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Jack Hirshleifer: A Nobel Prize left unbestowed

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Abstract

Jack Hirshleifer (1925-2005) contributed to investment theory, information economics, conflict, and bioeconomics, clarified the foundations of investment and capital theory in the spirit of Fisher, and made basic contributions to the analysis of covariance risk, gambling and insurance, the Modigliani-Miller Theorem, and public investment through a focus on time, uncertainty and information. He formulated new models of public goods, added to understanding of contest success functions, and explained the paradox of power. He developed a general equilibrium approach to conflict jointly encompassing production, exchange, appropriation and defense. He analyzed the emotions as guarantors of threats and promises, proposed alternatives to the tit-for-tat strategy, considered the bioeconomic causes of war, and investigated the truthful signaling hypothesis. Jack Hirshleifer was a leading scholar and original thinker of the 20th century. His scientific contributions have left a Nobel Prize unbestowed.

Keywords: Investment and capital theory; Information economics; Applied theories of the firm; Uncertainty and information; Price theory; Economics; Political economy; The economic theory of conflict; Public goods; Production; Appropriation; Fighting; Combat; War; Bioeconomics; Biology; Evolutionary economics; Evolutionary psychology; Water supply and resource economics.

JEL classification: C7; D3; D5; D7; D8

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1. Introduction

Jack Hirshleifer was a political economist with multi-disciplinary interests. He had an everlasting bright-eyed curiosity, an inquisitive mind, and humility combined with incisiveness when he had reached his conclusions. He had a deep need to understand phenomena across disciplines and expanded the neoclassical economic theoretical framework to analyze non-traditional issues in remarkably new and innovative ways.

Beginning in 1950, Jack placed the theory of investment, interest, and capital on a firm theoretical foundation. He was also a founding father of the information economics revolution. In particular, he felt that investment theory was a confused mass of ill-defined concepts that were in dire need of a clear integrative framework. He found the basis for that framework in the work of Irving Fisher, and was thereby able to dispel controversies and distinguish lucidly between past ideas that were sensible and those that were confusions.

From the late 1970s and thereafter, he was a leading economist contributing to our understanding of phenomena that had been usually studied within disciplines such as political science and biology. Jack was an economic theorist with broad-ranging interests. His fields of specialization included investment and capital theory, information economics, applied theories of the firm, uncertainty and information, price theory economics, political economy, the economic theory of conflict, public goods, production, appropriation, combat, war, bioeconomics, biology, evolutionary economics, evolutionary psychology, water supply and resource economics. During the period 1950-2005 he authored 7 books, some 75 articles, and 7 book reviews.

Section 2 sets out Jack Hirshleifer's background and career. Section 3 discusses investment theory and the information economics revolution. Section 4 proceeds with the expanding domain of economics, conflict and sociobiology. Section 5 considers the provision of public goods. Section 6 is on conflict and section 7 on biology. Section 8 provides a concluding evaluation of Jack Hirshleifer's scientific contributions.

2. Background and career

Jack Hirshleifer was born in Brooklyn, New York on August 26, 1925. His early childhood involved intensive Jewish education. He was the only one in his family going to college. He served in the US Naval Reserve 1943-45 and received all his degrees from the Harvard economics department headed by the known anti-semitic Harold H. Burbank. His 1950 PhD thesis was titled "Price Flexibility and General Independence". Jack was a postdoctoral student in Statistics and Economics at the University of Chicago 1951-52, and worked at the

Rand Corporation in Santa Monica, California, between 1949-1955, where he retained a consultancy position until the end of his life. The period up to 1955 witnessed much development of game theory, mathematical economics, and experimental, evolutionary and behavioral economics. Contributors proceeding beyond orthodox postulates were Shapley, Nash, Arrow, Debreu, Flood, Dresher, and others. Jack absorbed these developments in his formative years and saw their relevance for microeconomic theory and decision analysis with new significance for information, uncertainty, and conflict in human interaction. He was at the University of Chicago Graduate School of Business between 1955-1960, and then spent the rest of his life at UCLA.

At UCLA Jack joined Armen Alchian and Jacob Marschak, and subsequently John McCall, Robert Clower, Axel Leijonhufvud, Harold Demsetz, William Allen, Michael Intriligator, Lloyd Shapley, and others. One early contribution from this group was Alchian's 1950 article "Uncertainty, evolution, and economic theory". Far removed from the centers of the US east coast, this core group of UCLA economists developed original cutting-edge research. Topics were the role of information, the place of institutions, the importance of evolutionary dynamics, the dynamics of conflict, the social and private underpinnings of insurance, and more generally analytical economics. Jack had a central role in many of these developments.

A typical starting point for Jack was to identify a phenomenon inside or outside economics that he did not understand. He would then absorb the literature on the phenomenon, including claims by many professing to have proved something about the phenomenon. As Jack worked methodically through understanding the phenomenon, he would often realize that the claims were unsubstantiated, which provoked and irritated him since in fact, in his view, the previous authors had not proved anything at all! He was however far too polite to display his impatience, or to waste time and effort on emotions, but he was motivated to ensure that he himself would truly understand the phenomenon.

Jack worked with a key set of tools to obtain a comprehensive understanding of the world. He remained true to his home base in economics, while routinely venturing far abroad into other disciplines for inspiration. Examples of topics were mother-fetus conflict in the womb over resources and contests between the spermatozoa of different males within the uterus to be the first to fertilize the egg. Why not analyze these phenomena from a political economy point of view? Jack's cross-disciplinary focus was observed by researchers in other disciplines. In his book *Consilience*, the biologist Edward O. Wilson (1998:222) identified Jack, along with Gary Becker, Thomas Schelling, Amartya Sen and George Stigler, as

economists willing to trade with cognitive psychologists in an effort to "strengthen microeconomics." The rationality paradigm and equilibrium analysis were crucial elements in Jack's endeavors. His skepticism, which the economics profession both appreciated and reinforced, and inclination to question commonly accepted propositions, prevented him from accepting many proposed answers that were part of a traditional comprehensive understanding of the world. The skepticism was a key motivator in the search for increased understanding.

My personal encounters with Jack Hirshleifer included participation in April 2003 in the Thursday lunch group that Jack helped found many years ago. Armen Alchian and Werner Hirsch would argue in a scholarly fashion. Earl Thompson would run an argument in search of an ideologically neutral explanation free of paradoxes. Harold Demsetz would sometimes argue forcefully for a position. Regardless of the flavor of the conversation, as Al Harberger has phrased it (in a personal letter), "Jack always managed, in one war or the other, to remain above the fray, but not as an aloof observer from afar. On the contrary, he was always engaged, always in the middle of the conversation, yet totally free of animosity or rancor, even at the purely intellectual level." David Hume (1740) suggested that "reason is, and ought only to be, the slave of the passions." Jack always managed to align his passion in the service of progressing economic analysis in a rational manner, never dictating what the end result of the analysis would be. One could have intellectual disagreements with Jack, but the journey toward reaching agreement was always enjoyable.

Many of Jack's best papers seem to have started with an insight. He would try to develop an elegant model that would serve to further sharpen the insight, to ensure that its lesson would be widely understood and appreciated. Jack had an ability to do great things with relatively simple models. He had a love of building simple mathematical models and exploring their implications. If a model became complex, he would work to simplify it. He would occasionally bemoan the reliance on mathematical complexity at the expense of ingenuity. His articles are in general not difficult to understand. If Jack perceived some subject matter to be complex, he would work to make it more accessible. He could labor over a paragraph, tailor designing it for the specific target audience. Jack often spent an enormous amount of time refining the text. His prose and writing skill were beautiful. He also had an extraordinary ability to communicate ideas. In addition to developing the argument thoroughly and diligently, he would design diagrams that he thought would improve an article's comprehension. Telling use of numerical illustrations was a considerable part of his impact. He also worked in historical examples in serious academic articles. This makes his articles easier and more enjoyable to read, and the reader's understanding is deepened. Jack

thrived well within the neoclassical economics paradigm, and preferred to analyze novel areas of economics using conventional tools rather than venturing outside the paradigm.

Jack's early Jewish education and subsequent secular education, which involved evolutionary theory, made him diplomatic, questioning, truth-seeking, and skeptical. He had a certain modesty that can be advantageous when scrutinizing preconceived notions. He was humble, but not in the sense of having a low opinion of his abilities. He was modest in never placing undue emphasis on his own abilities or achievements at the expense of others or of the truth. He also had an unusual readiness to admit mistakes, exceptional among academics. It requires confidence to admit mistakes, and an absorption or at least considerable interest in the common good and advancing science, while not being too preoccupied with one's own minute by minute status.

Many adjectives can be used to describe Jack: he was a gentle person, good-natured, patient, warm, smiling, friendly, civilized, open-minded, humble, honorable, low-key, personal, tactful, meticulous, intellectually curious, searching, patient, and virtuous. His quest for the truth and a skeptical attitude made for attention for detail but he was free of arrogance, snobbishness or pedantry. The UCLA graduate students called him "Happy Jack" because one never saw him angry. Jack even had a dog named "Happy". His office door was always open for all and sundry to enter and interrupt. Reports from his earlier PhD students suggest that, when he thought you were wrong, you knew it, but never in ways that made you reluctant to continue the conversation. He always wanted to learn more himself, and thought that the way to learn more was to facilitate dialogue, even when much of the prior dialogue had not been all that useful.

He approached referee reports, which sometimes can be unclear and equivocal, in the same manner, trying to fathom what a referee intended. In role of a coauthor, I often found myself lining up all the interpretations for the various referee reports that I could think of, and then subsequently adding the unlikely ones. Concluding that a referee had misunderstood, or was wrong, was only a last resort. The response would then be to point out nicely and definitively the exact manner in which the referee had misunderstood, and subsequently clarify how the point should be made to be better understood.

He would scrutinize strategies to determine how they had survived evolutionarily, whether they were beneficial or not for the individual and society, and which alternative strategies might be more or less beneficial. As Martin McGuire has phrased it (in a personal letter), Jack revealed a certain "exasperation with the endless refinement of some areas of

economics (by assumption and deduction compounded): "so boring" he would say --- pronounced "boore ing." "Why not do something new like 'conflict theory'?"

Jack was a political liberal in his high school days. During 1943-45 he was on active duty at the U.S. Naval Reserve. As a radar officer on a warship off the coast of Japan, he waited to see if he was to be part of an attack on the mainland. Jack was spared that fight. Such experience may suggest why on-going skirmishes within and outside academia were of interest to Jack mainly as empirical data. There was likely no connection between his World War II experiences and his conservative development, as for example was the case for Dostoyevsky, who was a radical until before a firing squad for a second or two, and those instants of fear turned Dostoyevsky into an arch conservative politically for the rest of his life. Jack read intelligent conservative writers and his study of economics brought a gradual change in his thinking. The change was similar to Ronald Reagan's shift from being a Democrat and union leader to becoming a Republican. Jack gradually recognized that socialism did not work and caused incalculable human harm. He perceived socialism as an unsound economic system, and also as a false religion. Jack returned to Judaism more and more in later years, and as an economist was aware of the benefits of capitalism and the free market.

Many may have been puzzled by the apparent opposition or dissonance between Jack's personal characteristics and his focus on conflict theory. Jack's personal characteristics were perceived by many as inconsistent with a conflict seeking attitude, so we might ask why Jack spent half a life-time studying conflict. Any hypothesis is speculative, but why not, when equipped with an insatiable hunger for increased insight, attempt to understand phenomena associated with characteristics that Jack appeared not to possess. That would be a powerful signal that you are not missing out on something in life that everyone else is engaged in. That is, you are so engaged that you even research the topic scientifically! Since conflict, competition, and war over scarce resources are so pervasive in life, why not make sure that you understand such phenomena better than everyone else who is engaged in conflict on a daily basis? Such insight may preempt conflict, enable spotting it before it emerges, and allow appropriate counter measures to be devised. A plethora of advantages flow from understanding conflict.

One might interpret Jack Hirshleifer as being little prone to combat, but such an interpretation would miss the mark, or require an elaboration where combat is interpreted broadly. Jack chose the battles that he perceived as being worth fighting, and he fought according to his instinct and nature. If Jack did not accept your argument, his first instinct

would be to attempt to understand the other point of view, being open to the possibility that his own point of view might be challenged, and he would seek some way to propel the discussion forward in a mutually beneficial and truth-seeking manner to gain new insight. He actively sought input from people whom he knew disagreed with him, and sought to accommodate alternative interpretations to the extent possible. It was almost impossible to have a sustained intellectual disagreement with Jack, given that both discussion partners preferred increased understanding, and if both had the patience to persevere. Temporary disagreement was possible, for example in the early phase of a research project or if the phenomenon was complex. Breaking the complexity down to smaller manageable units, it was often possible to pinpoint the source of disagreement. That might either cause agreement, or a subsequent reasoning process with a new pinpointing to locate the challenge. The end result would often be a path-breaking contribution, which was Jack's ultimate objective. That was Jack's combat, and he fought very well. Observe the relation to Sun Tzu's (-320) suggestion of "subduing one's enemies without fighting". Such a strategy is a more refined form of fighting, which requires far more skill. The ultimate result may be quite impressive. In this light, Jack was to the highest extent prone to combat. In fact, his entire life was combat and a struggle to increase his understanding of the world. His desire to understand led him to combat, and struggle to understand combat and struggle, a doubling up to achieve what one bargains for.

Jack Hirshleifer was politically conservative (right-wing). He also participated in Torah study groups where the text is essential. Jack was very good at interpreting text. His instinct was to develop his views independently in a truth-seeking manner by relying on his powers of reasoning, rather than going along with conventional wisdom. Jack of course observed the liberal bias within academia, especially in the 1960s and 1970s. The bias was of interest to him as empirical data. Early in his career he had addressed the mainstream issues of economics. Having a deep sense of connection to Jewish tradition, it was perhaps not important for him to be contained by tradition in economics as well. His sound anchoring point enabled him to develop theoretical heterodoxy by expanding the boundaries of economics. He envisioned that he might teach the history of economic theory at the end of his career but never did teach that course.

Jack had an ethical or religious conception of God while at the same time agreeing with Darwin that natural selection explains the origin of species, and possibly also the origin of life itself. He perceived no inconsistency between Darwinism and a belief in God because in his view God created the universe in the first place, which he did not believe took literally

seven days, and natural selection needs a universe to work on. In other words, rather than directly creating species, God created a universe in which species were bound to develop.¹

His strong sense of modesty and reserve, combined with his sense of discipline and determination to proceed with his work, are rare and probably came from early and sustained textual study and learning combined with exposure to Jewish texts. Jack knew how to be *suaviter in modo, fortiter in re*, as expressed by the Jesuit General Claudio Aquaviva (1543-1615), which can be translated from Latin as gentle in manner and resolute (forcible, strong) in deed. Similarly, “speak softly and carry a big stick,” said Theodore Roosevelt. Jack’s big stick was manifested in his path-breaking contributions that clinched the argument at the end of the day. Jack seems to have reasoned that self-promotion is inefficient because it interferes with study and learning. On the one hand, that is a wonderful model. On the other hand, it is quite possible that Jack would have earned even greater recognition if he had been at all interested in self-promotion. Cases where Jack’s contributions are present but not acknowledged may support this latter possibility. As a leader Jack was leading without appearing to lead. He would take notes while others were talking, would make a bold innovation, and would report back via email with an organized coherent account of the discussion.

My own acquaintance with him reflects his intellectual curiosity. I recall walking across the University of Chicago Quads in 1992 when I was starting my dissertation.² I had just read his 1991 paper on the limits of reciprocity (Martinez-Coll and Hirshleifer, 1991). That paper is full of graphic illustrations about the strategies that can be expected to survive in the long run. With these graphics on my mind, I reflected during my walk on how Jack's results would differ if several groups were set up in parallel with various kinds of competition between the groups. Although I forwarded neither my dissertation nor my publications to Jack, he observed the publications in print. We began communicating by e-mail in 1995, with Jack sending me complex equation systems, which I solved using *Mathematica*. Our joint research gave rise to more complex models than those that Jack usually preferred. Jack worked hard to simplify my complex suggestions to ensure wide professional accessibility. In April 2003 I met Jack in person for the first time during a two-week visit to UCLA. Jack’s office, which I used for part of

¹ Jack’s views seem consistent with the scientific finding of a Big Bang 13.8 billion years ago, the emergence of the Earth 4.55 billion years ago, transition from non-organic to organic chemistry at some point thereafter, the oldest indication of life on earth in the form of a shale some 3.5 billion years ago, and the well established evolution of homo sapiens thereafter.

² The aim of my dissertation was to design a new multilevel game theory allowing for arbitrarily many levels of organization, arbitrarily many actors at each level, translating strategies and payoffs across levels (see e.g. Hausken and Cressman, 2004, and Hausken, 1998). In January 1995 I went to the Max Planck Institute in Cologne where director Fritz Scharpf had noted the lack of a two-level conception of game theory (Scharpf, 1991).

the stay, was filled to the brim with research material compiled over more than half a century of intellectual activity. It seems that Jack had almost unbounded ideas for future research. In my own joint research with him, we designed 21 projects. I shall complete some of them, but not all. The remaining will forever circulate through the back of my mind and influence my future research. Jack's last e-mail to me is dated June 21, 2005, after which he was too weak due to advanced prostate cancer and chemotherapy. I just had a look at that e-mail. 14 lines of clear reasoning, somewhat shorter and simpler sentences than usual, but clear and lucid to the very last, and signed "Cordially", as always. Jack died in Los Angeles on July 26, 2005. I am greatly indebted for having had the opportunity to come so close to Jack. I now turn to Jack's contributions.

3. Investment theory and the information economics revolution

Jack Hirshleifer clarified the foundations of investment and capital theory in the spirit of Fisher, and made basic contributions to the analysis of covariance risk, gambling and insurance, the Modigliani-Miller Theorem, and public investment, focusing on time, uncertainty and information. Through examples and applications, he made the abstract ideas of contingent claims concrete.

3.1 Investment and capital theory, and the economics of uncertainty

In the mid and late 1950s Jack published the exchange between quantity and quality (Hirshleifer, 1955a), on the economics of transfer pricing (Hirshleifer, 1955b), the economics of the divisionalized firm (Hirshleifer, 1957), peak loads and efficient pricing (Hirshleifer, 1958b), the sumptuary manifesto (Hirshleifer, 1959b), and a review of uncertainty and business decisions (Hirshleifer, 1956a). His 1958 JPE article (Hirshleifer, 1958a) was an early classic that analyzed different internal rates of return and present value rules when borrowing and lending rates diverge. He showed that, while the problem can be solved by considering the budget constraint, neither of these rules gives the correct answer all the time.

Jack early on established a reputation as a logical critic of the simplistic investment concepts in public finance. He criticized excessive confidence in the efficacy of government spending projects, such as California's Feather River project. He helped refute naive arguments in favor of massive government projects that were prominent in the 1950s and 1960s.

Although a theorist, Jack certainly had an appreciation for practical applications. In his coauthored 1960 book (DeHaven, Hirshleifer, and Milliman, 1960; see also Hirshleifer,

1960), alternative methods of supplying water to southern California were put to cost-benefit analysis. A 1967 AER article (Hirshleifer and Milliman, 1967) reviewed what actually happened: Policy makers ignored the advice, and chose what both prospectively and retrospectively was the worst economic choice. They concluded: "It appears that the agenda for economists, at this point, should place lower priority upon the further refinement of advice for those efficient and selfless administrators who may exist in never-never land. Rather, it should focus on devising institutions whereby fallible and imperfect administrators may be forced to learn from error."

His 1961 AER paper (Hirshleifer, 1961b) discussed how covariance of new risks with the existing portfolio makes it desirable to diversify by adding new risks, and he provided an exposition of the Bayesian approach to statistical decision (Hirshleifer, 1961a). He thereafter analyzed the equilibrium of the firm (Hirshleifer, 1962b), the firm's cost function (Hirshleifer, 1962c), efficient allocation of capital in an uncertain world (Hirshleifer, 1964a), and internal pricing and decentralized decisions (Hirshleifer, 1964b).

Thereafter, his 1965 and 1966 QJE articles, (Hirshleifer, 1965, 1966) developed the time-state-preference approach, today referred to as the state-contingent model, applied to traditional problems in economics such as gambling and insurance, the Modigliani-Miller Theorem, and evaluation of public projects. In 1967 Jack published a crucial note on the Bohm-Bawerk/Wicksell theory of interest (Hirshleifer, 1967). Jack's contributions on neoclassical capital theory established him as a pioneer of the role of time, uncertainty and information (Hirshleifer, 1989c) in Fisher's (1907, 1930) spirit. Thereafter came a brief article on the investment decision (Hirshleifer, 1968a), and an article on preferences and time (Hirshleifer, 1968b).

Jack's 1970 book *Investment, Interest and Capital* (Hirshleifer, 1970) became an essential textbook for graduate students, especially for those working in the then-young field of financial economics. Whereas Modigliani and Miller (1958) deserve recognition for their foundational work on debt and dividend policy, Jack deserves recognition for carefully laying out the details of the Fisherian paradigm in a way that provides the broad foundation for modern corporate finance theory. He resurrected, established, and further developed Fisherian general equilibrium analysis as the foundation upon which intertemporal economic theory and modern corporate finance theory are founded, at a time when the partial equilibrium framework was common. Jack's early critique of mainstream macroeconomics, as reflected in his 1970 book, is that it neglected the importance of expectations. He provided early examples of the effects of expectations on monetary and macroeconomic outcomes. A greater emphasis

on expectations eventually was the underpinning of the rational expectations revolution in macroeconomics, as well as more recent developments that allow for imperfect rationality of expectations. In today's analyses of stock markets and other markets, expectations play a crucial role. Jack thereafter published what he labeled the missing chapter of exchange theory (Hirshleifer, 1973b), 'sustained yield' versus capital theory (Hirshleifer, 1989b), and he published investment decision criteria in *The New Palgrave* (Hirshleifer, 1987d, 1993bc).

A subsequent contribution in his 1975 QJE paper (Hirshleifer, 1975) was that differences in tastes are not enough to explain speculation. Differences in beliefs are also required. In contrast to earlier work on speculation that ignored the endogeneity of prices, Jack was the first scholar to analyze speculation in a full general equilibrium model, carefully accounting for different structures of market completeness. He showed that market incompleteness alone cannot explain speculation. His article is the first to point out the indeterminacy of equilibrium when markets are incomplete. He proceeded with a theory of speculation under alternative regimes of markets (Hirshleifer, 1977b).

Building on the distinction between price risk versus quantity risk in speculative markets, David Hirshleifer (1988) analyzed risk, futures pricing, and the organization of production in commodity markets. Building directly on the same modeling approach, David Hirshleifer (1990) considered hedging pressure and futures price movements in a general equilibrium model.

Within capital theory Jack's main concern was to place the theory of investment, interest, and capital into an integrated and consistent logical framework that could incorporate the notions of optimization, equilibrium, prices, decisions over time, under uncertainty, and taking into account differences in information. He emphasized the term structure of interest rates. He thus thought that the emphasis on the rate of interest in the controversy involving 'reswitching' and 'truncation' theorems in capital theory was misplaced. Velupillai (2005) proposed that "the evolution of economic theory have vindicated Hirshleifer's Fisherian stance on this, as on many other matters of capital theory."

3.2 The information economics revolution

Jack's essential contribution about the private and social value of information was his 1971 AER article (Hirshleifer, 1971). He showed that the value placed on information by participants in competitive markets need not correspond to its social value. Public information may have zero or negative social value. The reason is that premature revelation of public information may remove the possibility for agents in the private sector to balance their portfolios in order to spread their individual risks. Considering an infinitesimal deviant

individual in a representative individual world, he showed that the benefit of receiving information first bears no necessary relationship to the social value of the information. Inventive activity can be oversupplied, which he illustrated with an inventor who can make investments, and thus speculate on securities markets, based upon knowledge of the invention. The first reason is the “commons effect” where undiscovered knowledge is a common-property resource, entry into which tends to continue as long as the average yield (not the marginal yield, as efficiency dictates) is remunerative. The second reason is the “speculative effect”. Even if the information has no social value, it may have private value by transferring wealth from uninformed to informed traders. Similarly, information about the future aggregate supply of resources in the economy is privately valuable to consumers since it allows informed consumers to profit at the expense of the uninformed. Furthermore, if information cannot affect aggregate production decisions, then it is also not socially valuable since what one consumer gains another loses. Such “races to be first” to invent or invest play a role in the literature on patent races, which is a challenge within intellectual property law that the profession still works to understand. Consequently, too much information, revealed without accounting for optimal timing, may reduce welfare. In contrast, without property rights for inventions, or for information already produced, we have a “public good effect” inducing underinvestment and free riding. He also published an article on liquidity, uncertainty, and the accumulation of information (Hirshleifer, 1972), a follow-up AER article about where we are in the theory of information (Hirshleifer, 1973a), an article on the origin, function, and future of privacy (Hirshleifer, 1980a), and he took time to review Schelling’s (1978) *Micromotives and Macrobehavior* (Hirshleifer, 1980b).

After a 1975 JEL expository survey with John G. Riley on “The analytics of uncertainty and information” (Hirshleifer and Riley, 1975), the book with the same title appeared in 1992 (Hirshleifer and Riley, 1992). Recent intellectual advances were presented, unifying important but previously partial results into a single picture. The economics of uncertainty and information was shown to generalize and extend standard economic analysis. First focusing on the economics of uncertainty, the state of knowledge is fixed and each person adapts by making an optimal choice among the immediate “terminal” actions available. These choices determine the overall market equilibrium, which reflects the social distribution of risk-bearing. Secondly focusing on the economics of information, the state of knowledge is no longer held fixed, and individuals can overcome their ignorance by “informational” actions. Examples of applications are analyzing stock market returns, evaluating accident prevention measures, and assessing patent and copyright laws. Examples

of topics are insurance, the Capital Asset Pricing Model, auctions, deterrence of entry, and research and invention. As of July, 2005, the book had been sold in over 10,000 paperback and 750 hardcover copies, making it the best selling Cambridge Survey in Economic Literature for the 1990s and beyond.

3.3 *Microeconomic theory*

Jack's successful *Price Theory and Applications* text was first published in 1976, emphasizing individual rationality. The book has been translated into Japanese and Spanish, and has been and will be essential for many generations of undergraduate students. The reason the book was so successful was that it was the first textbook to systematically integrate advanced microeconomic theory with real world applications of the theory. Subsequently this has become the industry standard for price theory texts, several of which, in the highest form of flattery, have even borrowed the precise words of his title! The 7th and latest edition appeared in 2005, co-authored with David Hirshleifer and Amihai Glazer. The book can be expected to play a key role for many years to come.³

4. The expanding domain of economics, to conflict and sociobiology

Jack's interests expanded simultaneously in many different directions. One can observe life-long interests expressed in a preference for general equilibrium analysis applied to ever new phenomena. Seeds from early in his career developed and matured in later years, always being true to economic reasoning. One example was his work on war damages (Hirshleifer, 1953a,b). Over the subsequent 25 years, he wrote on the social structure after a bombing disaster (Hirshleifer, 1956b), capitalist ethics - tough or soft (Hirshleifer, 1959a), on the civil defense debate (Hirshleifer, 1962a), and on economic recovery (Hirshleifer, 1969). Then came two breakthrough articles along these lines, first, economics from a biological viewpoint (Hirshleifer, 1977a), and second, the AER paper on competition, cooperation, and conflict in

³ Senior Editor Scott Parris reports on first meeting Jack "in February 1992, and he welcomed a still green economics editor on a campus visit from Cambridge University Press with genuine warmth and encouragement. That kind of introduction made it an enormous professional and personal pleasure to promote his long awaited work *The Analytics of Uncertainty and Information* with John Riley from that year onwards... It has been no less a pleasure to have sponsored Jack's collected essays in "The Dark Side of the Force." The Press also owes Jack a great deal for so commandingly supporting Cambridge's efforts to defend publishing Bjorn Lomborg's (2001) 'The Skeptical Environmentalist' in the face of some of the most scathing criticism the Press has ever received. It helped to have an ally like Jack, who was second to no one in the pursuit of open inquiry and freedom of expression... In thirteen years of visiting him at UCLA and in now countless e-mail messages Jack was forthright, incisive, inventive, and cordial, even when he was inspiring appropriate chagrin on my part for not following through promptly enough on some aspect of one of his projects. He was a straight shooter on any topic you discussed with him and unabashed about pointing out contradictions in arguments or weak assumptions. The upshot of this was to make you rethink first (and second and third) principles with vigor and insight, two hallmarks of Jack's thinking."

economics and biology (Hirshleifer, 1978a). These two articles drew connections between economics, biology, and conflict, and marked the beginning of Jack's joint and intertwined focus on sociobiology and conflict, which he pursued while developing his insights within information economics.

After a few intermediate articles, the pathbreaking AER article on the expanding domain of economics (Hirshleifer, 1985a) appeared 7 years later. This article is a broad overview of the application of economic logic to a variety of "non-economic" problems. Jack was a leader in extending economic methods to problems more traditionally studied in a variety of other disciplines. Jack began by examining the endogeneity of preferences. He identified the difference between altruistic preferences, and what would now be called the "warm-glow" effect of participation. He reviewed Becker's (1976) "rotten kid" theorem, which says that an altruistic parent can gain from altruism. As an alternative theory of preferences, models of status such as the rat-race were examined. The underlying point of view is that of "as-if" rationality - altruism must provide some benefit to the altruist. From this perspective, Jack examined the psychological model of "anger, gratitude, response" and proposed that seemingly irrational behavior does indeed benefit the individual. The final topic was once again that of conflict. A narrow range of possible settlements, it was argued, increases the potential for conflict. Increasing returns followed by diminishing returns explain the monopoly on military force within the state, while also explaining the multiplicity of states.⁴

5 The provision of public goods: weakest link versus best shot

Jack was also interested in the nature of public goods. He observed that it was traditionally assumed in Samuelson's specification of public goods that the socially available amount X of a public good is the simple sum of the separate amounts x_i provided by $i=1, \dots, I$ persons, i.e. $X = \sum_i x_i$. Rather than generating a new incremental contribution with this same assumption, Jack again proposed something new and extraordinary. The social composition could be $X = \min_i(x_i)$, which means weakest-link, or $X = \max_i(x_i)$, which means best-shot (Hirshleifer 1983,1985). He exemplified weakest-link with flood protection as a public good (Hirshleifer 1983:371):

⁴ Jack's expansive views on economic ideas in the social sciences were also an intellectual inheritance to his son David, as in the joint paper on fads, fashion, custom, and cultural change as informational cascades (Bikhchandani et al., 1992).

“Anarchia is a perfectly circular island, and each citizen owns a wedge-shaped slice (not all equal) from the center to the sea. Like the Netherlands, Anarchia is protected by dikes from occasional storms that threaten to flood the land. But since Anarchia has no government, everyone makes his own decision as to how high a dike to build. While the height of each citizen's dike is perfectly visible to all, the customs of Anarchia forbid enforcement of any threat, inducement, or contract whereby some parties might influence the choice of others. In times of flood the sea will penetrate the sector belonging to whichever citizen has constructed the lowest dike. but the topography of Anarchia is such that no matter where the sea enters, damage will be suffered equally over the whole island. The economists of Anarchia have long realized that flood-protection for their island is a public good." Each citizen is responsible for one dike, and the effectiveness of each dike is based on its height at the lowest point (which is zero if no dike has been built there)”.

Best-shot public goods were exemplified by missile defense protection (Hirshleifer 1983:373):

“Imagine a number of anti-missile batteries ringing a city, firing at a single incoming nuclear-armed ICBM, where destruction for all will be the consequence if the enemy device gets through the defensive ring. Then, for all practical purposes, the only relevant question is whether the single best defensive shot is good enough to destroy the incoming bogey. Or a logically similar situation: the supporters of two claimants to the throne might engage in battle, with all the combatants on each side instructed to aim exclusively to kill the rival pretender.”

The weakest-link arises where each individual has a veto on the total to be provided. The best-shot arises when there is a single prize and any individual's effort can secure the prize. Compared with the conventional summation formula, Jack observed that underprovision of the public good tends to be moderated when the weakest-link case applies, and aggravated when the best-shot case applies. Having worked on disasters, Jack realized where the survival of the community may depend on each person doing his or her duty, and the weakest-link case may therefore apply. Disaster conditions tend to elicit unselfish behavior. Harrison and Hirshleifer (1989) found strong empirical support for the theoretical anticipations for all three formulas using a sequential protocol. Even under the more onerous sealed-bid (simultaneous play) protocol, the subjects made partial progress toward the theoretical ideal. Subsequent research applying the weakest-link and best-shot formulations includes Bliss and Nalebuff (1984), and Anderlini and Felli (2006) who apply the formulations to analyze transaction costs and the robustness of the Coase theorem.

Conybeare et al. (1994) devised an empirical test procedure applied to the Warsaw Pact (1963-87), NATO (1961-87), the Triple Alliance (1880-1914, best-shot defense public good provided by Germany), and the Triple Entente (1880-1914, Britain as weakest-link). Jack's innovative public good concepts have been applied in policy contexts (Sandler 1997;

Arce M. and Sandler 2001): weakest-link and best shot are very much on the mind of policy makers concerned with health issues, cyber space virus control, atmospheric monitoring, deforestation, disease control, peacekeeping, pollution, and more. In Hausken (2002) I merged game theory and reliability theory to show that the weakest-link rule applies for a series system, while the best-shot rule applies for a parallel system: specific games are associated with each of these systems. Van Huyck et al. (1991) and Weber et al. (2004) consider 'weak-link' coordination games where strategies are numbered from 1 and upwards. The row player's payoff depends on the number he or she chooses and on the smallest number chosen by any other player. The payoffs are an increasing function of the smallest number chosen, and a decreasing function of how far the row player is from the smallest number. Weber et al.'s (2004) examples "include keeping a secret, meeting a group at a restaurant that will not seat anyone until everyone in the group has arrived, output in "high reliability" organizations in which a single failure or low-quality component causes disaster, or submitting chapters to a book that cannot be printed until all the chapters arrive." In his 1987 book (Hirshleifer 1987c), *Economic Behavior in Adversity*, Jack reprinted 10 of his articles on disaster, recovery, cooperation, and conflict, adding a brief background for each chapter, an introduction, and indices. Jack's identification of public goods that go beyond and differ from the standard Samuelson (1954) rendition has become part of textbook expositions (Hillman, 2003).

6. Conflict

6.1 *Ratio versus difference rent-seeking functions*

Jack's interest in conflict led him into the rent-seeking literature. Gordon Tullock (1967) had observed the losses from resources used to influence government to make personally favorable policy decisions. Tullock (1980) subsequently proposed a rent-seeking model based on a probabilistic contest success function. Other contest-success functions are possible.⁵ Jack generalized the conception of a contest success function and looked at the properties of ratio and difference models of relative success (Hirshleifer, 1989a).⁶ He observed in particular that the Tullock (1980) contest-success function had the limitation that neither one-sided submission nor two-sided peace between the parties could occur as a Cournot-Nash equilibrium. He found a formula that enabled both these two possibilities to arise, as is

⁵ Hillman and Samet (1987) considered rent seeking when the higher outlay wins with certainty, that is, where the contest success function has the characteristics of an "all-pay auction".

⁶ Skaperdas (1996) axiomatized the two forms, showing that these are the only forms satisfying a set of plausible properties, with an independence from irrelevant alternatives property as the key axiom,

consistent with military experience. In the difference formula, each party's success is a function of the difference between the parties' resource commitments to the contest. The contest success function for the difference form is a logistic curve with increasing returns up to an inflection point at equal resource commitments.⁷

6.2 A general equilibrium approach to production and conflict

Jack observed that rent-seeking competition falls within a broader category of conflict interactions that also include military combats, election campaigns, industrial struggles (strikes and lockouts), legal conflicts (lawsuits), rivalries among siblings or between spouses within the family, etc. He further reasoned (Hirshleifer 1989a:101-102) that

“Owing perhaps to failure to perceive these wider implications, the papers in the rent-seeking literature generally do not adopt a general-equilibrium approach which would make explicit provision for the alternative productive or consumptive uses of resources employed in rent-seeking competitions. Also, what is very important, a general equilibrium model would typically make the value of the prize an endogenous variable rather than an exogenously given parameter.”

Jack maintained this general equilibrium attitude toward conflict for the remainder of his career, and wrote a number of papers. After the economic approach to conflict (Hirshleifer, 1987a) and conflict and settlement (Hirshleifer, 1987a) came his analytics of continuing conflict (Hirshleifer, 1988). Rather than considering a radical disjunction between war and peace, or between conflict and settlement, Jack argued that contending parties will typically be simultaneously at war and peace. That is, the intensity of conflict among the parties can vary along a spectrum. Absolute peace and absolute war are extremes of the spectrum that will rarely if ever be attained. He first pointed out that rational and self-interested individuals, groups, or nations balance on the margin between two alternative ways of generating income. The first is "peaceful" production and exchange. The second is "appropriative" efforts designed to seize resources previously controlled by others (or to defend against such invasions). Both production and appropriation are normal lines of activity to the extent that doing so seems profitable. Applying a resource partition function, a social production function, a combat power function, and an income distribution equation, Jack showed that, in contrast with the harmonistic bias of orthodox economic theory, a general equilibrium model can also encompass the hostile and destructive interactions that characterize real-world social relations. The solutions were obtained under the symmetrical Cournot protocol, the familiar Stackelberg condition, and a novel hierarchical protocol called Threat-and-Promise.

⁷ Developments in conflict theory include Müller and Wärneryd (2001) and Garfinkel (2004) who showed how agents could devote separate fighting efforts at two levels of organization. In Hausken (2005) I compare rent-seeking models with production and conflict models at the individual and group levels.

Having established his basic framework for analysis of conflict, Jack proceeded in his 1991 AER paper (Hirshleifer, 1991b) to show that peace is more likely to the extent that the decisiveness of conflict is low, the stakes are small, or the technology favors defense. He also showed that increased productive complementarity between the parties does not systematically favor peace. That is, the poorer side is generally motivated to invest more heavily in fighting. This can make conflict an income-equalizing process.

6.3 The paradox of power

Elaborating upon the above insight, Jack investigated the paradox of power (Hirshleifer, 1991a), which he considered a very essential contribution, and which, among other things, explains political redistributions of income from the rich to the poor. On the one hand, in power struggles, the strong often grow stronger and the weak weaker. Powerful nations and tribes have often subjugated weaker neighbors. For example, the Jews of Europe, weaker in political and military terms, were repeatedly despoiled of their wealth. However, the weak can also sometimes prevail. First, in wars, smaller or poorer nations have often fought larger adversaries to a standstill, as in the Vietnam war. Second, historically, from the earliest times, poor nomadic tribes have successfully preyed on more affluent cities and empires. Third, in modern redistributive struggles, we almost always observe income transfers from upper to lower fractiles of the wealth distribution. Fourth, although in rich societies farmers have decreased in numbers and voting strength, they have gained increasing subsidies and benefits. Having mentioned the Jews, Jack might have mentioned that the Jewish experience may have motivated Jews to work harder in many ways, as evidenced by the presence of Jews within politics, commerce, and academia. Jack's explanation is that initially poorer contenders are rationally motivated to fight harder, to invest relatively more in conflictual activity. Consequently, poorer or smaller combatants frequently end up improving their position relative to richer or larger ones.

Jack distinguished between the strong and weak forms of the paradox of power. The strong form is such that, in mixed conflict-cooperation interactions, the contending parties will end up with exactly identical incomes regardless of the initial resource distribution. The weak form is such that the final distribution of income will have smaller dispersion than the initial distribution of resources. That is, if R_1/R_2 is the initial ratio of resources, where #1 is the better-endowed side, and I_1/I_2 is the final ratio of income, then $R_1/R_2 > I_1/I_2 > 1$. Jack found that only when the decisiveness of conflict is sufficiently high does the richer side gain relatively in terms of achieved income. Just as for his weakest-link and best-shot contribution,

for the paradox of power Jack also joined coauthors and tested his theory experimentally. Durham, Hirshleifer, and Smith (1998) found broad support for the theory.

6.4 Equilibrium strategies do indeed depend on incentives

Jack observed a rather startling claim in various major political science journals that a change in penalties may have no effect upon criminals' decisions, or, more generally, that altering incentives may not affect behavior. There are certainly games where payoffs can be altered without altering equilibria, and thus not altering behavior. Also, Schelling (1960) has shown how limiting one's options (such as burning one's bridges in war) can be advantageous. Hirshleifer and Rasmusen (1992) pinpoint where the argument goes astray, and illustrate how game theory is properly applied to social policy choices. The initial observation is that in a mixed-strategy Nash equilibrium, changing one player's payoffs affects only the other player's equilibrium strategy mix. This causes what can be called a Payoff Irrelevance Proposition (PIP). The issue is then how general this proposition is. They show, first, that the proposition does not hold in a sequential-move game where the policy-maker moves first. Second, in a simultaneous-move game, the proposition holds only when the policy space is discrete, and for sufficiently small payoff revisions that do not change the strategy elements entering into equilibrium. If choices are sufficiently lumpy, the proposition may apply over a certain range. Consequently, the proposition only rarely applies in actual policy making situations. Incentives almost always affect behavior in equilibrium. That is, as the payoffs change, a new equilibrium usually emerges, which makes it individually rational for each player to alter his or her strategy in accordance with the new equilibrium.

6.5 Jack's Presidential Address: the dark side of the force

Jack was elected Vice President of the Western Economic Association in 1990, became President-Elect in 1991, and was President from July 1, 1992 to June 30, 1993. The description above indicates what was foremost on Jack's mind at that time, and so his Presidential Address June 22, 1993 came as no surprise. It was titled "Cooperation, Conflict, and All That," and was published in a slightly expanded version in *Economic Inquiry* under the title "The dark side of the force" (Hirshleifer, 1994). This is probably the most entertaining of Jack's publications. I was not present at the Address, but, loaded with catchy formulations and tantalizing crowd pleasers, the 10-page article without equations is written to make one almost feel enjoyably present during the speech. No one ever doubted Jack's ability to expound economic theory, which he supplemented with examples, diagrams, and

rich verbal formulations. To illustrate that Jack's talents extended far beyond those of a theoretical economist, we can look at how he went about delivering a speech to listeners who want substance, but in a setting where the most dry, theoretical, abstract, and dull approaches are not necessarily the best vehicles of communication.

Jack started with Edmund Burke's accusation that "the age of chivalry is gone. That of sophisters, economists, and calculators, has succeeded: and the glory of Europe is extinguished for ever." He observed that "200 years later, it seems we economists and sophisters have still not managed to extirpate chivalry and generosity." For example, people contribute to charities and public goods, and cooperate in the Prisoner's Dilemma. After observing Adam Smith's argument for self-interest and division of labor, he proceeded with the more extreme Hayek argument that "only when people learned to be selfish, learned to overcome their innate instincts toward communal sharing, did it become possible to make the transition from primitive society to free civilized life." After this introduction, Jack laid out his main argument:

"Our profession has on the whole taken not too harsh but rather too benign a view of the human enterprise. Recognizing the force of self-interest, the mainline Marshallian tradition has nevertheless almost entirely overlooked what I will call the dark side of the force—to wit, crime, war, and politics. That's like telling the story of Luke Skywalker and Obe Wan Ben Kenobe without mentioning Darth Vader in *Star Wars*. "Crime," "war," "politics"—the words do not even appear in the index to Marshall's *Principles of Economics*."

Jack thereafter presented Marshall's "characteristically flat and prosaic" definition of economics as the "study of mankind in the ordinary business of life; it examines that part of individual and social action which is most closely connected with the attainment and with the use of the material requisites of well-being." Jack interpreted the definition as follows:

"So, for Marshall, economics is bean-counting. Boring, boring, boring. The title page of the *Principles* carries the famous epigraph: "*Natura non facit saltum*"—Nature doesn't make leaps. What Marshall really meant was: "No excitement please, we're English here."

Observing Pareto's division of the efforts of men into production and appropriation, Jack proceeded as follows:

"Pareto is saying, sure, you can produce goods for the purpose of mutually beneficial exchange with other parties—OK, that's Marshall's "ordinary business." But there's another way to get rich: you can grab goods that someone else has produced. Appropriating, grabbing, confiscating what you want—and, on the flip side, defending, protecting, sequestering what you already have—that's economic activity too. Take television. Cops chase robbers, victims are stalked by hitmen (or should I say hitpersons?), posses cut off rustlers at the pass, plaintiffs sue defendants, exorcists cast spells against vampires. What is all this but muscular economics? Robbers, rustlers, hitpersons, litigants—they're all

trying to make a living. Even vampires are making economic choices: sucking blood is presumably the cost-effective way of meeting their unusual nutritional needs.”

In contrast to Marx’s interpretation of conflict as class struggle, Jack pointed out “that in-group amity rises and falls in proportion to external menace, and vice versa.” Jack was inclined to take such a view based on his insight in war theory, human history, primate history involving phenomena such as hunting in packs, principles such as competitive exclusion in population biology, and evolutionary biology more generally. Observing Machiavelli’s argument that “it is impossible that good soldiers should not be able to procure gold,” Jack then observed:

“This is Machiavelli’s version of the golden rule: he who gets to rule, will get the gold. Human history is a record of the tension between the way of Niccolo Machiavelli and what might be called the way of Ronald Coase. According to Coase’s Theorem, people will never pass up an opportunity to cooperate by means of mutually advantageous exchange. What might be called Machiavelli’s Theorem states that no one will ever pass up an opportunity to gain a one-sided advantage by exploiting another party. Machiavelli’s Theorem standing alone is only a partial truth, but so is Coase’s Theorem standing alone. Our textbooks need to deal with both modes of economic activity. They should be saying that decision-makers will strike an optimal balance between the way of Coase and the way of Machiavelli—between the way of production combined with mutually advantageous exchange, and the dark-side way of confiscation, exploitation, and conflict.”

Observing that “rent-seeking, in its usual connotation of maneuvering for licenses and monopoly privileges, is to conflict as milkwater is to blood, sweat, and tears,” and that researchers in other disciplines do good work when they in fact do economics, Jack offered two propositions. First, “cooperation, with a few obvious exceptions, occurs only in the shadow of conflict.” Second, “when people cooperate, it is generally a conspiracy for aggression against others (or, at least, is a response to such aggression).” He justified these by quoting Clausewitz, Adam Smith, and Freud. Clausewitz argued that “for achieving the political aims that are the end of war, the decision by arms is what cash settlement is in trade.” That is, “trade can be conducted without cash settlement, but the ability to make cash settlement ultimately constrains what trades a merchant can engage in.” Similarly, “a state remains influential in peacetime only owing to the damage it could inflict in the event of war.” Further, Adam Smith observed that an industrious and wealthy nation is most likely to be attacked, and Freud argued that “it is always possible to bind together a considerable number of people... so long as there are other people left over to receive the manifestations of their aggressiveness.” Consequently, “the bottom line is that nations with wealth-enhancing laws and institutions will not be able to enjoy the fruits thereof unless, when challenged, they

can put up a tough fight. And the same holds for political parties, clubs, families, and business firms.”

After dividing the sources of conflict into opportunities, preferences, and perceptions, Jack proceeded with material from his other papers on the technology of conflict, the modeling of conflict interactions, and the consequences of conflict, and concluded his address as follows:

“Thus, in recognizing the role of conflict we must not go overboard in the other direction. All aspects of human life are responses not to conflict alone, but to the interaction of the two great life-strategy options: on the one hand production and exchange, on the other hand appropriation and defense against appropriation. Economics has done a great job in dealing with the way of Ronald Coase; what we need now is an equally subtle and structured analysis of the dark side: the way of Niccolo Machiavelli.”

6.6 Jack's final contributions on conflict

After his presidential period Jack published his paper on *anarchy and its breakdown* (Hirshleifer, 1995a). He defined anarchy as a non-chaotic spontaneous order in which participants can seize and defend resources without regulation from above. Each contestant balances between productive exploitation of the current resource base and fighting to acquire or defend resources. As an advance from his earlier models where the resource R for each contender equaled production E plus fighting F , $R=E+F$, now he defined $R=aE+bF$, where a and b are unit costs of transforming resources into production or fighting, respectively. Jack found that anarchy is sustainable only when the "decisiveness parameter" is sufficiently low (less than one), which means that there are strongly diminishing returns to fighting effort, and when incomes exceed the viability minimum.⁸ When the decisiveness is larger than one, anarchy becomes dynamically unstable, leading to dictatorship by the strongest. With increased population, fighting becomes rampant and per capita incomes fall below the viability limit. A common consequence is a dominance hierarchy in which at least a few strong individuals retain access to resources. As examples of anarchic relationships, Jack mentioned international struggles for control of the globe's resources, gang warfare in prohibition-era Chicago, miners versus claim jumpers in the California gold rush, animal territoriality, and male elephant seals who fight to sequester "harems" of females.

In the course of theorizing about conflict (Hirshleifer, 1995b), Jack summarized some of his conclusions and sketched a model of armed settlement under threat. In the same book, Martin McGuire (1995) discussed defense economics and international security. Jack had

⁸ In the ratio form of the contest success function the decisiveness parameter is the exponent to which each effort is raised. When the exponent is zero, efforts are irrelevant and distribution is egalitarian. When the exponent is one, distribution is proportional to effort. When the exponent is infinite, winner takes all.

earlier been influenced by Martin McGuire's research⁹ on the accumulation of strategic weapons and secrecy (McGuire, 1965), and the structure of choice between deterrence and defense (McGuire, 1967).¹⁰ In his macrotechnology of conflict (Hirshleifer, 2000), Jack drew the connection between the Lanchester (1916) model of warfare, where differential equations account for attrition rates of military forces, and the ratio form of the contest success function. The kill probabilities correspond to the unit battle effectiveness parameters and the initial force sizes to the committed fighting efforts. Lanchester's square law is somewhat analogous to the decisiveness parameter. In ancient linear war, squaring would not hold, so numerical superiority would be less decisive. Even for warfare as modern as the so-called Ardennes Campaign toward the end of World War II, Hausken and Moxnes (2005) find empirical support for linear rather than square war, which suggests low decisiveness. The deterministic Lanchester equations are limited such that the stronger side ultimately wipes out the weaker. Hence there is no way to scale degree of success. Neither Jack's approach to conflict nor the stochastic Lanchester equations have this limitation.¹¹

Jack usually did not distinguish between offense and defense. This has been a common approach, taken also by Neary (1997), Skaperdas (1992), Skaperdas and Syropoulos (1997), and others.¹² Jack did distinguish between an offensive and defensive contest success function in his macrotechnology of conflict (Hirshleifer, 2000), and illustrated the distinction with historical examples. Jack was of course acutely aware that war theorists such as Clausewitz (1832) made the distinction quite elaborately, and history is full of examples illustrating the need to make the distinction. Jack illustrated how geography, organization, truth, and morality can be accounted for in production and conflict models. Expanding on this latter insight, Hirshleifer and Osborne (2001) developed a Litigation Success Function for lawsuits. A truth ratio reflects the true degree of fault by the Defendant, multiplied by the ratio of litigation efforts by the two sides raised to the decisiveness parameter. When the parameter is zero or the two sides invest equal efforts, legal efforts are ineffective compared to the power of truth, i.e. the underlying merits of the case. Applying the Nash-Cournot and

⁹ Jack's pleasant attitude to diversity was expressed in his relationship with Martin, an Irish Catholic. They agreed after meeting that Jack would consider Martin an 'honorary Jew,' while Martin would consider Jack an 'honorary Catholic'.

¹⁰ See also Anderton (2003) on historical contributions and future possibilities for economic theorizing about conflict.

¹¹ Reuveny and Maxwell (2001) and my paper (Hausken, 2005) are other examples of dynamic production and conflict models.

¹² The late Herschel Grossman adopted a focus on property rights and distinguished between common-pool and initial-claims models. As an example, Grossman and Kim (1995) showed that, with defensive investment before appropriation, a sufficiently large defensive advantage causes initial possession to remain unchallenged. In Hausken (2004) I distinguished between the offense and defense to enable exchange to emerge, and Anderton et al. (1999) distinguished between one attacker and one defender in an exchange model.

Stackelberg protocols, they determined equilibrium litigation efforts, proportionate success, and the values of the lawsuit on each side. Outcomes were evaluated in terms of achieving ‘justice’, interpreted as equality between Defendant fault and relative Plaintiff success, and minimizing aggregate litigation cost.

With the period prior to World War II in mind, Jack asked whether appeasement could be successful (Hirshleifer, 2001a). He set up the four payoff matrices dependent on whether Germany was peace-loving, aggressive, appeasable, or bluffing, considering payoffs as a compound of preferences, opportunities, and perceptions. He reasoned that the Western leaders failed to appreciate that Hitler, incorrectly, perceived that Germany would succeed. Had the Western leaders acknowledged Hitler’s perception, appeasement was an error, since it served to strengthen Germany’s aggressive strategy. Jack presented various conditions for appeasement to be effective, and postulated a proposition: “If the opponent’s preferences are hostile and non-appeasable, the best strategy is to keep her so poor that she cannot afford to engage in deprivation. If the opponent is hostile but appeasable, the best strategy is to make her so affluent that she will no longer desire to exercise her deprivation option.” In his 2001 book (Hirshleifer, 2001c), *The Dark Side of the Force*, Jack reprinted 14 of his articles on conflict, adding a brief background for each chapter, an introduction, and indices.¹³

7. Biology

Jack’s focus on biology developed from the late 1970s and can be divided into four categories.

7.1 Economics, biology, psychology, and physiology

Jack’s rationality paradigm, incorporating biology, led into psychology, physiology, and ancient moral philosophy. First came the emotions as guarantors of threats and promises (Hirshleifer, 1987e), with regard to which Jack took an economic and game theoretic approach. This was one of the first attempts in the economics literature to deal systematically

¹³ We can compare the combined focus of Jack Hirshleifer and Herschel I. Grossman (who died October 9, 2004). They had in common an early focus within one core field of economics, and subsequently moved on to political economy, contest theory, and conflict. Herschel’s early focus was Keynesian macroeconomics, while Jack’s early focus was information economics, which involved investment and capital theory also related to macroeconomics. After contributions on credibility, time consistency, and reputation, Herschel reasoned that neoclassical economics could not explain in a straightforward way the connection between monetary and real variables. Eventually identifying the political system as the key influence on frictions in the economy, he reasoned that the survival probability of a regime depends on how the ruling elite discounts the future. That led him to analyze the role of the state, property rights, the technological factors of regime change, and the conflict of distribution (Grossman 2004, Kolmar 2005). In Jack’s case the link from information economics to conflict is less obvious, but his early research solidified his acquaintance with economic tools such as general equilibrium analysis, which played a role also in his later research.

with the “non-rational” phenomenon represented by human emotions, and was presented in 1985 at a Stanford University conference on evolution and information. Despite violating rationality, Jack claimed that emotions such as anger, gratitude, benevolence, malevolence, and spite, have been evolutionarily selected because they facilitate eliciting cooperation from the targeted parties. Jack’s theory of emotions as commitment subsequently entered the evolutionary psychology literature. Frank (1988) developed similar ideas focusing on passions within reason. Guttman et al. (1992) considered social investment in taste change related to rent seeking,¹⁴ and Hausken (1996) showed how agents may maximize a weighted sum of the utility to self and others.

Jack thereafter published the economic logic of the affections and the passions (Hirshleifer, 1993a). Jack’s rational approach to bioeconomics implied a certain reserve and skepticism toward the anti-rationalist behaviorism proposed by Kahneman and Tversky (1979).¹⁵ He thought that many of the experimental results could be interpreted in rational terms. Elster (1998), expressing reluctance to believe that norms in all respects are reducible to maximizing behavior, presented discussions and criticisms of the evolutionary approach, and provided a general analysis of research on emotions by economists and non-economists. After the mid-19th when Spencer (1851) and others expounded the link between biology and the social sciences, the two professions drifted apart. The cleavage was especially prominent in the 1920s. Both proponents and opponents of unity versus disunity of science have over the last half-century observed a variety of ways in which biology and the social sciences coalesce. Historical traditions, vested interests, and scientific progress, will likely prevent the union from returning to the close relationship of the mid-19th century. In a paper not particularly related to his other works, but related to psychology in the sense of focusing on learning and autonomy, Hirshleifer and Kourilsky (1976), compared experimentally the effects on learning and autonomy of socially emergent and imposed behavior modification. He also published an article on the game-theoretic interpretations of commitment (Hirshleifer, 2001b).

Jack was on the editorial board of the *Journal of Bioeconomics* between 1999-2005 where he cooperated, among others, with Paul Zak, whom he introduced as "the first professor of neuroeconomics." Together they investigated the bioeconomics of social behavior (Hirshleifer and Zak, 2004). Subsequently Paul Zak participated in a study of the biological basis of trust (Kosfeld et al., 2005).

¹⁴ Guttman (2000, 2003) has more recently applied the evolutionary approach to analyze endogenous preference formation.

¹⁵ They determined empirically a utility function that is concave for gains, convex for losses, steeper for losses than for gains, overweighting low probabilities.

7.2 Which strategies are optimal in evolutionary equilibrium models?

The 1980s witnessed an increased interest in evolution and game theory, for example by Maynard Smith (1982), and Axelrod (1984) on tit-for-tat. Jack at the same time published an article on evolutionary models in economics and law with a focus on cooperation versus conflict strategies (Hirshleifer 1982). Thereafter he published three papers applying replicator dynamics to account for the time dimension to analyze the strategies that are optimal in evolutionary equilibrium models. First, Hirshleifer and Martinez-Coll (1988) showed for the Prisoner's Dilemma that the tit-for-tat strategy is not robustly successful if there is a cost of complexity or probability of error, or there is an elimination contest rather than a round-robin tournament. They showed that evolutionary competition typically generates an interior equilibrium where more and less cooperative strategies simultaneously coexist. Second, Martinez-Coll and Hirshleifer (1991) found similar results for both the Prisoner's Dilemma and Chicken when the four strategies cooperate, defect, tit-for-tat, and bully, are simultaneously present. Third, Hirshleifer and Martinez-Coll (1992) demonstrated the preservation of diversity accounting more thoroughly for selection and mutation.

Jack's last paper in this category is his demonstration that there are many evolutionary pathways to cooperation (Hirshleifer, 1999). Considering the Prisoner's Dilemma, Chicken, and Tender Trap, and allowing the two protocols of single-round simultaneous move and single-round sequential move, Jack first demonstrated the roles of kinship and reciprocity. Thereafter he showed that once payoff modifications and/or more elaborate protocols are allowed, other pathways such as punishment options, complementary strategy mixes, recognition effects, coordination using external clues, and group selection may underlie cooperation.

7.3 The bioeconomic causes of war

Having distinguished the natural economy from political economy (Hirshleifer, 1978b), and spontaneous order and market economics (Hirshleifer, 1984), Jack proceeded to the bioeconomic causes of war (Hirshleifer, 1998). He began by observing that in biological terms the ultimate functional motives for fighting are food and sex, the essential elements of reproductive success. Like other animals, humans seek food and sex directly and also indirectly via dominance and prestige. The direct food and sex motives for warfare have waned in modern times. However, although largely disconnected from reproductive success, intangible goals such as prestige, dominance, and respect – amplified by the 'affiliative

instinct' – remain with us as continuing causes of war. In his conventional style, Jack added to his economic analysis World War I 1914 quotes from the British Sir Edward Grey and the German Chancellor von Bethmann Hollweg, as well as from Genghis Khan.

7.4 The truthful signaling hypothesis

Continuing to be influenced by paradoxes outside economics that can be analyzed with economic tools, Jack turned his attention to the Truthful Signaling Hypothesis (TSH), sometimes known as the handicap principle (e.g. the peacock's tail), which asserts that in mating competition higher-quality males signal while lower-quality males signal less or not at all, and the signals are believed by females. Developing a general equilibrium model, in contrast to the common partial equilibrium models within the economics signaling literature, in our joint research (Hausken and Hirshleifer, 2004) we applied a Mating Success Function, a congestion function, and a Malthusian condition, and showed that, for TSH equilibria, it is not strictly necessary that the high-quality males have an advantage in terms of lower per-unit signaling costs, but a cost difference in favor of the low-quality males cannot be too great if a TSH equilibrium is to persist. And, although the literature has paid less attention to these points, TSH equilibria may also fail if: the quality disparity among males is too great, or the proportion of high-quality males in the population is too large, or if the congestion effect is too weak. Signaling being unprofitable in aggregate, it can take off from a no-signaling equilibrium only if the trait used for signaling is not initially a handicap but instead is functionally useful at low levels. Selection for this trait sets in motion a bandwagon, whereby the initially useful indicator is pushed by male-male competition into the domain where it does indeed become a handicap.

8. Final observations

Jack Hirshleifer was a political economist who analyzed traditional and non-traditional issues in innovative ways. He has left a heritage of original ideas and contributions on which to build. He will in particular remain known for his contributions to information economics, public goods, the understanding of conflict, and bioeconomics. Had I been choosing, Jack Hirshleifer would have been a Nobel laureate.

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Biography

Jack Hirshleifer was born in Brooklyn, N.Y. on August 26, 1925. After serving on active duty in the U.S. Naval Reserve in 1943-1945, he received an S.B. degree in 1945 and a Ph.D. in economics in 1950, both from Harvard University. He was employed as an economist at the RAND Corporation from 1949 to 1955, taught at the University of Chicago Graduate School of Business from 1955 to 1960, and thereafter at the Department of Economics at UCLA. He was a Fellow of the American Academy of Arts and Sciences and a Fellow of the Econometric Society. He served as Vice-President of the American Economic Association and as President of the Western Economic Association, and as a member of the Editorial Boards of the *American Economic Review*, the *Journal of Economic Behavior and Organization*, and of the *Journal of Bioeconomics*. In 2000 he was elected a Distinguished Fellow of the American Economic Association. He died in Los Angeles July 26, 2005 at 7:25 am, survived by his wife Phyllis (née Zimmerman; married, 1946), and their two sons, John (born 1954) and David (born 1958).

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