argue that the puzzle can be explained by investors' aversion to short-term financial losses, called "myopic loss aversion".

2.3. Fairness judgments regarding economic behaviour

The existence and economic implications of preferences that depart from a narrowly defined pure self-interest have been discussed in the literature for a long time. Kahneman, Knetsch and Thaler (1986) studied with surveys what a typical economic agent might assess as fair or unfair behaviour. They showed that people generally find it acceptable for firms to raise prices or lower wages in response to concurrent shifts in their costs, but not in response to demand shifts or to shortages.

It is now widely accepted that preferences may depart from pure self-interest in non-trivial ways. One prominent example is the ultimatum game, first introduced by Guth and Tietz (1982), and replicated by Kahneman, Knetsch and Thaler (1986); the experiments demonstrated that individuals turn down lopsided offers. Also, it has been experimentally verified that individuals contribute to public goods more than can be explained by pure self-interest.

Kahneman, Knetsch and Thaler (1986) provided experimental demonstration of punishment behaviour that can be interpreted as retaliation based on moral indignation about unfair behaviour. In the experiment, the subjects were truthfully informed that their allocation decision would affect each of two other anonymous subjects – one who had in a previous experiment behaved unfairly, and one who had behaved fairly. Subjects were given the following choice:

- allocating $6 each to themselves and to the unfair party, with $0 to the fair partner, or
- allocating $5 each to themselves and to the fair party, with $0 to the unfair party.

Seventy-five percent of the subjects chose the $5 allocation, sacrificing $1 to (anonymously) punish the unfair party. It was an elegant illustration of individuals' motives in realistic market scenarios.

Reference levels and loss aversion play a significant role in the domain of fairness. Kahneman, Knetsch and Thaler (1986) argued that reference dependence causes individuals' general perceptions of fair behaviour to adjust over time. It may lead to situations when something initially viewed as unfair may in time acquire the status of a reference point. Clearly, such views have to be considered with caution, as they require further research about the nature of people's behaviour.

2.4. Economics as experimental science

Economics has been traditionally considered an "observational" science like astronomy or meteorology.[11] The great accomplishment of Vernon Smith and other experimentalists has been to convince economics profession that economics can be an experimental science. A variety of propositions become subjects of empirical investigation through controlled laboratory experiments. A large and growing community of economists is engaged these days in conducting these experiments, and the pace of experimental work has been accelerated over the last two decades. An important measure of the impact of experimental economics is its influence on the thinking of researchers working in game theory, in the theory of consumer choice, and in the applied areas such as public economics, industrial organization, resource economics, labour economics and finance.

Experimental economists have initiated the science of experimentally tested economics design – a new branch of economics that gains in importance. It is a promising way to propose institutional arrangements that lead to efficient social outcomes. The experimental laboratory could serve as a "wind tunnel" in testing new economics designs.

2.5. Market experiments

The use of control market experiments in economics have been initiated by E. Chamberlain (1948) in the context of market imperfections. Smith's experimental career began with the study of competitive markets.[12] He brought fresh ideas to the problem of price formation by using a double-oral auction scheme in which both buyers and sellers (arbitrarily selected among the students and assigned a buyer value and a seller cost, respectively) call out bids or offers while an auctioneer recognizes and records transactions resulting from accepted bids and offers. This continues until there are no more acceptable bids and

[11] See Smith (1987).

[12] See Smith (1991c).

offers. At the conclusion of trading, a new "trading day" starts on the market. In the new day, everyone has the same buyer value and seller cost as in the previous day. No goods are carried over from one day to the next. The market participants have the knowledge of the outcomes observed in the previous trading day, and may adjust their expectations accordingly. Usually, the subjects would iterate through four or five trading days.

Smith (1965 and 1991a) discovered that the convergence of double-oral auction results toward competitive equilibrium is robust to variations in the shape of demand and supply curves, to asymmetries in the distribution of profits between buyers and sellers, and to various permutations in experimental design.[13] In addition, he showed that the convergence to competitive equilibrium takes place even with a small number of agents, i.e. 6–8. It means the applicability of supply and demand theory goes far beyond the conventional economic theory.

Experimental methods used currently by researchers have been significantly influenced by Smith's work. An important step in the design of laboratory experiments was his introduction of actual monetary payoffs.[14] In further research, Smith (2000d) demonstrated that inexperienced subjects converge toward "rational" behaviour more rapidly with the size of monetary rewards. He stressed the importance of using sufficient monetary rewards to achieve "salience," i.e. that the subjects' objectives are not different from what the investigator thinks they are.

V. Smith is known for having developed a computer laboratory for experiments at the University of Arizona in the 1970s. He was able to investigate the performance of a wide range of alternative market institutions.[15]

Smith and Williams (2000) considered a variety of double-auction designs. They discovered that when computer manages the queuing of bids, offers and transactions, the system that works best in terms of price stability and market efficiency maintains a "rank queue," i.e., the lowest not-yet-accepted offer and highest not-yet-accepted bid. It is similar to procedures of the New York Stock Exchange, which suggests that evolutionary forces in actual stock markets promote efficiency and stability.

A famous alternative to the double auction is Leon Walras's tatonnement mechanism, which allows for trades in a given period only after a price is found at which demand and supply for that period are equal. Whereas in the double auction, actual trading goes on continuously between agents who do not know the equilibrium price, and thus may trade at other prices as well. The New York Stock Exchange determines the opening prices of securities by a method that is essentially the tatonnmenet mechanism.

[13] See also Smith and Williams (2000).

[14] See Smith (1964).

[15] For a summary see Smith (2000f) and Smith (2000c).

Smith (2000b) found in his experiments that, with changing demand and supply and multiple transactions, the tatonnement mechanism consistently performed less efficiently than the continuous double auction mechanism. An important conclusion drawn from the market experiments was that "institutions matter" in ways that a priori economic theory would not have predicted.

A prominent role of experiments has been seen in the analysis of bidding in auctions. In a series of papers V. Smith and his co-workers confirmed that English auctions and second-bidder seal-bid auctions, which are theoretically isomorphic in private values environment, produce the same results in the laboratory experiments.[16] However, the experiments demonstrated that Dutch auctions and first-bidder sealed-bid, which are theoretically isomorphic in private goods environments, lead to different outcomes. As predicted by theory, the laboratory experiments confirmed that English and second-bidder auctions produce more efficient outcomes than Dutch and first-bidder sealed-bid auctions, while the latter tend to be more efficient than the former.

Economists such as Klemperer (2002) emphasized that auctions should be tailor-designed to solve the unique institutional problems that arise in particular situations. He presented several cases where unsuitable institution design led to auction "fiascos" and inefficient outcomes. Rasetti, Smith and Bulfin (1991) and McCabe, Rasseti and Smith (1991) are examples of research focused on testing auction mechanism for specific problems.[17]

V. Smith applied laboratory experiments to study intertemporal assets markets, as well. An elegant experiment with a "two-season markets" was conducted by Miller, Plott and Smith (1977). Again the convergence to competitive outcome has occurred even with relatively small number of traders and without perfect information.

Smith, Suchanek and Williams (1988), Porter and Smith (1995), and Knez and Smith (1991) worked on laboratory-induced stock market bubbles. In these experiments they found that stock trading by inexperienced agents generates dramatic price bubbles that crash back to their fundamental values at some point in time. As subjects get more experience, the bubbles tend to disappear and prices approach those predicted by rational expectation model.[18]

2.6. Public goods experiments

An important issue for economists and politicians is to identify efficient institutions to provide public goods and to find equitable methods of paying

[16] See Coppinger, Smith and Titus (1991), Cox, Roberson and Smith (1991a), and Cox, Smith and Walker (1991b, 1991c, 1991d).

[17] Rasetti, Smith and Bulfin (1991) focused on a mechanism that allows airlines to submit various contingent bids for flight-compatible combinations of airport landing or takeoff slots. McCabe, Rasseti and Smith (1991) focused on dealing with the complexities of pricing natural gas at various geographical points.

[18] For a summary of that research see Porter and Smith (2000).

for these goods. There were many theoretical solutions offered, but none of the mechanisms that seemed to be the best have been actually implemented.[19] The question remains why?

V. Smith and C. Plott were among the pioneers to apply laboratory experiments to find out the answer.[20] Smith (1977 and 1991b) proposed a mechanism, called the Auction Method, that is quite close to existing practice of some fund-raising actions, where pledges will be collected from donors only if some target amount of funds is achieved. The Auction Method can be interpreted as an implementation of Wicksell's proposal of unanimity. Smith (1977, 1980, 1991b, and 1991d) found that with quasi-linear utility and with groups of 5–8 participants, quantities of public goods selected are very close to efficient levels, but the distribution of costs is far away from the expected equilibrium point. Unfortunately, using Cobb-Douglas preferences leads to inefficient outcomes.

Smith (1991b and 1991d) presented results of experiments with other mechanisms for public goods. An interesting finding was that his Groves-Ledyard mechanism usually resulted in near-optimal provision. However, Harstad and Marrese (1981) showed that mechanisms similar to Smith's implementation of the Groves-Ledyard mechanism frequently failed to converge to efficient outcomes.

Banks, Plott, and Porter (1988) tested the Smith auction mechanism, which was being considered as a possible device for allocating resources in the development and operation of a space station. They showed that Smith's method outperforms a simple direct contribution mechanism, but is still far away from full efficiency.

Despite some interesting work with public goods provision, this research is much relatively small in size and much less conclusive than the experimental work on private goods markets.

2.7. Bargaining, psychology and evolution

Experimental psychologists and behavioural economists have claimed for some time that people are not as rational as assumed by economic theory. Smith (2000e) argues that experimental economics offers "a third view". Smith believes that experimental evidence suggests that economists and psychologists need to abandon or at least revise two implicit premises: 1) that rationality in the economy emanates from and derives from the rationality of individual decision-makers, and 2) that individual rationality is a cognitively intensive, calculating process of maximization in the self-interest. Smith argues that institutions serve

[19] Theoretical solutions have been suggested for example by E. Clarke (1971), T. Groves (1973), Groves and Ledyard (1977), and earlier K. Wicksell (1958) and E. Lindahl (1958)

[20] For surveys of experimental tests of public goods mechanisms see, for example, Ledyard (1995), Chen (2002), and Plott and Smith (2003).

as social tools that reinforce, even induce economic rationality, so that people's choices cannot be satisfactorily tested by examining subjects' choices outside of institutional context.

Smith stresses that convergence to the outcomes expected by rational behaviour takes place despite the fact that people have little understanding of the economic situation. Moreover, many anomalies observed in laboratory experiments, such as "preference reversal," differences between "willingness-to-pay" and "willingness-to-accept," confusion about opportunity cost and sunk costs, and willingness to accept a small share in ultimatum games, may as well be seen in reality of a market.

V. Smith conjectured that the human ability to successfully trade in a market may be a gradually developed capacity, similar to the ability to learn languages. In 1776, Adam Smith made an analogous observation that human nature is characterised by "the propensity to truck, barter, and exchange one thing for another."[21]

Another viewpoint is that the structure of the markets themselves may generate rational outcomes, independently of the rationality of decision-makers.[22] Gode and Sunder (1993) conducted a simulated double auction with robotic players similar to the experiments ran by Chamberlin and Smith. The program prohibited agents from making deals that would lead to losses. They discovered that a market with "zero-intelligence" agents achieved outcomes that were almost as efficient as the results obtained by people. However, this conclusion should not be taken as convincing evidence that market structure itself usually eliminates the need for learning and rationality. For example, in more complex models, Smith illustrated that there are ways for inefficient outcomes to arise even in the case of traders earning money on every transaction.[23]

The game theory predicts that in one-shot ultimatum game under the assumption of rational, selfish behaviour, the first mover would offer a tiny amount of money to the second player and keep the rest for himself, and this offer would be accepted. However, the ultimatum-game experiments run many times in many different countries and societies suggest that the first mover's offers tend to be significantly higher than the amount predicted by the theory. In addition, if the first player's offer is not generous enough, it is rejected. These results indicate that people are altruistic or care about "fairness."

Smith (2000a) suggested an explanation based on context. Namely, the experimental ultimatum game is too abstract for the participants. Instead of maximizing the payoffs, many people apply decision rules borrowed from similar situations that involve repeated social interaction. In reality, those who acquire

[21] See Smith (1937).
[22] See Gode and Sunder (1993).
[23] Compare Bergstrom (2003).

a reputation for willingness to punish exploiters (especially when punishment is cheap) seem to have a better chance of success to those who are too forgiving.

Hoffman, McCabe, Sachat and Smith (2000a), and Hoffman, McCabe and Smith (2000b) investigated the robustness of the ultimatum game to increases in the amount of money involved, and to variations in the way the game is presented. For example, independent of the size of the pie to be divided, the first movers only rarely offered an amount below 30 percent of the stake, and the most common offer was an equal split.

A different test of generosity analysed in the experimental literature is the "dictatorship game" devised by Forsythe, Horowitz, Savin and Sefton (1994). They found that first movers are on average much less generous than in the ultimatum game, but still a significant share of "dictator" offer 30–50 percent of the stake to the other player. Hoffman, McCabe, Sachat and Smith (2000a) replicated these results and suggested further modifications of this experiment. They observed that adding anonymity of the dictator induces him to be rarely (or almost never) generous.

The results of laboratory experiments constitute a definite challenge to theorists and applied economists to produce better theories and better quality of empirical work.

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