ARTISTS AND AUTOMATA: TWO ESSAYS CONCERNING THE EVOLUTION AND DISTRIBUTION OF PROPERTY RIGHTS

by

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Abstract

This thesis contains two essays which are concerned with the evolution and distribution of property rights. Each of the essays deals with a different application of property rights analysis. The first essay entitled "Droit de suite: an economic analysis of regulation in the market for works of art", considers a particular regulatory intervention in the market for art works. The market for works of art is characterized by the production of unique assets each of which may have value both as a consumption good and as an investment good. Furthermore the art market is characterized by uncertainty concerning the future value of these assets and by a rich diversity of contractual arrangements and institutions that have evolved over time. The basis for legal rules governing art transactions falls under copyright law, but there is a significant difference between countries' use of "droit d'auteur" (moral rights) and "droit de suite" (resale royalty rights) provisions. The rule, known as "droit de suite" is a regulation which endows artists with an inalienable share in any capital gains resulting from the resale of their work. A model of the art market is developed in order to assess the partial equilibrium effects of a droit de suite regulation, based upon the criteria of economic efficiency, equity and the encouragement of creative activity. Risk preferences, the degree of competition between buyers and the structure of the information environment are taken into consideration in the analysis which demonstrate a number of positive and negative effects associated with the regulation. The combined impact of these neither supports nor rejects droit de suite, however the existence of a quasi-droit de suite rule in Canada suggests that further regulation may be unnecessary.

The second essay, entitled "Instincts as suspended rationality", is concerned with analyzing individual behaviour in a market where instincts may play a strategic role in determining a 'natural' distribution of property rights. Some selfless acts contradict the neoclassical model of self-interested, rational behavior due to emotions which "get in the way" of rational calculations. Instincts can be viewed as biological precommitments which suspend the rationality of decision-makers in certain situations. As such, instincts can generate strategic value in the form of a credible threat to sometimes act irrationally. A game-theoretic framework drawn from theoretical biology is developed to investigate the implications of instincts which suspend rationality and the particular emotion of temper is modeled as an instinctual precommitment to engage in potentially irrational fights. The model illustrates that an inalienable endowment of temper can have survival value in the most hostile of environments and when viewed from an evolutionary perspective, can result in dynamic equilibria in which temper survives as a successful strategy . The evolutionary properties of instincts are further explored through computer simulations in which finite automata compete for evolutionary fitness. This method of incorporating emotions and instincts in economic models holds the potential for explaining selfless acts without rejecting self interest as a fundamental tenet of individual choice theory.

Dedication

To my parents Tommy and Hetty Morrison,

and with much love,

to

Carolyn Seely

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Introduction:

THE DISTRIBUTION OF PROPERTY RIGHTS IN NATURAL, GOVERNED AND REGULATED MARKETS

Property rights analysis

In the last thirty-five years, the interest in explaining and understanding the institutions that govern human behaviour has spawned several theoretical departures from the Walrasian model in which, apart from the price system, there is no need for and hence no theory of institutions. In a Walrasian world, the price system is the only mechanism required for an efficient allocation of resources which is independent of the distribution of resources, however once the assumption of perfect information is relaxed, we are placed in a world where institutions are required to overcome measurement and enforcement problems that arise in forming and performing the terms of agreements between decision-makers. In a world of imperfect information and enforcement, individuals no longer automatically receive and are not necessarily capable of processing all the information relevant to the choices they must make. Instead, access to information is either constrained or costly as is the formation of institutions designed to mitigate the problems created by imperfect knowledge or enforcement ability. This complex world has become the domain of a growing literature which has spawned two important paradigms known as "transactions costs" and "property rights" analysis. With the aid of these two concepts, the economics of imperfect information has been able to establish that markets, if they exist at all, are not in general efficient in the Walrasian sense, that pure economic profits can exist in competitive markets, that rents may be efficiency enhancing and that the distribution of resources can have real implications for economic efficiency.[1]

In discussing property rights analysis, it is useful to define four distinct regimes, referred to here as perfect markets, natural markets, governed markets and regulated markets. The first category refers to the Walrasian model in which there is no need for any institution other than the price system. Consequently, property rights analysis has nothing to say on this topic, however the remaining

[1]See Stiglitz (1993) on the insights of what he calls "information economics". Also on the last point see Eaton and White (1983) and Shapiro and Stiglitz (1984).

categories all exhibit imperfect information environments. A natural market is that environment in which there is no exogenous third party enforcer of property rights. That is, a natural market is one in which any distribution and enforcement of explicit or implicit property rights is endogenously determined from a starting position of anarchy. If, on the other hand, the starting point is a market where it is assumed that "the state" already exists as a third party enforcer, then the market is "governed". The state's only role in a governed market is to police some existing distribution of rights. Finally, in a regulated market, the state acts as a decision-maker with the power to alter the existing distribution of property rights.

Natural Markets

One of the fundamental insights of the property rights paradigm is that the creation of rights can generate wealth, yet much of the analysis to date has assumed as a starting point, an initial set of contractual agreements and enforcement institutions. In contrast, relatively little attention has been paid to the nature of economic behaviour in anarchy, or the transition from a natural to a governed market. In its most basic form, property rights are a set of claims on resources which delineate an individual's right to derive utility or income from some initial distribution of assets, to exclude others from deriving income or utility from them and to alienate them. In the absence of imposed authority, each self interested individual will propose or assert that distribution of rights which sufficiently constrains the behaviour of others and liberates the individual's own behaviour, so as to maximize utility. An environment with two or more individuals and an initial endowment of scarce resources, will give rise to competing claims and in the absence of any exogenous third party enforcement, the resulting interactions will generate a "natural distribution" of property rights.[2]

Providing that the costs of interaction (transactions costs) are positive, the natural distribution will differ from the distribution defined by Walrasian equilibrium because some interactions will require

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[2]This is in line with what Bush (1972) terms the "natural distribution of income" and is discriptive of Hobbes' natural state.

information which is too costly relative to the benefits of a property right agreement.[3] In those circumstances where it is prohibitively costly to reconcile competing claims, individuals will allocate the resources currently in their possession to the use of stealth or physical violence in enforcing their own nominal property rights, whether it be in the protection of an initial endowment or the capture of resources claimed by another. Given the assumption of self interested behaviour, the absence of any authority would seem to conform to Hobbes' view of anarchy as Bush (1972) observes;

> " In Hobbes' natural state, the absence of authority presents the individual with a choice of using his labor to produce goods or to take by force, those goods produced by others. There is nothing in human nature, as such, that insures that all members of the community will opt for the first alternative. The well-being of a person depends on his ability to produce, to take from others and to protect his own. There is no demonstrable tendency toward equality of shares in this world of gross inefficiency and human suffering where life is surely "nasty, brutish and short".[4]

Two questions arise from the consideration of a Hobbesian world. Is there a natural order in anarchy and how do individuals motivated by self interest move from the Hobbesian world to one where individuals agree to and abide by a distribution of property rights? Bush constructs a simple two person model of a natural market, in which individuals must expend "Hobbesian" effort to protect or appropriate resources. He derives a "natural state" equilibrium in which the individuals maximize utility from the resources they are able to secure and minimize the disutility of effort. He then demonstrates the existence of a Pareto dominating distribution of resources in which property rights are voluntarily observed, thus suggesting a theory of self interested progression from Hobbes' world to a natural state of social order. However, in the model it is assumed that the property right system will be self-enforcing because;

> "both individuals know that the inferior anarchistic state will result if they do not abide by the rules" [5]

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[3]In defining transactions costs as the costs of interaction, I am thinking specifically of Barzel's (1989) definition of transactions costs as " the costs associated with the transfer, capture and protection of rights." (p2)

[4]Bush, supra note, p6.

[5]Bush, supra note, p15

This reasoning is flawed because the existence of a Pareto-improving set of actions does not imply that the Nash equilibrium will be pareto efficient, a point driven home by the well-known "prisoner's dilemma" game. A second problem in Bush's analysis is that although it is intended to capture the natural distribution of income resulting from anarchy, the model is devoid of violence. The individuals in his model expend effort in either stealing the other's resources or protecting their own initial endowment, but these activities are analogous to allocating effort between searching for someone else's hidden treasure and hiding one's own. There is no possibility of a confrontation in which the winner appropriates (or retains) all of the contested resources.

The issue of violence as a means of resolving competition for resources in the absence of a property right agreement has been addressed by Tullock (1972) and Umbeck (1981). Umbeck presents an interesting and detailed analysis of the California gold-rush, during which there was an absence of state authority over land claims for a period of almost twenty years. He focuses on what he terms the "original contract"; an agreement under which individuals are assigned explicit private property rights having been previously in a state of anarchy. In Umbeck's model, violence is represented as labor effort which is costly to individuals, and it is assumed that individuals are heterogeneous in their relative abilities to use violence. By also assuming that each individual has perfect information concerning the abilities of others in mining and violence, a natural distribution of land is achieved without any violence actually occurring because each individual knows the amount of force others are willing to use to protect or acquire land. So in actual fact, Umbeck's pre-property right equilibrium is not very different from the Bush model, but he goes on to demonstrate a transition to a contractually agreed distribution of property rights which does not suffer from Bush's incentive compatibility problem. As gold-mining land becomes more valuable, more individuals are attracted to claim some of it, which raises the costs of individual violence and lowers the feasible size of land plots which can successfully be protected and worked. Although an increasing number of participants also increases the costs of reaching property right agreements, there are economies of scale in the joint protection and enforcement of these property rights, such that as the value of land increases, the costs of attaining gold under a property right system increase at a slower rate than under a state of anarchy .

This result supports Demsetz (1967) who reports the emergence of property rights amongst the Algonquin and Iroquois native peoples and argues that property rights were formed with the event of the fur trade which increased the value of beavers. Beavers had principally been a source of food prior to the arrival of Europeans and according to Demsetz, the European demand for furs had the effect of increasing their value. This encouraged hunting and increased the magnitude of a common property externality which had previously not been sufficient to warrant action. As a result of the fur trade, native people began husbanding fur-bearing animals, which required that poaching be prevented and agreements be made concerning property rights. Both the Bush and Umbeck models characterize the natural state as one in which there is stability and order, but assume away the possibility of violence and so do not really capture the nature of Hobbes' nasty, brutish world. Their main objective is to focus on the transition from a state of anarchy to a system of property rights and so they do not dwell on the violent aspects of life in a Hobbesian jungle.

Tullock (1972) points out that in Bush's state of anarchy, there is no reason to trade when stronger individuals can simply take what they want from those who are weaker. He goes on to argue that the emotional response of "losing one's temper" acts as an inalienable biological mechanism which commits individuals to irrational fights when they are desperate. Given diminishing marginal utility, the more appropriated by dominant individuals, the less willing they will be to fight for additional resources. Similarly, the more appropriated by dominant individuals, their victims become more desparate and likely to lose their temper. If instinctual behaviour is a part of the natural order that exists in anarchy, then instinctual and emotional responses to certain stimulae are unlikely to disappear after the transition to some ordered system of property rights. Indeed they are likely to be instrumental in the determining the requirements for and specifications of the institutions that evolve. As an example, consider the survey of purchasing agents and sales representatives, by Macaulay (1963) in which he reports that although contracts usually stipulate that an order for the purchase of some commodity do not permit cancellation of the order once accepted, in many cases cancellation is allowed with more limited liability for the buyer than stipulated in the contract;

> "Disputes are frequently settled without reference to the contract or potential or actual legal sanctions. There is a hesitancy to speak of legal rights or to threaten to sue in these negotiations...."[6]

This may be true even though the vender possesses greater resources and can ultimately expect to win a court battle (the modern business metaphor for violence!). Applying Tullock's reasoning, this can be explained by the possibility that regardless of the explicit contract terms, businessmen expect to be treated "fairly" and will "lose their temper" and elect to fight a breach of contract suit even if they have clearly breached the explicit contract. Macaulay finds some casual evidence of this in his survey;

> "One businessman said that customers had better not rely on legal rights or threaten to bring a breach of contract law suit against him since he "would not be treated like a criminal" and would fight back with every means available."[7]

It seems no accident that legal rules are filled with adjectives like "fair", and "reasonable", because individual actions are still guided largely by implicit understandings of what should occur when explicit agreements are violated. The question is, how can such modes of behaviour be modeled in an economic framework entrenched in notions of self interest and rationality?

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[6]Macaulay, (1963), p9.

[7]Supra note p13.

Governed and Regulated Markets

The difference between natural and governed markets is that the latter concept attempts to explain economic behaviour given a particular set of institutions, without regard to how or why those particular institutions came into being. The rationale for this approach is found in Barzel (1989), who makes the following comment on Umbeck's study of the gold-rush:

> " The very success of Umbeck's study derives in part from the uniqueness of the California gold-rush situation. Umbeck is able to explain the role of violence, or more accurately, of the threat of violence, when the states authority is absent. His results, however, do not apply easily to more orderly circumstances. As a rule, in an already functioning society the creation of rights is an ongoing process. Rights are created in the presence of state authority, which has a comparative advantage over private individuals in the use of violence and which tends to discourage its private use. When a state authority is in place, the role of allocation devices other than violence is greatly enhanced."[8]

The assumption of an exogenous third party enforcer of property rights allows the construction of models in which enforcement mechanisms are already assumed to be in place. In a governed market system, there are essentially two tiers of property rights:... a "basic" pre-defined distribution of rights enforced by the state and an additional distribution of rights determined through private interaction. If basic rights are perfectly enforced by the state, then the opportunities for production and exchange are greatly improved by contractual mechanisms which promote private property rights agreements. When faced with ex-post opportunism problems, individuals in a perfectly governed market may post bonds to guarantee their performance (Schelling, 1960; Williamson, 1983), they may form a contract with some degree of shared residual claimancy (Cheung, 1970), or they may bestow rents on those with incentives to cheat, thereby increasing the expected costs of cheating (Eaton and White, 1983). If the state cannot perfectly enforce property rights, then the basic rights may not be respected if an illegal activity is a possibility.

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[8]Barzel (1989), p63

The existence of illegal activities dilutes the private incentives for production and distinguishes Barzel's concept of "economic" property from "legal" property:

> "Thieves lack legal rights over what they steal; nevertheless, they are able to consume from it and to exclude others from it, to derive income from it and to alienate it. Each of these capabilities is an attribute of ownership. The lack of legal rights may reduce the value of these capabilities, but it does not negate them".[9]

Essentially, governed market models are positive in their approach, and involve a ceteris paribus assumption that the currently observed legal system and set of institutions not directly related to the problem at hand are already in place. The focus is on particular aspects of contractual choices made, by transacting individuals, in which they further specify a distribution of property rights within the limits set exogenously by law given the degree of effectiveness with which those limits are enforced. While the early pioneers of property rights analysis (Knight, Gordon and Coase) tended to conjecture either property rights that were completely specified or completely absent, a more recent success of governed market models has been in developing an understanding of individual behaviour when property rights are only partially delineated or enforced. By identifying different contractual forms and the transactions cost environments in which they are observed to appear, governed market models have been able to generate a theory of institutions within a governed system.

The distinction between a governed market and a regulated market places independent emphasis on the state's role as a third party enforcer of an existing distribution of property rights and its role as a central authority with the power to effect changes in the distribution of property rights. In its role as regulator, the state can be portrayed either as a benevolent giant, who attempts to make redistributions (given his ability as an enforcer) which lead to gains in efficiency or equity, or as a self interested entity, which trades changes in the distribution of property rights with individuals or groups within society in return

[9]Supra note, p110.

for resources. The former could be called "normative" regulation and the latter has already been termed "capture" theory.

Within the normative approach, the decision of altering the privately determined (governed) distribution of property rights must either be efficiency enhancing or must satisfy some equity considerations to justify intervention. To be efficiency enhancing from a property rights perspective, three conditions are required. It must be demonstrated that under the governed system, those with the ability to privately change the distribution of property rights in the way proposed, are prevented from doing so by the private transactions costs involved. If this condition is met, it must still be demonstrated that the government possesses a transactions cost advantage in changing the distribution of rights and that the social benefits of regulation exceed the social costs. A common normative justification for government intervention then, is the state's comparative advantage in monitoring, policing and enforcing contractual agreements.

Empirically, defining a rationale for government regulation requires that the private costs and benefits of a redistribution of property rights be identified and measured, and then compared with the social costs of provision. If the private costs of effecting the proposed regulation cannot be accurately measured, then theoretically, the issue will remain unresolved, because of an observational equivalence problem. That is, without measuring the specific transactions costs and benefits to the individuals concerned, no inference can be made concerning private preferences for the proposed distribution of rights over the currently observed distribution. One valid theoretical approach in such circumstances is to model the private choice of property rights under the assumption that the proposed regulation can be implemented and enforced at zero cost. If, under this assumption, the analysis can demonstrate a private preference for the existing distribution of rights, then transactions cost considerations have no implications for public policy and the regulation should be abandoned.

Two essays on the distribution of property rights

The first of two essays in this thesis contains an analysis of a regulated market. In particular the essay considers the economic implications of a rule known as "droit de suite", which represents a redistribution of property rights in the sale of works of art. Specifically, the law curtails a buyer's rights to any capital gains that result if the work is resold and redistributes these resale profits to the artist. In addition the law curtails the artist's right to alienate that portion of resale capital gains proscribed by the law. A predominant argument favouring the adoption of droit de suite in North America is that private monitoring and enforcing costs are prohibitive and explain artists' lack of interest in writing private droit de suite contracts. This transactions cost argument suffers from the above-mentioned observational equivalence problem in the absence of data on or accurate measures of these costs. The approach taken in the essay therefore is to assume that these costs are zero, in order to ascertain whether artists (who are the intended beneficiaries of the regulation) can benefit from a droit de suite rule under the most favourable of circumstances.

The second essay is somewhat more unconventional and addresses a subject directly related the natural market roots of individual behaviour. It considers the role of instincts and emotions in the decisions of self interested individuals and the effects of instinctual behaviour on the natural distribution of property rights. In particular the paper explores the strategic value of instinctual behaviour and develops the notion of "suspended" rationality as a biological precommitment to potentially irrational acts. A model of conflict is developed in which, similar to Umbeck's model, rational individuals may recognize that they will lose resources if a violent encounter ensues. However, unlike the Umbeck model, the paper utilizes Tullock's insights regarding "loss of temper" and analyses the results of encounters given the existence of temper-prone individuals who have the potential to engage in irrational fights.

Bibliography

Barzel Y. Economic Analysis of Property Rights, Cambridge University Press, 1989.

Bush Winston C. Individual Welfare in Anarchy, in "Explorations in Anarchy", Tullock G. (ed.), Centre for the Study of Public Choice,1972.

Demstetz H. Towards a Theory of Property Rights. American Economic Revue, Papers and Proceedings, May 1967, p347.

Goldberg V. P. Prooduction Functions, transactions costs and the new institutionalism, in "Issues in Contemporary Microeconomics" Feiwel G. (ed.), MacMillan Press, 1984.

Macaulay S. Non-contractual relations in business: a preliminary study, (1963) reprinted in "Readings in the economics of contract law", Goldberg V. (ed.), Cambridge University Press, 1989.

Stiglitz J. Post Walrasian and Post Marxian Economics, Journal of Economic Perspectives, (7), number 1, 1993.

Stubblebine W. C. On Property Rights and Institutions, in "Explorations in the Theory of Anarchy", Tullock G. (ed.), Centre for the Study of Public Choice, 1972.

Tullock G The Edge of the Jungle, in "Explorations in the Theory of Anarchy", G. Tullock (Ed.), Centre for the Study of Public Choice, 1972.

Umbeck J. R. A Theory of Property Rights With Application to the California Gold Rush, Iowa State University Press, 1981.

Essay I:

DROIT DE SUITE: AN ECONOMIC ANALYSIS OF REGULATION IN THE MARKET FOR WORKS OF ART.

I. Introduction

Stereo-typical images of the art world tend to draw attention to certain glamorous or intriguing aspects of the market and tend to obscure the variety of institutions which have governed art transactions over time. For example, the popular image of an art auction is one in which art works that originally sold for the price of a loaf of bread are resold for millions of dollars, and indeed such instances do occur (see table 1 below) and are much publicized, yet there are many recorded sales in which art works have appreciated in far more moderate terms and in some cases have diminished in value or even become obsolete. As far as art buyers are concerned, wealthy aristocracy who have often been depicted as the main source of income for artists have at various times been cash strapped despite their wealth. Similarly, history shows that despite the characterization of patrons as philanthropists who provide artists with guaranteed sources of income, patrons rarely offered stipends or lump-sums without expecting something in return. Art dealers and art experts are also a part of traditional perceptions of how the appreciation of an art work can translate into huge capital gains for those who can spot a "grand master" in the attic of an unsuspecting layman. The private contracts between dealers and hired experts such as the secret agreement between famous dealer Joseph Duveen and art expert Bernard Berenson, have lead to gossip and speculation about the manipulation of art prices and the undue exploitation of private knowledge. But equally strong arguments can be made that the research and expertise undertaken or contracted by dealers has benefited the art market through matching buyers with sellers and providing expert opinion where uncertainty exists about the identity of the original creator. Finally, artists are often perceived to conform to the image of a poor, eccentric individual who is driven to create works that are rarely valued by society until or after his or her death, but in fact history shows that artists as a professional group have been relatively wealthy during their lifetimes. These perceptions and counter-perceptions of the art market help to illustrate that the art market offers a diverse collection of transactions and exchange relationships which define some interesting economic problems.

The analysis of such a "cultural" market may seem removed from mainstream economic theory, however the arts have received a growing amount of attention from economists in the last twenty-five years. Beginning with Baumol and Baumol (1966), several books have investigated economic aspects of the arts in general including such topics as the cost characteristics and pricing behaviour of arts organizations, the supply decisions of artists, policy analysis of government agencies and the rational for government subsidies to the arts (see for example Blaug (1975); Throsby and Withers (1983); Globerman (1983) and West (1986)). As a subset of this literature, studies of the visual arts have tended to focus on the financial performance of art as an investment asset, with relatively less emphasis on issues relating to government intervention. However, two forms of government regulation which are specific to the art market, and which pose interesting economic problems are "droit moral" (moral rights) and "droit de suite" (resale profit-sharing rights). The latter of these is the focus of this essay which sets out to provide some analysis and explanation of a law which endows artists with an inalienable share of capital gains in the art resale market.

The essay plan is as follows. Section II develops a stylized understanding of the institutions that characterize the art market through a historical account of the lives of artists, and art transactions during the last three hundred years or so. Section III provides descriptive details of droit de suite regulation as it exists in copyright legislation, including an international comparison of legislation. An account is also given of recent proposals advocating the adoption of droit de suite in the U.S.A. and the process of copyright reform which has led to the consideration of droit de suite in Canada. In section IV, the economic issues raised by the concept of droit de suite are discussed, and a framework for analysis is proposed. A simple theoretical model of the art market is developed in section V and extended in sections VI-IX. Section X contains a summary of results derived from the model and offers some discussion of the policy implications.

Table 1.

Some Art Resale Prices

Artist	Title of Work	Original Sale Price (year)	Resale Price (year)
Van Gogh	Irises		$53.9m (1987)[10]
Van Gogh	Sunflowers		$39.9m (1987)
Van Gogh	Portrait of Dr. Gachet		$82.5m (1990)
Picasso	Les Noces de Pierrette		$53m (1989)
Jasper Johns*		$2,000	$17.1m
Jasper Johns*	Out the Window		$3,600,000 (1986)
Jackson Pollock*	Blue Poles	$6,000 (1956)	$2m (1973)
Jackson Pollock*	Search		$4,840,000 (1988)
Roy Lichtenstein*	Kiss II		over $6m (1989)
Willem de Kooning*	Pink Lady		$3,600,000 (1987)
Willem de Kooning*	Interchange		$20.7m (1989)[11]

Sources: The Economist (1990), Financial World, (1989), Caplin (1989)

* Living artists.

[10]This painting was sold in 1947 for $84,000. The 1987 price includes the 10% commission paid to Sotheby's.

[11]Currently the highest price paid at auction for a contemporary living artist.

II. Characterizing the art market[12]

Historically, the art market has undergone many transitions in which the identities of and relationships between creators, dealers, experts and buyers have changed over time. Prior the early part of the sixteenth century, artists did not paint on canvas and the art market was characterized largely by personal service contracts between buyers and artists for creations that would not be resold except as a part of the buyer's domicile. Up until this time therefore, artists (painters in particular) were skilled tradesmen who were relatively wealthy and who did not create without the certainty of a sale. Once art works became transportable, pictures which gained prestige value became tradable and the art resale market was born. Of course this represented a double edged sword for living artists at the time for although the transferability of their work added value to it, they also faced competition from an increasing stock of works by past masters. Nonetheless, Reitlinger (1960) reports that by the middle of the 17th century, the art market was well established in France, where the Royal Academy of Fine Arts was founded in 1648 and in England where in 1650, Charles I received a price of £2,000 for a painting by Raphael.

An artist's life in 17th century Italy and Holland was still geared to well defined personal service contracts. It was common for unestablished artists to sign contracts in which they agreed not only to supply the "patron" with a certain number and type of art works, but also to work as house servants in return for an allowance. Upon the establishment of a reputation, the next step was for the artist to leave house service and open a studio, but even then art works were largely created as the result of a forward contract with a specific buyer and exhibiting art for sale as a method of obtaining income for artists was regarded as a last resort.

Around the middle of the eighteenth century, the market witnessed a sensational art sale when the King of Saxony purchased "Cistine Madonna" by Raphael in 1754 for £8,500. It was around this time that the first regularly scheduled art exhibitions by living artists were held both in London and Paris. The French exhibitions were regulated through the Royal Academy and the art selected by jury and exhibited in the "Paris Salons". The salons enjoyed a brief period of open access in the period 1791-1798 following the abolition of the Royal Academy, however a jury system was reinstated in 1798 and the Academy restored (under the new name; Academie des Beaux-Arts) in 1816. While art exhibitions were popular and well subscribed at this time, the majority of artists in

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[12] The descriptive material in this section draws largely on volume 1 of Reitlinger (1963) and from Grampp (1989).

the eighteenth century made their living by painting portraits or by acting as dealers trading the works of past masters. Reitlinger states that by the 1780's, painters were amongst the wealthiest men in England, with artists such as Renolds charging two hundred guineas for a full length portrait which aside from the head would be painted by his apprentices or their assistants. Reitlinger also reports that during the 1790's

> "...there were no less than 28 English and Scottish painters residing in Rome and trading in old masters and antiques". [13]

Other wealthy painters of the time include the American painter Benjamin West, who resurrected the popularity of subject paintings in Britain and who, after an opulent life (which included being paid an annual allowance from King George of £1,000 per year for thirty-seven years), was worth well over £100,000 when he died in 1820. West's career can also be used to illustrate the unpredictable nature of art prices. In 1814, West created his massive painting "Christ Rejected by Caiaphas" and was believed to have refused an offer of £10,000 (He sold another smaller painting "Christ Healing the Sick", two years earlier for £3,150). Some twenty years later, the same painting was discovered rolled up in the back room of a small store. The depreciating value of his works were also evident in 1829 when a series of 14 works he had painted for the Chapel Royal at Windsor Castle were sold for a total of £546, with one painting selling for a mere £26.

Three significant events occurred in the art market during the second half of the nineteenth century. Firstly, independently wealthy aristocrats were being replaced as the buyers of art by the mercantile classes, who in addition to wealth actually had the cash with which to buy. The English aristocracy needed funds to maintain their estates and with the enactment of the Settled Lands Act in 1882, they were free to sell off the family heirlooms. Secondly, in the late eighteen hundreds the Academie Des Beaux-Arts excluded works by the impressionist school from the Paris Salon exhibitions. This dealt the impressionists a severe blow, since at this time, the Salons were the art market in France, with a daily attendance of up to 10,000 and as many as 5,000 pictures being displayed at one salon.[14] Along with an English market that was uninterested in French impressionism and a huge increase in the number of artists and paintings in the market, this meant that impressionists received low prices for their works. According to Reitlinger, it was these circumstances that generated the stereo-typical image of the starving artist:

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[13]Supra note 3, p10.

[14]Reported in Grampp (Supra note 3) p92.

> "The 'starving artist' was a product and a victim of the exclusive Paris Salon between the 1840's and the 1890's. He (*the starving artist*) began with Meryon and ended with Van Gogh and in England he was a rarity. In late eighteen century England, even a journeyman painter belonged to a prosperous class of tradesman. A fashionable portrait painter was a merchant prince, besieged by clients and dining with the great".[15]

The suggestion is therefore that the "starving artist" was an anomaly that somehow became a stereo-type. Furthermore, Grampp (1989) suggests that it was the low prices of impressionist work that attracted American buyers in the first place and that the market for their work would not have developed so quickly if they had not suffered through this period of low prices.

A third event in the late nineteenth century and early twentieth century, was a price trend which occurred in both the English and French market. Art prices began to follow periods of brief crescendo upon an artist's death followed by decline. Shortly after the death of the English painter Turner, his paintings appreciated rapidly in value and were acquired in preference not only to works by living artists but also to old masters. Only once did a painting of his sell for more than £1,000 during his lifetime, but shortly after his death in 1851 "The Grand Canal" was sold for £2,205 (1860), it was resold in 1875 for £7,350 and again in 1885 for the reputed price of £20,000. However according to Reilinger, the rate of appreciation fell off before the turn of the century, sending the market for works by his followers into decline. This phenomena also occurred in France where the works of Delacroix (who died in 1863) and his contemporaries appreciated in value from 1865-1880 and then fell into decline, as they were usurped by Millet (who died in 1875) and the "realist" school. These works now appreciated but only until the early 1900's, when they were superseded by the "impressionists" following the death of Renoir in 1919. The sale prices of Renoir's work did not surpass £3,500 and rarely exceeded £900 during his life, but in the period 1919-1932, sale prices ranged from £4,000-£50,000.

Between 1929 and 1945 the art market was characterized by the effects of the depression, followed by the Second World War. Then, in the late nineteen fifties, a new sort of art market evolved, in which according to Reitlinger, buyers looking for old masters outstripped the available supply and turned their attention to "the inferior prizes" thereby bidding up prices.[16] The effect of

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[15]Supra note 3, p15.

[16]Reitlinger condescendingly refers to this trend as "Taste on the Expense Account". See Supra note 3, p228.

this was to severely curtail the number of endowments to art galleries in the U.S., and to encourage endowments back to the pre-war levels, the government introduced a 30% tax deduction. This created an incentive for museums to overvalue works in order to enhance their tax value in return for endowments and bequests, and the result was inflated sale prices.

The sixties and seventies saw a growing market for contemporary art which blossomed with the auction in 1973 of 50 art works (paintings and sculptures) by contemporary art collector Robert Skull. The total revenue generated by the sale was $2,200,000 including $240,000 paid for Jasper John's "Double White Map" (1965) and $180,000 paid for de Kooning's "Police Gazette" (1955). In addition to demonstrating the financial viability of collecting contemporary art works, the auction also gained notoriety for an incident which took place involving Skull and artist Robert Rausenberg. Scull sold two works by Rausenberg at the auction for a total of $175,000, having purchased the works from the artist for $3,400 some fifteen years earlier.[17] Following the auction, Skull was publicly confronted by the artist who was angered by the amount of money Skull had made from the resale. Rausenberg later proclaimed "From now on, I want a royalty on the resales and I'm going to get it".[18]

The growth in sales of contemporary art works continued throughout the seventies and into the eighties which was characterized by an increasing number of big sales. Nash (1989) suggests that although "Notre Dame" by Julian Schnabel sold for $93,000 at Sotheby's in 1983, it would have fetched less than $10,000 a few years earlier. The big sales of contemporary works by living artists continued through the eighties, peaking with the sale of de Kooning's "Interchange" for

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[17]Bloch et al (1988), point out that the rate of return on one of the works ("Thaw", purchased for $800 in 1958 and resold in 1973 for $85,000) was no more than could be earned by an investor who purchased IBM stock over the same period.

[18]Reported in Hochfield (1975), P20.

$20.7 million in 1989, a year which witnessed the sale of Van Gogh's "Portrait of Doctor Gachet" for $82.5 million.[19]

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[19] However in the following year, the market began a down-turn, and aside from acknowledging that there were fewer masterpieces on the market, there was some indication that something more fundamental was occuring, with the Economist magazine reporting:

> "When it can cost more to buy a painting than to set up a medium sized business, a market correction looms." Economist (December, 1990), p68.

III. Droit de suite regulation

Droit de suite rules as they currently exist are contained in copyright legislation, which in general is concerned with defining and allocating intellectual property rights with respect to the *expression* of original ideas. France was the first country to legislate a droit de suite law in 1921 and still retains it at present. The current French law (based upon a 1958 statute) imposes an inalienable 3% royalty on any capital gains resulting from the public resale of an artist's work (for prices in excess of Fr10,000) for a duration of the artist's life plus fifty years. The royalty is either paid to the artists or their beneficiaries.

The concept of droit de suite can be traced to the last decade of the nineteenth century, at a time when the impressionists were still excluded from exhibiting their art in the Paris Salons, controlled by the Academie des Beaux-Arts. Also, as shown in the previous section, between 1850 and 1930 the art market witnessed a period in which the value of works increased quite dramatically, upon the death of the creator. Filer (1984) reports that an organization " La Societe des Amis du Luxemburg" was formed in 1903 with the express purpose of lobbying for droit de suite, and that during this time, there was outrage in Paris over the poverty suffered by the surviving family when an artist died. The artist Jean François Millet who died in 1875, sold his work "Angelus" in 1859 for £75, but just six years after his death, this work was resold for £6,400 and when it was resold again eight years later for £32,000 his daughter was discovered selling flowers in the streets of Paris. Thus the primary motivation for the introduction of droit de suite appears to have been the perceived need for a compulsory life insurance policy which would provide artists' families with some financial security when they died.

Since the introduction of droit de suite in France, several other countries in Europe and South America have adopted droit de suite rules (see table 2). The German version of droit de suite appears similar in content to the French law, requiring that for any resale within ten years of the initial purchase, 5% of any resale price in excess of 100 marks must be paid to the original creator. However, the German law is different in its philosophy, as noted in Knowles and Kochanowski (1991) who state that:

> "The German Law is based on the 'theory of intrinsic value' which is premised on the notion that the greater value which is later recognized in the work has always existed in latent form" (p4).

The role of the German legislation then is to assign to the artist, the "discovered" value of that which they create (more on this in section 4). One of the more elaborate droit de suite rules has existed in what was formerly Yugoslavia, where Article 40 of the Copyright Law (1978) states that upon request, the owner of an original work of art (musical or visual) must inform the creator of the identity of any new owner or user and that if an original work is resold, the seller must enable the creator to participate in the selling price. The resale royalty must then be set by agreement between the creator's organization, the Economic Chamber, the Federation of Trade Unions and the Socialist Alliance of Working People!

Support for droit de suite has also grown significantly during the last twenty or so years in the United States. In California, a droit de suite law has been in effect since 1976, outlined in Civil Code No. 986 which states that artists must receive 5% of the resale price for art works which are resold for more than the original price within California State boundaries (subject to a minimum resale price of $1000). More recently in 1987, federal proposals for a droit de suite law in the U.S. were made by Senator Edward Kennedy and Representative Edward Markey. Their copyright reform proposal calls for an inalienable 7% royalty any resale price over $1,000 which exceeds the original selling price of paintings, graphic art or sculptures, however these proposals have not been adopted.

Copyright reform and droit de suite proposals in Canada

In Canada, the issue of droit de suite for art works has emerged through the process of reforming our copyright legislation, which is based on English legislation dating back to 1710. Copyright law in Canada was first formalized in 1832 as a statute of the Legislature of Lower Canada which made copyright the jurisdiction of federal government. The first Canadian Copyright Act was passed in 1924 and was closely modeled on the English Act of 1911.

Apart from a report by the "Ilsley Commission" in 1957 and the Economic Council of Canada's "Report on Intellectual and Industrial Property (1971) the process of copyright reform did not begin until 1977, when Consumer and Corporate Affairs (C.C.A) published a report by A. Keyes and C. Brunet entitled "Copyright in Canada: Proposals For A Revision of the Law". This study contained a detailed account of intellectual property right policy issues and an in-depth analysis of all the rights pertaining to existing and proposed intellectual property. By this time it was plain that the Copyright Act should be completely revised, if for no other reason that the existing act had become outdated in its wording and its ability to cope with rapidly changing technology. Following this publication, C.C.A . proceeded to sponsor several studies on specific issues.

Table 2.

Comparison of Existing Droit de Suite Legislation

Country	Legislation	Details
France	Copyright Law #57-298 (1957)	3% of any resale price in excess of 10,000fr at public sale, duration is artist's life plus 50 years.
Germany	Copyright Act (1965), Article 26, (amended 1972).	5% of any resale price in excess of 100 DM, within 10 years of initial purchase.
Hungary	Copyright Act III (1969), Article 46A	5% of resale price on works marked with serial numbers and author's initials.
Italy	Law for the Protection of Copyright (1941), Articles 144-155	Sliding scale of 2-10% of the capital gain realized in the first public resale of a work, plus a portion of subsequent capital gains relative to previous sale price.
Belgium	Copyright Act (1921),	2% of the resale price (resale price = 100FB-10,000FB), 3% (10,000FB-20,000FB), 4% (20,000FB-50,000FB) and 6% (over 50,000FB)
Uruguay	Law Concerning Literary and Artistic Copyright (1938), Article 9	25% of any increase in value resulting from resales of a work.
Brazil	Copyright Act (1973), Article 39	20% of the increase in price obtained in each sales transaction relative to the one immediately preceding it.
Portugal	Decree Law #46980 (1966), Article 59	10% (resale prices up to 10,000 escudos) and 20% (over 10,000 escudos) when resale price represents an increase in value.
Chile	Law on Intellectual Property (1971), Article 36	5% of any increase in value, paid exclusively to creator (not to heirs).

Source: World Intellectual Property Right Organization, (1979, 1989)

In 1984, Consumer and Corporate Affairs and Federal Department of Communications published a White Paper which, based on the analysis of the past fifteen years, made specific recommendations for the revision of copyright. A large part of the white paper was concerned with updating existing legislation and making legislation less vulnerable to changes in technology. However, a number of issues were addressed which could result in the repealing of the old legislation or the creation of new rights. Among these were proposals for the introduction of droit moral and droit de suite. Following the White Paper, in February 1985, an all party sub-committee (G. Fontaine, Chairman) was formed in the House of Commons to consider "all aspects of the revision of copyright" . Later the same year after many public hearings, at which various interested parties lobbied for the changes they desired, the subcommittee published its report:..."A Charter of Rights for Creators". The report contains no fewer than 137 recommendations, many of which are direct descendants of those made in the earlier White Paper and a statement of the goals of copyright revision:

> "....the sub-committee agrees with those for whom the adoption of a substantially revised copyright act is seen as an occasion to make a statement of our pride in the achievement of Canadian authors and performers and in the coming of age of this country as a place where cultural pursuits and creative activity are fully recognized". (p4)

While the committee did recommend the institution of moral rights for all creators, and exhibition rights for visual artists (the right to exhibit an original work in public) but did not recommend the adoption of droit de suite. Echoing the views of the white paper, the report states:

> "Despite the emotional debate surrounding this issue, there is still a considerable lack of factual information in Canada on the consequences of introducing droit de suite, as well as its practical implementation." (p28)

and concludes:

> "Droit de suite should not be introduced at this time in the new Act. Ongoing study should be undertaken to evaluate fully the implications of the right." (p29)

IV. Economic Issues

The logic of economic theory when applied to cultural markets is guaranteed to elicit emotional and scathing criticism from those who dislike the idea of quantifying and objectifying works of art or the behaviour of artists. Nonetheless, these same individuals are often only too happy to invoke economic arguments when it suits their purpose. This sort of debate can be illustrated by considering the German interpretation of droit de suite (described in the previous section) as compensating artists for the "inherent value" of their work. It is not hard to see that the logic of this perspective is seriously flawed. If an art work has some "true" value which may only be discovered at some later date, then the true value could either be above or below the initial purchase price. Therefore a droit de suite law which subscribes to the theory of inherent value should also require that artists share in any capital losses resulting from the resale of their work.[20]

During the Canadian public hearings on droit de suite, the representative for the Association of Universities and Colleges (CAUC) asked the committee to consider whether artists should also share in capital losses. Committee member Lynn McDonald responded by saying:

> "I would like to begin by asking you a question from your written brief on page 7 on the droit de suite, where you propose that , if there is going to be recognition of this right, the creator would subsequently be able to benefit from any increase in value but he or she also ought to be punished by a decrease in value. Do I understand you correctly? How would this happen? I am quite amazed by this proposal".[21]

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[20]It is worth noting that the concept of legal transfer or alienation of an asset in continental europe differs from the North American perspective, which regards transfer of propery as a complete alienation of all rights. Indeed the California droit de suite law was challenged in as a violation of both the constitution and copyright law (Morseberg v. Balyon, 201 USPQ, 518 CD Cal., 1978). Contract law states that an owner has complete rights to his or her property including the right of free disposal. Nonetheless, the validity of the California law was upheld both in the lower courts and in the Supreme Court.

[21]Published transcripts from the "Subcommittee on The Revision of Copyright", Issues 1-27, 33rd Parliament, 11:10, 12/6/1985.

Ms McDonald went on to inform another participant representing the Canadian Artists Representation (who support droit de suite) of the CAUC submission saying:

> " ...I just think it is important to have your (*negative*) reaction to that (*the CAUC proposal*) in the record. I was appalled by it."[22]

In contrast to the German interpretation of inherent value the French interpretation of droit de suite as a from of life insurance holds more promise in terms of economic rationale. The French perspective also appears in the transcripts of public hearings on copyright reform, as stated by the Counsel for the Canadian Artists Representation (National):

> "I think that droit de suite should be perceived, or may be perceived as the pension fund for artists. Artists do not belong to pension funds. They do not participate in benevolent societies. There is no way other than the appreciation of their art works, for their heirs and their children to participate in what their parents have created. The reason that droit de suite came into existence in France was precisely to benefit the children of artists."[23]

In order to make economic sense of the pension-fund view of droit de suite, several questions must be answered. What prevents artists from investing in their own art? If upon their death, an artist's works become valuable, their families would benefit from this just as they would under droit de suite, accept that their benefit would result in the sale of works bequeathed to them. One answer is that the probability of success is related to the artist's exposure during his/her lifetime and that stockpiling art works operates against the establishment of a reputation. Alternatively, if artists are cash-strapped early in their careers, they may be forced to sell every work they produce for whatever price they can, just to survive. In this way, the self-interested actions of individual artists which favour selling the entire stock may diverge from the joint interests of their family as a whole which could be better served by stockpiling.

Alienation in a governed market

In a governed market, the legal principle of alienation (sometimes known as exaustion) makes it illegal to retain rights in an asset that has been sold. If this principle were applied to the art market any privately written droit de suite contract would we illegal. However, if droit de suite was deemed to have desirable effects, regulation would not be required. Rather, legislation would be

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[22]Supra note 11, 15:14, 14/6/1985. (Italics added)

[23]Supra note 11, 15:13, 14/6/85.

necessary in order to make private droit de suite contracts exempt from the alienation principle. In America, private droit de suite contracts are available to artists and have not been challenged as a violation of the alienation principle. Consequently, any justification for droit de suite regulation must explain why artists in the private market voluntarily trade away all rights of transfer. What stops artists from writing private droit de suite contracts? If participating in resale capital gains is beneficial, presumably self-interested artists would sell works with a contingent contract specifying just that. Standardized private droit de suite contracts do exist, the most notable being the "Projansky Agreement", which was created in 1971 by art dealer S. Siegelaub and lawyer Robert Projansky to provide artists with a standardized legally correct, agreement that would allow them to retain resale rights.[24] In fact, artists have not shown much interest in using this or any other private droit de suite contract, but private unpopularity does not necessarily mean that a publicly imposed droit de suite rule would not be beneficial. Even when individual and joint family interests coincide and favour using droit de suite agreements artists could be discouraged by relative price effects which would make works sold without droit de suite contracts more attractive to buyers. A necessary condition for these relative price effects is either inflexibility in the initial purchase price of art, or buyers with risk-taking preferences. If artists using droit de suite contracts set the same purchase price as those who do not, then their expected values will diverge. On the other hand, if initial purchase prices of art adjust to reflect the investment value implied by the sale contract and buyers are assumed to be risk neutral, then artists using private droit de suite contracts would be expected to receive lower initial purchase prices reflecting the decline in investment value created by sharing resale capital gains. Purchases prices would fall until the expected value of droit de suite and "no droit de suite" contracts were equalized.[25]

Another possible explanation for the unpopularity of private resale right contracts is that the costs of monitoring and enforcing such contracts are prohibitively high for individual artists. Artists who have employed droit de suite agreements have expressed difficulty in keeping track of resales and enforcing the agreements.[26] To the extent that those who purchase art under droit de suite

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[24]The Projansky contract binds a purchaser to pay the artist 15% of any gross profit on its transfer by sale, gift or trade and the purchaser must agree to transfer the work only to those who will sign the agreement. The term of the contract is the life of the artist plus 21 years. See Appendix 1 for a copy of the Projansky Aggreement.

[25]Given the lower purchase prices associated with droit de suite, it worth noting that applying the regulation in the case of cash-strapped artists would make them worse off early in their careers by trading off current income in return for the chance of a share in future profits.

[26]For example Hochfield (1975) reports that after using the Projansky contract, artist Carl Andre and his dealer John Weber discovered the several works had been resold in breach of the agreement. They were neither informed of the resales or compensated for the realized capital gains.

agreements have little incentive to reveal resale information and assuming that the cost to artists of monitoring resales is high, buyers may sign a private droit de suite contract with no intention of sharing future capital gains. This transactions cost argument lends support to the introduction of a centralized agency specialized in the enforcement of resale right agreements and collection of royalties.

This argument was presented by Canadian artist Don Kane at the public hearings on copyright reform:

> "Listen to this: establish a registration system of art works under the joint control of the Canadian Artists Representative (*CARFAC*) ...... and the Professional Art Dealers Association of Canada Inc. that would allow the artists, if they so desire, to register artworks they would like to obtain a resale value on or resale royalty. ...This system would be established and kept up in Toronto at the offices of CARFAC. Artists would expected to pay a fee for registration of any artwork they produce and want registered. The system would be responsible for doing a cross-check for any capital sales reported through Revenue Canada of art sold in the tax year in question." [27]

He continues;

> "...the artist would have the right to sell - granted, here it is; the option for the dealer and everybody else - the copyright ownership to any buyer, individual gallery, government or other, who in turn would be able to collect through the same system, as long as they are registered, the percentage royalty outlined in the contract of sale between the two parties."[28]

The suggestion implicit in Mr. Kane's proposal is that while the costs of individual monitoring and enforcement are prohibitive, collective costs of administering droit de suite are low, so that artists would voluntarily pay a fee in return for a collectively administered droit de suite. In other words, for those artists participating, a droit de suite rule would increase their expected income by an amount which would exceed the collective cost per member of CARFAC. Once again, this does not seem to require any direct government intervention, except for a law creating CARFAC as a agency with the right to collect resale royalties on behalf of its members. In essence, a transactions cost argument in support of droit de suite regulation implies that in the absence of

[27]Super note 11, 15:48, 14/6/1985.

[28]Super note 11, 15:48, 14/6/1985

monitoring and enforcement problems, artists would prefer to attach droit de suite agreements to the sale of their work.

The arguments mentioned thus far have been evaluated with regard to the efficiency implications of droit de suite. While the German interpretation presupposes a market failure associated with buyers consistently undervaluing art at the time of initial purchase, the French interpretation has efficiency implications associated with maximizing collective benefits or reducing collective costs associated with droit de suite. However, there are two alternative criteria on which to evaluate droit de suite regulation. As already outlined in section 3, droit de suite falls under the jurisdiction of copyright law, which in general attempts to encourage creativity through the assignment of property rights. Based upon this criterion, support for droit de suite should rely upon evidence that the creative output of artists will increase as a direct result of such a law.[29] Alternatively, droit de suite may be supported purely on equity grounds, in which case it need only be demonstrated that it is a superior instrument for making artists (as a group) better off.

The above discussion has demonstrated the need to determine the likely effects of droit de suite on the welfare of artists and the efficiency of the market yet the inclusion of monitoring and enforcement costs creates a somewhat muddy picture. Unless the costs in question can be identified and quantified, there is little hope that economic analysis can come to any definite conclusions. For this reason, a theoretical model is developed in sections 5-9 in which it is assumed that the cost of administering, monitoring and enforcement of droit de suite are zero for the regulating agency. While these costs are clearly non-zero, their exclusion will not matter if it is shown that artists' welfare is reduced or not changed significantly by the introduction of a costless droit de suite regulation.

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[29]Essentially, this presupposes that increased creativity is socially desirable, the usual intellectual property right arguments of non-appropriable external benefits having been applied.

V. A model of art as an investment good

The framework for analysis in this section is provided by considering the decisions of rational artists and buyers of art who must consider what will occur in tomorrow's art market before making a decision today. To avoid transaction cost considerations, contracting and enforcement costs are assumed to be zero under any droit de suite regulation. Suppose that an art market occurs over two periods and that each art work is created and sold in period one. Those who purchase works in period one place them in a resale auction in period two. Initially, the buyers in period one are assumed to be "pure" investors in the sense that they attach no personal consumption value to art works. They are also assumed to have risk neutral preferences.

In this model, the value of any given art work to potential buyers in period one is determined by the expectation of what will occur in the resale auction. The resale auction mechanism is assumed to be an English (ascending bid) auction in which each seller may set a reservation price. On the supply side of the market, each artist is assumed to produce one work of art in period one, subject to a market entry condition given by $EU(W) > U(S)$, where $EU(W)$ is an artist's expected utility from income earned in the art market and S represents the opportunity cost (in certain dollars) of being an artist.

An artist will receive a purchase price (P) in period one for his/her work and may participate in the buyer's period two profits through a droit de suite contract. Such a contract specifies that a portion of any capital gains earned in the resale auction must be paid to the artist. It is assumed that the discount rate is one (neither artists nor buyers have a preference for income in one period over another), so that an artist's income under a droit de suite contract is given by:

$$W = \max [P , (P + \alpha(Q - P)], \qquad (1)$$

Where α $(0 \leq \alpha \leq 1)$ is the droit de suite parameter, P the period one purchase price, and Q the *revealed* resale price in period two. [30]

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[30] Note that under droit de suite contracts, artists do not share in capital losses. In actual legislation, some monetary appreciation of an art work may be allowed before any capital gains are shared. In this case, the artist's expected income becomes $W = \max [P , (P + \alpha(Q - \beta P)]$, where $\beta > 1$. However, no generality is lost in my analysis by assuming $\beta = 1$.

If artists participate in the resale of their work, we should expect some impact upon purchase prices because the expected profits retained by initial buyers are contingent on these prices. To show the overall effect of droit de suite regulation, we need to know the precise relationship between the initial purchase price and the share of capital gains retained by the artist. Specifically, to what extent is a risky share in future capital gains offset by a fall in the initial purchase price? Let there be n bidders in the resale auction each with independent, private valuations of any given work. Following the auction literature, these valuations can be regarded as being independently drawn from a probability distribution with some density function f(x), which is known to all market participants including artists.[31]

Now let the valuations of all n bidders in the resale auction be ordered from highest to lowest such that $x_{(n)} > x_{(n-1)} > \dots\dots\dots > x_{(1)}$. A well established result in auction theory states that the bidder with the highest valuation ($x_{(n)}$) will win an English auction with a bid equal to the second highest valuation ($x_{(n-1)}$).[32]

Now consider the period one art market. Given the above information concerning the resale auction, potential buyers in period one will only be interested in the distribution of second highest valuations. That is, in period one, each buyer will regard the winning bid for a given work in the resale auction ($x_{(n-1)}$), as an independent drawing from some known distribution with density function g(X,n). In words, the function g(X,n) is the probability density function of the (n-1)th order statistic in a sample of size n, drawn from f(x).[33]

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[31]This corresponds to the "Independent Private Values" Model in auction theory. See McAfee and McMillan (1987), for a good review of auction models. Note that in a world of heterogeneous art, each work will have a specific density function associated with it.

[32]This result is attributed to Vickrey (1961).

[33]Formally, from the theory of order statistics, g(X,n) is the density function associated with the (n-1)th order statistic given by the formula:

$$g(X,n) = f_{X_{(n-1)}}(X) = \frac{n!}{(n-2)!}.F(X)^{n-2}.[1-F(X)]\ f(X)$$

where $\frac{n!}{(n-2)!}.F(X)^{n-2}.[1-F(X)]$ is the probability that (n-2) of the n values drawn lie below X.

For a discussion of order statistics, see Larson and Morris (1986) pp144-146.

Although this is a two period model, as a simplification it is assumed that the interest rate is zero, thus avoiding the need for discounting terms. So in the case of a zero droit de suite contract (where $\alpha=0$), the expected value of an art work to any prospective buyer in period one is given by:

$$[V|_{\alpha=0}] = E[x_{(n-1)}] \tag{2}$$

or

$$[V|_{\alpha=0}] = \int_0^{\infty} X\, g(X,n)\, dX \tag{3}$$

Assuming competition between two or more buyers in the first period, provides an equilibrium condition which sets each buyer's profits equal to zero. That is, the equilibrium purchase price received by an artist will always capture the full expected value of the work to buyers. For a zero droit de suite contract, the equilibrium condition implicitly defines the initial purchase price as:

$$P = [V|_{\alpha=0}] \tag{4}$$

From equation (1) we know that when $\alpha=0$, the period one purchase price comprises the artist's total income. Combined with the period one equilibrium condition in (4), this defines an artist's income as:

$$[W|_{\alpha=0}] = P = \int_0^{\infty} X\, g(X,n)\, dX \tag{5}$$

For a positive droit de suite contract, the expected value of an art work to an initial buyer must be modified to reflect the possibility that a period one buyer will pay resale royalties in period two. The initial buyer's expected revenue in the period two auction depends upon the period one purchase price and is given by:

$$[V(P)|_{0<\alpha\leq 1}] = \int_0^{P} X\, g(X,n)\, dX + \int_P^{\infty} [X - \alpha(X-P)]\, g(X,n)\, dX \tag{6}$$

The term $[\int_0^P X\, g(X,n)\, dX]$ is the initial buyer's expected payoff when the work resells for a price lower than the original purchase price, in which case the initial buyer keeps the entire amount.

The term $[\int_P^\infty [X- \alpha(X-P)]\, g(X,n)\, dX]$, is the expected payoff to the initial buyer when the work resells for a price which is higher than the initial purchase price. In this case, the initial buyer must pay $\alpha(X-P)$ to the artist.[34]

Now let us examine an artist's income under a positive droit de suite contract, which must now be written as an expectation because of the artist's participation in any resale profits. For $0 < \alpha \leq 1$, the artist's expected income is:

$$E[W(P)\,|_{0< \alpha \leq 1}] = P + \int_P^\infty \alpha(X-P)\, g(X,n)\, dX \qquad (7)$$

As before, the zero profit assumption guarantees that the period one purchase price is implicitly defined as:

$$P = [V(P)\,|_{0< \alpha \leq 1}] \qquad (8)$$

Equation (6) can be thus be substituted for P in equation (7) to give:

$$E[W(P)\,|_{0< \alpha \leq 1}] = \int_0^P X\, g(X,n)\, dX + \int_P^\infty [X- \alpha(X-P)]\, g(X,n)\, dX$$
$$+ \int_P^\infty \alpha(X-P)\, g(X,n)\, dX \qquad (9)$$

Equation (9) reduces to:

$$E[W(P)\,|_{0< \alpha \leq 1}] = \int_0^\infty X\, g(X,n)\, dX \qquad (10)$$

Comparing equation (10) with equation (5), we can see that an artist's expected income under a positive droit de suite contract exactly equals the income received under a zero droit de suite contract. This is because the purchase price paid by the initial buyer is depressed so as to exactly offset the expected loss in capital gains due to resale royalty payments.

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[34]The impact of a droit de suite law on art buyers is similar to the distorting effects of a capital gains tax in that future payoffs to present day buyers are reduced, thereby affecting current valuations and prices. However, the analogy is not perfect for two reasons. Firstly, the "tax" burden under a droit de suite law, is invariant to the future income of the buyer and secondly, the applicability of a droit de suite law is dependent upon a fixed term (usually equal to the life of the artist plus fifty years), which is unrelated to the buyer.

Risk Neutral Artists

While it has been assumed that buyers are risk neutral, no explicit assumptions have yet been made regarding artists' preferences. Consider first the case where artists are risk neutral. The above analysis has shown that an artist's expected income will be invariant to the value of the droit de suite parameter (α). This result gives rise to the following proposition:

Proposition 1:

If the initial buyers of art are competitive pure investors and all agents are risk neutral, artists will be indifferent between a zero droit de suite *contract* (α=0) *and any positive* droit de suite *contract* ($0< \alpha \leq 1$).

Proposition 1 follows from the fact that $E[W(P)\,|_{0<\alpha\leq 1}]$ exactly equals $[W(X)\,|_{\alpha=0}]$, which under an assumption of risk neutrality means that an artist's expected utility is invariant to the contractual value of α.

Risk Averse Artists

A positive droit de suite contract allocates not on'y future capital gains but also some risk to the artist. This has led some authors to suggest that the unpopularity of droit de suite contracts in the private art market reflects an asymmetry of risk preferences.[35] Given the preceding analysis, an implication of assuming that artists are risk averse, while buyers remain risk neutral is that ex-ante, artists will no longer be indifferent to the introduction of a droit de suite law. This yields a second proposition.

Proposition 2:

If the initial buyers of art are competitive pure investors with risk neutral preferences and artists are risk averse, then a zero droit de suite *contract* (α=0) *will be preferred by all artists to any positive* droit de suite *contract* ($0< \alpha \leq 1$).

A positive droit de suite contract transfers some risk from the initial buyer to the artist, and since there is no compensation in expected income, risk averse artists will unambiguously prefer to

[35]Risk aversion arguments appear in E. Landes and R. Posner (1989) and S. Rottenberg (1976).

receive a purchase price equal to $[W(X)\,|_{\alpha=0}]$ with certainty to the risky prospect of earning the same amount under a positive droit de suite contract. Propositions one and two can now be used to generate propositions 3(a) and 3(b) regarding the impact of resale rights upon the market entry decisions of artists and thus upon the supply of art.

Proposition 3(a):

If the initial buyers of art are competitive pure investors, and all agents are risk neutral, then the supply of art is invariant to the value of a contract's droit de suite *parameter* (α).

Proposition 3(b):

If the initial buyers of art arc competitive pure investors with risk neutral preferences and if artists are risk averse, then the supply of art will be lower under a positive droit de suite *law* ($0< \alpha \leq 1$) *than under a zero* droit de suite *regime* ($\alpha=0$).

Returning to the market entry assumption that EU(W) must at least equal U(S) (where S is the opportunity cost of entering the market), consider those marginal artists who receive a purchase exactly equal to S dollars under a zero droit de suite contract.

Since $E[W(P)\,|_{0< \alpha \leq 1}] = [W(X)\,|_{\alpha=0}]$, these artists will also earn an expected income equal to S. Therefore, if artists are risk neutral, their expected utility from the art market prior to entry will be unchanged by the introduction of a positive droit de suite law. Consequently, the number of artists entering the market (which equals the supply of art) will be invariant to the contractual value of α. If artists are risk averse, then marginal artists will expect a utility level of $EU(W(X)\,|_{\alpha=0}) = U(S)$ under a zero droit de suite regime. However a positive droit de suite law will only yield $EU(W(X)\,|_{0<\alpha\leq 1}) < U(S)$. It follows that if positive droit de suite contracts are mandatory, then marginal artists will not enter the art market because the regulation reduces their expected utility below its opportunity cost level.

Discount rates and the rate of time preference

On the basis of the analysis thus far, when art is a pure investment good and artists are assumed to be risk averse while buyers are risk neutral, then droit de suite fails all three criteria for evaluating copyright legislation. The law reduces artists' welfare along with the supply of art but is also inefficient because it forces some artists to adopt second best occupations. Alternatively, if artists and buyers are assumed to be risk neutral, droit de suite law has been shown to have no implications for the art market. But suppose that the zero interest rate assumption is relaxed and replaced with an assumption that the discount rate is less than one for artists. With a rate of time preference that favours period one over period two and imperfect capital markets, even risk neutral artists would be made worse off by droit de suite, because it has no effect on total expected income, but shifts income from the first to the second period. Considering the income trend over the lifetime of an artist, the casual evidence suggests that income is low when the artist begins his or her career and rises if/when they establish a reputation, peaking after their death. This implies that unestablished artists are most likely to want to trade away future potential income for current earnings, and will harmed relatively more by a droit de suite law.

VI. The Aesthetic Value of Art

So far, first period art buyers have been assumed to be pure investors, but in reality, art works are often purchased for their perceived aesthetic value in addition to being purchased as investments. This observation is supported by empirical evidence of the actual rate of return on art as an investment. While some financial analysts have touted art as a superior investment compared other financial assets (for example in 1974, the managers of British Rail's pension fund invested £40m in art works) Pesando (1992) points out that if financial markets are efficient, the risk adjusted rate of return on works of art should equal that of other assets. Indeed researchers may have good reason to be suspicious of the high prices paid for some art works during the late 1970's and 1980's. During this period several commercial banks and at least one auction house (Sotheby's) offered loans to art investors. When Van Gogh's "Irises" was sold to Alan Bond (an Australian businessman) in 1987 for $53.9m, he received a loan of $27m from Sotheby's for the purchase. After the purchase, Mr. Bond defaulted on the financing payments and the work is now owned by the J. Paul Getty Museum in California which paid an undisclosed sum for the work.

Pesando's empirical investigation of repeat sales in identical art prints shows that they have both a lower mean real rate of return and lower risk (standard deviation) compared with stocks over the period 1977-1988. Other empirical studies of original art works such as Keen (1971) and Anderson (1974) and Frey and Pommerehne (1989) also show that art works are somewhat inferior as investments assets in comparison to other financial assets. Stein's (1982) study of art purchased in the U.S. over the period 1946-68 leads him to conclude that art is rather ordinary as a financial asset, with an annually compounded nominal appreciation of 10.5% compared to 14.3% for the stock market. Art performs even more poorly as an investment asset in Baumol's (1986) investigation of art sales over a three hundred year period from 1760-1960, yielding a real rate of return of less than one percent! The generally accepted implication of these results is that the rate of return differential between art works and alternative financial assets is accounted for by the aesthetic pleasure derived from art as a consumption good.

Given that art has a private consumption-based value in addition to investment value, it becomes important to capture a second source of uncertainty in the resale market. First period buyers must take into account the possible outcomes resulting from *their own* future valuation of a work purchased in period one.This additional aspect of the problem can be incorporated into the model by assuming that period one buyers have a private aesthetic valuation (Y) for their purchase which is not revealed to them until the second period. As a simplification, the aesthetic valuations of all buyers in the first period is assumed to be identical and are normalized to zero. The period one buyer must now account for the possibility that he/she as a seller in the second period, will value an art work more than the highest bidder in the resale auction. Each period one buyer will now set a reservation price in the resale auction as a function of his/her (private) aesthetic valuation (Y), creating the possibility that an art work which is sold in period one will not be resold in the resale auction. Recalling that $x_{(n-1)}$ is the *revealed* highest bid in the resale auction, an art work will not be resold in a zero droit de suite environment unless $x_{(n-1)} \geq Y$. This is efficient in the sense that each work is allocated to the individual who values it most highly.

When resale capital gains must be shared with an artist, first period buyers will only wish to resell a work if the revealed highest bid in the resale auction is sufficiently high to generate *net* profits greater than their revealed aesthetic valuation. Suppose that the highest bid in a resale auction exceeds the initial price (P), so that any resale will involve a side payment to the artist of $\alpha(x_{(n-1)}-P) \geq 0$. In this case, the net revenue earned by an investor in the period two auction cannot fall below P regardless of the value of α. Thus, when $P \geq Y$, the imposition of a positive droit de suite law will have no effect n the initial buyer's resale decision. However, if $P < Y$, there are values of the droit de suite parameter (α) which will reduce net revenue below the initial buyers valuation Y.
This means that when Y is greater than P, an art work will not be resold under positive droit de suite unless it satisfies a reservation price constraint given by:

$$x_{(n-1)} - \alpha(x_{(n-1)}-P) \geq Y \tag{11}$$

or

$$x_{(n-1)} \geq \frac{Y-\alpha P}{(1-\alpha)} \tag{12}$$

Equations (11) and (12) show that the imposition of a droit de suite law will introduce a distortion in the resale auction by inflating the reservation price when $P \leq Y$. This is inefficient because some works will not be resold, although they are valued more by the highest bidder in the resale auction than by the initial buyer.

The cost of this market failure is born not only by bidders in the resale auction, but also by artists themselves. In period one, buyers incorporate the distorting effects of the droit de suite law on the resale auction into their expected value calculations. The result is an additional depression of the period one purchase price, with consequences for artists' incomes as indicated by proposition 4.

Proposition 4:

If all agents are risk neutral, and the initial buyers of art are competitive and have uncertain future (period two) private valuations of art, a zero droit de suite *contract will be preferred by all artists to all other contracts.*

In a zero droit de suite environment, the expected revenue generated by a work in the period two auction to an initial buyer in period one, will be conditional upon the revealed value of Y:

$$v_1(Y) = Y.\int_0^Y g(X,n)\, dX + \int_Y^\infty X\, g(X,n)\, dX \tag{13}$$

In (13), the highest bid in the resale auction falls into one of two categories; If the highest bid is in the range [Y,∞], work will be resold, but if it lies in the range [0,Y], the initial buyer will choose not to resell.

In a droit de suite environment, an initial buyer's expected revenue calculation can be separated, according to the relationship between the initial purchase price (P) and any given value of Y. First if $P \geq Y$ and $0 < \alpha \leq 1$, the expected value of a work is:

$$v_2(Y,P) = Y.\int_0^Y g(X,n)\, dX + \int_Y^P X\, g(X,n)\, dX + \int_P^\infty [X - \alpha(X-P)]\, g(X,n)\, dX \tag{14}$$

When $P \geq Y$, (14) shows that there is no distortion of the reservation price because the work will always be resold when the highest bid exceeds Y. The highest bid in the resale auction falls into three possible categories. If it is in the range [0,Y], then there is no resale. If it is in the range [Y,P], then the work will be resold, but since the resale price is lower than the initial purchase price, there are no capital gains to share with the artist. If the highest bid is in the range [P,∞], then the work is resold and the initial buyer receives the highest bid less the artist's share of the capital gain.

Now suppose that $P < Y$. For a given value of Y, and P, the expected revenue from a work is:

$$v_3(Y,P) = Y.\int_0^{X^*} g(X,n)\, dX + \int_{X^*}^\infty [X - \alpha(X-P)]\, g(X,n)\, dX \tag{15}$$

Equation (15) shows that when P < Y, resale only occurs when the highest bid is greater than X*, where:

$$X^*(Y,P,\alpha) = \frac{Y-\alpha P}{(1-\alpha)} \tag{16}$$

When P < Y, any resale must offer the initial buyer net returns which are greater than Y. Since any resale under these conditions will involve a side payment to the artist, the initial buyer must inflate the reservation price set in the resale auction conditional upon the droit de suite parameter (α).

So far in this section, the expected value calculations have been expressed for a given value of Y, but in period one, the value of Y is uncertain. To incorporate the first period expectation of Y into the model, let Y be an independent drawing from a known distribution with density function h(Y). In a zero droit de suite environment, an art work's expected value in period one is now given by:

$$[V\,|_{\alpha=0}] = \int_0^\infty [v_1(Y)]\, h(Y)\, dY \tag{17}$$

Substituting (13) for v_1 gives:

$$[V\,|_{\alpha=0}] = \int_0^\infty [Y.\int_0^Y g(X,n)\, dX + \int_Y^\infty X\, g(X,n)\, dX\,]\, h(Y)\, dY \tag{18}$$

In the case of a positive droit de suite contract, using equations (14) and (15), a work's expected value in period one is given by:

$$[V\,|_{0<\alpha\leq 1}] = \int_0^P [v_2(Y,P)]\, h(Y)\, dY + \int_P^\infty [v_3(Y,P)]\, h(Y)\, dY \tag{19}$$

To see the effect upon an artist's expected income, we start as before by expressing expected income as a combination of the period one purchase price and the expected shares in future capital gains. The period one equilibrium condition implicitly defines P as being equal to the expected value of a work to an initial buyer. Therefore under a zero droit de suite contract, (17) can be substituted for P to give an artist's total (certain) income. That is:

$$E[W|_{\alpha=0}] = [V|_{\alpha=0}] = \int_0^\infty [Y.\int_0^Y g(X,n)\,dX + \int_Y^\infty X\,g(X,n)\,dX]\,h(Y)\,dY \quad (20)$$

In a positive droit de suite environment, the artist's expected income is:

$$E[W(Y,P)|_{0<\alpha\leq 1}] = P + \int_0^P [\int_P^\infty \alpha(X-P)\,g(X,n)\,dX]\,h(Y)\,dY + \int_P^\infty [\int_{X^*}^\infty \alpha(X-P)\,g(X,n)\,dX]\,h(Y)\,dY \quad (21)$$

Now, substituting equation (19) for P in equation (21) gives us an expression which reduces to:

$$E[W(Y,P)|_{0<\alpha\leq 1}] = \int_0^P [\,Y\int_0^Y g(X,n)\,dX + \int_Y^\infty X\,g(X,n)\,dX\,]\,h(Y)\,dY + \int_P^\infty [\,Y\int_0^{X^*} g(X,n)\,dX + \int_{X^*}^\infty X\,g(X,n)\,dX\,]\,h(Y)\,dY \quad (22)$$

Again, the advantage of holding a share in capital gains is entirely offset by a fall in the purchase price, however an additional effect is now present. Unless $\alpha = 0$, the resale auction reservation price X^* will be greater than Y, which means that under positive droit de suite, there is a higher probability that any given work will not be resold. By comparing (20) with (22), we see that $E[W|_{0<\alpha\leq 1}]$ is unambiguously less than $E[W|_{\alpha=0}]$. In the previous section, droit de suite regulation had no implications when artists were assumed to be risk neutral, but now some art is not resold even though efficiency demands that is should be, and this results in a lower income for artists regardless of their risk preferences, hence proposition 5.

Proposition 5:

If the initial buyers of art are competitive investors with uncertain (period two) private valuations of purchases made in period one,and if all agents are risk neutral, then a zero droit de suite *contract* (α=0) *will be preferred by all artists to any positive* droit de suite *contract* ($0<\alpha\leq 1$) .

The additional effect upon artists' expected income also gives rise to a sixth proposition concerning the effects of a droit de suite law on the supply of art.

Proposition 6:

If the initial buyers of art are competitive investors with uncertain (period two) private valuations of purchases made in period one and if all agents are risk neutral, then the supply of art will be lower under a positive ($0< \alpha \leq 1$) droit de suite *law than under a zero* ($\alpha=0$) droit de suite *regime.*

Consider again the case of marginal artists who, in a zero droit de suite regime will receive a total income given by:

$$E[W \mid_{\alpha=0}] = P = S \qquad (23)$$

As shown by equations (20) and (22) above, $E[W \mid_{0<\alpha\leq 1}]$ is unambiguously less than $E[W \mid_{\alpha=0}]$. This means that for marginal artists, expected income will fall below the opportunity cost of entry (S) under a positive droit de suite law, causing them not to enter the market.

In summary, the analysis in this section has shown that a legislated positive droit de suite contract results lowers artists welfare and the supply of art, regardless of their risk preferences. It also produces an inefficient allocation of art in the resale market because some art will not be resold by the initial buyer, even though it is valued more highly by at least one participant in the resale auction.

VII. The future stock of art works and resale values

In the market for works by living artists, the future supply of works is subject to change at the time when works from the existing stock are resold. It follows that foresighted buyers in the resale auction of an original work will incorporate expectations concerning the effects of future changes in the size of the stock of works on the value of the original into their current bids. To the extent that resale prices represent a signal of the demand for additional works by the same artist (usually in the same style), an incentive exists for the artist to exploit this revealed popularity by producing more works after the resale has taken place which will lower the value of works in the existing stock. In the same way that consumers of a durable good produced by a monopolist are aware of the producer's incentive to flood the market in the future, buyers in the resale auction will expect the artist to increase his or her stock of art if it is revealed to be popular, putting downward pressure on the resale price. In this context, droit de suite can act as a mechanism which credibly commits the artist to a lower future output by tying his or her income to the resale price of the original work.

To examine the effects of droit de suite when artists' future output is contingent upon revealed popularity, consider the following extension of the model in which it is assumed as before, that an artist produces one work in period one which is sold in a competitive buyers' market. The work is placed in a resale auction in period two and following this a third period occurs in which the artist can produce any number of additional works at zero cost. For simplicity it is assumed that each work produced in the same style is a perfect substitute for the artist's original work (produced in period one) and that all the artist's works have no value after period three. In period two the resale auction now conveys important information to the artist, namely the aesthetic valuation of the second highest bidder, which signals the magnitude of demand for additional works. Again for simplicity, it is assumed that the distribution of aesthetic valuations revealed in period two remains the same in period three. In other words, the individual with the highest bid in the period two resale auction will still hold the highest valuation of the original work in period three so that it will not be resold again.

Proposition 7:

If the buyers of art are pure investors and if the resale auction defines the future demand for copies by the artist, then a positive droit de suite contract ($0 < \alpha \leq 1$) will be preferred by all artists to a zero droit de suite contract ($\alpha = 0$).

The period three demand for the artist's work is revealed in period two to be:

$$q_3(P_3) = A - P_3 \tag{24}$$

where A is the aesthetic valuation by the second highest bidder of the consumption services provided by the work in period two and P_3 is the price per unit of each additional work produced in period three.

If the original work is resold, then the price will reflect the buyer's expectation of the artist's production of additional works. Given the assumption that the distribution of aesthetic valuations is unchanged in period three, the winning bidder in the resale auction would pay a price of 2A if assured that no additional works would be produced. But given the artist's incentives to produce more works, and assuming that the expectations of period two buyers are accurate, the resale price (X) will be:

$$X = A + P_3(q_3) = 2A - q_3 \tag{25}$$

A zero resale rights contract

If the artist does not participate in any capital gains realized in period two, there is no incentive to restrain the period three output of works. In period three, the artist's income is:

$$w_3 \big|_{\alpha=0} = Aq - q^2 \tag{26}$$

so that the equilibrium (profit maximizing) output and price of the artist's works in the third period will be:

$$q_3^* = P_3^* = A/2 \tag{27}$$

If buyers in the period two resale market hold accurate expectations of the artist's future output (that is, $P_3^e = P_3^*$), then the resale price will now reflect buyers' belief that the artist will produce additional works in the next period so that $X = 3A/2$.

The initial buyers as pure investors

If it is assumed that the initial (period one) buyers are pure investors who have a zero aesthetic valuation of the work in all periods, in the absence of positive resale rights, the initial purchase price of the work is:

$$[V\,|_{\alpha=0}] = \int_0^{\infty} \frac{3A}{2}\, g(A,n)\, dA \qquad (28)$$

and the artist's total expected income is:

$$E[W\,|_{\alpha=0}] = \int_0^{\infty} [\frac{3A}{2} + \frac{A^2}{4}]\, g(A,n)\, dA \qquad (29)$$

Where g(A,n) is the distribution function of aesthetic valuations by the bidder with the second highest valuation in the resale auction.

Now consider the imposition of a resale right contract which stipulates that in period three the artist will receive a share of any capital gains realized by the sale of the original in period two. If the work does not appreciate in the second period, the artist's profit maximizing output in period three and therefore the expected value of the work is unaltered, but if the resale price exceeds the initial purchase price, then the profit maximizing output for the artist in period three will fall and the period three value of a work by the artist will rise. This is because the artist's period three income is now:

$$[w_3\,|_{0<\alpha\leq 1}] = \alpha[(2A - q) - P_1] + Aq - q^2 \qquad (30)$$

The resulting profit maximizing output decision for the artist is

$$q_3^* \text{ Argmax } [w_3\,|_{0<\alpha\leq 1}] = \frac{A-\alpha}{2} \qquad (31)$$

so that $P_3^* = \frac{A+\alpha}{2}$

In period two, the resale price will rise, reflecting the period two buyer's expectation of the resale right's effect on the period three price, so that $X = [\frac{3A}{2} + \frac{\alpha}{2}]$ when $X > P_1$. However, the seller in the resale auction will not capture all of the appreciation due to the buyer's expectation of period three because under the resale right agreement, the artist will claim $\alpha\,[\frac{3A+\alpha}{2} - P_1]$. Capitalizing these changes back to the first period, the expected value of the original work (thus the period one purchase price) becomes:

$$[V\,|_{0<\alpha\leq 1}] = \int_0^{P_1} (\frac{3A}{2})\, g(A,n)\, dA + \int_{P_1}^{\infty} [\frac{3A}{2} + \frac{\alpha}{2}] - \alpha[\,(\frac{3A}{2} + \frac{\alpha}{2}) - P_1]\;\; g(A,n)\, dA \qquad (32)$$

The artist's expected income under the resale right contract is:

$$E[W\,|_{0<\alpha\leq 1}] = [V\,|_{0<\alpha\leq 1}] + \int_0^{P_1} (\frac{A^2}{4})\, g(A,n)\, dA$$
$$+ \int_{P_1}^{\infty} \frac{(A-\alpha)^2}{4} + \alpha[(\frac{3A}{2} + \frac{\alpha}{2}) - P_1]\;\; g(A,n)\, dA \qquad (33)$$

Substituting for $[V\,|_{0<\alpha\leq 1}]$ gives:

$$E[W\,|_{0<\alpha\leq 1}] = \int_0^{P_1} (\frac{3A}{2})\, g(A,n)\, dA + \int_{P_1}^{\infty} [\frac{3A}{2} + \frac{\alpha}{2}] - \alpha[\,(\frac{3A}{2} + \frac{\alpha}{2}) - P_1]\;\; g(A,n)\, dA$$

$$+ \int_0^{P_1} (\frac{A^2}{4})\, g(A,n)\, dA + \int_{P_1}^{\infty} \frac{(A-\alpha)^2}{4} + \alpha[(\frac{3A}{2} + \frac{\alpha}{2}) - P_1]\;\; g(A,n)\, dA \qquad (34)$$

or

$$E[W\,|_{0<\alpha\leq 1}] = \int_0^{P_1} (\frac{3A}{2} + \frac{A^2}{4})\, g(A,n)\, dA$$
$$+ \int_{P_1}^{\infty} [(\frac{3A}{2} + \frac{\alpha}{2}) + \frac{(A-\alpha)^2}{4}]\, g(A,n)\, dA \qquad (35)$$

Comparing this with $E[W\,|_{\alpha=0}]$, shows that the artist's expected income is higher under the resale right contract. That is $E[W\,|_{0<\alpha\leq 1}] > E[W\,|_{\alpha=0}]$ for all possible values of α.

Initial buyers with uncertain future aesthetic valuations

Section VI examined the case where the initial buyer's aesthetic valuation of a work in period two is unknown in period one when the work is purchased, and it was shown that the institution of a resale right law would increase the likelihood that a work would not be resold. If the durable asset model is extended to include this possibility, then the resale contract will have two effects, one which enlarges the artist's expected income by mitigating the ex-post opportunism problem and another which lowers it by increasing the probability that the work will not be resold when its value appreciates beyond the initial purchase price.

Proposition 8:

If the initial buyers of art have uncertain future aesthetic valuations and if the resale auction defines the future demand for copies by the artist, then the net effect of a droit de suite contract on an artist's expected income is indeterminate.

As previously assumed, the initial buyer's aesthetic valuation (Y) of a work purchased in period one remains zero, but in the second period his/her aesthetic valuation is distributed by the density function h(Y). Now, given the durable asset problem, in the absence of resale rights case, the period one value of the work is:

$$[V \,|_{\alpha=0}] = \int_0^{\infty} [v_1(Y)]\, h(Y)\, dY \tag{36}$$

where:

$$[v_1(Y)] = Y.\int_0^Y g(A,n)\, dA + \int_Y^{\infty} \left(\frac{3A}{2}\right) g(A,n)\, dA \tag{37}$$

The artist's income is now equal to the initial purchase price plus the period profits from selling additional copies if the work is resold.

$$E[W \,|_{\alpha=0}] = [V \,|_{\alpha=0}] + \int_0^{\infty} \left[\int_Y^{\infty} \frac{A^2}{4}\, g(A,n)\, dA\right] f(Y)\, dY \tag{38}$$

Substituting for $[V \,|_{\alpha=0}]$, this gives:

$$E[W \,|_{\alpha=0}] = \int_0^{\infty} \left[Y.\int_0^Y g(A,n)\, dA + \int_Y^{\infty} \left(\frac{3A}{2} + \frac{A^2}{4}\right) g(A,n)\, dA\right] h(Y)\, dY \tag{39}$$

Now consider the introduction of a droit de suite law, such that the initial purchase price of an art work when the artist shares in resale profits is:

$$[V \mid_{0<\alpha\leq 1}] = \int_0^{P_1}[v_2(Y,P_1)]\, h(Y)\, dY + \int_{P_1}^{\infty}[v_3(Y,P_1)]\, h(Y)\, dY \tag{40}$$

where

$$V_2(Y,P) = Y\int_0^{Y} g(A,n)\, dA + \int_Y^{P_1} \frac{3A}{2}\, g(A,n)\, dA + \int_{P_1}^{\infty}[\frac{(3A+\alpha)}{2} - \alpha(\frac{(3A+\alpha)}{2} - P_1)]\;\; g(A,n)\, dA \tag{41}$$

and

$$V_3(Y,P) = Y.\int_0^{Y^*} g(A,n)\, dA + \int_{Y^*}^{\infty} [\frac{(3A+\alpha)}{2} - \alpha(\frac{(3A+\alpha)}{2} - P_1)]\;\; g(A,n)\, dA \tag{42}$$

for $Y^* = \dfrac{Y-\alpha P_1}{(1-\alpha)}$

Substituting for $v_2(Y,P_1)$ and $v_3(Y,P_1)$ gives the rather messy expression:

$$\begin{aligned}[V \mid_{0<\alpha\leq 1}] = \int_0^{P_1} [Y.\int_0^{Y} g(A,n)\, dA &+ \int_Y^{P_1} \frac{3A}{2}\, g(A,n)\, dA \\ &+ \int_{P_1}^{\infty} [\frac{(3A+\alpha)}{2} - \alpha(\frac{(3A+\alpha)}{2} - P_1)]\;\; g(A,n)\, dA]\, h(Y)\, dY \\ &+ \int_{P_1}^{\infty}[Y.\int_0^{Y^*} g(A,n)\, dA \\ &+ \int_{Y^*}^{\infty} [\frac{(3A+\alpha)}{2} - \alpha(\frac{(3A+\alpha)}{2} - P_1)]\, g(A)\, dA]\, h(Y)\, dY\end{aligned} \tag{43}$$

The artist's expected income now has three components; the initial purchase price, the income from additional copies and a share of resale profits:

$$\begin{aligned}E[W \mid_{0<\alpha\leq 1}] &= [V \mid_{0<\alpha\leq 1}] + \int_0^{P_1} [\int_Y^{P_1} \frac{A^2}{4}\, g(A,n)\, dA] \\ &+ [\int_{P_1}^{\infty} \alpha(\frac{(3A+\alpha)}{2} - P_1) + \frac{(A^2-\alpha^2)}{4}]\;\; g(A,n)\, dA]\, h(Y)\, dY \\ &+ \int_{P_1}^{\infty} [\int_{Y^*}^{\infty} \alpha(\frac{(3A+\alpha)}{2} - P_1) + \frac{(A^2-\alpha^2)}{4}]\, g(A,n)\, dA]\, h(Y)\, dY\end{aligned} \tag{44}$$

After substituting for substituting for $[V|_{0<\alpha\leq 1}]$ the expression simplifies to:

$$E[W|0<\alpha\leq 1] = \int_0^{P_1}[Y.\int_0^Y g(A,n)\,dA + \int_Y^{P_1} \frac{3A}{2} + \frac{A^2}{4} g(A,n)\,dA$$
$$+\int_{P_1}^{\infty}[\frac{(3A+\alpha)}{2} + \frac{(A^2-\alpha^2)}{4}]\, g(A,n)\,dA]\, h(Y)\,dY$$
$$+\int_{P_1}^{\infty}[Y.\int_0^{Y^*} g(A,n)\,dA + \int_{Y^*}^{\infty} [\frac{(3A+\alpha)}{2} + \frac{(A^2-\alpha^2)}{4}]\, g(A)\,dA\}h(Y)\,dY \quad (45)$$

To compare the artist's expected income in each case we can restate the artist's expected income from (39) as:

$$E[W|\alpha=0] = \int_0^{P_1} [\Delta_1] + [\Delta_2] + [\Delta_3]\, h(Y)\,dY + \int_{P_1}^{\infty} [\Delta_4] + [\Delta_5]\, h(Y)\,dY \quad (46)$$

where:

$$[\Delta_1] = Y.\int_0^Y g(A,n)\,dA$$

$$[\Delta_2] = \int_Y^{P_1} \frac{3A}{2} + \frac{A^2}{4}\, g(A,n)\,dA$$

$$[\Delta_3] = \int_{P_1}^{\infty} \frac{3A}{2} + \frac{A^2}{4}\, g(A,n)\,dA$$

$$[\Delta_4] = Y.\int_0^Y g(A,n)\,dA$$

$$[\Delta_5] = \int_Y^{\infty} \frac{3A}{2} + \frac{A^2}{4}\, g(A)\,dA$$

In each case above, where the work is resold with no resale right law, the buyer's valuation and the artists third period revenues reflect the ex-post opportunism problem.

The effects of a resale right law on the artist's income can be expressed in a similar fashion to (46):

$$\text{Let } E[W \mid 0 < \alpha \leq 1] = \int_0^{P_1} [Z_1] + [Z_2] + [Z_3]\, h(Y)\, dY + \int_{P_1}^{\infty} [Z_4] + [Z_5]\, h(Y)\, dY \tag{47}$$

where:

$$[Z_1] = Y.\int_0^{Y} g(A,n)\, dA$$

$$[Z_2] = \int_Y^{P_1} \frac{3A}{2} + \frac{A^2}{4}\; g(A,n)\, dA$$

$$[Z_3] = \int_{P_1}^{\infty} \left[\frac{(3A+\alpha)}{2} + \frac{(A^2-\alpha^2)}{4}\right] g(A,n)\, dA$$

$$[Z_4] = Y.\int_0^{Y^*} g(A,n)\, dA$$

$$[Z_5] = \int_{Y^*}^{\infty} \left[\frac{(3A+\alpha)}{2} + \frac{(A^2-\alpha^2)}{4}\right] g(A)\, dA$$

Comparing the Δ's with the Z's:

$[\Delta_1] = [Z_1]$
$[\Delta_2] = [Z_2]$
$[\Delta_3] > [Z_3]$
and
$[\Delta_4] > [Z_4]$

However a comparison between $[\Delta_5]$ and $[Z_5]$ cannot reveal one to be larger than the other because while the income level given by $[Z_5]$ is higher than that given by $[\Delta_5]$ the probability of receiving the income in $[Z_5]$ is lower. The artist loses expected income from an increased probability that the original work is not resold, but gains from the increased income received if the work is resold. The total effect on the artist's expected income cannot be assessed without more specific assumptions concerning the distribution functions so that the effect of droit de suite on the artist's expected income is indeterminate.

VIII. Art dealers as agents or expert buyers

In a market where the products are highly differentiated and unique, search costs and information are likely to play an important role. This is true of the art market, where dealers either act as agents representing artists or as expert consultants to buyers (in this role the dealer is the initial buyer who then resells to art consumers/investors). In agency contracts between artists and dealers, it is normal for artists to sign revenue-sharing agreements. In a standard share contract of this type, for any represented work that is sold, the dealer receives 40-50% of the purchase price in exchange for the dealer's services which can include general marketing and the organization and promotion of exhibitions. If on the other hand, the dealer buys the work outright, then the (wholesale) price charged to the dealer will represent a discount of more than 40-50% of the "gallery" price.

In terms of the pure investment model (see section 5), we can express an artist's net income (after commission) under an agency contract with zero resale rights as being:

$$E[W|_{\alpha=0}] = (1-\beta).\ [V|_{\alpha=0}] \tag{48}$$

where

$$[V|_{\alpha=0}] = \int_0^\infty X\ g(X,n)\ dX$$

and β = the commission rate, $0 < \beta < 1$

As previously demonstrated, the introduction of droit de suite will, in the absence of dealer commissions lower the initial purchase price but leave the artist's expected income unchanged. Once commissions are included, the final effect of droit de suite depends upon whether or not some of the reduction in revenue from the initial sale is absorbed by the dealer. If many artists compete to be represented by a few dealers, then the commission rate will adjust in response to any depression in the equilibrium purchase price of art works. This seems to be a reasonably accurate description of the contemporary art market as described by dealer James Corcoran (1989), who states that there are an estimated 50,000 art students in California alone, many of whom will seek profession representation from the ten established contemporary art galleries in L.A. The combined representation of these galleries amounts to around two hundred artists. Given this sort of competition, the dealers' compensation is likely to remain invariant to purchase prices, in which case droit de suite will have no effect on artists' expected incomes. Since dealers may simply charge a higher commision rate if the purchase price of art falls as a result of droit de suite dealers demand an amount (k) from the artists they represent which is inflexible downwards.

If ß it is expressed as a proportion of the sale price, this gives:

$$ß = \frac{k}{V(\alpha)}, \tag{49}$$

so that

$$E[W] = (1-\frac{k}{V(\alpha)}).\ V(\alpha) + \int_{P1}^{\infty} \alpha(X-P_1)\ g(X,n)\ dX \tag{50}$$

or

$$E[W] = V(\alpha) + \int_{P1}^{\infty} \alpha(X-P_1)\ g(X,n)\ dX - k \tag{51}$$

and since $\{[V(\alpha) + \int_{P1}^{\infty} \alpha(X-P_1)\ g(X,n)\ dX]\} = [V|_{\alpha=0}]$, the artists expected income remains $E[W] = [V|_{\alpha=0}] - k$, for all values of the resale right parameter (α).

On the other hand, some recent trends in the art market suggest that dealers might in fact absorb some part of the depression in prices resulting from droit de suite regulation. Art dealers who represent contemporary living artists also tend to buy and resell works by deceased artists so that resources are split between the resale market and representation services. However in the last ten to fifteen years, auction houses have come into prominence as a primary retail market for buyers rather than a wholesale market for dealers. David Nash (senior V.P. of Sotheby's in 1989) describes the five year period 1983-1988 as one in which:...

> "The traditional role of the auction house as a place where dealers come to buy inventory was replaced as greater and greater numbers of private collectors came and bought for their private collections. The aggressiveness shown by collectors in the sales led frequently to unprecedented prices, which themselves influenced the dealers market".(p306)

Although a reduction in profits from the resale market suggests that dealers might have less resources available to organize exhibitions (Corcoran points out that dealers often "subsidize" exhibitions by living artists with profits from the sale of works by dead artists) there is every reason to suppose that dealers would have access to capital markets which they would exploit in the pursuit of profits. Also, less time spent in the auction houses implies a shift in relative focus to artist representation at a time when the demand for contemporary art has grown substantially. These observations suggest that the capacity of dealers to represent artists has increased with no appreciable decline in the quality or quantity of services offered. If in valuing potential, dealers hold a common ranking of some sub-set of available artists then some degree of competition will cause dealers' compensation to be less than contracted artists' maximum willingness-to-pay for their services. It follows that the decline in purchase prices under droit de suite regulation would, given some degree of competition be absorbed by dealers thus increasing the expected income of those artists offered representation (in terms of the model, the term denoting the artist's expected revenue remains constant while commission costs (k) fall).

However, holding market conditions (demand for contemporary art) constant, the expected profits of competing dealers will fall under droit de suite, which at the margin would result in fewer artists being represented. Specifically, lower ranked (unestablished) artists would have less chance of obtaining representation. In summary, if there is some competiton between dealers for the right to represent certain artists, then droit de suite will increase the expected incomes of artists who obtain representation but at the margin will reduce the number of artists represented.

The dealer as initial buyer

In the analysis so far, it has been assumed that both artists and first period buyers have the same information concerning future market conditions. It has also been assumed that there is sufficient competition between buyers to allow artists to extract their full willingness to pay. However, when dealers are characterized as a small number of expert buyers and they purchase works directly from artists, they may exploit both superior bargaining power and information. In an attempt to assess the effects of relaxing these assumptions, a simple game theoretic model is developed in this section to assess the implications of droit de suite regulation in a market characterized by informational asymmetries and a high degree of market power for some buyers. Some proponents of droit de suite legislation argue that one reason for the imposition of an inalienable droit de suite is that it provides a means of credibly committing artists in a vulnerable bargaining position to more lucrative contracts.[36]

The analysis of informational asymmetries in microeconomics defines a class of problems in which market failure may occur unless there is a way to trade credible information. Buyers and sellers in such markets may be willing to employ the services of third party experts who can verify the quality or potential of a good. The art market may be thought of in this context. Artists may be assumed to face search costs in finding buyers with the highest willingness-to-pay and may also have difficulty in assessing or credibly assuring the value of their work. In this environment,

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[36]See Hochfield, (Supra note 3) p22 and Millinger (1981), p73 for example.

dealers or auction houses sell their expertise in assessing the future market value of art works and can also minimize both artists' and consumers' search costs. In return for these services, they will extract a share of each work's value, the size of which depends upon their market power.

While there is no strong theoretical or empirical case for assuming that competition between dealers, auction houses and other expert buyers is limited, the intent in this section is to consider the effects of a market structure which exploits the interests of artists. In particular, the model creates an art market in which a professional buyer holds monopsony power combined with an informational advantage. This is clearly an extreme case, however the implications of relaxing the severity of artists' disadvantage will be explored later on.

A Sequential Game with Asymmetric Information

Suppose the period one market consists of two buyer types. Pure consumers are assumed to be competitive buyers who are uninformed about the true market value of art. They purchase any given art work purely on the basis of an aesthetic valuation (r), which is known to the artist. The other buyer is a single art dealer who is a profit maximizing, pure investor. The dealer is endowed with complete, certain information concerning the future market value of each art work.
Assume that each artist will create a "great" work of art with some probability (ϕ) which is known to artists. It is also known to artists and the dealer that great art sells for v dollars in the resale auction ($v > r$) and, as a simplification, it is assumed that art which is not great resells for a price equal to the current consumer valuation (r). Let there be a small positive cost (c) of entering an art work in the resale auction and assume that $\phi < \frac{c}{(v-r)}$.[37]

[37]The assumption of a small positive resale auction entry cost (c), eliminates several other "non-revealing" equilibria. In these equilibria, the dealer would be indifferent between offering a purchase price lower than r or a purchase price equal to r. In these equilibria, the dealer offers the same contract, regardless of the artist's type, so the artist cannot update beliefs from observing the dealer's offer. However these non-revealing equilibria do not affect the validity of proposition 7, since the dealer will still only offer a purchase price of at most r, and the artist will still reject any contracts containing a purchase price lower than r.

The assumption that $\phi < \frac{c}{(v-r)}$ guarantees that the artist will not hoard his/her work and then sell it in the resale auction, since for $\phi < \frac{c}{(v-r)}$, the artist's expected income from hoarding is less than the reservation income (r).

Now consider the following sequential game of asymmetric, incomplete information, played between the monopsonic dealer and an artist in period one. Initially this game takes place in the absence of a droit de suite law. Define the dealer's action set as $d = \{(P,\alpha)\}$, where (P,α) represents the offer of a contract with purchase price P and a promised share of resale profits equal to α, $(0 \leq \alpha < 1)$. The artist's action set is a = {Accept, Reject}, where Accept means accepting the dealer's contract offer. Reject means both rejecting the dealer's offer and accepting a consumer offer equal to r.

The game is played sequentially using the first stage of the game to create the informational asymmetry. In stage one, Nature reveals an artist's type with certainty, only to the dealer. In stage two, the dealer offers the artist a contract (P,α), and in stage three, the artist infers his/her type after observing the dealer's offer and either accepts or rejects it. If the artist rejects the offer, the work is sold to a consumer for a price $P = r$, and it is not resold. The information structure and sequential nature of the game suggests that any Nash equilibria will be characterized by actions which depend upon the artist's beliefs. An artist's prior beliefs about his/her type can be updated upon observing the dealer's offer, therefore the appropriate solution concept is Bayesian equilibrium.[38] The game's equilibrium, is defined by the artist's strategy set (s_a), the dealer's strategy set (s_d), and the artist's revised beliefs (b_a), and it supports the following proposition.

Proposition 9:

If a monopsonic buyer alone knows the investment value of art, then no private, positive droit de suite *contract* $(0 < \alpha \leq 1)$ *will be accepted and no artist will earn an amount in excess of the reservation income* (r).

Consider the following triple (s_a, s_d, b_a), where s_d is the dealer's strategy set;

$$s_a = \{\text{Accept the offer if } P \geq r;\ \text{Reject the offer if } P < r\} \quad (52)$$

$$s_d = \{\text{If artist is great, offer } (r,0);\ \text{if artist is not great, offer } (k,\alpha)\} \quad (53)$$

where (r,0) represents a zero droit de suite contract with purchase price

[38]For an introduction to Bayesian games, see Tirole (1989), or Rasmussen (1988).

$P = r$, and (k,α) represents a contract with purchase price $P = k < r$ and $0 \leq \alpha < 1$.

$$b_a = \{\text{Artist believes he/she is great if } P \geq r; \quad \text{Artist believes he/she is not great if } P < r\} \tag{54}$$

To prove proposition 9, it must be shown that (s_a,s_d,b_a) is a Bayesian equilibrium of the game and that no other equilibria exist which contradict the proposition. The triple (s_a,s_d,b_a) generates two possible outcomes as determined by the state of the world; {Offer (r,0); Accept} is the outcome when the artist is great and {Offer (k,α); Reject} is the outcome when the artist is not great. In each state, the artist's actions can be shown to be best responses to the dealer's strategy. If a great artist refuses an offer of (r,0) from the dealer, he/she will earn reservation income r. Although the artist can earn the same amount by rejecting (r,0), the dealer's offer of a purchase price equal to r represents the lowest price the artist will accept in the limit. Thus payoffs to a great artist are maximized by accepting (r,0).

If the artist is not great and accepts (k,α), he/she will earn $(1-\alpha)k + \alpha r$, which is less than the reservation income (r) received when (k,α) is rejected. Therefore, payoffs to a "not great" artist are maximized by rejecting (k,α). From the dealer's perspective, if (r,0) is offered to a great artist, the contract will be accepted and a profit of (v-r-c) will be made. If the dealer offers any other contract, the profits will not equal or exceed (v-r-c) because any purchase price below r will be rejected. So the offer (r,0) maximizes dealer's payoff when the artist is great. When the artist is not great and (k,α) is offered, the dealer makes zero profits because the offer is rejected, but any contract offer accepted by the artist must offer a purchase price of at least r and will make a loss of at least c dollars. The cost of entering the resale auction will not be recovered because the resale value of a "not great" work is r. Therefore the offer of (k,α) maximizes the dealer's profits when the artist is not great.

In each equilibrium outcome described above, the artist's revised beliefs are consistent with the strategies of both artist and dealer. It follows that (s_a,s_d,b_a) is a "revealing" equilibrium of the game in the sense that the artist always infers his/her type correctly after observing the dealer's offer. An examination of (s_a,s_d,b_a) shows that the equilibrium outcomes ({Offer (r,0); Accept} and {Offer (k,α); Reject}), support the proposition that an artist will never accept a private positive droit de suite contract and will never earn more than the reservation income (r). Now it must be shown that no other equilibria exist in which the artist receives more than r, or accepts a resale right contract.[39] Consider the following alternative outcomes. First, suppose that when the artist is great, the outcome is {offer (P > r, 0), accept}. Given the payoffs, offering a purchase price greater than r is not a best response for the dealer since the artist will accept a purchase price equal to r.

Now consider the same outcome when the artist is not great. Again, offering P > r is not a best response for the dealer, therefore in equilibrium, the artist will not earn more than the reservation income (r). A similar investigation of the outcome {offer (k,α), accept} reveals that this cannot be an equilibrium outcome of the game. If the artist is not great, accepting (k,α) means a payoff for the artist which is lower than r, so this cannot be a best response. If the artist is great, accepting (k,α) can give the artist a payoff at least equal to r (when $\alpha \geq \frac{(r-k)}{(v-k)}$), however, this will always be part of a strategy involving actions which are not best responses for either the artist or the dealer in the event that the artist is not great. Thus {offer (k,α), accept} cannot be an equilibrium outcome.

There are two elements which drive the solution to this game. Firstly, monopsony power allows the dealer to extract all of a work's value above the reservation price (r). Secondly, the informational asymmetry creates an incentive for the dealer to falsely represent a work as being great. If the artist could be convinced that his/her work is great when in fact it is not, the dealer could profit from a private positive droit de suite contract. By offering a purchase price lower than r, in return for a share in the resale profits from great art, the dealer could write a contract with a false expected value to the artist of $[k + \alpha(v-k)] \geq r$. If accepted, the contract would actually yield a return of $[k + \alpha(r-k)]$ to the artist and the dealer would make profits equal to $[(1-\alpha)(r-k) - c] > 0$. It is awareness of this incentive that causes rational artists to avoid contracts in which the purchase price falls below the reservation income level (r).

The Imposition of a droit de suite Law

Suppose that a mandatory positive droit de suite contract of the form (j,α^*) is imposed on the art market, where j is still a discretionary variable representing the dealer's offered purchase price and

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[39]It is assumed that $c < (1-\alpha)(r-k) < (v-r)$.

$0 < \alpha^* < 1$ is the regulated minimum value of α. In this environment, a positive droit de suite law enables some great artists to share in the dealer's profits, as indicated by proposition 10.

Proposition 10:

If a monopsonic buyer alone knows the investment value of art, then a mandatory positive droit de suite *contract* (j,α^*) *will generate an increase in income for some artists without reducing the income of others.*

If the game between dealer and artist is played with a positive droit de suite law in place, it is easily verified that (s_d^*, s_a, b_a) is the new equilibrium, where s_a and b_a remain unchanged, since they are not affected by any particular value of α, and:

$$s_c^* = \{\text{If artist great, offer } (r,\alpha^*);\ \text{if artist not great, offer } (k,\alpha^*)\} \tag{55}$$

Assuming that the opportunity cost of entering the art market (S) varies across artists, proposition 9 implies a market failure regarding the supply of art. Prior to entry, an artist cannot observe the dealer's offer and thus cannot infer anything about his/her type, so the entry decision of an artist is based on the given prior probabilities (ϕ and $(1-\phi)$). If each artist could receive the full market value of his/her work, an artist's pre-entry expected income would be:

$$E[W] = r + \phi(v-r) \tag{56}$$

Recalling that each artist faces an opportunity cost of entry into the art market given by S dollars, efficiency requires that all artists with an opportunity cost defined as $S \leq [r + \phi(v-r)]$ should enter. In the absence of regulation, artists (regardless of type) will never earn more than the reservation income (r) therefore artists with opportunity costs in the range $[r, r + \phi(v-r)]$ will not enter the market. Consequently, the supply of art in an unregulated market will be inefficiently low. The analysis in support of proposition 10 indicates that a droit de suite law increases the incomes earned by great artists. It follows that a corresponding change will occur in the expected payoffs to artists prior to entry and will thus affect the supply of art.

Proposition 11:

If a monopsonic buyer alone knows the investment value of art, then the supply of art in an unregulated market will be lower than the supply of art under a positive droit de suite *law.*

As before, the entry decisions of artists will depend upon their expected earnings relative to the opportunity cost of entry (S). Under the droit de suite law, an artist's expected income, prior to entry is:

$$E[W_{(j,\alpha^*)}] = \phi[r + \alpha^*(v-r)] + (1-\phi)r = [r + \phi\alpha^*(v-r)] \tag{57}$$

Artists with an opportunity cost S, such that $S \in [r, (r + \phi\alpha^*(v-r))]$ who would not enter the market in the absence of a droit de suite law, will now enter, thereby increasing the supply of art.

In this section, the inclusion of dealers as either agents or initial buyers has shown two instances where a droit de suite law would benefit some artists. In the competitive buyers model, if dealers as agents absorb a fraction of the reduction in purchase prices resulting from droit de suite, then those artists who obtain representation are made better off. In a market where artists are exploited by the monopsony power of an expert dealer and disadvantaged by their lack of information a droit de suite law enhances efficiency by reducing the number of artists in second best occupations thereby increasing the supply of art. The law also increases the incomes of some artists without reducing the incomes of others.

IX. Attribution, appropriability and measurement costs

While an artist's death does mitigate the moral hazard problem addressed in the previous section, death does not guarantee perfect knowledge of the stock of works produced during the artist's lifetime. A lack of records concerning private sales of the artist's work and the artist's personal inventory of unsold works creates the possibility of errors in attributing works to their true creators, which may or may not be due to deliberate attempts to falsify the creator's true identity through forgery. The lack of an individual-specific signature and a similarity in the styles of artists in a particular period in history can generate innocent mistakes in attributing authorship. On the other hand deliberate forgery could mean copying a work known to have been created by a past master when the location of the original work cannot be accounted for, or it could mean creating a new work and falsely attributing it to a past master.

Attribution problems are not absent in the market for works by living artists and while some countries have legislated "droit moral" clauses in copyright law which explicitly assigns artists the right of paternity (the right to be acknowledged as the creator of a work and to disclaim authorship of works which are falsely attributed) the problem of detecting and discouraging forgery or misrepresentation remains. Artists themselves cannot easily (or costlessly) keep track of the locations of their works and cannot always be relied upon to verify the authenticity of works attributed to them. For example, Grampp relates the story of a forger who, having been caught imitating the work of Marc Chagall was brought to trial. The artist himself was called as a witness for the prosecution and surprised everyone by testifying that the works in question were his original creations, which was in turn disputed by the defendant (who must have already pleaded guilty!).

The effects of successful forgeries (by artists) or fraudulent misrepresentations (by dealers) of an artist's work are two-fold. Firstly, if the forgery represents a new (previously unknown) work, then the size of the recognized stock of works is increased, thereby reducing the value of other legitimate works. Secondly, if the work is a copy of an existing original, then the forger appropriates rents created by the original idea. If the discovery of illegal copying is sufficiently costly that it can not be effectively prevented, then a second-best policy is to tax the copying activity in order to discourage it and to divert some portion of the appropriated rents back to the original creator. A modern example of this is the taxation of blank video tapes which serves to compensate copyright owners for illegal copying by consumers with video tape machines. In the art market a droit de suite law provides both a disincentive to produce forgeries and compensates the original creator if a forgery is successful. One effect of a droit de suite regulation is to depresses the initial purchase price of art works which at the margin reduces the returns to forgery thereby acting as a disincentive. If however the expected risk adjusted returns to forgery are sufficient to encourage the activity, then works which are falsely attributed to an artist and are successfully resold for profit will result in a payment to the original creator. In this way, droit de suite acts as a sort of compulsory license which ensures that the creator at least receives some share of the appropriable rents from his or her creation. A further argument in favour of droit de suite is that the institution of the regulation would involve the creation of an art registry to ensure that artists receive their allocated share of resale capital gains. A registry of this kind would also serve as an improvement in monitoring the location of art works, thereby increasing a forger's probability of being caught. Of course nothing has been mentioned about the costs of administrating a droit de suite regulation.

X. Conclusion

The approach of this essay has been to explore several aspects of droit de suite regulation as they relate to various characterizations of the market for art works and its participants and to evaluate the effects of droit de suite in terms of efficiency, equity and increased creative activity. Throughout the analysis, it has been assumed that the administration, monitoring and enforcement costs of the regulation are zero, in order to explore whether the implementation of droit de suite could satisfy any of the criteria under the most favourable conditions. While the essay does provide some explanation and assessment of the economic rationale for the introduction of this law in other countries, the implications for the adoption of droit de suite in Canada or the U.S. are less than clear. Rather, the analysis has demonstrated the difficulty in finding a characterization of the art market in which a costless droit de suite regulation will increase artists' welfare, increase creative output or correct for market inefficiencies.

The models developed in this essay can be calssified as exploring two questions:.. is droit de suite efficient and would droit de suite contracts be observed in a governed market (voluntary private contracts monitored and enforced by the state)? In sections V and VI droit de suite was found to be both privately and socially inefficient, in sections VII and IX the regulation is both privately and socially efficient and would be observed as private contracts in a governed market where no transactions costs were born by artists. In contrast, the analysis in section VIII shows the regulation to be efficient but in this case private droit de suite contracts would not be observed in a governed market.

One argument against the adoption of droit de suite in Canada is that it has existed implicitly for over fifteen years. In 1972, Canada's federal government arts agency, the Canada Council began an "art bank" program with the mandate of amassing a national collection of art works by contemporary Canadian artists. Today, art bank is still in operation and currently boasts an inventory of about 17,000 works of art. These works are lent for exhibition to galleries and museums for the cost of transportation, or are rented for a fee to non-profit organizations or government agencies. The process of selecting works for the art bank is a three tier jury system, each jury being comprised of professional artists. Each year, artists who wish to be considered can submit up to fifteen slides of their works, along with a price list. On the basis of these submissions, the jury picks a number of artists for on site visits by a three-person traveling jury and based on their recommendations, the jury then decides which works to purchase. There is no emphasis on purchasing works by established rather than new talent and the price paid for works is what the jury perceives to be the market price. This reflects the Art Bank's wish to avoid crowding out private art buyers, so that an artist cannot improve his or her chances of selection by setting prices below what they could receive in the private market.

Works in the Art Bank are never offered directly for sale to private buyers, however since 1977, the Council has run an art repurchase program which allows the original artist to buy back a work from the art bank, providing it has been in the collection for at least three years. The buy-back price is set by a simple formula which requires the artist to pay the greater of the original price plus twenty percent or fifty dollars. The twenty percent mark-up represents administration costs and in either case the artist must also pay any set-up or transportation costs incurred by the Art Bank. Thus, if an artist is approached by a buyer some time after selling a work to the Art Bank, the artist has the option to repurchase the work and participate in the entire capital gain minus about twenty percent of the initial purchase price. In terms of the model, the art repurchase program provides the artist with an income given by $W = \max [P , (P + (Q - (1.2)P)]$ and since the initial purchase price is the market price in that period, the repurchase program must increase the expected incomes of artists. Also, the resale price will reflect the fact that private buyer retains the full value of the work's expected future appreciation because the artist does not participate in any capital gains after the first resale. It also means that there no monitoring or enforcement costs for the artist to incur. If the repurchase right was extended to the artists beneficiaries for say fifty years following the artist's death, then this would also satisfy the French interpretation of droit de suite as an insurance policy against success. The fact that this program has been running for fifteen years and the administration already in place, suggests that with some adjustments, it could provide much of what a droit de suite law would bring to the art market. However, an interesting message lies in the actual number of works repurchased to date. Since the inception of the program, only one hundred and fifty works, (representing less than one percent of the total stock) have been bought back. To the extent that this is an indication that the benefits to artists from resale participation are small and given the theoretical results derived in this essay, it would appear that the implementation of a droit de suite regulation would be unlikely to achieve significant improvements in efficiency, equity or the encouragement of creativity.

XI. Appendix 1

A standardized private droit de suite contract:
The "Projansky Agreement"

Agreement of Original Transfer of Work of Art

Artist: ______________________ address: ______________________
Purchaser: ______________________ address: ______________________

WHEREAS Artist has created that certain Work of Art ("the Work"):
Title: ______________________ dimensions: ______________________
media: ______________________ year: ______________________
WHEREAS the parties want the Artist to have certain rights in the future economics and integrity of the Work, the parties mutually agree as follows:

1. Sale
Artist hereby sells the Work to Purchaser at the agreed value of $______________.

2. Retransfer
If Purchaser in any way whatsoever sells, gives or trades the Work, or if it is inherited from Purchaser, or if a third party pays compensation for its destruction, Purchaser (or the representative of his estate) must within 30 days

(a) Pay Artist 15% of the "gross art profit", if any, on the transfer; and

(b) Get the new owner to ratify this contract by signing a properly filled-out Transfer Agreement and Record (TAR); and

(c) Deliver the signed TAR to the Artist.

(d) "Gross art profit" for this contract means only: "Agreed value" on a TAR less the "agreed value" on the last prior TAR, or (if there hasn't been a prior resale) less the agreed value in Paragraph 1 of this contract.

(e) "Agreed value" to be filled in on each TAR shall be the actual sale price if the Work is sold for money or the fair market value at the time if transferred any other way.

3. Non-Delivery
If the TAR isn't delivered in 30 days, Artist may compute "gross art profit" and Artist's 15% as if it had, using the fair market value at the time of the transfer or at the time Artist discovers the transfer.

4. Notice of Exhibition
Before committing the Work to a show, Purchaser must give Artist notice of intent to do so, telling Artist all the details of the show that Purchaser then knows.

5. Provenance
Upon request Artist will furnish Purchaser and his successors a written history and provenance of the Work, based on TAR's and Artist's best information as to shows.

6. Artists Exhibition
Artist may show the Work for up to 60 days once every 5 years at a non-profit institution at no expense to Purchaser, upon written notice no later than 120 days before opening and upon satisfactory proof of insurance and prepaid transportation.

7. Non-Destruction
Purchaser will not permit any intentional destruction, damage or modification of the Work.

8. Restoration
If the Work is damaged, Purchaser will consult Artist before any restoration and must give Artist first opportunity to restore it, if practicable.

9. Rents
If the Work is rented, Purchaser must pay Artist 50% of the rents within 30 days of receipt.

10. Reproduction
Artist reserves all rights to reproduce the Work.

11. Notice
A Notice, in the form below, must be permanently affixed to the Work, warning that ownership, etc., are subject to this contract. If, however, a document represents the Work or is part of the Work, the Notice must instead be a permanent part of that document.

12. Transferees Bound
If anyone becomes the owner of the Work with notice of this contract, that person shall be bound to all its terms as if he had signed a TAR when he acquired the Work.

13. Expiration
This contract binds the parties, their heirs and all their successors in interest, and all Purchaser's obligations are attached to the Work and go with the ownership of the Work, all for the life of the Artist and Artist's surviving spouse plus 21 years, except the obligations of Paragraphs 4, 6 and 8 shall last only for Artist's lifetime.

14. Attorneys' Fees
In any proceeding to enforce any part of this contract, the aggrieved party shall be entitled to reasonable attorneys' fees in addition to any available remedy.

Date: ______________________ ______________________
Artist

____
Purchaser

XII. Bibliography

Baumol, H. and Baumol, W. J., Performing Arts: The Economic Dilemma, M.I.T. Press, 1966.

Blaug, M., The Economics of the Arts, M. Robertson, 1975.

Bolch, B. W., Damon, W. W. and Hinshaw, C. E., Visual Artists' Rights Act of 1987: A Case of Misguided Legislation, The Cato Journal, 8,1988, pp71-78.

Caplin, L. The Business of Art, (Second Edition), Prentice Hall, 1989.

Cheung S. The Contractual Theory of the Firm,

Journal of Law and Economics, 1974.

Coalition of Creators and Copyright Owners, Position Statement on Copyright Revisions, Toronto, February, 1991.

Department of Communications, Canadian Federal Government; A Charter of Rights for Creators' (All Party Sub-Committee report to the Minister), 1985.

Donnelly H., Alsop J. and Victor, E. The Art Market, Editorial Research Reports, June 1987, pp274-287.

Editorial Research Reports, The Art Market, volume 1, June, 1987, pp273-288.

Filer R. A Theoretical Analysis of the Economic Impact of Artists Resale Royalties, Journal of Journal of Cultural Economics, V.8 No. 1. 1984.

Frey, B. S. and Pommerehne, W. W., Art Investment: An Empirical Inquiry, Southern Economic Journal, 56, October, 1989, pp396-409.

Gibbens, R. D., The Moral Rights of Artists and the Copyright Act Amendments, The Canadian Business Journal, 15, 1989,pp441-470.

Globerman, S., Cultural Regulation in Canada, Institute for Research on Public Policy, Montreal, 1983.

Grampp, W. D., Pricing the Priceless, Basic Books, 1989.

Hochfield, S. Artists Rights: Pros and Cons, Art News, May 1975, pp20-25.

Knowles, B. E. and Kochanowski, P., Protection of Artist's Rights: A Legal and Economic Analysis, mimeo, Indiana University at South Bend, 1991.

Landes E. and Posner R., An Economic Analysis of Copyright Law, 18,

J. Legal Studies, 1989.

Lansner K., The Two Sides Of Art, Financial World, December 26, 1989, p88.

Larson R. J. and Morris L. Marx, An Introduction to Mathematical Statistics and Its Applications, Prentice-Hall, Second Edition, 1986, pp144-146.

McAffee R. P. and McMillan J., Auctions and Bidding, Journal of Economic Literature, 25, June 1987, pp699-738.

McCain R. Resale Rights and Efficient Markets, Cultural Economics 88: An American Perspective, The Association of Cultural Economics, Akron 1988

Markey E. J. Let Artists Have A Fair Share of Their Profits,

New York Times, December 20th 1987, Sec. 3 p2.

Millinger D., Resale Royalty Rights, American Artist, June 1981, pp70-73.

Pesando, J. E., Art as an Investment: the Market for Modern Prints, mimeo, Institute for Policy Analysis, University of Toronto, October, 1990.

Price, M. E. and Price, A. B., Rights of Artists: The Case of the Droit de Suite, Art Journal, Winter, 1971/72, pp144-148.

Rasmusen, E. Games and Information, Blackwell, 1988, pp54-65.

Reitlinger, G., The Economics of Taste, Barrie and Rockliff, London, 1961.

Rottenberg S. The Remuneration of Artists, In Frontiers of Economics ,

(G. Tullock Ed.), 1976.

Stein J. The Monetary Appreciation of Paintings, Journal of Political Economy, 1982.

The Economist, The World Art Market-Yesterday's blooms, December 22nd, 1990.

Throsby R. and Withers, G., Economics and Arts: a review of seven years, The Economic Record, 58, September, 1983.

Tirole, J., The Theory of Industrial Organization, MIT Press, 1989.

Vickery, W.,Counterspeculation, Auctions and Competitive Sealed Tenders,

J. Finance, 16(1), 1961, pp8-37.

West, E. G., Subsidizing the Performing Arts, Ontario Economic Council Policy Studies, 1986.

World Intellectual Property Organization, Copyright Law Survey, Geneva, 1979, 1989.

Essay II:

INSTINCTS AS "SUSPENDED RATIONALITY"

I. Introduction

It is neither difficult nor controversial to observe that some forms of human behaviour result from emotions or that some actions are instinctual rather than the result of a conscious decision-making process. When viewed from the perspective of theoretical economics however, these observations give rise to awkward facts which are not easily explained or dismissed by a social science where self-interest has survived as a fundamental tenet of individual motivation. To the extent that human instincts and emotions often give rise to outcomes which are in some sense irrational, they have been deliberately excluded from mainstream economic analysis in favour of homo economicus, the rational, self-interested maximizer. This essay investigates the role played by instincts in human behaviour, and sets out an analytical framework to consider the economic implications of replacing homo economicus with a self interested individual whose ability to make rational decisions is constrained through a biologically endowed mechanism that triggers automatic responses to certain external conditions.

The essay proceeds in section II, by exploring the relationship between self interest, rationality and optimality in economic theory. In section III, some basic concepts in game theory are reviewed and related to irrational behaviour. Section IV considers the strategic value of instincts and emotions, and introduces the concept of suspended rationality, while section V focuses on the specific emotion of temper and the development of a game-theoretic model of retaliatory aggression. In section VI, the model is extended to consider that instinctual tendencies may be subject rational strategic manipulation and in section VII the evolutionary stability of temper as a behavioural strategy is considered. Several computer simulations of evolutionary competition are conducted in section VIII, using finite automata to represent an expanded set of pure strategies to test the stability of instinctual behaviour. A summary and conclusion is offered in section IX.

II. Self interest, selfless acts and rational behaviour

The fundamental tenet of economic theory is the postulate of self interest as the motivation behind individual behaviour. When combined with the notion of rationality, self interest implies that individuals will maximize the net benefits from any given set of feasible actions, yet on many occasions real world behaviour does not appear to conform to this postulate. That is, we can often observe that the chosen actions of an individual are dominated by alternative actions from the feasible set which would, if chosen, result in a higher payoff than the payoff actually received. The conventional response to such observations is to point out that introducing "irrational" or non-self interested behaviour into economics would prohibit having any theory at all because allowing irrational behaviour places no restrictions whatsoever on individual behaviour. Instead, those scenarios in which actions appear to be irrational are reinterpreted in ways that make the observed action rational and self interested. There are three possible ways of doing this which can be illustrated with a simple example. Suppose that a social scientist observes the history of a population of agents (individual decision-making units) each of whom chose an action at time t. The combined actions of these agents result in an event occurring at time t+1 which maps a payoff to each agent. The social scientist collects these data at time t+2, at which time he or she knows the set of feasible actions at time t for each agent, the feasible information set for each agent at time t, the set of chosen actions and the set of actual payoffs received at time t+1. Now suppose that for at least one agent, the payoff received at t+1 is less than the agent could have received if an alternative action had been chosen from the feasible set. Formally this can be represented for the ith agent as:

$$\Pi_i(t+1)[(a'_i, a_{-i}) \mid I(t)] < \Pi_i(t+1)[(a^*_i, a_{-i}) \mid I(t)]$$

when

$$a'_i, a^*_i \in A_i(t) \text{ and } i \in [1,n]$$

for $A_i(t)$ = the feasible set of actions available to the ith agent at time t

$I(t)$ = feasible information set at time t

$\Pi_i(t+1)$ = payoff to ith player at time t+1 contingent upon the combined actions of all n agents.

There are three ways in which the choice of action a'_i can be depicted as being the result of rational self interest. Two of the three explanations focus on the feasible information set at time t and both rely upon the rationality of self-interested individuals making decisions with less than the available amount of relevant information. However, they differ in their theoretical implications. The first explanation is the neoclassical 'transactions cost' approach, which postulates that the acquisition of information relevant to the agent's decision is costly so that I(t) can be thought of as a collection of messages each of which imposes a cost on the agent if received. The decision to take action a'_i is thus the second stage of a two-stage decision-making exercise in which the agent must first decide how much information to acquire. The result is that some decisions are made with less than all the available relevant information so that a'_i maximizes $\Pi_i[(a_i, a_{-i}, c(I) \mid I(t)]$, where c(I) represents the cost of acquiring information. This preserves maximization as a decision-making process and sets the emphasis on finding the "correct" set of constraints or measurement costs to explain observed outcomes.

Alternatively, the "bounded rationality" approach pioneered by Simon (1955, 1978, 1982), identifies the limited computing power of the human brain as an upward bound on the amount of information processing that is possible in any given unit of time.[40] If an agent knows that the information set I(t) contains more information than he/she can process, the individual will make a rational decision to ignore some part of I(t) which may contain valuable messages. Again the decision to take action a'_i is made with a subset of feasible information, however the implication

[40]For example, the well known "prisoner's dilemma" game, if repeated 100 times has $2^{2^{100}}$ pure strategies and as Robert Aumann (1989) points out:

"...all the books in the world are not large enough to write this number even once in decimal notation. There is no way that all these strategies can be considered truly available to the players".(p42) for a theoretical decision-making rule is quite different. Under bounded rationality constraints, agents become "satisficers" rather than "maximizers".

A third explanation for the apparent sub-optimality of a'_i is that the decision-making problem has been mis-specified, and with a "correct" specification, a'_i will become the rational self interested choice of the agent. This approach can be thought of as making a distinction between locally and globally rational actions, where the former refers to observations of single mappings from an action to a payoff and the latter refers to situations where an action maps onto several outcomes. In other words global rationality considers the possibility of an action having both direct links to some events and indirect links to others. In terms of the example, suppose that the agent must choose a second action b_i at time t+1 which will result in the payoff:

$$\Pi_i(t+2)\{[b_i, b_{-i} \mid I(t+1)], [a_i, a_{-i} \mid I(t)]\}$$

When the event (payoff) $\Pi_i(t+1)$ is viewed independently of event (payoff) $\Pi_i(t+2)$, action a'_i can appear sub-optimal but the problem so defined is under-specified and it may be demonstrated that in the correct specification, a'_i maximizes the agent's joint payoff. If there are observations of behaviour where an agent with all feasible information chooses an action that is locally irrational, then only the third explanation can preserve rational self interest.

Environments where actions have a cumulative impact fit into this category, for example if the outcome of each individual transaction generates a signal which effects the number or profitability of future transactions, local behaviour may seem irrational if viewed in isolation. A reputation for replacing defective goods when not contractually obligated to do so imposes unnecessary costs on the seller, but can be motivated by self interest if future sales increase as a result goodwill or a perceived commitment to provide a high level of quality. Any model of behaviour where signals are important and related to current actions, locally irrational acts can be recast as being globally rational. However there are other observed instances of selfless behaviour in which the actions taken imply a decision which is neither locally or globally rational for the agent concerned. These are cases where individuals, motivated by an "emotional" response to their current circumstances choose actions which do not reflect a cost-benefit calculation of any kind. Emotions such as love, benevolence, anger, frustration and fear manifest themselves in everyday life as instinctual choices. These include heroic rescues, acts of cooperation and honesty involving complete strangers, non-compliance to credible threats of aggression and the refusal to trade when contractual terms although conferring mutual benefits are perceived to be unfair. In these examples, with no informational deficiency either imposed or chosen, the conclusion must be that such actions constitute "irrational" behaviour by a self interested agent. A conventional way of dealing with irrational actions which cannot be usefully interpreted as rational behaviour is to invoke the evolutionary principle of natural selection. Friedman (1953) espouses the argument thus:

> " .....unless the behavior of businessmen in some way or other approximate behavior consistent with the maximization of returns, it seems unlikely that they would remain in business for long. Let the apparent immediate determinant of business behavior be anything at all — habitual reaction, random chance or whatnot. Whenever this determinant happens to lead to behavior consistent with rational and well informed maximization of returns, the business will prosper and acquire resources with which to expand; whenever it does not, the business will tend to lose resources and can only be kept in business by the addition of resources from outside. ......given natural selection, acceptance of the hypothesis can be based largely on the judgment that it summarizes appropriately the conditions for survival."[41]

When individuals who do not choose the actions associated with well informed maximization are selected against by the environment relative to those who do (for whatever reason), this implies a dynamic which eradicates irrational behaviour. However, a distinction needs to be made between the evolutionary fitness of an individual as distinct from the evolutionary fitness of a mode of behaviour. An action choice may be irrational for an individual but at the same time may define behaviour which has evolutionary survival value. While this may be true for a population of

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[41] Friedman (1953, p22).

individuals who each play a game against "nature" independently from one another, the result is not so apparent in environments where individuals play a series of games against other individuals. In markets where decision-makers are price-takers, and prices convey all the necessary information, individual behaviour amounts to a game against nature in which the existence of individuals who choose selfless actions has no impact upon rational agents. If however, markets involve localized competition between individuals, and there is imperfect information, then the behavioural characteristics of the population become important in determining outcomes and payoffs. In this environment, the existence of selfless individuals affects the payoffs of rational agents because encounters with "crazy" individuals are a possibility. One approach to modelling individually selfless behaviour comes from biology, where the decision-making unit need not be an animal entity. In biological contest (or "interference") models the decision-maker is a gene rather than a life-form per se. The advantage of this approach is that the assumption of self interest need not be relaxed, instead the process of rational self interest is moved one level back so that the gene, defined only as a set of behavioural rules maximizes its own welfare without regard for the individual life-forms that it inhabits. From a theoretical standpoint, animals are nothing more than robots who are preprogrammed to follow a set of rules. The fact that humans are capable of conscious thought appears to run against this characterization of behaviour suggesting that if we have been programmed at all, we have been given the ability to process external information rather than simply respond to it. But while it may appear that economic theory has modeled the actual conscious decision-making process employed by humans, this is a fallacy. In fact, individuals in economic theory are also automata, created to generate actions and outcomes which can explain and predict real world events. The internal decision-making mechanism in these robots is not designed to represent actual motivating forces in human behaviour. Rather it is real individuals who are observed to behave as if they possess the inner workings of some theoretical automaton.[42]

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[42] Friedman (1953) observes:

It follows that any explanation of instinctual behaviour which involves adapting the automaton's conventional program of cost-benefit calculations lies entirely within the theoretical framework of conventional economics.

In summary, there are modes of behaviour which are not easily explained by economic theory if the tenet of self interest is to be preserved. Such behaviour often corresponds to emotional or instinctual responses which potentially are neither locally or globally rational. However instinctual behaviour can be incorporated as the result of self interest on the part of "genes" that represent behavioural strategies which are mechanically employed by the individuals whose behaviour we study. This approach borrows from theoretical biology but is consistent with the methodology of conventional economic theory.

" Of course businessmen do not actually and literally solve the system of simultaneous equations in terms of which the mathematical economist finds it convenient to express this hypothesis any more than leaves or billiard players explicitly go through complicated mathematical calculations or falling bodies decide to create a vacuum."(p22)

Also, Alchian (1950) points out:

" All that is needed by economists is their awareness of the survival conditions and criteria of the economic system and a group of participants who submit various combinations and organizations for the system's selection and adoption." (Alchian, 1953, p219).

III. Game theory and irrational behaviour

In addition to it's evolutionary properties (see section VII), game theory is an appropriate tool for analyzing irrational behaviour. Within the game theory literature, direct interest in the anomaly of cooperation has spawned an extensive literature on the "prisoner's dilemma" game in which self interest creates an incentive for each player to gain at the expense of the other, resulting in an outcome which is Pareto dominated by the one in which the players cooperate. Despite this theoretical result, computer tournaments and experimental studies have provided substantial evidence of cooperative (joint payoff maximizing) behaviour in prisoner's dilemma games.[43]

Indirectly, game theory also embraces notions of irrational behaviour through a refinement of the "sub-game perfection" criterion (itself a refinement of Nash equilibrium) known as "trembling hand" perfection. While Nash equilibrium defines a self-enforcing, non-cooperative solution to a game in which no individual would prefer to change his/her strategy given the strategies of the others, there are often multiple Nash equilibria in game theory, so the refinement known as "sub-game perfectness" (Selten, 1975) allows some Nash equilibria to be eliminated and often enables the selection of a unique solution in games with multiple Nash equilibria. The rationale for this refinement is that some of the equilibria represent strategies which are not 'best responses' to the strategies of others in the event of a deviation from the equilibrium path. As an illustration, consider the following property game in which a player (player 2) possesses 100 units of corn, contained within the boundaries of some property line. Another (player 1) has no corn and stands outside the boundary deciding whether to steal some corn (S) which means crossing player 2's property line and helping himself or to retreat (R) which means leaving the area. Player 2 must decide either to fight (F) or not (NF) in response to player 1's move. A fight results in a negative

[43] For an introduction to the prisoner's dilemma game, see Rasmusen (1989) p27, or Tirole (1989) p426.

payoff for both players, and not fighting results in equal shares (common property) if player 1 steals.[44]

Player 2

Player 1		F	NF
	S	-100, -100	50, 50
	R	0, 100	0, 100

Table 1

"Stealing corn"

In this game there are two pure strategy Nash equilibria which result in the action combinations (S,"NF no matter what") and (R,"F no matter what"), however the combination (R,"F no matter what") is viewed as an inferior Nash equilibrium since it represents a non-credible threat on the part of player 2 to fight. If player 1 decides to steal, fighting is clearly not a best response for player 2, thus the concept of sub-game perfectness restricts equilibrium strategies to be best responses in all sub-games, not just in subgames along the equilibrium path.[45] The strategy "F no matter what" is a best response for player 2 in the sub-game where player 1 retreats but is not a best response in the sub-game where player 1 steals. In contrast, the strategy "NF no matter what" is a best response in both sub-games. Therefore the unattractive equilibrium is eliminated by sub-game perfectness. However sub-game perfectness relies upon there being distinct single

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[44]This is similar to the "Entry Deterrence" game played in Rasmusen (1989), p86. It also has elements of Eaton and White's "corn model". See Eaton and White (1991).

[45] In the extensive form of a game, a sub-game is a single decision node such that all succeeding nodes are in the same information set for all players.

decisions nodes (which define the sub-games) in order to eliminate "bad" equilibria. Suppose that the above game, was changed slightly so that nature moves first and selects one of two states (x or y) with equal probability such that player 1 does not observe nature's move while player 2 does. There may still be two Nash equilibria in this game but sub-game perfectness can no longer eliminate the less appealing one because there only is one sub-game, namely the game itself.

One solution to this weakness is "trembling hand" perfection (Selten, 1975) which requires that all the strategies in a Nash equilibrium be robust to small perturbations. That is, the action rules implied by strategies must be best responses even if there is a small probability that another player will pick an out of equilibrium action. The question that arises from the notion of trembling hand perfection is "why would a rational player choose an out-of equilibrium action?". The usual justification defines such events as random errors; a "mistake" by a rational player, whose hand trembles as she inputs her action choices into the computer. However, an alternative deterministic interpretation of such out-of equilibrium choices is to establish the possible existence of players who are not fully rational. The introduction of even a small probability of an irrational strategy existing has been shown to significantly alter the results of games. For example, in a finitely repeated prisoners' dilemma played by rational agents, the dominant strategy for each player in the last round of play is to defect. Knowing this, each player now has an incentive to defect in the penultimate round, and so on back to the start of play so that the perfect equilibrium of the game is for both players to defect in every round.[46] However if there is a small positive probability that one player is playing a 'tit-for-tat' strategy, (which requires the player to act in the current round as her opponent did in the previous round) then the rational strategy diverges from "always defect" and becomes "imitate tit-for-tat until the opponent defects, then always defect". In this way, cooperation is generated for a significant portion of the game, even although the players are

[46] This is known as the 'chainstore' paradox (Selten, 1978).

rational almost all of the time.[47] Similarly, Milgrom and Roberts (1982) examine entry deterrence games in which there is a small probability that the encumbent is "crazy" and will retalliate irrationally against an entrant.

Instinctual behaviour provides a somewhat less ad hoc justification for introducing strategies which on occasion generate irrational acts and implies a deterministic choice mechanism, capable of over-riding rational decisions to move otherwise rational players off the (rational) equilibrium path. A subtle difference between the approach taken by Kreps et al and that implied by instincts is that the possibility of instinct-driven irrational behaviour is not restricted to other players. Instead of rational players considering the possibility that their opponent is irrational, players who are currently rational must consider the possibility that they themselves will not be rational in the future. So instinctual behaviour has the potential to generate competition not only between individuals, but also between 'selves' of the same individual. Agents who are rational most of the time must (rationally) calculate the implications of their own potential irrationality.[48]

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[47] Depending upon the precise payoff structure and discount rates there is still a rational incentive to defect when the opponent has a history of cooperating, but the incentive is restricted to the later stages of the game. See Kreps et al (1984).

[48] Schelling (1984) considers some implications of competition between "selves" of the same individual.

IV. Instincts as suspended rationality

In general, instincts can be defined as genetically endowed, emotion-based responses to external stimuli which are automatic, requiring no conscious decision-making. There are two central features of instinctual behaviour which have important strategic implications. Firstly, instincts represent a credible precommitment to potentially irrational behaviour under certain circumstances and secondly instincts which suspend rational decision making suggest the existence of thresholds which activate instinctual responses. The existence of a credible precommitment to potentially irrational acts changes the strategic complexion of games such as "stealing corn" (see section III). If instinctual behaviour is conceptualized as a genetic endowment, credibility can be restored to strategies which involve irrational acts. In "stealing corn" player 2's lack of credibility in the Nash equilibrium {R, "F no matter what"} is derived from the rational decision to never choose an action unless it is a best response in each subgame, but if player 2 is precommited by instincts to fight all trespassers, and this is known to player 1, then the game tree is essentially changed so that a fight is inevitable if player 1 steals.

The fact that player 1 must be aware of player 2's pre-programmed behaviour suggests that the strategic value of instincts will depend upon the ability to credibly communicate a commitment to potentially irrational acts. When individuals become emotional, this is often accompanied by signals designed to indicate their state of mind to others. Frank (1987, 1989), argues that signals are a key to understanding many forms of observed selfless behaviour and proposes that information about "behavioural predispositions" is provided by the way in which we carry out actions. For example, physiological traits such as pupil dilation, perspiration or facial expressions are among the observable signals of an individual's character which occur naturally during interactions with others.

The particular characteristic of these signals as emphasized by Frank is that they are inseparably linked to chosen actions and are produced by general modes of behaviour rather than specific instances. Frank states:

> "Character influences behaviour of course. But behaviour also influences character. Despite our obvious capabilities for self interest and rationalization, few people can maintain a predisposition to behave honestly while at the same time frequently engaging in transparently opportunistic behaviour."[49]

If honest individuals have green beards, then by Frank's reasoning, a green beard can only be obtained by behaving honestly (even when cheating cannot be monitored). An individual who cheats in situations where self interest dictates it will be unable to fake the green beard signal to appear honest in situations where self interest favours honesty. This "green beard" effect thus prevents individuals from exploiting situations where there are incentives to be dishonest, since doing so would destroy their credibility as an honest person in situations where honesty pays. Frank's signaling theory offers an explanation of such phenomena as tipping in distant restaurants by travelers who expect never to return to the restaurants location. In order for Frank's theory to hold, signals must convey valuable information, which means that signals must be robust to imitation. The "stealing corn" game can be adapted to one in which signals are possible. Suppose there exists two types of corn owners; fighters (who always fight thieves) and pacifists (who allow stealing). In this game, nature moves first, observed only by player 2 and selects either state x in which player 2 is a fighter or state y (player 2 is a pacifist). Player two then chooses one of two signals; either signal "h" indicating him to be a fighter or "m" which indicates that player 2 will not fight. Following this, the game is the same as the original (player 1 decides between steal (S) and retreat (R), followed by player 2 either fighting (F) or not (NF)). The extensive form of this game appears below in figure 1.

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[49] Frank (1988), p18

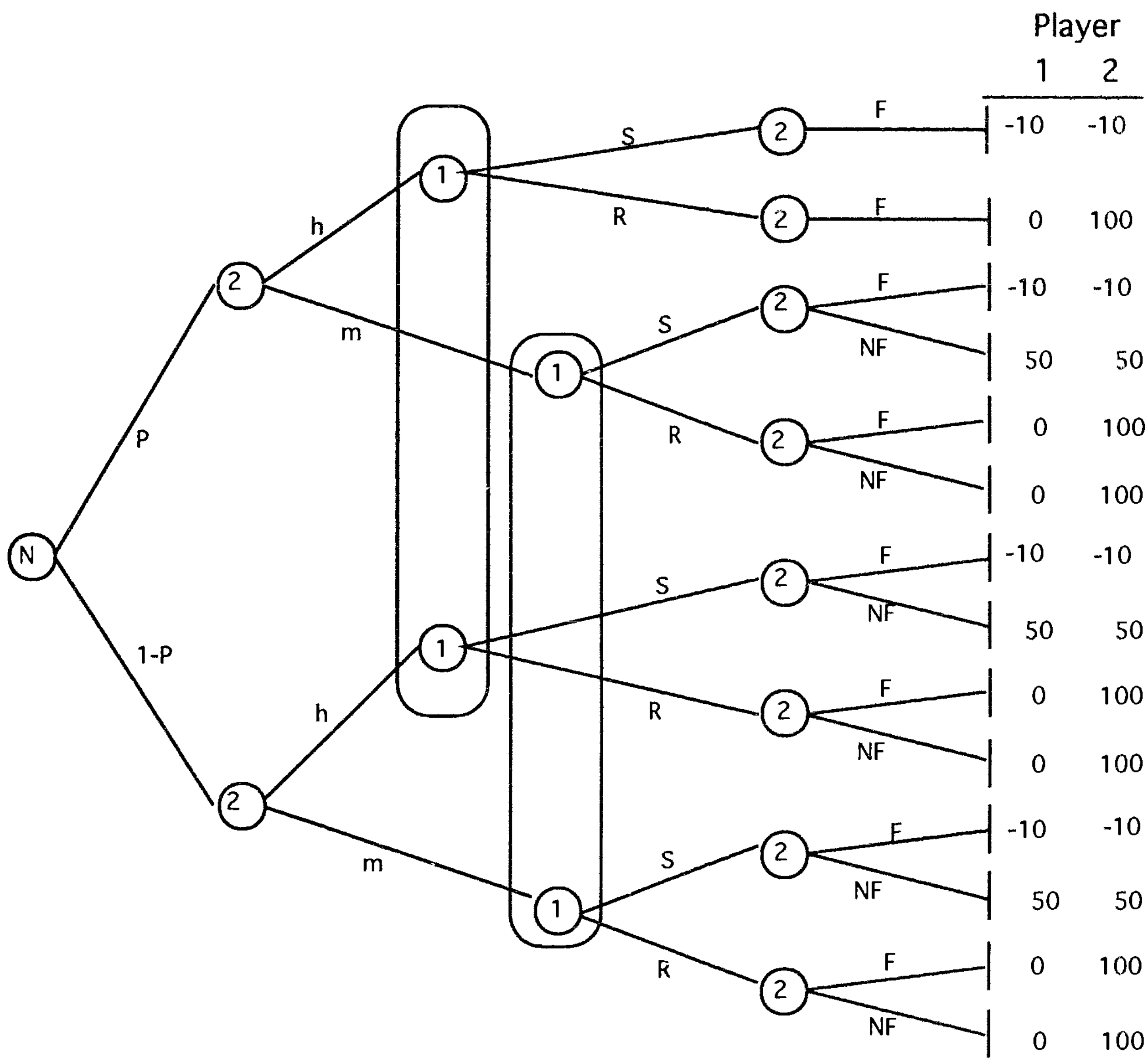

Figure 1.

"Stealing corn II"

In this version of stealing corn, the appropriate solution concept is Bayesian (Nash) equilibrium, since player 1 may be able to update prior probabilities p and (1-p) after observing the signal chosen by player 2. However, a closer examination shows that player 2 does not have any incentive to signal truthfully, because if state y occurs the signal "m" will cause player 1 to steal and player 2 will then choose "not fight" with a resulting payoff for player 2 of 50. This strategy is weakly dominated by always signaling "h" so that when state y occurs, the worst that can happen is that player one will steal and player 2 will not fight, however there is a chance that player 1 will not steal when y occurs in which case player 2 gets 100. When player 2 always signals "h", the signal has no value to player 1, since the updated prior probabilities (using Bayes rule) are unchanged.[50]

To incorporate Frank's approach into this game, the acquisition of a truthful "h" signal must be made prohibitively costly to m-type individuals. Given the configuration of payoffs, any h-type player 2 will pay up to 100 for a signal that cannot be imitated by m-types, but m-types will only be willing to pay up to 50 for an "h" signal (since their reservation payoff is 50 when they signal "m"). Therefore if the cost of signal acquisition is greater than 50 but less than 100, h-types will successfully convey their true identity to player 1. The notion of a rational individual signalling irrationality is the basis for Milgrom and Roberts (1982) ananlysis of entry deterrence. In their model, rational individuals purposefully commit irrational acts to gain a reputation for being "crazy". To the extent that such acts impose costs upon them, this amounts to paying for an "h" signal. The relationship between observed signals and predisposed motivations may explain instances of selfless acts, but signals cannot be relied upon to provide credibility to instinctual behaviour. There are many observations of animal and human interactions in which signal pollution appears to be a problem. For every instance of honesty or trust amongst strangers, there

[50]Note that the particular solution of this game is sensitive to the value of p. Specifically, for $p > 5/6$, player 1 will always retreat and for $p < 5/6$ player 1 will always steal.

are many instances in which individuals deliberately signal their trustworthiness in order to exploit selfish gains at the expense of others and in so doing diminish the value of signals which indicate honesty. "Con-men" are an example of signal imitation at a "professional" level where the trick is to attain the image of someone in whom others will place their trust. The credibility of instinctual behaviour is certainly strengthened by valuable signals, but cannot depend upon their existence.

Rather than rely upon costly signals, the credibility of instinctual precommitments can be justified as common knowledge in a more basic sense. In a world where all individuals are endowed with emotions, and each is consciously aware of their own emotional baggage, the existence of emotion-driven behaviour is not in question. Furthermore, instinctual precommitments will occasionally provide individuals with observable evidence that individuals cannot always be relied upon to choose actions which are best responses. For example, in the instinct-augmented "stealing corn" game, some individuals will be observed to engage in irrational fights. Rather than providing accurate individual-specific information, this amounts to a more crude, imperfect signal by nature, communicating only the existence of irrational behaviour and perhaps some indication of its frequency in certain contexts.

Another characteristic of instinctual behaviour is the existence of thresholds effects. Casual observation suggests that instinctual mechanisms in humans and in other animals are often invoked in a way that suggests that some sort of emotional threshold has been crossed to trigger the response. For example, imagine that you are late for an important meeting, and are rushing to get ready and make the trip. Now suppose that a series of mishaps occur (you knock into the coffee table and simultaneously hurt your knee and spill the coffee or you rush out of the house, forgetting to take your glasses etc.). Circumstances like this are a recipe for loss of temper. Frustration builds with each event until an emotional outburst of anger occurs when the trigger is finally activated. Indeed certain emotional outbursts often appear to be more irrational (sometimes inexplicable and sometimes hilarious) than they actually are, since unconnected observers witness what seems to be a gross overreaction to a minor incident, when in fact, the event was preceded by a build-up of emotion caused by a history of mishaps.

In those cases where instincts are involved, individuals are often consciously aware of an optimal, self interested action, yet reject it in favour of an inferior alternative. When individuals behave in this way, it is as if rational self interested calculations are suspended temporarily and replaced with some automatic response. The notion of "suspended rationality" suggests that homo economicus should be self interested and rational most but not all of the time, and should be rationally aware of his own as well as others' predisposition to deviate from rational choice. The above discussion suggests that in order to make instincts operational in analytical models, the existence of credible precommitments to potentially irrational actions should be assumed known by all players and an instinctual threshold mechanism should be specified which describes the context in which emotions override rational decisions. To yield any insights, a model of suspended rationality must identify the emotions that are specific to the problem at hand and must fully specify the instinctual response mechanism. In this regard, instinctual models are no different than theories which rely upon transactions costs for their results and require the identification of problem-specific costs. In the next section, a game theoretic model of suspended rationality is developed to investigate the specific role of temper and the instinctual response of retaliatory aggression in interactions between individuals.

V. Retaliatory aggression in asymmetric contests

Emotions such as frustration, resentment and anger can contribute to situations where individuals experience a 'loss of temper' (LOT) and indulge in some form of retaliatory, aggressive behaviour. The strategic value of such a genetically endowed instinct is the credible precommitment to acts of aggression, without regard to the costs involved.

Tullock (1972) argues that individuals who are over-exploited beyond some level are genetically precommited to "lose their temper and retaliate against those who dominate them, even when they can expect to lose any such confrontation. This instinct is present in many forms of animal conflict where the payoffs to teamwork and cooperation appear to be undermined by individual self interest in the competition for limited food resources. For example, lions are most efficient as a hunting unit when they hunt in numbers, however within each pride there exists a hierarchy based upon physical strength. The dominant lion will always eat first and if uninterrupted will consume food until completely satiated. Tullock observes the predicament of weaker lions in obtaining enough food to survive when stronger lions have not reached satiation:

> " Suppose there is a quantity of meat and two lions, one larger than the other, who want it. If they fight, the larger has a very good chance of winning and the smaller, therefore, will get nothing to eat but will probably be quite severely injured. Nevertheless, we do observe occasional fights and a great deal of behavior which can only be described as threatening of fights under such circumstances. Further, on occasion the larger lion will give way. Granted the larger lion does occasionally give way, the behavior of the smaller lion becomes rational. In essence, the smaller lion is rationally designed to engage in irrational behavior."[51]

Tullock's argument is based upon differentials in marginal utility as a motivation for weaker lions to get food. The leaner, and more hungry weaker lions become, the greater is the marginal utility of food and the more motivated they are to crossing a temper threshold. Similarly, stronger lions diminish in resource-holding motivation as their marginal utility diminishes approaching satiation.

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[51] Tullock (1972) p66.

Empirical support for Tullock's argument can be found in several studies of animal behaviour. For example, Andersson and Åhlund (1991) report a clinical experiment involving house sparrows where birds were classified into "subordinates" who had lost a triadic contest for food in earlier tests and "dominants" who had won the triadic contests. The subordinates and dominants were then deprived of food for twenty hours and three hours respectively prior to a series of dyadic contests between one of each. The results showed that motivated (food-deprived) subordinates were more aggressive in attempting to displace a dominant bird from the feeder and although the success rates of the subordinate birds did not exceed 50% in encounters with familiar dominants (who had defeated them in earlier contests) it did improve from the contests in which their motivation was equal.[52]

Applying the insights of Tullock's lion example to human interactions, consider a population of individuals in a state of anarchy with heterogeneous endowments of strength and fighting ability. If these individuals are also endowed with a LOT instinct, a limit may be placed on the exploitation of weaker individuals to the extent that they will retaliate if pushed too far. Such aggression might not be in the self interest of the retaliator who invokes and looses a fight, but if fighting costs are imposed upon both of the parties involved, a rational dominant individual will not exploit another beyond the point where the (diminishing) marginal gain is equal to the expected costs of conflict. Note that temper is not a precommitment to unilateral aggressive behaviour, rather it is a limited form of retaliatory aggression, which brings us closer to the notion of suspended rationality. In cases where a rational, weak individual is unlikely to provoke a fight in an encounter with a stronger rival, the same individual may retaliate if provoked or frustrated when endowed with a temper.

The type of situation outlined in Tullocks analysis fits well into several dyadic encounter models developed in the biological sciences (behavioural ecology in particular), where the focus is on the

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52 Andersson and Åhlund (1991) pp895-897.

behaviour of animals engaged in competition for resources. Contests between animals are categorized into "dyadic encounters" which are contests between two animals (either from the same species or from another species) and "scrambles" where one animal is viewed as competing with all of the remaining population of the same species. In the former category, biologists have tried to understand the nature of these struggles in an evolutionary context, where one might expect the forces natural selection to favour those animals with the more efficient or powerful weapons. But there are some complex tradeoffs between the enhancement of individual characteristics within a species and the survival of the species itself. Consequently, there are many examples of seemingly unusual behaviour which has the effect of placing limits on aggression between animals:

> " In mule deer (*Odocoileus hemionus*) the bucks fight furiously but harmlessly by crashing or pushing antlers against antlers, while they refrain from attacking when an opponent turns away, exposing the unprotected side of its body. And in the Arabian oryx (*Oryx leucoryx*) the extremely long, backward pointing horns are so inefficient for combat that in order for two males to fight they are forced to kneel down with their heads between their knees to direct their horns forward. How can one explain such oddities as snakes that wrestle with each other, deer that refuse to strike "foul" blows and antelope that kneel down to fight?"[53]

Game theory has been used extensively to model animal behaviour. In particular, the "Hawk-dove" game (Maynard Smith, 1973,1974), is a seminal work in the theory of animal conflicts, in which two players compete simultaneously for V units of a resource. If both players choose 'dove' they share the resource equally but if both choose 'hawk', a fight ensues which each player has a 0.5 probability of winning. The winner receives all V units and the loser incurs a fight cost (D), thus the expected value of a fight is $\frac{(V-D)}{2}$. If one player chooses hawk and the other chooses dove, then the hawk dominates and enjoys all V units of the resource while the dove receives

[53]Maynard Smith and Price (1973), p15.

zero. The game's extensive form is illustrated below in figure 2.[54] If the costs of losing a fight are such that C < V, then there is a unique Nash equilibrium in pure strategies in which both players choose "hawk", but for C > V, there are two asymmetric Nash equilibria; {hawk, dove} and {dove, hawk}. In addition, there is a mixed strategy equilibrium with "nice" evolutionary properties in which each player will choose hawk with probability V/C.[55] The hawk-dove game, has been extended to analyze asymmetric, dyadic contests in which one animal is endowed with superior "resource holding potential" or "RHP" (Maynard Smith and Parker, 1976).

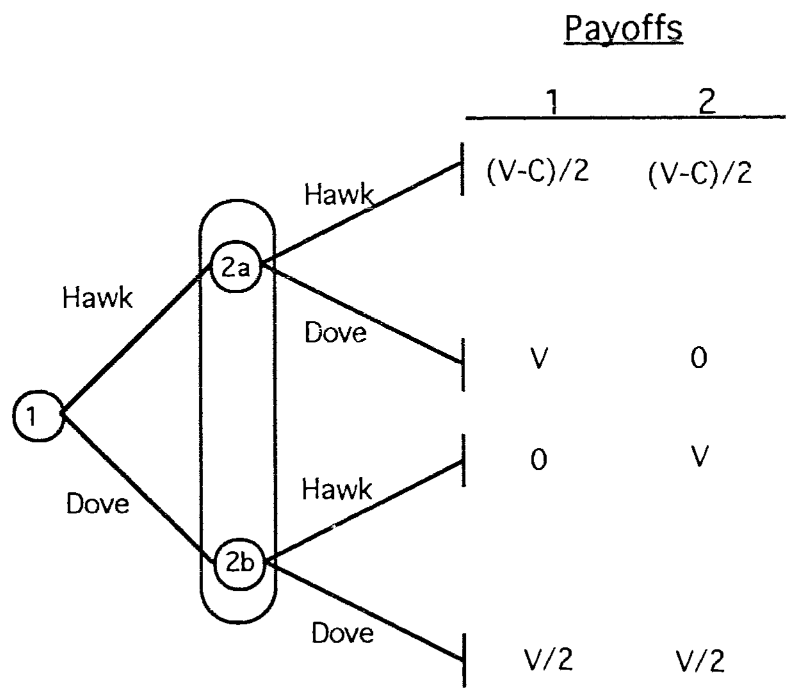

Figure 2:"Hawk-Dove"[56]

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[54] The 'hawk-dove' game is similar to the game of 'chicken'; see Rasmusen (1989, p73 and p122). The fact that this is a simultaneous move game means there is no signalling since neither player can observe whether the other is a 'hawk' or a 'dove' prior to choice of action.

[55] A discussion of issues relating to evolutionary stability is deferred until section VII.

[56] The nodes 2a and 2b are circled to indicate that they are both in the same information set, meaning that player 2 does not observe 1's move

Player 2

Player 1	H	D
H	V(1-x) - Cx / Vx - C(1-x)	V / 0
D	0 / V	V/2 / V/2

Table 2.

An Asymmetric Hawk-Dove Contest

In one of several games developed by Maynard Smith and Parker, the asymmetry in RHP represents a difference in size which has an effect on the chances of victory in the event of a fight.[57] The payoff matrix for this game (see table 2) reflects a higher probability of a win for player 2 who will win a fight with probability x, (where x is assumed greater than 1/2). The Nash equilibria of this game depend upon the relationship between fighting costs (C), the amount of the resource (V) and the magnitude of the asymmetry (x). If C is greater than V, but not by too much (C must be less than $\frac{Vx}{(1-x)}$) then there is only one Nash equilibrium in pure strategies where player 2 (with greater RHP) is a hawk and player 1 is a dove. If C exceeds $\frac{Vx}{(1-x)}$ then the pure strategy equilibria are the same as the original hawk-dove game but there are no mixed strategy equilibria which exhibit evolutionary stability. Aside from the evolutionary properties of these games (discussed in section VII, below), the framework of the asymmetric hawk-dove game sets the stage for an analysis of instinctual temper.

[57]Each player is assumed to have perfect information concerning their probability of a victory if a fight occurs.

"David and Goliath"[58]

A new game of dyadic encounters can be created by making four assumptions to adapt the structure and payoffs of the asymmetric hawk-dove game. The new game involves two individuals, (David and Goliath) who are distinguished by an asymmetric endowment of genetic characteristics. First it is assumed that Goliath is unambiguously dominant and will always win a fight, thus a rational David will always avoid a fight when possible.[59] Second, it is assumed that fights impose costs on both players (C and K for Goliath and David respectively). Thirdly, the information structure of the game is changed by assuming a sequential choice of actions so that David may react instinctually to Goliath's chosen actions. Finally, it is assumed that David may be endowed with a temper that commits him to engage in (potentially) irrational fights.

Consider the following two stage, sequential-move game between David (D) and Goliath (G), in which both players are endowed with W units of corn.[60] Goliath moves first and must decide whether to appropriate a large amount (L) or a small amount (S) of David's corn (where $0 \leq S < L \leq W$) and in the second stage, after observing Goliath's move, David must react by either choosing to fight (F) or retreat (R). Without loss of generality, we can assume that L = W and S = 0, so that Goliath's choices can be restated as "take all" (A) or take none" (N). If David retreats then Goliath attains the amount he chose at no cost, but if David chooses to fight, then Goliath will win and will capture all of David's corn but will also incur a fighting cost.[61] The payoff matrix is shown in table 3.

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[58] Note that the game is not intended as a model of the biblical story of David and Goliath. The title merely serves to indicate the possibility that in an unambiguously asymmetric contest, a weaker player can still impose significant costs upon the stronger of the two.

[59] In terms of the asymmetric hawk-dove game this amounts to an assumption hat $x=1$.

[60] This can be interpreted as 'nominal' property rights in their respective endowments.

[61] It is assumed here that Goliath will always fight when David decides to fight.

Goliath

David		A	N
	F	-K, 2W-C	-K, 2w-C
	R	0, 2w	W, W

Table 3.
"David and Goliath"

David and Goliath: Game 1

Before introducing instinctual LOT into the game, consider the game in which both players are fully rational. The extensive form for this game is shown below in figure 3. Clearly, David has a dominant strategy which is to always retreat, and since Goliath has a "first-mover" advantage, the perfect pure strategy equilibrium to the game is {always be aggressive; always retreat}, resulting in the action combination {A,R}.

David and Goliath: Game 2

Now suppose that David is known with certainty to be ill-tempered and precommited by his instincts to fight anyone who attempts to take his corn (see figure 4). An unprovoked (and therefore consciously rational) David will always prefer to retreat, and knowing this, Goliath will choose to take none of his corn unless fighting costs are lower than W. That is, the pure strategy equilibrium depends upon Goliath's fighting cost parameter (C). If C is less than W, then the equilibrium gives rise to the action combination {A,F}, but if C exceeds W then the perfect pure strategy equilibrium generates the action combination {N,R} Comparing this solution with that of game one shows that the institution of instinctual LOT improves David's performance over the range of Goliath's fighting cost given by; $C \in [W,2W]$.

Versions one and two of David and Goliath are games of perfect, complete information, where, it is assumed that the identity and motivations of each player are known with certainty (there are perfect signals). With a simple modification, 'David and Goliath' can be used to study instinctual LOT in an environment of imperfect information by incorporating a first move by nature in which David is endowed with one of two discrete temper thresholds; he is either 'mild-mannered' (m), or hot-headed (h). If David is hot-headed, he will initiate a fight if his endowment is threatened,

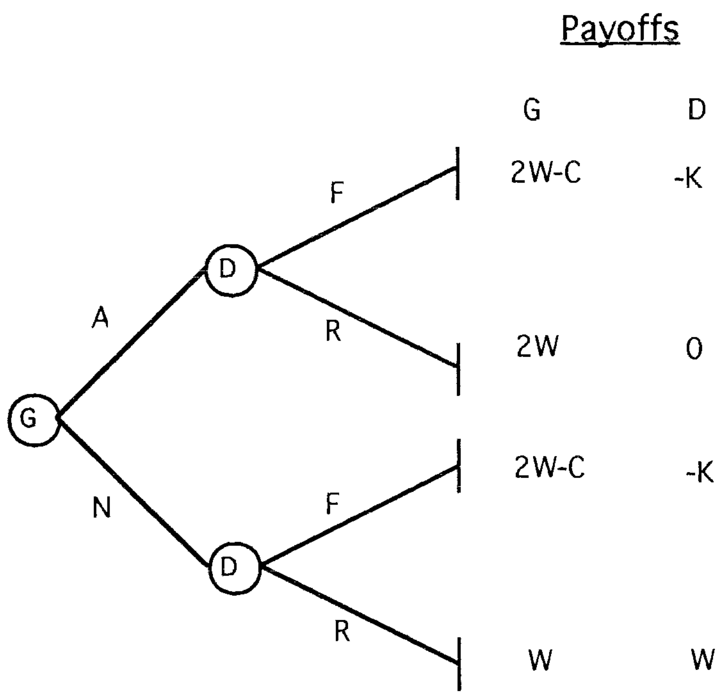

Figure 3.

"David and Goliath I"

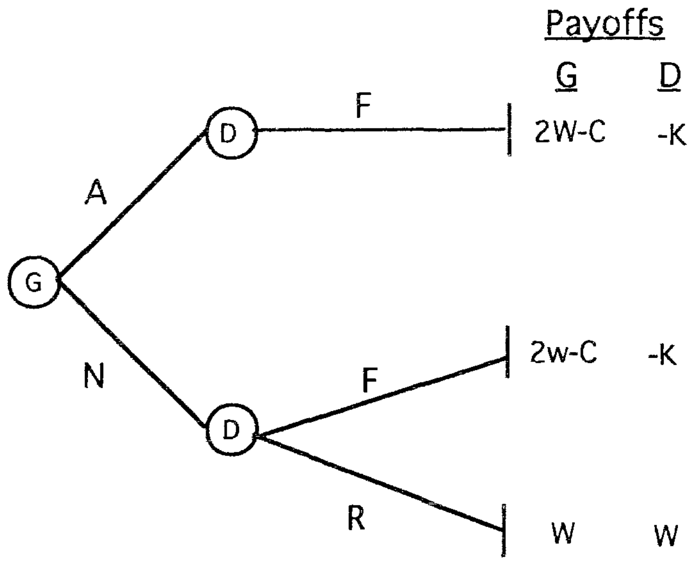

Figure 4.

"David and Goliath II"

and if he is mild-mannered, he will never lose his temper and will make rational decisions.[62] It is assumed that Goliath knows the proportion (p) of Davids that are hot-heads, but does not know the true genetic identity of his rival (he does not observe nature's move).The game is thus a composite of games one and two, where Goliath considers that he is playing game one with probability p and game 2 with probability (1-p). The extensive form of this game is illustrated in figure 5.

Working backwards, David's best responses to the possible actions chosen by Goliath requires that he choose "retreat" in every case except when he is an h-type and Goliath chooses to take all his corn, in which case David automatically responds by fighting. Given this mix of best and automatic responses by David, Goliath's expected payoffs from "taking all" and "taking none" are

[62]Recall that the model may be specified more generally so that Goliath either steals L units or S units of David's corn. In this framework, if David is hot-headed it means he will fight when his endowment is reduced below L units and if he is mild mannered, will fight when his endowment falls below S units.

$\Pi_{GA} = 2W - pC$ and $\Pi_{GN} = W$ respectively. Therefore, Goliath will choose to take all of David's corn when $\Pi_{GA} > \Pi_{GN}$ or when $p < p^* = \frac{W}{C}$. It follows that the existence of some temper-prone Davids will benefit those who are mild-mannered, providing Goliath's fighting cost is sufficiently high. The relationship between threshold probability p* and C is illustrated in figure 6 (below).

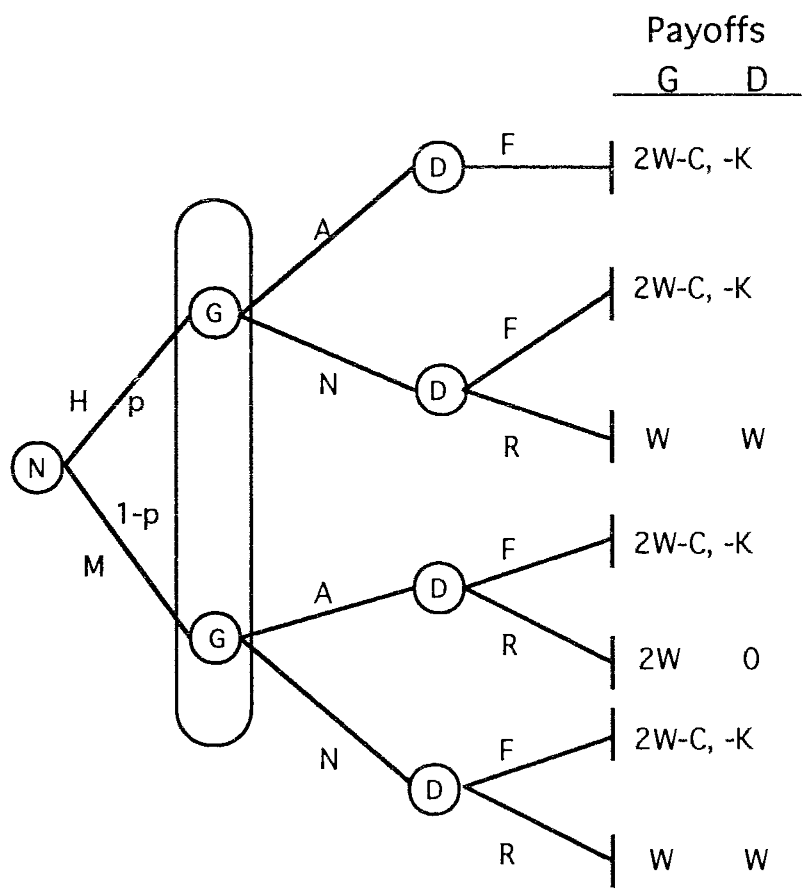

Figure 5.

"David and Goliath III"

In region 1 of figure 6, (below and to the left of p*), a rational Goliath will always claim all of David's corn but in region 2 (the shaded area above and to the right of p*), a rational Goliath will claim none of David's corn. The boundary between the regions, is $p^* = \frac{W}{C}$ which falls as the cost of fighting to Goliath rises. The information environment of game 3 can be further restricted by assuming that Goliath does not know the probability that David is a hothead. In the absence of any other information concerning David's type, Goliath will form passive conjectures resulting in a special case of game 3 in which p=0.5. In this case, fighting costs in excess of 2w will induce Goliath to appropriate none rather than all of David's corn (see figure 6, below).

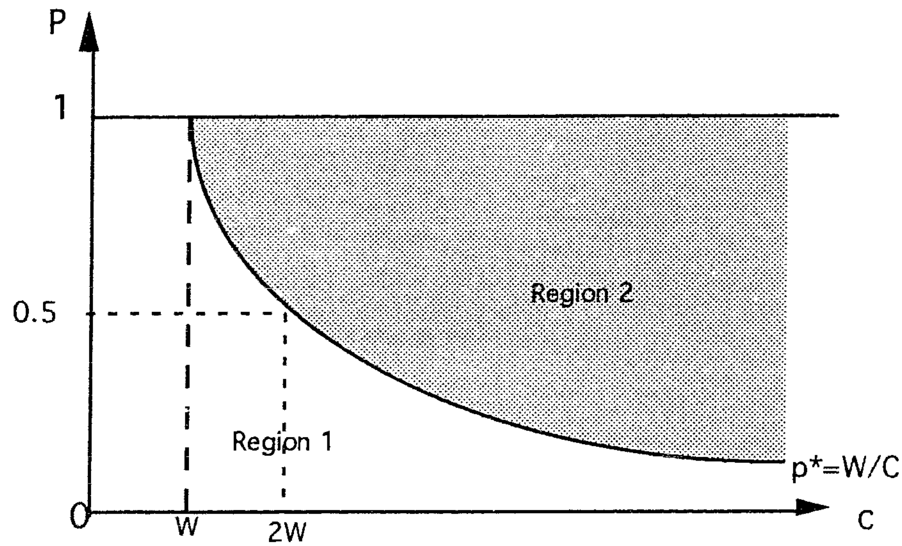

Figure 6.
Equilibria in "David and Goliath" III as a function of Goliath's fighting costs and the probability of David being "ill-tempered".

VI. Strategic behaviour with instinctual precommitments

As discussed earlier, an alternative interpretation of the "trembling hand" perfection criterion is that it requires each rational player consider the possibility (however small) that an opponent may act in an irrational way, thereby causing an outcome off the Nash equilibrium path. Instinctual precommitments which suspend rationality can extend this notion by requiring that *currently* rational players consider that in addition to their opponent, they themselves may act irrationally in the future. Provided that the mechanism which suspends rational decisions is sufficiently well specified, (such as the temper thresholds in section IV), it becomes possible that individuals will rationally manipulate their instincts to their strategic advantage. Schelling (1984) in particular, has proposed that current decisions by an individual are often subject to strategic manipulation as a result of possible future events in which the individual's own actions will not serve to maximize their current "dominant" preferences. He argues that when we observe one person's behaviour, we are in fact observing the resolution of competition between the various 'selves' which make up an individual. Given that each 'self' is differentiated by preferences, the current self must make commitments to future behaviour that take account of foreseeable circumstances in which a competing self could make choices which diverge from current preferences. Schelling (1984) gives the following examples:

> "Please do not give me a cigarette when I ask for it, or dessert or a second drink. Do not give me my car keys. Do not lend me money."[63]

The idea that individuals will make voluntary precommitments to constrain their own future behaviour suggests that an awareness of one's own emotional thresholds could lead to a strategic manipulation of the external forces which are likely to trigger a particular instinctual response. An individual who is aware of a precommited tendency to irrational behaviour can gain strategically, by increasing or decreasing the possibility of a future irrational act. Anyone who has witnessed a

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[63] Schelling (1984), p1.

cat fight may have seen the strategy of backing into a corner which has strategic value because it credibly limits the possible responses to aggression. In order to avoid a fight, the aggressor must back down.

David and Goliath: Game 4

The strategic manipulation of instincts can be applied to the David and Goliath game by allowing David to commit the seemingly irrational act of destroying all or some of his own endowment. In the following extension of David and Goliath, temper thresholds are modeled in a continuous framework by assuming a "LOT" (loss-of-temper) function which relates the probability that David will fight, to the amount of his endowment appropriated by Goliath. Goliath now must maximize a value function with respect to the amount of David's endowment he appropriates. Consider first of all the case where there is no manipulation by David of his own endowment. Let p be the probability that David will initiate a fight in response to Goliath stealing X units of his corn. As before in a fight, Goliath will win with certainty and capture all of David's corn, but will incur fight costs (C), while David will lose and incur fight costs (K). Now define David's LOT function as $p = p(X)$, where $p(X)$ is smooth and continuous with $p'(x) > 0$ and $p''(x) \leq 0$. Goliath will now maximize through choice of X, the expected payoff function:

$$\Pi_G = p(X).(2W\text{-}C) + [1\text{-}p(X)].(W + X)$$

or

$$\Pi_G = W + X + p(X).(W - X - C)$$

The first order conditions for a maximum are:

$$\frac{d\Pi_G}{dX} = 1 + p'(X^*).(W - X - C) - p(X^*) = 0$$

As a simple illustration, consider a linear LOT function of the form:

$$p = \frac{X}{W}$$

Goliath's value function is now:

$$\Pi_G = W + X + \frac{X}{W} \cdot (W - X - C)$$

or $$\Pi_G = W + 2X - (\frac{X^2 + CX}{W})$$

and the first order conditions yield:

$$\frac{d\Pi_G}{dX} = 2 - \frac{2X}{W} - \frac{C}{W} = 0,$$

or

$$X^* = W - \frac{C}{2}.$$

Clearly, X^* varies inversely with fighting costs (C) and directly with W; as C increases, the expected cost of stealing one more unit rises for any given probability of a fight and as W increases, the expected cost of stealing one more unit falls as the probability of a fight declines for all values of X and C.[64]

Strategic manipulation of the temper threshold

Now consider a game in which David moves first and can destroy any portion of his own endowment he wishes. Goliath moves second and decides how much to steal from David after observing his move. Since the LOT function relates the probability of a fight to the proportion of David's endowment remaining after Goliath's move, by destroying his own endowment David

[64] Second-order conditions are satisfied.

increases the probability of a fight for each unit of resource taken by Goliath.[65] Let d equal the number of units destroyed by David in stage 1 of the game ($0 \leq d \leq W$), so that David's LOT function in stage 2 is given by p(X,d). In stage two, Goliath chooses X to maximize:

$$\Pi_G = p(X,d).(2W - C - d) + [1-p(X,d)].(W + X)$$

subject to: $0 \leq X \leq (W-d)$

Using rational foresight, David will incorporate Goliath's best response function $X^* = X^*(d)$ into his objective function so that in stage 1, David chooses d to maximize his expected net benefits, given by:

$$\Pi_D = p[X^*(d),(W-d)].(-k) + \{1-p[X^*(d),(W-d)\}.[W - d - X^*(d)]$$

With probability $p[X^*(d),d]$, David will be provoked into a fight in which he will lose K, and with probability $1- p[X^*(d),d]$, David will consume his initial endowment less the amount he chooses to destroy, less the amount appropriated by Goliath. To illustrate, consider an extension of the linear LOT function which incorporates David's choice of d, given by:

$$p[X,d] = \frac{X}{W-d}$$

In stage 2, Goliath now chooses X to maximize:

$$\Pi_G = \frac{X}{W-d}.(2W - C - d) + [1-\frac{X}{W-d}].(W + X)$$

Differentiating with respect to X yields Goliath's optimal appropriation as:

[65]The strategy of destroying one's own endowment is similar to the notion of posting a bond to guarantee performance. On this see Eaton and White (1983).

$$X^* = W - d - \frac{C}{2}$$

In stage 1, David chooses d to maximize:

$$\Pi_D = \frac{X^*(d)}{W\text{-}d}.(-k) + [1 - \frac{X^*(d)}{W\text{-}d}].[W - X^*(d) - d]$$

and by substituting X* into the payoff, we get:

$$\Pi_D = (1 - \frac{C}{2(W\text{-}d)}).(-k) + [1 - (1 - \frac{C}{2(W\text{-}d)}).\frac{C}{2}$$

or

$$\Pi_D = \frac{2CK + C^2}{4(W\text{-}d)} - K$$

where

$$\frac{\delta\Pi_D}{\delta d} > 0$$

David gains from destroying units of his endowment because a unit increase in d causes a unit decrease in X*, while leaving his net stock of corn unchanged in stage 2 when a fight does not occur. At the same time, an increase in d reduces the probability of a fight occurring in equilibrium, thereby increasing David's expected payoff. Therefore, the outcome is a corner solution in which David sets $d^* = W - \frac{C}{2}$ such that $X^* = 0$, giving him a payoff of $\frac{C}{2}$ with certainty. In this way, David's rational awareness of his predisposition to engage in irrational fights causes him to manipulate his temper in a way that mitigates its negative effects.

The distribution of wealth and the efficiency of institutions

When resources are common property, efficiency gains can be realized through the creation of private property rights, but to be meaningful these rights must be enforced and in a governed market, if the state cannot perfectly enforce property right agreements then "illegal" activity is to be expected. Eaton and White (1991) demonstrate that in this case, the efficiency of the system is sensitive to the relative magnitude of enforcement parameters and the distribution of wealth. Specifically, the instruments of enforcement are monitoring (the probability that a thief will be caught), sanctions (the penalty imposed on those caught stealing) and restitution (the ability to compensate the victims of theft). They construct a simple, two period game between two players each of whom are endowed with a quantity (W) of the economy's only scarce good (corn). Corn may be consumed or planted in period 1, there is no discounting and utility is linear in corn consumption, of the form:

$$U_D = d + y_D$$

for David and

$$U_G = g + y_G$$

where d = the amount consumed by David in period one

y_D = the amount consumed David in period two

g = the amount consumed by Goliath in period one

y_G = the amount consumed by Goliath in period two

The technology of production defines a linear growth parameter (α) such that:

$$V_G = \alpha(W-g) \text{ and } V_D = \alpha(W-d)\ ;\ g,d \leq W\ ;\ \alpha > 1$$

where

W = each player's endowment of corn in period one.

V = the corn harvest in period two resulting from the amount planted by each in period one.

Providing that the players are able to exclusively consume their period two harvests, both will elect to plant all of their endowment in period one and this will result in an aggregate level of utility equal to $\alpha(W_1+W_2)$. If however, harvests are common property in the second period such that each individual can expect to acquire half of any harvest (regardless of who planted it), the equilibrium of the game is for neither player to plant corn when the growth parameter is in the range $1 < \alpha < 2$. This places the economy within its production possibility frontier because the aggregate utility level falls to $W_1+W_2 < \alpha(W_1+W_2)$.

Eaton and White proceed by replacing the assumption of common property with a governed market in the second period such that the players have property rights to their own harvests, which are enforced by an incorruptible third party. It is also assumed that enforcement is imperfect so that stealing becomes viable as a means of acquiring corn in the second period. The decision to steal is represented as a risky prospect with a known probability (p) of getting caught and a known penalty if apprehended equal to some proportion of the thief's own property in the second period (represented by $0 \leq \lambda \leq 1$). The amount of corn defined by the penalty is redistributed to the victim along with the return of stolen property. In contrast to the common property case, second period property rights can increase the incentive to plant corn in period one (thereby improving economic efficiency) but the equilibrium to this two-stage game is shown to be sensitive to the relative magnitudes of the enforcement parameter (p) and the punishment parameter (λ) along with the initial distribution of wealth. The paper thus draws attention to the complexity of obtaining the most efficient outcome when moving from a system of common property to an imperfectly governed market, however the common property result may be an inappropriate benchmark as a representation of resource allocation in the absence of third party enforcement. In a state of anarchy, violence is a means by which resources may be acquired (and retained), and barring equal endowments of abilities to in the use of violence, anarchy cannot be guaranteed to produce equal shares. In addition, the analysis in this essay has demonstrated that an instinctual precommitment to "loss of temper" can mitigate domination by individuals with superior fighting abilities and that the strategic manipulation of these instincts can further support the stability of nominal resource claims. For this reason, it may be possible to obtain a natural distribution of resources which is more efficient than the common property system.

To explore these issues, consider the following adaptation of the Eaton and White model. In the same two-person, two-period corn economy, with the same linear utility functions and production technology, suppose that the players are David and Goliath and that each is endowed with W units of corn in period one. In the second period, each holds a claim on (initially possesses) his own harvest but these claims are not enforced by a third party. Instead the two players decide whether or not to appropriate, an amount of corn harvested by the other. This is represented by two independent, sequential-move encounters. In one encounter, David moves first and decides how many units (X_D) to appropriate from Goliath's harvest and in the other Goliath decides how much (X_G) of David's harvest to take. In both games, the second-mover responds either by fighting or by retreating and as in previous David and Goliath games, Goliath is assumed to be physically dominant so that and, if a fight occurs Goliath always wins the disputed harvest. The costs of engaging in a fight are represented by parameters K and C for David and Goliath respectively.[66] In contrast to the Eaton and White model, the focus here is on confrontation and violence rather than stealth and detection, therefore it is assumed that each player observes the others attempt to steal. As a further simplification, it is assumed that Goliath's fighting cost satisfies the condition: $C < (\alpha-1)W$. This guarantees that irrespective of the amount that Goliath expects to appropriate from David, he will always have an incentive to plant all of his corn.

If both players are fully rational (never engage in irrational fights), in period two, David will choose to appropriate $X_D = C$ units of Goliath's harvest and Goliath wiil retreat since he cannot gain by fighting. In the stage two game where Goliath chooses to appropriate David's property,

[66]These costs are, in a sense a reinterpretation of Eaton and White's punishment parameter (λ).

he will take all of David's harvest ($X_G = V_D$) and David will respond by retreating, resulting in a payoff of zero compared to -K if he were to fight. Working back to the first period, this means that Goliath will plant all of his corn ($g^* = 0$) and David will plant none ($d^* = W$) so that in equilibrium, David's utility is $U_D = W+C$ and Goliath's is $U_G = \alpha W-C$, giving an aggregate utility of $(1+\alpha)W$.

David's decision to plant no corn appears to mirror that obtained under the common property regime, but the threat of physical domination gives rise to a more pervasive inefficiency; the decision not to plant is invariant to the value of the growth parameter. That is, David will consume all his corn in period one, even if the value of α exceeds two. Although the value of the parameter C has been restricted by assumption, the result illustrates that there does exist a range of values for Goliath's fighting cost over which differential abilities in the use of force to appropriate or retain resources leads to an outcome which is a Pareto improvement over the common property solution. In this case both the aggregate utility level and each player's share of resources are higher than under common property regime.

Instinctual loss of temper

Now suppose that Goliath remains fully rational, while David is endowed with a linear "loss of temper" function of the form:

$$p(X,V_D) = \frac{X_G}{V_D}$$

or

$$p(X,V_D) = \frac{X_G}{\alpha(W-d)}$$

where p is the probability that David will fight in period two, when Goliath appropriates X_G units of his harvest. With the endowment of a LOT function only to David, there is no change in the period two game in which he (David) appropriates from Goliath. However, the encounter in which Goliath appropriates from David is transformed into a version of game 4 as previously described. Now, David is able to obtain a strategic advantage by manipulating the size of his second period harvest, thereby effecting the probability that he will fight and consequently Goliath's decision to appropriate from him in the second period. One difference is that he now derives some utility from his strategic behaviour by consuming his corn in the first period instead of destroying it. In similar fashion to game 4, Goliath chooses X_G in period two to maximize:

$$\Pi_G = \frac{X_G}{\alpha(W-d)}.[\alpha(W-d) - C] + [1-\frac{X_G}{\alpha(W-d)}].(X_G)$$

giving: $$X_G^* = \alpha(W-d) - \frac{C}{2}$$

In period one, David chooses d to maximize:

$$\Pi_D = \frac{X^*(d)}{\alpha(W-d)}.(-k) + [1 - \frac{X^*(d)}{\alpha(W-d)}].[\alpha(W-d) - X^*(d)] \ + d$$

As before, the partial derivative of Π_D with respect to d is positive and the result is a corner solution in which David consumes an amount:

$$d^* = W - \frac{C}{2\alpha}$$

which is an amount that is just sufficient to set $X_G^* = 0$, thereby reducing the probability of a second period fight to zero. The credible commitment to fight Goliath results in David planting a positive amount of corn ($\frac{C}{2\alpha}$ units) in equilibrium, which yields him a net harvest (which is not appropriated by Goliath) equal to $\frac{C}{2}$ units. Goliath's equilibrium level of utility is unchanged from the "no temper" case ($U_G = \alpha W - C$), but David's utility is now:

$$U_D = W + C + (\frac{C}{2} - \frac{C}{2\alpha})$$

This represents an increase of $(\frac{C}{2} - \frac{C}{2\alpha})$ units, so that aggregate output (and efficiency) rises and is a Pareto improvement over the "no temper" case.

The efficiency gains credited to the enforcement of property rights by a third party may be overstated if the benchmark used for comparisons is a system of common property where all agents can expect an equal share of contested resources. Furthermore, if legal action in contemporary governed markets serves as a metaphor for the violence employed in a state of anarchy, then it may be inferred from this model that the instinctual response of engaging in irrational (costly) litigation will be efficiency enhancing and may strengthen or permit trade agreements that do not appear sustainable or are not permitted through the use of explicit contracts.

VII. Evolutionary pressures and evolutionary stability

Game theory is often employed in theoretical biology because it enables a gene to be defined as a strategy which outlines all the contingent behavioural responses of its animal recipient, thus allowing the investigator to

> "...analyze evolution at the phenotypic level without having to model in detail the genotypic level." [67]

In biological games that analyze the evolution of a population of animals, it is supposed that each member engages in a dyadic contest with a randomly selected opponent. Afterwards, each animal asexually reproduces a number of genetically identical offspring in direct proportion to the payoff received in the contest. In this way, the game's payoffs translate into evolutionary "fitness" for the participants (or more accurately, for the strategies that represent the participants' genes) and the resulting equilibria can be evaluated in terms of evolutionary stability. To be evolutionarily stable the strategies defined by an equilibrium, must define a population which is immune to invasion by any random mutation within the feasible strategy space. Formally stated, a strategy s* is an evolutionarily stable strategy (ESS) if:

$$\Pi(s^*,s^*) > \Pi(s,s^*),$$

or if

$$\Pi(s^*,s^*) = \Pi(s,s^*) \text{ and } \Pi(s^*,s) > \Pi(s,s)$$

$$\forall\ s, s^* \in S;\ \ s^* \neq s$$

where

S = the set of all feasible strategies

$\Pi(s_i, s_j)$ = the payoff to strategy i which results from the strategy combination (s_i, s_j) for $s_i, s_j \in S$

---

[67] Van Damme (1983), p209. The evolutionary properties of instinctual behaviour are explored section 7 of this paper.

A property of evolutionary stability in game theory is that it embraces the Nash equilibrium concept, since in equilibrium, each individual is required to choose a strategy that is a best response, given the strategies being played by others. But more than this, if a strategy s* is an ESS then (s*,s*) is a perfect Nash equilibrium because s* is not only a best response to the current distribution of 'types' strategies in the population, but is also to be best response to any perturbation of the equilibrium distribution. An ESS can be a mixed strategy p*, where p* is a probability distribution supported by the set of feasible pure strategies. If p* is an ESS, the equilibrium (p*,p*), can be interpreted either as an equilibrium in which each member of a "monomorphic" population plays the mixed strategy p*, or alternatively, (p*,p*) can represent equilibrium in a "polymorphic" population where each individual plays one pure strategy. In the latter interpretation, p* represents the distribution of individuals playing each feasible pure strategy and for remainder of this essay, evolutionary stability will be characterized from this perspective.[68]

The game which has brought evolutionary stability to prominence in theoretical biology is the 'hawk-dove' game (introduced in section 5, above). In hawk-dove, neither of the pure strategies are stable from an evolutionary perspective when the fighting costs (C) exceed the winners prize (V). Checking the payoff matrix (shown below) confirms that the strategy "dove" does better against "hawk" than it does against itself and vice versa, so that any population playing only one of the pure strategies would not be immune to invasion by the other.[69] However, there is one unique ESS which is the mixed strategy p* = V/C, so that (p*,p*) is an evolutionary stable equilibrium.

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[68]The analogy between polymorphic and monomorphic populations is accurate for games involving two pure strategies, but becomes more complex and restrictive if more than two pure strategies are involved. In particular, the stability conditions differ, such that polymorphic ESS's become a subset of monomorphic ESS's. See Van Damme, (1983), chapter 9.

[69]The pure strategy equilibria {hawk,dove} and {dove,hawk} are not of interest from an evolutionary point of view since "...an animal cannot condition its behaviour on whether it is called player 1 or player 2".(Van Damme, (1983), p210.

Using the polymorphic interpretation of mixed strategies, P* = V/C represents the proportion of hawks that would exist after the population had evolved to an evolutionary stable state.

		Player 2	
		H	D
Player 1	H	(V-C)/2, (V-C)/2	V, 0
	D	0, V	V/2, V/2

Table 4

"Hawk-Dove"

In contrast to this result, the asymmetric version of hawk-dove in which one player has better odds of winning a fight (and both players know it) has no mixed strategy which is an ESS. Instead, there are three pure strategies which can be ESS depending upon the relative values of V (the winner's prize), C (loser's costs of fighting) and x (the probability that the dominant player will win a fight). The pure strategy equilibria make sense from an evolutionary point of view in this model because, unlike the original hawk-dove game, the asymmetry defines an identity to each player which allows each to condition its behaviour (for example "if smaller than opponent, play dove, if larger, play hawk"). This was not possible in the original game when the players' identities extended no further than "player 1" and "player 2".

If $C/V > (1-x)/x$ then the pure strategy equilibrium (dove, hawk) is an ESS.[70] In this case, fight costs are relatively serious but need not be greater than V, due to the higher probability of player 2 winning a fight. If $C/V < (1-x)/x$, then fighting costs are relatively insignificant and the pure strategy "hawk" is an ESS for both players.

[70]That is, the small player chooses "dove" and the large player chooses "hawk".

		Large	
		H	D
Small	H	V(1-x) - Cx / Vx - C(1-x)	V / 0
	D	0 / V	V/2 / V/2

Table 5.

The Asymmetric Hawk-Dove Game

Finally, for $C/V > x/(1-x)$ fight costs are prohibitively costly even to the dominant player so that the "paradoxical" pure strategy equilibrium (hawk,dove) is evolutionarily stable. So, provided that $C/V > (1-x)/x$, population never resorts to conflict in the resulting evolutionary equilibrium.[71]

Evolutionary properties of the David and Goliath game

When played once, David and Goliath III demonstrates that David's relative success is improved by an instinctual precommitment to fight. However, if there is an evolutionary process whereby relatively unsuccessful strategies are selected against by nature, then the dynamic properties of instincts in repeated encounters must be considered. Do the equilibria in David and Goliath III consist of strategies which are ESS? In order to answer this question, it is necessary to define the particular nature of the evolutionary process. Specifically, if David-types and Goliath-types are thought of as two distinct species of animal, then a distinction can be made between inter-special and intra-special competition (in biological terms this refers to group versus individual selection). In the case of inter-special competition, the survival of Davids or Goliaths relies entirely upon their success in contests against members of the other species. In this environment, it is possible

[71] See Maynard Smith and Parker (1976) p165-166.

for a species to be completely eradicated. Alternatively intra-special competition does not threaten the existence of either species, but nature selects successful types within the species.

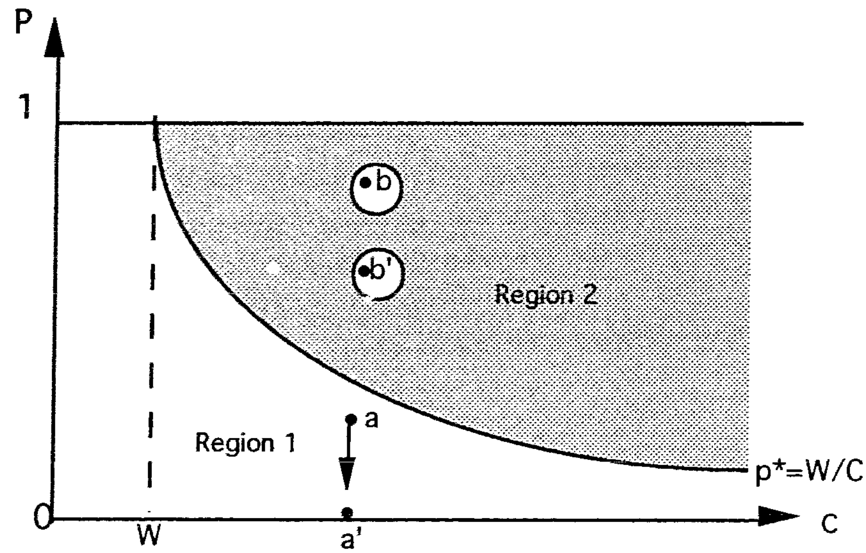

Figure 8

Evolution in David and Goliath III

An assessment of David and Goliath III, using the concept of intra-species competition shows that in region 1 of figure 8 (above), the institution of instinctual LOT is not a successful characteristic. This can illustrated by picking an arbitrary point such as point "a". At this point, all ill-tempered David's receive payoffs of -K in their encounters while all mild-mannered Davids will incur a payoff of zero. Nature will therefore select against hot-headed Davids in favour of Davids who are submissive in contests with Goliath. The dynamic thus moves point a to point a' in figure 8, which is a stable equilibrium, since no proportion of hot-headed Davids can invade and outperform their mild-mannered counter-parts. In region 2, both types of David receive the same payoff in encounters with Goliath, thus any arbitrary point, (such as point b in figure 8) is a dynamic equilibrium, since there are no evolutionary pressures that favour one type over another.

None of the points in region 2 are stable equilibria because any local perturbation of point b moves the population of Davids to another dynamic equilibrium such as point b'. Nonetheless providing that any perturbation is small, "hot-heads" will survive within the population of Davids.

When evaluated on the basis of inter-special competition, it is clear that the David species will be eradicated in region 1 of figure 8. For C < W, the highest payoff any David receives is zero, while Goliaths receive either 2W-C or 2W. As a result, natural selection will generate a stable dynamic equilibrium in which only Goliaths exist.[72] In region two every point is once again a dynamic equilibrium in which there are no evolutionary pressures for change. This is because Goliaths do not steal in encounters with Davids and so the members of each species receive the same payoff. While region 2 shows that instinctual LOT can lead to have dynamic equilibria which are locally stable in both intra and inter-special competition, by addressing these forms of competition separately, it does not fully address the tradeoff between strategies that encourage individual versus group selection. One way of reconciling the tradeoff is to consider an environment in which there is inter-special competition but where the evolutionary process selects purely on the basis of individual performance. In this framework, there are three possible dyadic contests:... David vs. David, David vs. Goliath and Goliath vs. Goliath. Now, if nature selects against one species in favour of another, it will also increase the probability that any future contest will be between members of the successful species.

To the extent that an instinctual precommitment such as LOT is modeled in David and Goliath as a particular strategy of irrational retaliatory aggression, the model excludes in an ad hoc fashion, other equally admissible strategies with alternatively specified irrational tendencies. For example, the game restricts Goliath to always be the first mover and to always be rational, furthermore instinctual aggression is limited to a one-time retaliation by David which Goliath cannot prevent

[72]Notice that in an evolutionary equilibrium, only Goliaths would be left to compete for resources.

from escalating into a fight. Also, both Davids and Goliaths are not permitted to be instinctually precommited to unprovoked aggression. Unfortunately, an expansion of the game to allow for simultaneous inter and intra-special competition and the relaxation of these behavioural restrictions implies a very large, cumbersome game with a high level of analytical complexity. One way of solving this problem is through computer simulations in which the feasible pure strategies available to each member of each species are represented by a finite automata.

VIII. The evolution of finite automata in dyadic contests

Finite automata are stimulus-response machines with finite memories, that exhibit actions as a function of an 'internal state', which depends upon the external environment.[73] Such machines have been used to model strategic behaviour in repeated plays of such games as the prisoners' dilemma (Rubinstein, 1986) and have been used to study bounded rationality (Radner, 1980; Neyman, 1985). A 'Moore' machine, is a particular finite automaton which is well suited to modeling strategies in repeated games since its current actions result from an internal response to the most recent actions of other machines in its environment. Following Marks (1992), let X_i be the finite set of possible internal states of the i^{th} Moore machine, for i = 1, 2,.....,n and define $x_i(t) \in X_i$ as the internal state of machine i in period t. Also, let x_i° be the i^{th} machine's initial state (prior to any stimuli) and let A_i be machine i's set of feasible actions with $a_i(t) \in A_i$ representing the action taken by machine i in period t. The machine's internal state in period t+1 is then a function (δ) of its current internal state and the actions of other machines. That is:

$$x_i(t+1) = \delta[x_i(t), a_j(t)] , \quad \forall \; i, j = (1,....,n), i \neq j$$

where $\delta[x_i(t), a_j(t)] = \{\delta: (X_{i,t}).(A_{j,t}) \rightarrow X_{i,t+1}\}$ is a 'transition function' which maps combinations of machine i's prior internal state and external stimuli (given by the actions of another machines) onto the machine i's next internal state. The i^{th} machine's actions in period t+1 are given by:

$$a_i(t+1) = \lambda[x_i(t+1)]$$

where $\lambda[x_i(t+1)]$ is an 'action' function' which maps the machines current state into some specific action. Thus, Moore machines can be completely described by the quintuple $\{A,X,x^{\circ},\delta,\lambda\}$ which

[73] Not all machines have finite memories; the 'Turing machine' is an example of an infinite automaton.

describes the machine's set of feasible actions, set of feasible internal states, starting state, transition function and action function. As an example, consider a Moore machine representing a player who follows the well known "tit for tat" strategy in a repeated prisoner's dilemma game. Given a choice of either cooperating or defecting, "tit-for-tat" is a strategy that instructs the player to cooperate in the first period and thereafter to choose the action chosen by her opponent in the previous round of play. A "tit-for-tat" Moore machine is thus described by:

$$\{ A_i=(C,D);\ X_i=(x_C, x_D);\ x_i^{\circ}=x_C;\ \delta_i = \delta_i: x_i(t+1)=x_{aj}(t);$$
$$\lambda_i=\lambda_i: x_{iC}(t) \rightarrow C(t),\ x_{iD}(t) \rightarrow D(t) \}$$

where C = "cooperate"; D = "defect"; x_C = the cooperative state; x_D = the defecting state; and i,j = 1,2 for $i \neq j$.

Moore machines can be conveniently summarized by transition diagrams as illustrated in figure 9 which shows that the tit-for-tat machine has two internal states; a cooperative state (xc) which results in the action cooperate (C), and a punishment state (x_d) which results in the action defect (D).

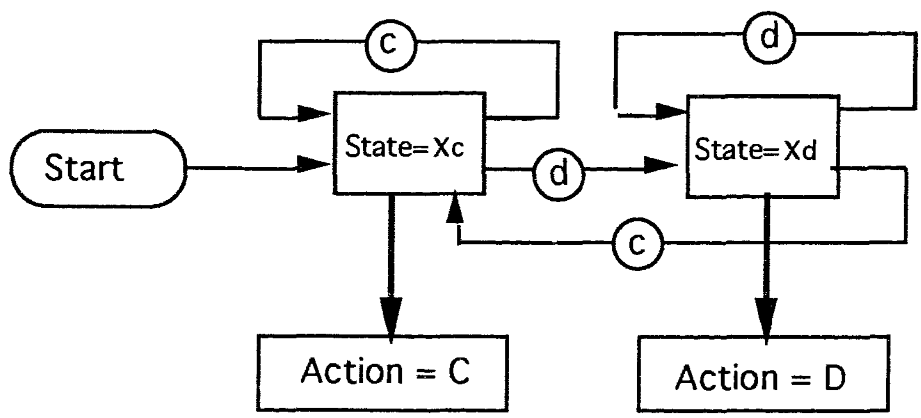

Figure 9

A "tit-for-tat" Moore machine

The machine's initial state is xc and providing the other player's action (shown as lower case letters) is cooperate, the machine will remain in this state. If the opponent defects, the transition function sends the machine into state x_d, and the action function correspondingly generates action D. The machine now stays in state x_d until the other player cooperates, an action which sends the machine back to x_c. This example suggests that Moore machines can be used in a similar fashion to model the dyadic contest games derived from theoretical biology. Furthermore, if used in combination with a genetic algorithm that summarizes the conditions under which strategies procreate, computer simulations can be used to explore the evolutionary fitness of strategies and the stability of any resulting equilibria. However, the computational magnitude of such game simulations rises quickly and exponentially as the strategy space is expanded.

Consider, a game between David and Goliath in which either may be the first mover and each chooses between an aggressive action "escalate" (E) and a submissive action "retreat" (R). The payoff matrix for this game (illustrated below in table 6) indicates that if both players choose "escalate", a fight automatically occurs which Goliath will win at a cost (C) while receiving all of David's corn (W). If one player chooses "escalate" when the other chooses "retreat" then the aggressive player wins all (2W) without a fight. Finally if both choose the submissive action, they each retain their initial endowments (W) and no fight occurs.

David \ Goliath	E	R
E	-K / 2W-C	2W / 0
R	0 / 2W	W / W

Table 6.

The "escalate-retreat" game:

This simple game has two-players, sequential-moves, two discrete action choices and equal probabilities of being the first mover but this is sufficient to generate eight feasible Moore machines each with the general characteristics:

$$X_i = \{x_E, x_R\},\ A_i = \{E,R\}, \text{ and } \lambda_i = \lambda_i: x_{iE} \to E,\ x_{iR} \to R,\ (i = 1,2)$$

Each machine will be differentiated from the other possible strategies by its initial state (x_i^o), and transition function (δ_i). The machine's initial state indicates its actions in the absence of external stimuli, and therefore implicitly represents the action taken when the player moves first. The transition function maps the combination of the machine's own, current internal state and the current action chosen by its opponent into the machine's next internal state, thereby representing the player's action when moving second. For example, consider the machine which retreats in all circumstances. This pure strategy is represented by :

$$M = \{x^\circ = x_R\ ,\ \delta = \ \delta : \delta[x_R(t), e(t)] \to x_R(t+1),\ \delta[x_R(t), r(t)] \to x_R(t+1)\},$$

where the opponent's actions are represented by the lower case letters e and r. The expression $\delta[x_R(t), e(t)] \to x_R(t+1)$ means that when the machine's current state is x_R and the opponents current action is "escalate" then the machine's internal state in the next period is still x_R. The transition diagram for the "retreat no matter what" machine (see figure 10), illustrates that x_R is a 'trapping' state, so called because the machine remains in that state regardless of the other player's actions.[74]

[74] Since the machine has only one state, this is true by definition, however trapping states can have significant effects in machines with more than one state, and can capture the notion of irreversibility. For example, in the repeated prisoners dilemma game the strategy "defect for ever if my opponent defects", implies a trapping state.

A machine which describes the instinctual LOT strategy is the "retreat unless provoked" machine, is more complex, involving two internal states is given by:

$$M = \{x^{\circ} = x_R,\ \delta = \{\delta\text{: } \delta[x_R(t), e(t)] \rightarrow x_E(t+1),\ \delta[x_R(t), r(t)] \rightarrow x_R(t+1)\}\ \}$$

The transition function for the "retreat unless provoked" machine does not define how it reacts to external actions when in state x_E because when the machine goes to state x_E, it will choose action "escalate" as second mover in retaliation to "escalate" by the first mover and a fight automatically occurs, ending the game.

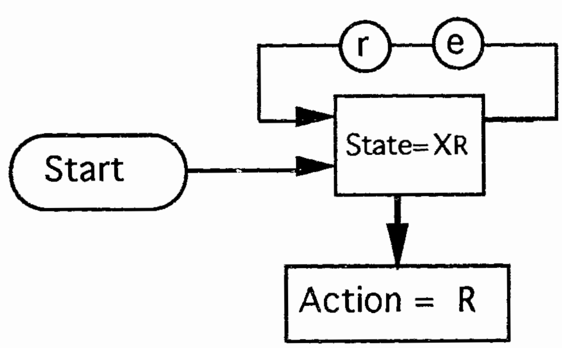

Figure 10

The "retreat no matter what" machine

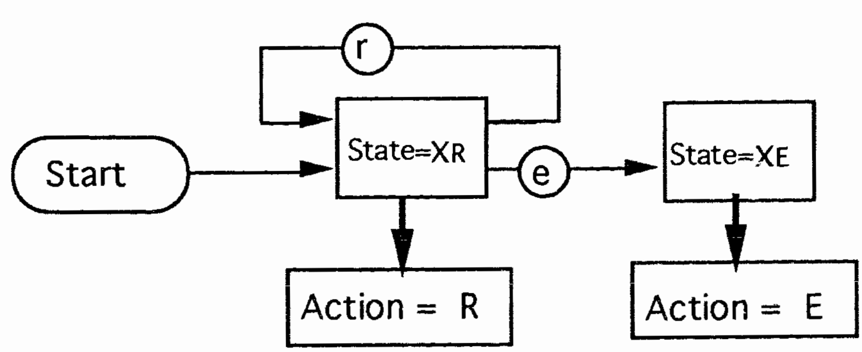

Figure 11
A "retreat unless provoked" machine

Computer simulations of the "escalate-retreat" game

As already mentioned, there are eight feasible pure strategies for each player in the "escalate-retreat" game and for the purposes of composing a computer program to simulate the game, each Moore machine representing these is conveniently summarized by a triple of the form: {$a_0(x^\circ)$, $a[\delta(e)]$, $a[\delta(r)]$}, where $a_0(x^\circ)$ represents the action taken by a first mover (assumed to occur with probability 0.5), and ($a[\delta(e)]$, $a[\delta(r)]$) represents the contingent actions taken as a second mover. For example, the 'retreat unless provoked' machine is summarized by the string {R,(E,R)}, which indicates that the machine's initial state results in "retreat" as the chosen action when the machine is a first mover and that as a second mover, the machine responds to 'escalate' by escalating and to 'retreat' by retreating. Given this format, the feasible set of pure strategies are shown below in table 7.

Five additional elements are required for a computer simulation of this game. These are the payoff matrix, a genetic algorithm, some initial distribution of David and Goliath types, a mechanism which stops the game when an equilibrium is reached and a test of any equilibria for evolutionary stability. When all the interactions between feasible strategies are considered, there are sixty-four possible outcomes to a pairwise encounter between David and Goliath which gives rise to an eight by eight payoff matrix. Since the payoffs are parameterized, the computer simulation program should allow for selection of parameter values so that the effects of changes in the magnitude of Goliaths fighting costs can be explored.

Strategy	Description		
	If first mover	If second mover	
		Opponent Escalates	Opponent Retreats
{E, (E,E)}	escalate	escalate	escalate
{E, (E,R)}	escalate	escalate	retreat
{E, (R,E)}	escalate	retreat	escalate
{E, (R,R)}	escalate	retreat	retreat
{R, (E,E)}	retreat	escalate	escalate
{R, (E,R)}	retreat	escalate	retreat
{R, (R,E)}	retreat	retreat	escalate
{R, (R,R)}	retreat	retreat	retreat

Table 7

Possible Pure Strategies in the "escalate-retreat" game

In an evolutionary game, the dynamic through which successful strategies are selected by nature is the asexual reproduction based on evolutionary "fitness" as measured by the payoffs received in each dyadic contest. A computer simulation of this process must therefore contain a 'genetic algorithm' which maps the specific relationship between the payoff received by a machine and the number of genetically similar offspring it produces. One simple genetic algorithm is one which creates a number of offspring in direct proportion to each machine's payoff relative to the average payoff of all competing machines. Let $\beta_i(t)$ = the payoff of the ith machine relative to the average payoff of all competing machines that exist in round t of the game so that:

$$\beta_i(t) = \{\Pi_i(t)/[\Sigma\Pi_i(t)/n(t)]\}$$

where:

$\Pi_i(t)$ = the payoff received by the ith machine in period t.

and

n(t) = the number of competing machines in period t

Now define:

$$p_i(t+1) = \alpha_i(t).p_i(t)$$

for

$$\alpha(t) = \beta_i(t)/\Sigma\beta_i(t).p_i(t)$$

where:

$p_i(t)$ = the frequency of machines playing the ith pure strategy in period t.

and $\alpha(t)$ = a normalization parameter to ensure that the new frequencies sum to one.

Thus, the frequency of machines playing the ith pure strategy in the next round will be a multiple of the current frequency currently such that the expansion (or reduction) factor is the normalized performance of the ith strategy relative to the population average in the current round (where $\alpha_i(t)$ is the normalization formula). Since the genetic algorithm must specify which machines are competing in evolutionary terms, it can include or exclude inter-special competition. So, in the "escalate-retreat" game, if the competition is intra-special, then there will be a maximum of eight competing machines within each species (either Davids or Goliaths), however if inter-special competition is permitted, then there are a total of sixteen machines drawn from both species which compete for fitness.

In each simulation, it is important to consider whether any resulting equilibrium is sensitive to the initial distribution of machines. Correspondingly, the computer simulation should allow for the selection of various starting distributions for sensitivity analysis. Also, as a pragmatic measure to reduce computation costs, the computer program should contain a tolerance variable to prevent unnecessary iterations of the game as the change in the expected payoff to any existing machine goes to zero. Thus given some tolerance measure, a dynamic equilibrium is defined as that iteration of the simulated game where the frequencies of remaining machines do not change beyond some arbitrarily small amount. If a dynamic equilibrium is reached, the expected payoffs will be equal for those machines which remain and in order to test for evolutionary stability, an 'invasion' test should be conducted. If it can be shown that no feasible machine can be introduced to the equilibrium population and earn a greater expected payoff than the amount defined by the equilibrium frequencies then the dynamic equilibrium is evolutionarily stable.

Simulation 1: intra-special competition[75]

In this simulation of the "escalate-retreat" game, each round of play involves inter-special encounters between David machines and Goliath machines. The evolutionary process selects in favour of individual machines which are most successful in these encounters but does not select in favour of one species at the expense of the other. The genetic algorithm used for this simulation was:

$$p_{ij}(t+1) = \alpha_{ij}(t).p_{ij}(t)$$

where

$$\alpha_{ij}(t) = \beta_{ij}(t)/\Sigma\beta_{ij}(t).p_{ij}(t)$$

and

$$\beta_{ij}(t) = \{\Pi_{ij}(t)/[\Sigma\Pi_{ij}(t)/n(t)]\}^4$$

for $i = D, G$; $j = 1, 2,....,8$; $n(1) = 8$; $p_{ij}(1) = 1/8$

[75]The computer simulations reported in this essay were performed utilizing an original program, composed using the QuickBASIC programing language.

Here, $\beta_{ij}(t)$ is the 'fitness' factor for the ith machine in iteration t of the game, defined as the ith machine's payoff relative to the species average, raised to the fourth power.[76] As before, the term $\alpha_{ij}(t)$ is a normalization of the fitness factor to ensure that the new frequencies sum to one.

In the first round of simulated play, each machine type represented 1/8th of the total species population (a uniform distribution) and the program was run three times, for varying values of Goliaths fighting costs. The numerical values W = 6, and K = 8 were assigned to the payoff parameters and the simulation was performed three times. In simulation (1.1) Goliath's fighting costs were set at C= 2 to satisfy C < W, indicating the region in which the costs are low relative to the gains of winning a fight. Simulation (1.2) set Goliath's fighting costs at C = 8 in the intermediate range (W < C < 2W) and simulation (1.3) set C = 14, satisfying C > 2W for high fighting costs.

A dynamic equilibrium was reached at the 101th, 160th and 451th iteration of simulations (1.1), (1.2) and (1.3) respectively. Each simulation was carried out using a zero tolerance level (the program continued to iterate the game until the change in frequencies was zero) and in each case, the expected payoffs to each surviving machine was found to be equal in equilibrium.[77] When tested for stability, any feasible invading machine not represented in the dynamic equilibrium was found to have a lower expected payoff than that of the equilibrium population, indicating only weak evolutionary stability in the sense that any machine not represented in equilibrium could not survive if it was reintroduced. However any perturbation of the equilibrium population frequencies (reported in table 7 below) would result in another equally valid dynamic equilibrium.

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[76] Raising the relative payoff to the fourth power serves only to speed up the evolutionary process, thereby significantly reducing the number of iterations performed by the computer.

[77] The tolerance level was set either at 1E-17 or zero all the simulations conducted. At a tolerance level of zero, the number of itterations is greatly expanded, with no significant change in the results.

Goliath's Fighting Costs	Equilibrium Frequencies					
	David			Goliath		
	low	med.	high	low	med	high
Strategy						
E,EE	0	0	0	0.968	0.716	0
E,ER	0	0	0			
E,RE	0	0	0.763	0.032	0.284	0.994
E,RR	0	0	0.237	0	0	0.006
R,EE	0	0	0	0	0	0
R,ER	0	0	0	0	0	0
R,RE	0.814	0.752	0	0	0	0
R,RR	0.186	0.248	0	0	0	0

Table 7

"Escalate-retreat" simulation 1:

intra-species evolution

The surviving machines in both species were identical in simulations (1.1) and (1.2) with minor differences in frequencies. In these two simulations, ill-tempered David-machines were selected against by the genetic algorithm in favour of more submissive machines. Specifically, the only David-machines to survive were {R,(RE)} and {R,(RR)} which are both submissive when a first mover and also when Goliath escalates as first-mover. The {R,(RE)} David-machine was far more successful than the completely submissive machine {R,(RR)} because it exploited the opportunity to escalate when any Goliath retreated as first mover.[78] The only two Goliath-machines that survived in these simulations are {E,(E,E)}, which practices unilateral aggression and {E,(R,E)} which retreats if David escalates as first-mover but is otherwise aggressive. In equilibrium both machines receive a payoff of 2W against either of the surviving Davids, while

[78]This fact that this was possible highlights the effect of restricting the game to two stages. Any Goliath-machine programmed to retreat as first mover has no recourse against aggression by a David who moves second.

the Davids receive zero. The result of simulation (1.1) supports the result of "David and Goliath III" where Goliath's low fighting costs do not make loss of temper an effective strategy in deterring his appropriation of David's corn. However, while the existence of temper-prone Davids do mitigate Goliath's aggression when fight costs exceed W, in the game, they do not survive in simulation (1.2). The reason for this is that although the rational strategy for Goliath against a temper-prone David is to retreat, choosing "escalate" as first mover results in a payoff of (2W-C) > 0 for Goliath while the temper-prone David receives -K. As a result, the temper-prone Davids do very badly against all of the aggressive Goliath-machines relative to other members of their species while the aggressive Goliath's performance is only slightly worse than other members of their species against David machines that retaliate. Consequently, the aggressive Goliaths survive and grow stronger as temper-prone Davids diminish in frequency. The aggressive Goliath-machine {E,(EE)} not only acts rationally against a rational David-machine, but is more resilient to irrational opponents than temper-prone Davids.

In simulation (1.3) the magnitude of Goliath's fight costs lead to a dynamic equilibrium in which the David-machines {E,(RE)} and {E,(RR)} were the sole survivors. These machines gained from the poor performance of Goliaths who were aggressive as second movers against the other aggressive David machines {E,(E,R)} and {E,(E,E)} as these Goliaths were selected against in favour of more submissive machines. At the same time {E,(RE)} obtained the maximum available payoffs as a second mover by retreating when faced with aggression by a Goliath-machine moving first and escalating if the first mover retreated. The other David survivor {E,(RR)} was not nearly as successful due to the fact that it did not exploit the last mover advantage when faced with submissive behaviour by a Goliath-machine moving first. The effect of high fight costs also caused a change in the dominant Goliath-machine to {E,(RE)} since effectively Goliaths were now faced the same consequences of a fight as Davids (a negative payoff), however the {E,(EE)} machine also survived as a small proportion of the Goliath population.

Simulation 2: inter-special competition

To allow for the process of natural selection to choose between individual machines regardless of their species, the parameters of the computer program were altered to allow for the possibility that a contest could be between members of the same species. For the purposes of designing the genetic algorithm, there are now sixteen machines (eight Davids and eight Goliaths) used in calculating the average payoff in each iteration of the game and using a uniform distribution of machines in the first round of play means that each machine represents 1/16 of the total population. It is assumed that a fight between two individuals of the same species will result in an equal share of the resource and an equal fighting cost [(W-k) for Davids and (W-C) for Goliaths). The inclusion of encounters between "like kinds" means that the set of possible outcomes (payoffs) is now represented by an expanded 16 X 16 matrix. As before, one simulation was conducted for each of three levels of Goliath's fighting costs and the resulting equilibrium population frequencies are summarized in table 8 below.

Goliath's Fighting Costs	Equilibrium Frequencies					
	David			Goliath		
Strategy	low	med.	high	low	med	high
E,EE	0	0	0	0.72	0	0
E,ER	0	0	0	0.18	0	0
E,RE	0	0.017	0.207	0	0.766	0.579
E,RR	0	0.004	0.055	0	0.213	0.159
R,EE	0	0	0	0	0	0
R,ER	0	0	0	0	0	0
R,RE	0	0	0	0	0	0
R,RR	0	0	0	0	0	0

<u>Table 8</u>

"Escalate-retreat" simulation 2:

inter-species evolution

Simulation (2.2):

The results of simulations (2.1) and (2.3) are not surprising in that no David-machine survives when Goliath fight costs are low and when fight costs are high, the same David-machines survive as in simulation (1.3). What is interesting is that the David-machines {E,(RE)} and {E,(RR)} both survive when Goliath fight costs lie in the intermediate range.

The reason for this is that the machines {E,(RE)} and {E,(RR)} do badly (receive a negative expected payoff) against {E,(EE)} and {E,(ER)}, but these machines are eliminated early on because they do badly against each other and relatively worse against other machines. Of the remaining machines, {R,(EE)} and {R,(ER)} do badly against {E,(RE)} and while {R,(RE)} and {R,(RR)} do not do badly against any machine, the machines they do well against are eliminated making their performance lower than average. In the end the machines {E,(RE)} and {E,(RR)} (regardless of species) are left playing themselves and in any of the three possible pairwise encounters each machine receives an expected payoff of W.

There are a number of interesting elements of the equilibria in these simulations. Firstly, the machine {E,(RR)} which does not take advantage of submissive behaviour when a second-mover survives because the evolutionary process eliminates the machines that would give rise to this situation, thus its expected payoff is no worse than that received by {E,(RE)}. Secondly, the Goliath-machines that survive exhibit the seemingly irrational action of retreating when a David machine escalates as first-mover. If the Goliath-machine were to chose "escalate" when David escalates a fight would occur and Goliath would receive a payoff of $(2W-C) > 0$ compared with zero if "retreat" were chosen. A third point of interest is that the David-machine which is mild-mannered unless provoked {R,(ER)} does not survive in this environment, for while it performs well against the rational-acting Goliath who decides not to steal when $C > W$ in "David and

Goliath III", its success in the simulation is thwarted by the existence of David-machines that exploit any Goliath-machine that retreats as a first mover.

Clearly, these simulations suffer from the limitations of the finite, two-stage game on which they are based. There is a clear first-mover disadvantage to strategies that involve cooperative play ("retreat") since they are open to exploitation without the opportunity to respond at a future stage. To solve this problem, the strategy space must be expanded to allow a series of "escalates" and "retreats" before a fight occurs, or to allow the first mover to reconsider the opening move in a third stage. However, this type of expansion results in a disturbing growth in the number of possible pure strategies and computational complexity.

IX. Conclusion

There is no doubt that great insights have been attained through conventional economic models in which individuals are assumed to be rational, self interested and devoid of emotion. Yet, there are valuable insights to be gained from understanding how mechanisms of instinctual response can augment self interested behaviour, how knowledge of others' potential to react instinctively affects an individual's rational calculations and how knowledge of our own potential to respond instinctively can enable strategic manipulation of the variables to which we are likely to respond.

This essay has introduced a simple game-theoretic framework in which instincts are portrayed as biologically endowed mechanisms which, under certain circumstances, suspend an individual's ability to make rational calculations by substituting an automatic response which may not be in the individual's self interest. The model of asymmetric contests between David and Goliath illustrate that the particular instinct of "loss of temper" exhibits strategic value as a credible precommitment to engage in irrational retaliation. The analysis further demonstrates that rational awareness of an individual's ability to engage in irrational fights can lead the individual to manipulate (to his or her advantage) those thresholds which invoke the instinctual response. Backing yourself into a corner by increasing the probability that you will fight if provoked can increase your payoff from interactions with others by increasing the likelihood of a conflict which is costly to all involved. A linear "loss of temper" model was applied to the Eaton and White corn economy model and demonstrated that the efficiency of a natural economy in which instinctual temper is present can exceed that of a common property system in which individuals expect equal shares of all contested resources.

The results of the theoretical model are supported by the biological process of natural selection, in that the equilibria in which temper-prone individuals survive are dynamic Nash equilibria. Although they are not evolutionarily stable, the equilibria are nonetheless a sufficient condition for the continued existence of instinctual temper because no small perturbation of any dynamic equilibrium will result in an eradication of the temper gene (pure strategy). The David and Goliath game demonstrates the dynamic stability of instinctual temper, however it is restrictive in that it only allows competition between a rational Goliath and two possible "types" of David. To test the robustness of instinctual behaviour from an evolutionary point of view, the model was expanded to allow for the existence of all the possible types or pure strategies. To do this, two computer simulations of a two-stage, sequential game were conducted in which all the possible pure strategies were represented as finite automata. The results of evolutionary competition between these Moore machines indicated that several pure strategies which do not behave rationally in all circumstances nonetheless enjoy evolutionary success. However, these simulations must be regarded as preliminary tests of evolutionary stability, since they are sensitive to the precise extensive form of the game on which they are based. However they do indicate that automata playing pure strategies which involve suspended rationality can perform well in environments inhabited by fully rational pure strategies.

The consideration of evolution seems quite appropriate in a model of instinctual endowments, since the biological connection between instincts and genetic endowments is naturally extended to a discussion of genetic mutation and evolutionary dynamics. However, the relative success of pure strategies is not enough in itself to fuel evolutionary change in gene-driven models. As illustrated by the contrast between inter and intra-species evolution, the characteristics of encounters play an important role in determining the appropriate genetic algorithm, but unless there is a sufficient scarcity of resources (competition) in encounters, the eradication of weaker strategies cannot be guaranteed. The saying "only the strong survive" loses its relevance when the weak have sufficient resources to live and procreate. Put another way, a genetic algorithm which selects based on relative success is not justified unless the payoff to relatively less successful individuals is sufficiently low as to adversely effect their procreativity. In the context of instinctual loss of temper (LOT), it could be argued that while fatal fights (resulting in mortal wounds or death) do occur in animal and human environments, the many situations in which LOT occurs, the costs are much less severe. Indeed, only fatal fights between prepubescent individuals would wholly guarantee the eradication of inferior genes.

A major challenge to the theoretical approach taken in this essay is the potential difficulty in formulating empirical tests that are capable of distinguishing instinctually motivated behaviours from other causes of apparently selfless acts. Particularly in the context of signalling and reputation games, can instinctual loss of temper be distinguished from "the lean and hungry look"? Experimental economics may hold the most promise in this regard, since controlled experiments could perhaps be designed to ensure that there is no signalling value to selfless behaviour and that individuals do suffer from the informational deficiencies that are characterized in the transactions cost or bounded rationality paradigms.

As human beings, we are undoubtedly capable of conscious rational decision-making, but we are also motivated by emotions and are subject to instinctual responses which have real effects on the way in which we interact with one another. If economics is to be regarded as a social science concerned with the study of human behaviour, it should not exclude or ignore modes of action that do not conveniently fit the mold of existing analysis. Attempts to account theoretically for instincts and emotions may provide some answers to questions which have been troublesome for traditional economic models. In particular, there are a plethora of models involving incentive compatibility constraints which suffer from the vicious circularity of 'who monitors the monitor' and 'who monitors the monitor that monitors the monitor' and so on. In many instances, the existence of naturally occurring instinct-driven property rights may explain the sustainability of contracts in the absence of a monitor and an expanding interest in experimental economics offers the possibility of empirical testing and validation for suspended rationality models.

X. Bibliography

Alchian A. A., Uncertainty, Evolution and Economic Theory, Journal of Political Economy, 58, 1950, pp211-222.

Andersson, S. and Åhlund, M. Hunger affects dominance among strangers in house sparrows, Animal Behaviour, 41, 1991, pp895-897.

Aumann, R. J., Game Theory, in: "The New Palgrave Game Theory", Eatwell J. et al (Editors), W.W. Norton, 1989.

Binmore, K. and Dasgupta, P., Game Theory: A Survey, in "Economic Organizations as Games", Binmore K. and Dasgupta P., (Editors), B. Blackwell, 1986.

Bush W. C., Individual Welfare in Anarchy, in "Explorations in the Theory of Anarchy", G. Tullock (Editor), Public Choice Monograph, 1972.

Cheung S. Transactions Costs, Risk Aversion and the Choice of Contractual Arrangement, Journal of Law and Economics, April, 1970, p23.

Coase R., On Competition, Cooperation and Conflict in Economics and Biology, A.E.R., 68, 2, 1978, pp244-245.

van Damme, E. Refinements of the Nash equilibrium concept, Springer-Verlag, 1983.

Eaton B. C. and White W. D. The Economy of High Wages: An Agency Problem, Economica, May, 1983, p175.

______ The Distribution of Wealth and the Efficiency of Institutions, Economic Inquiry, April, 1991, p336.

Frank R. H., If Homo Economicus Could Choose his own Utility Function, Would he Want one with a Conscience?, American Economic Revue, 77, 1987, pp593-604.

______ Passions Within Reason; The Strategic Role Of the Emotions, Norton, 1988.

Friedman M., The methodology of Positive Economics, in: "Essays in Positive Economics", Chicago University Press, 1953.

Hammerstein P., Biological Games, European Economic. Revue, 33, 1989,

pp635-644.

______ Economics From a Biological Viewpoint, J.L.E. V20, pp1-52, 1977.

______ Competition, Cooperation and Conflict in Economics and Biology, American Economic Revue, 68, 2, 1978, pp239-243.

Kreps D. M., Milgrom P., Roberts J. and Wilson R., Rational Cooperation in the Finitely Repeated Prisoners Dilemma, Journal of Economic. Theory, 27, 1982, pp245-252.

Marks, R. Repeated Games and Finite Automata, in " Recent Developments in Game Theory", Creedy, J. et al (Editors), E. Elgar, 1992.

Milgrom P. and Roberts J., Limit pricing and entry under incomplete information: an equilibrium analysis, Econometrica, 50, 1982, pp443-460.

Rasmusen E. Games and Information, Blackwell Books, New York, 1989.

Ruse M. Sociobiology: Sense or Nonsense, (Second Edition), D Reidel Publishing Company, Boston, 1985.

Schelling T. C. The Strategy of Conflict, Harvard University Press, 1960.

______ Micro Motives and Macro Behavior, Norton Books, 1978.

______ Altruism, Meanness and Other Potential Strategic Behaviors, A.E.R., 68, 2, 1978, pp229-230.

______ Self-Command in Practice, in Policy, and in a Theory of Rational Choice, Richard T. Ely Lecture, American Economic Review, Papers and Proceedings, May, 1984, pp1-11.

Simon, H. A., Theories of Decision-Making in Economics and Behavioral Science, American Economic Revue, 1959.

______ Rationality as Process and as Product of Thought, American Economic Revue, 68, pp1-16, 1978.

______ Models of Bounded Rationality, M.I.T. Press, 1982.

Selten, R., Reexamination of the Perfectness Concept for Equilibrium Points in Extensive Games, International Journal of Game Theory, 4, 1975, pp25-55.

______ The Chainstore Paradox, Theory and Decision, April, 1978, pp127-159.

Smith J. M., Game Theory and the Evolution of Behavior, The Behavioral and Brain Sciences", 7, 1984, pp95-125.

______ and Price G. R., The Logic of Animal Conflict, Nature, 246, 1973,

pp15-18.

_______ and Parker G. A. The Logic of Asymmetric Contests, Animal Behavior, 24, 1976, pp159-175.

Tirole, J., The Theory of Industrial Organization, M.I.T. Press, 1989.

Tullock G., The Edge of the Jungle, in "Explorations in the Theory of Anarchy", G. Tullock (Editor), Public Choice Monograph, 1972, p65.

Williamson, O. E. Credible Commitments: Using Hostages to Support Exchange, American Economic Revue, 73, 1983, p519.