The Social Efficiency of Fairness

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Property rights provide incentives to create information but they also provide incentives to hoard it prior to the award of protection. All-or-nothing rights, in particular, limit prior sharing. An unintended consequence is to slow, not hasten, forward progress when innovation hinges on combining disparately owned private ideas. In response, we propose a solution based on a reward definition of "fairness," that unblocks innovation by increasing willingness to share private knowledge.

We present four arguments. First, we show that fairness can increase the rate of innovation. Welfare can improve both in the absolute sense of enabling new projects and in the relative sense of reordering the social sort order of which projects agents prefer to undertake. Second, in contrast to models of "other regarding" preferences, we show how self-interest alone is sufficient to justify fairness. Third, we show how this problem is more acute for information than for tangible goods. Fourth, we argue that liability rather than property rules can be more conducive to innovation based on information reuse and recombination.

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1 Introduction

We argue that firms and societies can increase the rate of innovation by committing to fair attribution in recombinant intellectual property. The reason is that, unlike tangible resources, ideas cannot be withdrawn once shared. The prospect of unjust taking, literally the absence of fairness, then causes people to hoard ideas rather than share them. It also causes rights holders to police their rights vigorously lest unjust borrowing lead only to more borrowing. Reduced information sharing implies that fewer ideas are available for use, recombination, and entrepreneurial activity. We show how committing to a fair process reduces deadlock and improves the private ordering of investment priorities. Procedural fairness then has broad application as a means to growth in an information society.

Investments that create information present unique challenges. Reasons, identified as far back as Arrow (1962), include inspecting the value of information, non-excludability, and uncertainty over future contingent claims. Although others benefit from the receipt of ideas, why should individuals share when they risk losing exclusive use themselves? We seek to prove that fairness in innovative endeavors is not only socially efficient but also provides necessary sharing incentives to sources of ideas. When one person's idea can benefit another's innovation, the inherent uncertainties surrounding both idea value and the ultimate prospects of success present obstacles to cooperation. Neither party can be certain how or to what degree contributing their assets and ideas will lead to creating new wealth. In the case of information assets, these parties face a paradox: they cannot create a desired outcome until they agree to contribute their ideas, but they are unlikely to contribute their ideas until they agree on dividing a future outcome. The more innovative is this outcome, the higher the uncertainty over asset values and the greater the chance of deadlock.

This situation leads individuals to withhold their ideas, resulting in a reduced dissemination of existing knowledge and an overall reduction in innovation either because knowledge

is unavailable or because organizations waste resources rediscovering it. Further, nonrivalry of information creates the potential for leakage among the developing participants and, with leakage, the potential for competitive supply. The result of Bertrand price competition among the players is to destroy profits. Realizing this risk beforehand, valuable participants can rationally avoid new opportunities and shun their associated costs.

In contrast, a commitment to fairness not only mitigates risk, it can also prompt early disclosure. Such a commitment has the potential to maximize the willingness to contribute an asset ex ante, which can then be used to create new ideas and encourage subsequent participation. An increase in feasible agreements then increases potential innovation. More precisely, a commitment to a fair allocation ex ante reduces "opportunism risk" in a transaction cost and ownership sense ex post. Further, fairness encourages new information to be gathered that, by increasing the convergence of beliefs, increases the range of feasible transactions.

Our key argument is that commitment to a fair reward is socially efficient. The capacity for innovation rises as parties with complementary resources, particularly information, find ways to agree on combining those resources. Traditional mechanisms that focus on ownership and control as the means to eliminate opportunism overlook this form of efficiency gain. We show this proposition formally both for individuals and two-party transactions, then more generally for repeated and multi-party interactions. Individuals can rationally prefer a rule of fairness based on pure self-interest in a single event without the added justification of repetition, reciprocity, or "other regarding" preferences of any kind. Section 2 provides motivating cases. In Section 3, we review relevant literature and provide definitions. Parts 4.1, 4.2, and 4.3 show how self-interest can motivate fairness, how society has an even greater economic interest than individuals, and how exercise of our fair reward principle improves resource allocation. Final Sections 5 and 6 develop legal implications for use of liability rather than property rules for information and provide summary conclusions.

2 Motivation: Evidence of Fairness and Innovation

We begin with an old question: what factors are relatively more important in helping societies create wealth? If governing institutions are relatively more important than other factors, then misallocations of entitlements have large effects. Fairness, we argue, represents one such factor. We illustrate with examples of historic growth, scientific research, and entertainment.

2.1 Just Governance & Wealth Creation

Environmental hypotheses dating to the 16^{th} century hold that geographic factors such as heat affect human effort (Machiavelli 1519), that types of crops, domesticated animals, and agriculture affect food production (Diamond 1997), and that diseases, such as malaria, and available transportion, such as navigable waterways, drive income (Sachs 2001).

A competing institutions hypothesis, however, is almost as old. Arguing in favor of property rights, Locke ([1690] 1980) wrote that individuals require the ability to appropriate the fruits of their labors and that the main purpose of government is "the preservation of the property of ... members of the society" (p. 47). Adam Smith argued similarly that efficient allocation of property rights contribute to the wealth of nations (1776). North and Weingast propose that wealth is a function of "whether the state produces rules and regulations that benefit a small elite and so provide little prospect for long-run growth, or whether it produces rules that foster long-term growth" (1989, p. 805-806).

Using data on hundreds of colonial interventions as natural experiments, Acemoglu et al. (2000, 2002) show that governing institutions explain as much per capita GDP as competing hypotheses that include climate, disease, and natural resource endowments. Naturally richer populations often saw their fortunes reverse under the influence of "extractive" governance even as relatively poorer populations grew rich under "good" governance. In contrast to the former, the latter more fair institutions are characterized by (i) a respect for property rights

that favor investment and participation (ii) checks on the power of elites who could unjustly take investments of others and (iii) a measure of equal opportunity. Beyond speculative theorizing, statistical evidence suggests that "forces of nature" explain less poverty than "man made" influence. The startling importance of just institutions to wealth creation is easily apprehended upon realizing how different were the growth of domestic product and rates of innovation that followed the partitioning of Germany into East and West, and of Korea into North and South (Acemoglu et al., 2002).

2.2 Collaborative research: the fight over HIV blood tests

Property rights that function in all-or-nothing fashion can discourage information sharing. When asset owners contribute assets to an innovative activity without prior agreement specifying ex post divisions of surplus, asset owners can feel cheated, even if they had no ex ante expectation of compensation. Even when formal agreement has occurred, as in many employment contexts, employee inventors can feel exploited (Merges, 1999). Having felt cheated once, neither the source of an idea nor an analogous third party will typically share further, chilling innovation.

Development of HIV blood tests, for example, arose from expeditious sharing across three laboratories: the National Cancer Institute (NCI), the Institut Pasteur, and the Institute of Cancer Research (ICR). NCI and IP each filed for patents, but the USPTO issued NCI the patent in 1985. An Institut Pasteur suit filed in 1987 led to a royalty sharing settlement. Later, information emerged that raised questions about the relative contributions of NCI and Institut Pasteur, particularly in light of contributions that ICR made to Institut Pasteur's efforts as well as questions as to whether the NCI used a copy of the Institut Pasteur version of the virus to develop the blood test. Institut Pasteur felt that its contribution was being undervalued and threatened additional litigation, however ICR complained that

Institut Pasteur had broken its promise to share profits. Thus the French were upset with the Americans, and the British were upset with the French. Although the dispute was ultimately settled with a reallocation of royalties, the acrimony prompted the director of IP to proclaim at one point that without a proper resolution, "I'm afraid that the cooperation which has existed between our two institutions, and more generally between scientists, will be greatly damaged" (Cohen, 1994, p. 23). The lead researcher involved with ICR's efforts similarly expressed "little appetite to enter into new negotiations [as] Institut Pasteur has not honoured a previous cooperative agreement" (Seytre, 1992, p. 358). In the absence of fair allocations, information sharing halts.

2.3 Entertainment, Hold-up and Recombinant Culture

At the turn of this millenium, business models for information goods evolved significantly due to initial misapprehension of how recombinant information and redistribution created value. In 1996, Paramount issued cease and desist letters to webmasters of Star Trek fan sites over copyright enforcement concerns.[1] Yet, by 2008, Casey Silver productions provided fans with tools to remix scenes from its movie Forbidden Kingdom and post fan-supplied modifications on the Web.[2] In 2000, A&M Records along with the band Metallica filed suit against Napster for contributory copyright infringment based on peer-to-peer file sharing.[3] Yet, in 2008, Radiohead freely offered tracks for fans to remix and distribute in order to promote its music.[4] In the 1980s, Apple Computer charged thousands of dollars for its systems development toolkits (SDKs) yet twenty years later reversed course and gave away iPhone development tools for free (Eisenmann, et. al. 2006). Microsoft, taking this a step further for its Xbox gaming platform, gave away SDKs such that even gamers with modest

[1]Steve Silberman, "Paramount Locks Phasers on Star Trek Fans" *Wired* Dec. 18 (1996).
[2]Source: http://www.youtube.com/forbiddenkingdom. Retreived April 20, 2008.
[3]17 U.S.C. A&M Records. Inc. v. Napster. Inc. 114 F. Supp. 2d 896 (N. D. Cal. 2000).
[4]Source: http://www.radioheadremix.com/.

programming skills could create content and add platform value.[5] For most of 2006–2009, the single most popular video on YouTube was "The Evolution of Dance," a six minute humorous choreography, interpreting thirty two hit songs.[6] No segment lasts longer than twenty seconds, a sample size smaller than that provided by Apple to help consumers choose to buy individual songs online.[7]

Among numerous legal issues, two economic issues arise from these developments: (1) does putative infringement serve as complement to or substitute for the original work and (2) do negotiation costs under threat of injunctive relief swamp the economic benefits relative to other forms of protection.

Infringment of copyright provides injunctive relief as remedy. This permits copyright owners the use of take-it-or-leave-it offers as strategy. The trouble that results from such a hold-up strategy is that it allows the injunctive rights owner, when bargaining with a non-owner, to extract nearly the full value of any transaction (with full information it *is* full value.) For recombinant works, this affords the last negotiating rights holder undue influence much as the last negotiating landowner exercises undue bargaining power relative to other landowners. Any effort to develop indistinguishable parcels from a multi-parcel tract of land faces rising hold-up costs. For works of modest value, such as a single sample of a song, image, or video, negotiation costs can vastly exceed market value. For transformative works, insignificant inclusions of lesser material can retard or reduce the prgress of more valuable material as when the release of the movie *12 Monkeys* was enjoined due to the appearance in several scenes of a copyrighted chair.[8] As we argue in Section 5.1, "the progress of science and useful arts" is better served by a fair use of liability rather than property rules in the

[5] "Microsoft Gives XBOX 360's SDK to the World" *OS News* Aug. 14, 2006.

[6] Erin Carlson "Footloose! Video of dance medley becomes Internet hit" *USA Today* Jun 5, 2006 and Wikipedia.org entry "Evolution of Dance" retreived July 14, 2009.

[7] Ibid. and Apple iTunes Store, accessed June 30, 2009.

[8] Woods v. Universal City Studios, Inc., 920 F. Supp. 62, 65 (S.D.N.Y. 1996). Cited in Lemley & Weiser (2006).

cases presented above in order to address the issues of complementarity and negotiation costs.

2.4 Ownership of Employee Innovations:

Although R&D employment in an established firm entails less risk than in a startup, employees in established firms can feel they have been treated unfairly when they invent a successful technology (Merges, 1999). The inventor of sedatives Librium and Valium, for example, earned several hundred thousand dollars, yet this represents a tiny fraction of the earnings of his employer Hoffman-Laroche. Under current default rules, employers generally own the inventive output of their employees who are "hired to invent" (Merges, 1999). As one court held, however, if the inventor is opportunistic he or she can use the firm's R&D resources and "virtually conceive" an invention, as long as the inventor leaves before "completely conceiving" the entire invention.[9] According to Merges, "an employee is in general free to leave a firm, develop an inchoate concept, and enjoy full ownership of the resulting invention" (1999, p. 51). Thus, in order for the employee to reap the full benefit of their invention, they must leave the firm at a point in time where the successful exploitation of the invention is highly uncertain. Why would an employee engage in such behavior, particularly if the established firm has the necessary complementary assets to fully exploit the invention? An employee who believed he or she would receive fair compensation ex post, would be more inclined to fully disclose inventive activities, even if the ultimate outcome would be to spin off a new firm to focus on the new invention. Since the current default rules are "property" rules, which dictate ownership, rather than "liability" rules, which determine compensation, (Calabresi & Melamed, 1972; Kaplow & Shavell, 1996), they generally lead to such all-or-nothing outcomes. As Merges notes, "Ownership is too blunt an instrument

[9]Jamesbury Corp. v. Worcester Valve Co., 318 F. Supp. 1 (D. Mass. 1970), but see Cubic Corp. v. Marty, 229 Cal. Rptr. 828 (Ct. App. 1986) (inventor granted a patent on invention developed while still an employee of the firm; firm ultimately awarded ownership of the patent).

to be an effective inducement to employee-inventors" (1999, p. 37).

3 Relevant Literature

3.1 Philosophy of Ethics & Behavioral Empirics

A brief review of conceptions of fairness will aid analysis. One widely used articulation is Aristotle's well worn dictum to "treat equals equally and unequals unequally" (Aristotle 350 B.C.E). Equality of individuals along any given dimension – position, ability, effort – implies equality of disbursements along that dimension. Inequality of individuals implies unequal disbursements. To address the latter case, he recommends proportional fairness, letting the ratio of individuals' attributes point to the ratio of their rewards. Aristotle's rule is generally interpreted as an impartial and universal principle, implying that fairness is more than consistency in one's own subjective decisions; it is also an objective justification of one's decisions to others.Certain authors have interpreted consistency in equal-treatment-of-equals as a consequence of rationality because inconsistency implies irrationality (Berlin 2001) but multiple authors take this form of fairness as an axiomatic starting point from which to judge allocative efficiency (Moulin 2004). Emphasizing the former case, Aristotle's dictum is an insight we seek to derive rather than assume. In fact, we can take self-interest rather than consistency as axiomatic.

Moore (1903 [2004]), however, argues that formal derivation is difficult by calling into question the objectivity of ethical determinations such as goodness or in our case fairness. He labels as a "naturalistic fallacy" any attempt to prove claims about the truth or falsity of ethical assertions. In his view, such assertions are *sui generis* and neither reducible to nor derivable from scientific assertions. Whether a decision is "good" or a division "fair" depends on a value judgment, not a property of nature. Without recourse to derivation from

non-moral truths, one must recognize ethical propositions as self-evident moral intuitions. Their purpose is motivational, to guide action. That one "ought to do x" means that "x will produce the most good" (Moore, 196-198 [2004]). Allowing v to represent a placeholder for any index of value, we take the modest approach of rank ordering natural outcomes in order to show that $v + \Delta > v$ whatever v may be. If the absence of fairness implies the absence of Δ then, in a formal sense, we might be said to have proven Moore's injunctive intuition that fairness will produce the most good.

A third set of ideas that will aid analysis depends on Rawls' conception of justice as fairness. Rawls poses the question of how to design the fairest possible social contract accounting for individual endowments such as position, ability, and wealth. To be truly fair, he asserts that one should choose the rules for allocation behind a "veil of ignorance" regarding such endowments. Stripped of knowledge regarding one's race, class, wealth, and skill, all parties have equal and unbiased voice. Rawls argues that as the purpose of justice is to resolve disputes and allocations on the basis of prior agreement rather than force, negotiating from behind the veil of ignorance is fair. He concludes that justice, as fairness, puts people in positions they would have held but for undeserved disadvantages as well as advantages. We further develop these insights into rational choice while modestly challenging distributive policies that can reduce effort incentives.

If these are the relevant theories on fairness, what then are people's actual behaviors? Substantial experimental evidence documents routine violations of the standard axiom of "self-interest." Instead, people typically divide resources more equitably (Fehr & Schmidt, 2003; Jap, 2001). The classic test is the Ultimatum Game in which one person, the proposer, has power to divide \$1 in two amounts, one for himself, the other for an agent who only has power to accept or reject the offer. If accepted, both parties get the proposed amounts, but if rejected, both parties get nothing and negotiation halts. The standard theory of self-interest argues that agents should accept any offer above 0. Knowing this, proposers should offer a

($.99, $.01) split. Empirically, however, 40-60% of agents reject offers below $.20. By this logic, a majority of proposers offer enough to maximize their expected gains (Fehr et al., 2003). A literature survey finds that dozens of experimental variations confirm one basic result: people's internal preferences weigh some measure of equity. Interestingly, the literature offers no axiomatic reason why this should occur, and instead revises utility functions to explicitly weight fairness (Fehr et al., 2003). Indeed tendencies toward fairness appear to be innate in humans, appearing as early as age four (Hauser, 2006) and even in non-human primates (de Waal, 2006). Field research on organizations outside the laboratory confirms similar results. Would-be collaborators face a delicate balance between trying to "expand the pie" versus laying claim to larger portions of a "divided pie." Firms evaluate collaborators in terms of outcome fairness, relative contributions, and also future expectations for similar projects and similar behaviors (Jap, 2001). If agents behave opportunistically in the short run, they can develop reputations that limit their collaborations in the long run. Indeed, reputations have served this function for centuries (Greif, 1993) - a function we revisit in Section 4.2. Current economic theories of fairness and reciprocity are based on the idea that actors compare themselves with a set of reference actors (Fehr et al., 2003). Our framework does not require such a comparison. We do not suggest that "other regarding preferences" do not exist - plenty of empirical evidence suggests they do. Rather, we are among the first to demonstrate a simple model of self-interest that can explain fairness without recourse to more complex assumptions.

While many since the time of Moore have considered fairness a moral choice, we argue it is an economically rational choice. The reason is that, unlike tangible resources, ideas cannot be withdrawn once shared. In section 4.1, we combine a simple mathematical model of the Ultimatum Game with precepts of moral philosophy (Rawls 1999) to demonstrate fairness is rational on the basis of self-interest alone. It is not necessary to resort to reciprocity, inequality aversion, or other regarding preferences.

3.2 Information and Innovation

Arrow's (1962) seminal article examines whether the market will allocate the socially optimal level of resources to inventive activities and finds that they do not. He then identifies four factors that cause innovation markets to fail, all based on information. First, utility and production functions must be well-defined functions of a market's commodities. The absence of complete contingent claims markets, however, rules out the possibility of hedging against uncertainty. Among risk averters, underinvestment necessarily follows. In fact, the "value of information for use in developing further information is much more conjectural than the value of its use in production and therefore much more likely to be underestimated" (Arrow, 1962, p. 618). Second, innovators cannot always fully capture returns to innovation. As in the case of most public goods, the problem of non-excludability deters the production of assets by private investors who cannot recover their costs. If investors could contractually capture the future value of such investments, the non-excludability problem would disappear, but this is infeasible for ideas that are pre-grant of property. Third, is the problem of monopsony identified as an instance of hold-up (Williamson, 1998). If a sole landowner is unaware of the prospect her land contains oil, an oil firm with relevant expertise can be under-motivated to develop this information without a claim on project profits. Further, the mere act of sending an oil firm representative to negotiate alerts the landowner to this prospect, allowing her to hold the firm to its reservation price. Some might argue this is efficient because the landowner provides the indispensible asset but this is incorrect. It considers projects strictly in isolation and distorts the incentives of this, and similar, firms who can strictly prefer competing projects of lower net social welfare. Fourth, is the problem of "demand determination," which is more easily understood as the "inspection paradox" (Van Alstyne, 1997). A prospective buyer frequently cannot assess information's value without possessing the information. After receiving it, however, the buyer no longer needs the provider. In the

usual sense of things, it cannot be returned. Being less able to sell it, inventors are less likely to create it.

3.3 Property Rights and Principal Agents

While fairness is sufficient to prompt disclosure, ownership is not. Ownership permits one person to physically dispossess another of a tangible good but ownership of an idea never permits one to remove it from another's comprehension once shared. When ideas rise to the level of property, they can be excluded from use but they cannot be forcibly forgotten. This nonrivalry produces positive externalities for people other than the source of an idea. The Coase Theorem (Coase, 1960) suggests that who has control ought not matter so long as transaction costs are negligible, contracts enforceable, and property rights well defined. The question of who can produce a positive benefit (or avoid a negative benefit) at lowest cost can, in theory, be solved by markets. The Coase Theorem, however breaks down in this context. First, it does not resolve the Inspection Paradox, which limits information trading. Second, it has little to say about externalities that have yet to be produced and whose trading value has yet to be determined. Coase acknowledges that if a diffuse group experiences the externality, then collective action and free riding problems raise transaction costs and do affect the optimal assignment of property rights. With respect to producing information, however, the revelation problems due to inspection and monopsony also impair contract negotiations, producing market failure. Resolution in the current context will focus not on the assignment of entitlements but on the establishment of processes. Insights from the Coase Theorem have received new interpretation in other ways as well. A central tenet of more recent property rights and principal agent literatures is that ownership matters to economic efficiency. It provides not just control but also incentives. These rights matter when unforeseen contingencies arise giving the owner a choice over how to proceed. Asset

disposition then tracks the interests of its owner, which in turn leads to "opportunism risk" for the non-owner, the condition of "self-interest seeking with guile" (Williamson, 1985, p. 30). Where necessary investments are concerned, a more risk neutral party should receive ownership relative to a more risk averse party in order that projects with positive expected gains are actually pursued (Fama & Jensen, 1983). We add to the economic theory of incentives that, until now, has focused on effort rather than disclosure. Under the theory of incomplete contracts (Grossman et al., 1986; Hart et al., 1990), ownership provides the incentive to invest creative effort because the residual right to control an asset in unforeseen contingencies assures its possessor of gains derived from that asset. Ownership provides bargaining power via the right to dispossess others. Not so for ideas and information. To disclose an idea is to forfeit bargaining power. Nonrivalry prevents the originator from ever dispossessing his audience of any concept he chooses to reveal. If his ownership were to rise to the level of a property right, which is rare for most ideas, then he could prevent use but he could not actually effect disposition. Losing residual control over gains derived from his asset, can easily motivate the originator to guard against disclosure. But before the act of transfer, the audience has little basis for judging either the idea's merit or its indispensability in an invention that has not yet occurred. The parties deadlock. Under our proposal, an ex post guarantee of reward in proportion to contribution provides incentive to disclose ideas where ownership, protected only by information asymmetry, is ineffective. Upon disclosure of an idea for purposes of transfer, the discloser loses all bargaining power with respect to claims on gains derived from that idea. Assuming that efficiency gains are sufficient to merit buying complementary assets, the theory of incomplete contracts (Grossman et al., 1986; Hart et al., 1990) argues persuasively for combining complementary assets under a single owner. Yet, in the case of information goods, it remains silent on how transfer might be achieved. Goods whose existence are protected by secrecy represent poor candidates for market trade. Information revelation remains a problem. In a manner analogous to the

processes of "gap-filling" that allows incomplete contracts to proceed (Ben-Shahar, 2004), a commitment to fairness moves the weight of contract negotiations from haggling over anticipated contingency enumeration to ex post verification of contributed value. Those who, in retrospect, add more value now, receive more value later. A commitment to fair allocations also provides the means to avoid revelation problems that hamstring contract negotiations when at least one party is ill-informed. We turn to more precise definitions below.

3.4 Definitions and Mechanism Choice

For innovation purposes, we define "fair" to be reward in proportion to one's contribution.[10] Of several interpretations of fairness, this is the most economic (Moulin, 2003).[11] While we will use the reward definition of fairness together with the axiom of self-interest, we do not require that a mechanism be perfectly fair. Such a strict criterion can well be untenable: transaction costs can be excessive; perfect information can be unknowable; and the color of perfectly fair - seen through the lens of self importance - can be unverifiable. Rather, we require that a mechanism approximate fairness in the sense that an allocation induces the broadest possible participation in actuarially positive entrepreneurial activity both before and after the allocation is realized. The reward principle and axiom of self-interest can, as we will show, achieve this. But, of the properties that they induce, two criteria are paramount:

- Ex ante, the prospect of reward fairness is sufficient to motivate essential parties to invest their resources in innovative activity.

- Ex post, realized reward fairness is sufficient that neutral third parties, with analogous

[10] Examples include Shapley Value (1953), Edgeworth's "Core" (1881) or Schmeidler's "Nucleolus" (1969).

[11] Others are exogenous rights (e.g. "one person, one vote"), compensation (e.g. providing shelter after a natural disaster), and fitness (e.g. giving the flute to the floutist).

resource opportunities, would likewise have chosen to invest.

So long as each party's notion of fairness conforms to these two attributes, they need not have the exact same definition of fairness. Thus one party could be guided by Rawlsian notions of justice (Rawls, 1971) while another party's notions of fairness could be influenced by conceptions of morality (Habermas, 1993) or principles of human welfare (Kaplow & Shavell, 2001). Judged in terms of total social welfare, we assert that no allocation mechanism can do better. We provide a syllogistic proof. Consider the contradiction implied by any mechanism that violates either criterion. First, if any person or coalition is motivated to withhold useful project resources, then some level of innovation is blocked. Total welfare will be inferior. Second, if on project conclusion any analogous party is motivated to withhold useful resources to any analogous or subsequent opportunity, then the potential for at least some further innovation is likewise blocked. Total social welfare can never be greater. If an inferior mechanism is one that violates either criterion, then an optimal mechanism must have both. These criteria do not by themselves address the question of relative innovation value. Given limited resources in a space of less limited opportunities, they do not select for which projects members of a society should choose. As a first cut, these criteria are simpler than that. From among the pool of possible mechanisms, they select and discard those mechanisms that preclude innovation by discouraging participation. As we shall see, however, the ordinal ranking of projects can also improve, implying further gains in efficiency. Still, of particular interest, is the fact these criteria show certain widely used mechanisms to be suboptimal. This includes, for example, the Coase Theorem, which encourages the use of property as distinct from liability rules as a means to social efficiency. Under the new proposal, efficiency gains result from (1) unblocking innovation due to information hold-up and (2) improving the sort order of projects in which people invest.

4 Model

4.1 Self Interest in Fairness

This section illustrates the ubiquitous nature of the problem caused by a lack of information about the future. Thus a reason for resorting to procedural fairness is not having ex ante access to actual fairness. Before it has arrived, no party knows the future, which assets will have become indispensible, or which will turn out to have been irrelevant. This blindness, though ultimately resolved, metaphorically imposes Rawls' original position in which parties must agree on rules for justice behind a "veil of ignorance." The problem applying basic principal-agency theory, the main model of information asymmetry, is that, without Rawls' veil of ignorance, each party already knows his endowment, and self-interest in fairness is already too late. The principal knows he's the prince and the agent knows he's the pauper To demonstrate self-interest in fairness without inequality aversion, other regarding preferences, or recourse to reciprocity, we revise the Dictator Game using Rawls' idea of original position to create a simple model. As before, the "dictator" has power to allocate share $x\%$ of a future reward to himself leaving $(1-x)\%$ for a recipient.

Proposition 1 *(Sufficiency of Self-Interest): In a Rawlsian Dictator Game, self-interest is sufficient to motivate fairness. The greater the role uncertainty, the more equal is the division rule chosen by a risk averter. For complete uncertainty, the equal division rule is the unique optimum regardless of risk profile.*

Proof. *Utility maximization from exercising the proposer's role with likelihood λ, while keeping $x\%$ for oneself is:*

$$max\ \pi = \lambda u(x) + (1-\lambda)u(1-x)$$

Rearranging the first order condition $\frac{\partial \pi}{\partial x} = \lambda u'(x) - (1-\lambda)u'(1-x) = 0$, *produces*

$$\frac{\lambda}{1-\lambda} = \frac{u'(1-x)}{u'(x)}$$

Complete uncertainty occurs when $\lambda = \frac{1}{2}$, *implying* $u'(x) = u'(1-x)$. *For any strictly increasing utility function* $u'(x) > 0$ *defined on* $x \in [0, 100\%]$, *this equality can only hold when* $x = 1 - x$. *Thus complete uncertainty implies* $x = \frac{1}{2}$ *uniquely. Further, for risk averters* $u'(x) < u'(1-x)$ *for all* $x \in [\frac{1}{2}, 1]$ *thus the above ratio also shows that rising certainty in the dictator role* $\lambda \in [\frac{1}{2}, 1]$ *implies keeping a rising share* x *for oneself.*[12]

■

Two points bear mentioning. First, this shows only that ex ante role uncertainty coupled with self-interest justifies preferring an equal division rule. Ex post, knowing λ to be either 1 or 0 eliminates impartiality, and self-interest motivates unequal division. The proposer and receiver, beign equally important to the outcome, each get equal shares. Natural preferences espoused ex ante therefore require enforcement ex post. Preventing this shift is at least consistent with observed willingness to punish low offers in the Ultimatum Game. We describe another forebearance mechanism in Proposition 4. Our distinction between pre and post innovation codifies Rawls' insight that an original position of ignorance with respect to one's role leads to a preference for equality among roles. Ignorance of the future is a "veil of ignorance." Arrival of the future pierces this veil. Second, our demonstration so far only speaks to the division of surplus not to its creation. For that, we introduce a model of innovation among two parties and show that absent a fair process, they can jointly fail to innovate despite sure positive gains. Commitment to a fair process reduces this form of market failure.

[12]This is true for any increasing but marginally diminishing utility function $u'(x) > 0$ and $u''(x) < 0$, i.e. for all risk averters. To illustrate, let $u(x) = ln(x)$ since $u'(x) = \frac{1}{x}$ which then implies $x = \lambda$ for all x.

Let v represent intrinsic value and Δ represent the increment or change in value created by innovation. If v corresponds to a tangible good, it is socially efficient and privately rational to contribute whenever $\Delta > v$. As v is consumed in the production of Δ, total social wealth naturally grows when Δ exceeds v. Further, v's owner can lay claim to at least value v[13] by virtue of bargaining power conferred by property entitlements in v. In contrast, if v corresponds to an intangible good, it is socially efficient to invest whenever $\Delta > 0$. Nonrivalry of v implies that production does not consume it. The division of Δ and effects on v's value, however, can imply that private incentives diverge from social incentives except in limiting cases. Sharing private knowledge can create new wealth enjoyed by others yet simultaneously cause the value of that knowledge to degrade. Because v is nonrival, source i keeps v, but good ideas that are not (or are not yet) property create no entitlement in Δ. She cannot force j to forget v or forgo its use. Thus she has no bargaining power. This constrains her sharing because recipient j is also now source j and yet also competitor j for any benefit derived from v.

To clarify, we carefully examine the aphorism "give a man a fish and he'll eat for a day but give a man a fish and he'll eat for a lifetime." which contains deep insight while it obscures deeper hidden costs. Sharing information creates no reduction in the but creates competition for the value. A fisherman might feed his family, and even neighbors best, by sharing his fish with a few and not his private knowledge with the world. If information provides a claim on an even partially rival resource, then either the loss of bargaining power or the threat of competition can make hoarding privately rational when sharing is socially optimal. Fairness softens this problem. The problem of motivating innovation based on intangibles is subtler and harder than that based on tangibles.

Proposition 2 *(Divergence of Rival and Nonrival Incentives): Relative to tangible goods,*

[13]For simplicity, we use 'v' interchangeably to denote both a specific resource and its value.

the threshold for creating wealth from intangibles is lower and yet the likelihood of divorcing benefits from costs is greater. Increased incentive to hoard information can result from loss of bargaining power, threat of competitive supply, and threat of competitive claims.

While the above illustration highlights the problem for a single individual, the problem becomes more complex for two or more parties in negotiation. In fact, even if agents have correct expectations about the value of an asset v and the incremental wealth Δ created by using it to innovate, they can still fail to reach agreement if uncertainty about the range of values for Δ is large enough. To illustrate this problem more specifically, let there be prospective partners i and j and, as before, let each have an asset with true value v_i and v_j respectively. The first agent can invest on his own and create value Δ_i but if both parties combine assets, then together they can create incremental value $\Delta_i + \Delta_{i+j}$. To make the problem simpler and also establish conditions favoring a negotiated agreement, let agent j have no outside investment option so $\Delta_j = 0$ and let both parties agree that $E[\Delta_{i+j}] > 0$ so that investing always makes sense. Further, let there be no uncertainty over jointly created value such that $\sigma_{i+j} = 0$ implies $E[\Delta_{i+j}] = \Delta_{i+j}$, providing no cause for disagreement. But then let there be private information over i's relative contribution alone. Specifically, let agents have independent beliefs x_i and x_j both drawn from the distribution $x \sim [\Delta_i - \epsilon, \Delta_i + \epsilon]$. Prior to investment, no one knows realized value $\tilde{\Delta}_i$ for certain. Rather each has an imperfect impression that is actually unbiased, since the mean is zero, but since the range is $-\epsilon$ to $+\epsilon$, the variance $\sigma_i = \frac{\epsilon^2}{3}$. Since this is above 0, they can fail to agree.[14] We explore ways to relax these assumptions below. For reference, a Nash bargaining or "fair" economic price would split the jointly created value, giving i an amount $v_i + \tilde{\Delta}_i + \frac{\Delta_{i+j}}{2}$ and j an amount $v_j + \frac{\Delta_{i+j}}{2}$, but parties do not know $\tilde{\Delta}_i$ in advance. For the moment, our question is simply: If prospective partners are required to decide on an allocation ex ante, is there

[14]Variance on a uniform distribution $x \sim [a, b]$ is $\sigma^2 = \frac{(b-a)^2}{12}$.

sufficient reason to believe that they will fail to agree. In its simplest form, if i were to sell his asset to j, is there positive probability that seller i thinks the asset is worth more than buyer j is willing to pay? Even with the most generous seller, allowing the buyer to capture all incremental surplus, the answer is yes.

Proposition 3 *(Joint Innovation Failure) Despite sure positive returns $\Delta_{i+j} > 0$ with favorable $E[\Delta_i] > 0$ and unbiased $E[\epsilon] = 0$ beliefs x_i and $x_j \sim [\Delta_i - \epsilon, \Delta_i + \epsilon]$, there is positive probability that two agents cannot reach agreement due to non-overlapping expectations over contributed value.*

Proof. *We show that a positive probability exists that the buyer thinks the asset is worth less than the seller does, even after accounting for value creation. Initially, the line defining equal beliefs is the 45° line $x_j = x_i$. As shown in Figure 1, all points northwest of this line are the zone of possible agreement ($ZOPA$) where the buyer believes the project to be worth at least as much as the seller does. Southeast of this line, the seller believes it to be more valuable than the buyer believes he should rationally pay. The seller's $BATNA$ is then to walk. If the buyer receives the marginal investment value of the seller's asset Δ_i, then he only needs to believe the project is worth $x_j - \Delta_i$. This belief shifts the boundary down, increasing the $ZOPA$. More precisely, if the probability of no agreement is the ratio of the lower right triangle ($BATNA$) to the total area, then agreement is reached with probability:*

$$p(ZOPA) = 1 - p(BATNA) = 1 - \frac{\frac{1}{2}(2\epsilon - \Delta_i)(2\epsilon - \Delta_i)}{(2\epsilon)(2\epsilon)} = 1 - \frac{(2\epsilon - \Delta_i)^2}{8\epsilon^2}$$

If $2\epsilon > \Delta_i$, then reaching agreement is not certain despite the fact that the project always creates positive surplus $\Delta_{i+j} > 0$, the seller is willing to accept his own project value alone $v_i + x_i$, and the buyer gets the full jointly created value Δ_{i+j}. Failure results simply from divergent private beliefs over the contribution from i's assets. ■

Several additional observations follow regarding group level investment failure. First, if i's marginal contribution Δ_i is sure enough, agreement always occurs. Graphically, for $\Delta_i \geq 2\epsilon$, large payoffs expand the zone of possible agreement in Figure 1 past the boundary for even the worst possible outcome. $BATNA$ shrinks to zero. Reward not only outweighs the risk, it is so great relative to agents' diverging beliefs that even their opposing views leave room for exchange. Second, in contrast to the previous result, this proof has nothing to do with the risk profile of either agent. Either can be risk loving, risk neutral, or risk averse, and this condition can hold. We state the third observation more formally as a corollary.

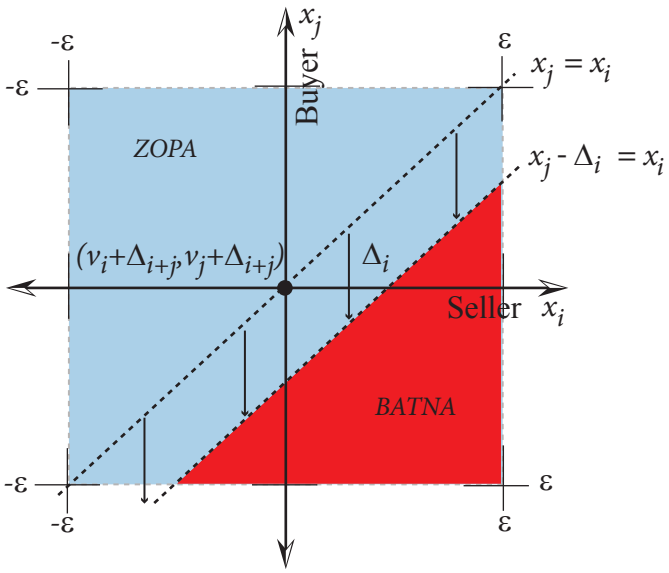

Figure 1: The Zone of Possible Agreement expands as innovation value increases but shrinks as uncertainty increases.

Corollary 1 *When investment is not a sure bet* $2\epsilon > \Delta_i$*, rising uncertainty decreases the chances of agreement and rising innovation value increases the chances of agreement, i.e. derivatives are respectively* $\frac{\partial p(ZOPA)}{\partial \epsilon} = \frac{\Delta_i(\Delta_i - 2\epsilon)}{4\epsilon^2} < 0$ *and* $\frac{\partial p(ZOPA)}{\partial \Delta} = \frac{2\epsilon - \Delta_i}{4\epsilon^2} > 0$.

Proposition 3 and its Corollary show that even though the asset could always be contributed to the research project at a fair price, transfer can fail to occur because beliefs of both parties permit no room for negotiation. Increasing the number of investors, each with different beliefs over their relative contributions, can increase problem difficulty. Further,

this analysis actually assumes that the project returns not just Δ but $v + \Delta$, which is reasonable given that the owner can contribute v and will still have it by virtue of the fact that an information resource is nonrivalrous and is therefore recoverable ex post. But if another party to the project learns this information and becomes a competitor, also because it is nonrivalrous, then by Bertrand price competition this value can fall to zero. If a person risks losing the asset entirely, then a project that generates positive benefit Δ for society leaves the investor worse off than before she started, and she never rationally invests. Reducing contractual uncertainty has the potential to increase social surplus. For individuals, this contractual uncertainty is the range between when an investment yields positive expected value and when it yields positive expected utility. Since the probability of deal failure due to opportunism risk is given by $p(BATNA)$ in the group case, we have the following.

Proposition 4 *(Social Welfare Gains) The potential increase in expected welfare is given by* $p(BATNA)(\Delta_{i+j}) = \frac{(2\epsilon-\Delta_i)^2}{8\epsilon^2}(\Delta_{i+j})$.

We can interpret these gains as expected increments to social surplus from "agreeing to disagree." These are the potential change in beliefs times the joint innovation value.

Note that the entire region of Figure 1 is red in the case that neither person is aware of the other's resource and thus unable to negotiate. Suppose, in contrast, that the default rule enforced the fair reward principle in any instance where i used j's resource. Then j (and also i) to broadcast her idea. This has the potential to recover the entire region.

4.2 Social Interest Exceeds Self Interest

The fact that unforeseen contingencies create opportunism risk does not imply that parties advantaged by new developments will necessarily exploit those placed at a disadvantage after project completion. A reputation for self-restraint can tip the willingness of others

with similar projects in favor of consummating a deal. What conditions cause rational agents to avoid exploiting their partners when given the chance to do so? Suppose that exploiting a partner now implies that new partners will, on margin, avoid you in the future despite the existence of deals within the ZOPA, a situation similar to the AIDS problem. If among the population there are at least Nother similar projects, then the expected gain of sharing half of the future surplus from lost projects discounted to the present time is $\frac{1}{2}\sum_{i=1}^{N}\delta^i p_i(ZOPA)\Delta_i$ where δ^i is the discount applied to the i^{th}project having investment value Δ_i. Then, to make exploitation as attractive as possible and stress voluntary fairness as much as possible, we imagine that unforeseen contingencies arise giving one party all the residual surplus on the first deal. Given multiple projects, let subscript ij refer to a project between i and j. Then, a self-interested agent will voluntarily forgo exploiting a partner when $\Delta_{12} < \frac{1}{2}\sum_{j=3}^{N}\delta_1^{j-1}p_{1j}(ZOPA)$. In effect, this inequality establishes the following observation.

Proposition 5 *(Voluntary Self-Restraint): Given the chance to exploit a partner by seizing all project gains from the current project, high future project values Δ_i, high chances of reaching agreement $p_{ij}(ZOPA)$, and high levels of patience δ can each provide sufficient reason for self-interested parties to exercise self-restraint.*

We use this observation not for any intrinsic novelty[15] but rather as a baseline from which to draw social comparisons. The test of voluntary self-restraint becomes interesting when it fails. Frequently, the value of a just-completed innovation exceeds the expected future value of other projects available to an investing agent. If a patent is worth billions, a centuries old theorem is finally proven, or private knowledge was unprotected and need not by law be compensated, then one-time exploitation can be rational. Beyond an independent moral imperative, does society have an innovation interest in ensuring fairness when self-interest

[15]See Axelrod '84 for reputation as a forbearance mechanism

alone is insufficient and after innovative gains on one project have already been realized? Measured in terms of innovation value, the answer is often yes. If the lesson that independent parties learn from the experience of the exploited is the prospect of sharing similar fates, then they will choose non-participation. In such cases, the status quo is Pareto inferior to an investing alternative. Society is better served by ensuring an equitable division in order that in the future there is more to divide. In terms of a model, it is easy to construct cases where the self-interest of individuals costs a society dearly in terms of innovation. Apart from the two parties involved in the concluded project, if we simply account for the opportunities available to the $N-2$ other agent pairs, then where the test formerly failed on a value proportional to N for an individual, it now fails on a value proportional to N^2 for a society. Since the total social interest is the gains to both parties, the forgone social surplus is $\sum_{i=1}^{N}\sum_{j>i}^{N}\delta_i^{j-1}p_{ij}(ZOPA)\Delta_{ij}$. This opportunity loss worsens as we account for projects involving three, four, and more participants. This complexity leads us to observe:

Proposition 6 *(Social Interest in Allocative Efficiency): Measured in terms of innovation efficiency, society's interest in fair allocations exceeds that of the individual. Further, under fairly general assumptions, the opportunity cost to society of permitting unfair allocations ex post can arbitrarily exceed the realized gains of the unscrupulous investor or*

$$\sum_{i=2}^{N}\sum_{j>i}^{N}\delta_i^{j-1}p_{ij}(ZOPA)\Delta_{ij} > \Delta_{12}$$

In other words, the social surplus not realized by the population due to investment not undertaken is at least that forgone by the individual. It cannot be less by virtue of the fact that the social total includes the individual total. While this logic seems obvious once stated, it is non-obvious in accounting. In standard accounting practice, investments not made are investments not counted. Rather than intervene, the alternative is a facile status quo where none other than a single aggrieved party experiences any misappropriation, an alternative

that occurs only after innovation has, in fact, already happened. Returning again to the HIV problem, an inherent risk in exploiting an innovation partner is loss of agreement for repeated interactions with the same participant, or even with similarly situated participants who may communicate with each other. This notion can be generalized with a reference to the aphorism, "fool me once, shame on you; fool me twice, shame on me." The exploitative innovator will quickly find that the pool of potential collaborators quickly diminishes, and society ultimately pays the price in the form of lost innovation opportunities. Society's interest in fairness exceeds that of individuals so that diminishing fairness for one person literally diminishes us all.

4.3 Decentralization & Prioritization Advantages of Fairness

We can extend this analysis to demonstrate a second form of efficiency gain simply by allowing different projects to yield different payoffs. Then each person prefers to undertake the project that pays her the most first. A fair mechanism has the desirable property of aligning private choices with social optima. To simplify notation, without loss of generality, index the order of innovations by value such that $\Delta^1 \geq \Delta^2 \geq ...\Delta^N$.

Proposition 7 *(Social Sorting Principle) Under a fair reward mechanism, agents receiving their expected marginal contributions prefer the same ordering over their own projects as that preferred by a social planner. Thus vector* $\langle \Delta_i^1, \Delta_i^2, ...\Delta_i^N \rangle = \langle \Delta_{SP}^1, \Delta_{SP}^2, ...\Delta_{SP}^N \rangle$.

Proof. *Consider proof by induction across all possible projects. For the first agent, her preferred order defines the order of the social planner. For the induction step, consider any two coalitions* s_x *and* s_y *that offer competing projects to agent* i*. If marginal and total value of one project both exceed that of the other, then the agent and social planner both prefer the former to the latter. But, if marginal value for* s_x *exceeds that of* s_y *while total value of* s_y

exceeds that of s_x *then:*

$$V(s_x \cup \{i\}) - V(s_x) > V(s_y \cup \{i\}) - V(s_y)$$

but

$$V(s_x \cup \{i\}) < V(s_y \cup \{i\}).$$

Since the agent receives her expected marginal contribution, she strictly prefers project s_x *based on the first equation. Based on total welfare, the social planner prefers to assign* i *to team* s_x *when:*

$$V(s_x \cup \{i\}) + V(s_y) > V(s_y \cup \{i\}) + V(s_x)$$

Subtracting $V(s_x)$ *and* $V(s_y)$ *from both sides of this equation reproduces the first equation, confirming that the social planner also prefers that* i *join project* s_x*. Since projects* s_x *and* s_y *were arbitrary, pairwise ordering across all projects produces parallel orderings.* ■

Thus commitment to the use of a fair reward mechanism allows the decentralization of individual choices regarding innovation. Individuals choosing their privately optimal projects inadvertently choose the best projects without having to take direction from a social planner.

Suppose that among the population are agents j that would cheat agent i by expected amount h Alternatively, let any other allocation rule, form of favoritism, discrimination, or deceit introduce bias term $h > 0$, representing expected deviation from the fair allocation. Let s_x represent a coalition that has j as a member and s_y one that does not. Then we have the following observation.

Proposition 8 *(Bias Principle) By commiting to a fair reward mechanism, the joint sharing of information via project participation is at least as great as that under competing allocation mechanisms. Biased mechanisms cannot do better.*

Proof. *If $V(s_x \cup \{i\}) - V(s_x) - h < 0$, then agent i strictly prefers non-participation. If $V(s_x \cup \{i\}) - V(s_x) - h < V(s_y \cup \{i\}) - V(s_y)$, agent i strictly prefers to invest in her next best opportunity. In contrast, if $h < 0$ then bias represents a form of favoratism or subsidy to i. Then there exists at least one j, who receives less than her marginal contribution. Person j can now prefer her next best opportunity or strict non-participation for the same reasons as bias against i.* ■

Consider an allocation in which an entity with resource control receives more than proportional value. While this entity has reason to participate, project partners necessarily receive less than their proportional value. They therefore have reason to defect to other opportunities, on potentially inferior projects, so long as their allocation is at least as great. Deviation up or down from a proportional allocation thus implies the potential to select inferior projects. It should be clear that not only is the expected allocation proportional to expected contribution, but also that realized allocation is proportional to realized contribution. These need not be the same, in general, implying that any predetermined allocation introduces risk that allocation differs from contributed value. Divergence in turn implies at least a potential desire to defect with a concomitant loss in innovation. A mechanism that aligns allocation with contributed value should then correct this inefficiency. If this opportunity dominates alternative uses for this resource, then the person or coalition possessing it should rationally participate. The marginal value of the resource on this project exceeds the marginal value on its next best use, that is its opportunity cost. Conversely, consider an allocation in which an entity with resource control receives more than proportional value. While this entity has reason to participate, project partners necessarily receive less than their proportional value. They therefore have reason to defect to other opportunities, on potentially inferior projects, so long as their allocation is at least as great. Deviation in either direction from a proportional allocation thus implies the potential to select inferior projects.

A property rights mechanism, in contrast, does not guarantee the best choice of projects in total welfare terms. Rather, it encourages property rights owners to choose highest private gains that can be secured by the threat of project defection. In cases where anticipated gains are unambiguous, property rights and low cost negotiation lead to an optimal choice of projects, consistent with the Coase Theorem. But, if due to the inspection paradox, the author of an idea risks losing it merely through attempting to communicate its value, then relying on property rights for a nonrival good can lead to failed or inferior investments. Authors of ideas that do not rise to the level of patents or copyrights can rationally choose to withhold them in an effort to pursue other opportunities with greater private expected gains. Thus fair mechanisms, as distinguished by reward proportional to contribution and thus bias free participation, offer two forms of efficiency gain. First, projects can be undertaken that might otherwise fail due to breakdowns in negotiation (on best available information). Second, alternate mechanisms lead to badly sorted projects. Individuals can rationally choose inferior projects because their personal share exceeds gains on superior projects for which their private share holds greater risk.

5 Implications

This section applies the fair reward principle to media markets, employment contracting, and traditional knowledge

5.1 Copyright: Liability vs. Property Rules in Media

One implication is that media industries might be better served by a shift from property rules toward liability rules. Property rules that confer a right to exclude discourage experimentation. If the owner of an indispensable upstream asset, such as a media platform, can completely block or appropriate rents from downstream innovation, the downstream com-

munity loses economic incentive to innovate. It is Hirshleifer's (1973) monopsony problem. Indeed, if members of the downstream community disclose their ideas, the owner of the upstream platform can often proceed to implement them without negotiation or compensation.

Alternatively, liability rules that confer a right to compensation can actively encourage experimentation. Implementation can ensure that existing rights holders participate in the upside of newly created wealth. The problem for owners of information goods is that information, especially media content, can be reused in myriad unanticipated ways, and the source of a new idea often has only information asymmetry to preserve bargaining power. To allow for such unanticipated uses, downstream innovators should be encouraged to proceed with experiments secure in the knowledge that their entire contribution will not be appropriated by upstream rights holders who did not anticipate subsequent innovations.

Ordinarily, property protection shields the property owner from unjust taking and compensates even for the emotional or subjective value of personal attachment. Jack might claim he values Jill's car more than she does but if "rights trump utility" (Dworkin 1975), Jack's claim creates no entitlement. He can demonstrate his claim, if true, by acquiring rights from Jill in a Pareto superior transaction (Krauss 1999). She can, by definition, decline any offer below the sum of market price and private value. Because Jill can enjoin Jack's taking, he must seek ex ante approval for any use of her car.

Protection by a liability rule, in contrast, differs in two important respects. It does not entitle Jill to ex ante injunction and it does not entitle compensation for subjective private value. When Jack drives his own car, he creates risk for Jill and others yet she may not enjoin his activity – and information, unlike cars, can be consumed without interfering in another's consumption Only after Jack has done damage will his activities be examined to determine compensation, which, absent negligence occurs at fair market value (Krauss 1999). This necessarily underestimates Jill's value as she had not chosen to sell at the market clearing price (Polinsky 1980). To understand clearly the attractiveness of liability rules relative to

property rules for creating intangible wealth, it helps first to understand their advantages in avoiding tangible waste. When two parties jointly create damage, what rule should we apply to avoid mutual causation in the most efficacious way?

Consider the Supreme Court case *LeRoy Fibre Co. v. Chicago, Milwaukee & St. Paul R.R.* (1914) in which sparks from a passing coal-fired locomotive set fire to the plaintiff's several stacks of flax straw. The proximate cause of the fire being the spread of live coals, the plaintiff sued to recover the value of his straw. The defending railroad, however, having commenced operations before the plaintiff had, observed that LeRoy Fibre had stacked its straw adjacent to the railroad's tracks. Had the plaintiff exercised due care in stacking the flammable fiber elsewhere on its property, the damage would not have occurred. In a split decision, the Supreme Court found for the plaintiff on the basis that LeRoy Fiber could not be enjoined from reasonable uses of its own property. While agreeing with this first step, dissenting Justice Oliver Wendell Holmes Jr. found the plaintiff also negligent. LeRoy's voluntary decision reduced the joint fiber company/railroad company output (Krauss 1999). As noted in the "problem of social cost" (Coase 1960) more than two generations later, the second logical step is to realize the bilateral causation of damage, then seek the lowest cost solution. Between the railroad and LeRoy, if each is equally at fault, or if the proportion is sixty/forty, or even ninety/ten, then had LeRoy been protected by a liability rule, giving the defendant responsibility for *incremental* damage, LeRoy serves its own self-interest by stacking crops out of harm's way. Damage due to moral hazard is avoided at the lowest cost.

As with Jack and Jill, each is free to use his or her own car, subject to liability protection for incremental damage done to the other. To put Coase precisely and together with Calebresi, when transaction costs are high, as they are in unforeseen contingencies, society's greatest interest is served by placing the problem of social cost with the lowest cost avoider, subject to liability protection for another's basic entitlements.

The final step, for our purposes, is to invert Coase's insight. When transaction costs are

high, society's greatest interest is served by placing the opportunity of social surplus with the lowest cost *producer* subject to liability protection for entitlements of others. As shown in Proposition 7, private interests then align systematically with social interests. The problem of social cost has its parallel in the social efficiency of fairness.

Whether the initial assignment of rights should take the form of property or liability rule protection has a standard normative answer: "where transaction costs are high, the allocation of resources to their higest valued uses is facilitated by denying property rights holders an injunctive remedy against invasion of their rights and instead limiting them to a remedy in damages" [Posner (1972) p. 29].

The occasional caveat is that courts themselves can have high costs of assessing damages. Plaintiffs exaggerate them and defendants minimize them. If courts have few tools for scrying accurately, adjudicating settlements associated with liability rules can be less efficient than negotiated settlement associated with property rules (Polinsky 1980). Epstein (2001) also critiques liability rules as the "cheap option" exercised by rogues seeking better deals than their bargaining power would allow them to negotiate. Property rules compensate copyright owners for their subjective value as well as that of the market.

Three aspects of recombinant information goods undermine these critiques, tipping the scales toward liability rules.

First, the marginal values of recombinant information goods is often trivial. The transaction cost argument speaks loudly when pricing a single hour of attorney time swamps the total aggregated price of a parent posting her child's music recital online. When there is no economic substitution cost to the copyright holder or, indeed when the new work is complementary in any amount, no social function is served by enjoining the downstream innovation purely on the basis of a property interest in a nonrival resource. In those cases where recombinant information produces significant harm or significant value, a liability rule affords protection for any downside and participation in any upside.

Second, prior focus on transaction costs or assessment costs overlooks opportunity costs. Transaction and assessment costs erect tariffs on static trade in existing goods. But what of dynamic losses from goods society fails to create? While the price of a single hour of attorney time surpasses that of the majority of recombinant information goods, frustrating their isolated creation, it falls far short of their vast aggregation, suggesting that a shift in the locus of decision rights increases welfare. The owner of a broadway musical is unlikely to ever make a short video of every interested parent's child. Placing that opportunity with the lowest cost provider suggests using a liability rule that motivates the parent and compensates the rights holder. If there is downside, the parent justly assumes responsibility. If there is upside, the owner justly profits from the entitlement.

Finally, an unappreciated statistical fact is that large scale recombinant information is exactly what assessors need to estimate fair worth of the original work and that of the new work. To accurately estimate change in a dependent variable – such as value, ad revenue, page rank, or rating – requires variation in the independent variables – such as which song, which child, which arrangement, and which instrument. The larger the various combinations and recombinations, the easier it is to tease apart the worth of each piece. Immense variation such as that found on video upload sites provides the resources for precisely estimating fair compensation, with "fair" defined as reward in proportion to contribution.

6 Conclusions

This article demonstrates how principles of fairness can be used to mitigate risk, facilitate agreement, and encourage information sharing. A fair procedure is an ex ante commitment to an ex post reward in proportion to contribution. Specifying the process for allocation rather than the allocation itself frees contracting parties from having to specify the myriad unknown and frequently unknowable contingencies that affect received value. The fair reward principle

implies that individuals increasingly share private information, which creates the option to combine ideas in new ways. Second, uncertainty over future contingent claims together with self-interest is sufficient to justify fairness. Third, ownership is a less successful stimulus for innovation based on nonrival inputs than on rival inputs. Fourth, liability rules rather than property rules can be more conducive to innovation based on information reuse and recombination.

While ownership mitigates investment risk for tangible goods, it can function badly for ideas. Ownership confers bargaining power via the right to dispossess others, but disclosing an idea for purposes of evaluation forfeits bargaining power. Even for ideas that do rise to the level of property, the inventor can only force exclusion; he cannot force forgetfulness. For ideas that are not property, capitalizing on them often means keeping them secret.

Measured in terms of innovation, the fair reward principle offers three forms of efficiency gain. First, projects can be undertaken that might otherwise fail due to breakdowns in negotiation on the best available information. Second, it encourages people who have unprotected private information to disclose their ideas so that others become aware of their existence – awareness necessarily precedes negotiation. Third, alternate allocation mechanisms lead to badly sorted projects. Absent fairness, individuals can rationally choose welfare poor projects because their personal stake exceeds that on welfare rich projects.

The mechanism serves to foster agreement among parties whose beliefs diverge by allowing them to "agree to disagree." In fact, one or more parties may remain ignorant of the underlying proposition at the outset and yet collectively move forward under contract. So long as the party has sufficient reason to believe the proposal is a good use of his or her assets, an ability to verify value upon conclusion facilitates agreement before commencing. This benefit helps resolve both the monopsony problem and inspection paradox. Each problem limits one party's willingness to divulge information at a time when the other party can quit negotiations and leave with critical value. Investment, effort, and the passing of time

permit them to seek new information or disclose it in stages, revealing the true value of an investment.

Society's collective interest in fair allocations exceeds that of any individual. Projects exist for which individual opportunism makes sense, even for those who are far sighted. Even though a given innovation has itself occurred, implying total surplus is unaffected by its division, future innovators, who can see themselves in a position analogous to that of an aggrieved party, will avoid similar projects. In this sense, commitments to fair allocations call forth investments that were otherwise avoided.

Further, fairness by our exact definition is unnecessary. Rather, the principle of fair reward requires only "sufficient" fairness, characterized by two properties. Before innovation, individuals have sufficient confidence in a reward proportional to their contribution that they choose to contribute. After innovation, and after reward allocation, informed and neutral third parties would rationally have made the decision to contribute. The allocation therefore need not be exact.

These results have diverse applications in media markets, employment contracting, shared scientific research, and traditional knowledge.

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