"Sharing Nicely";
On shareable goods and the emergence of sharing as a modality of economic production

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Abstract

The paper offers a framework to explain large scale effective practices of sharing private, excludable goods. It starts with case studies of distributed computing and carpooling as motivating problems. It then suggests a definition for "shareable goods" as goods that are lumpy and mid-grained in size, and explains why goods with these characteristics will have systematic overcapacity relative to the requirements of their owners. The paper then uses comparative transaction costs analysis, focused on information characteristics in particular, combined with an analysis of diversity of motivations, to suggest when social sharing will be better than secondary markets to reallocate this overcapacity to non-owners who require the functionality. The paper concludes with broader observations about the role of sharing as a modality of economic production as compared to markets and hierarchies (whether states or firms), with a particular emphasis on sharing practices among individuals who are strangers or weakly related, its relationship to technological change, and some implications for contemporary policy choices regarding wireless regulation, intellectual property, and communications network design.

I. Introduction

The world's fastest supercomputer and the second largest commuter transportation system in the United States function on a resource-management model that has not been well specified in contemporary economics. Both SETI@Home, a distributed computing platform involving the computers of over four million volunteers, and carpooling, rely on social relations and an ethic of sharing, rather than on a price system, to mobilize and allocate resources. Yet they coexist with, and outperform, price-based and government-funded systems that offer substitutable functionality. Neither practice involves public goods, network goods, or any other currently-defined category of "quirky" goods as either inputs or outputs. PCs and automobiles are privately owned, rival goods with no obvious demand-side positive returns to scale when used for distributed computing or carpooling.[1] The sharing practices that have evolved around them are not limited to tightly knit communities of repeat players who know each other well and interact across many contexts. They represent instances where sharing[2] is either

[1] Computers as communications devices do have demand side returns to scale, or network externalities, but in the SETI@Home example, what is used by the project is the pure processing power of the PCs, whose intrinsic value is paramount.

[2] "Sharing" is an uncommon usage in the economics literature, though it is common in some of the anthropology literature. I choose it because it is broader in its application than other, more common but also narrower terms for associated phenomena—more importantly, "reciprocity," or "gift." I hesitate to use "reciprocity," because of its focus on more or less directly responsive reciprocated reward and punishment as a mechanism to sustain cooperation—in the teeth of the standard assumptions about collective action. See Dan Kahan, The Logic of Reciprocity: Trust, Collective Action, and Law Yale Law School Public Law

utterly impersonal or occurs among loosely affiliated individuals who engage in practices that involve contributions of the capacity of their private goods in a pattern that combines to form large scale and effective systems for provisioning goods, services, and resources.

This paper seeks to do two things. First, I define a particular class of goods as "shareable goods" that systematically have excess capacity, and combine comparative information costs and motivation analysis to suggest that this excess capacity may better be harnessed through social sharing relations than through secondary markets. Second, I explain how the observation about shareable goods meshes with the literature on social norms, social capital, and common property regimes, and with my own work on peer production, to suggest that social sharing is an underappreciated modality of economic production, parallel to market and state-based production,[3] whose salience in the economy is sensitive to technological conditions.

Shareable goods are goods that are (a) technically "lumpy" and (b) of "mid-grained" granularity. By "lumpy" I mean that they provision functionality in discrete packages rather than in a smooth flow. A PC is "lumpy" in that you cannot buy less than some threshold computation capacity, but once you have provisioned it, you have at a minimum a certain amount of computation, whether you need all of it or not. By "granularity" I seek to capture (1) technical characteristics of the functionality producing goods, (2) the shape of demand for the functionality in a given society, and (3) the amount and distribution of wealth of that society. A particular alignment of these characteristics will make some goods or resources "mid-grained," by which I mean that there will be relatively widespread private ownership of functionality-producing goods that systematically exhibit slack capacity relative to the demand of unit owners for their functionality. A steam-engine is large-grained and lumpy. An automobile or PC is mid-grained in the United States, Europe, and Japan, but large-grained in Bangeladesh.

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and Legal Theory Research Paper No. 31, Center for Law, Economics and Public Policy Reesearch Paper No. 281. Given the presence of purely redistributive practices like tolerated theft or demand sharing in the anthropology literature, *see infra*, note 79, the presence of evidence of non-reciprocal pro-social behavior, *see* Bruno S. Frey and Stephen Meier, Pro-Social Behavior, Reciprocity, or Both? Institute for Empirical Research in Economics, Zurich, Working Paper No. 107 (Feb 2002), and more generally our intuitive experiences of acts of humanity towards others whom we will never encounter again, I suspect that there some forms of redistribution are non-reciprocal except in the broadest sense of the reciprocation of living in a humane society. Mutual aid and cooperation without the possibility of reciprocal exchange likely exists, the Lion and the Mouse fable notwithstanding. See, *e.g.*, James Woodburn, *Sharing is not a form of exchange*, in C.M. Hann, Propery Relations, Renewing the Anthropological Tradition (1998). I hesitate to use the term "gift-exchange" because the highly developed gift literature, *see infra* note 5, has focused very heavily on the production and reproduction of social relations through the exchange and circulation of things. As will soon become clear, I am concerned with the production of things and actions/service valued materially, through non-market mechanisms of social sharing. "Sharing", then offers a less freighted name for evaluating mechanisms of social-relations based economic production.

[3] In this, my position tracks the tripartite mapping of the universe of organizational forms that resulted from the work on non-profits in the early 1980s. See Henry Hansmann, The Role of Non-Profit Enterprise, 89 Yale L. J. 835 (1980); Susan Rose-Ackerman, The Economics of Nonprofit Institutions, 3-17 (1986); Burton A. Weisbrod, The Nonprofit Economy 1-15 (1988). Unlike the nonprofit literature, my focus is outside the boundaries of firms—whether for- or non-profit—on sharing among individuals in informal associations more resembling markets in the price-based economy than firms. Both tripartite divisions, unsurprisingly, follow Hegel's framing of the market, the state, and civil society.

Reallocating the slack capacity of mid-grained goods—say, the excess computer cycles, or car seats going from *a* to *b*—becomes the problem whose solution can be provided by secondary markets, sharing, or bureaucratic management. I offer reasons to think that sharing may have lower transaction costs, improve the information on which agents who own these resources act, and provide better motivation for clearing excess capacity.

In particular, both markets and (firm or state) bureaucracies require crisp specification of behaviors and outcomes. Crispness is costly. It is not a characteristic of social relations, which rely on fuzzier definitions of actions required and performed, of inputs and outputs, and of obligations. Furthermore, where uncertainty is resistant to cost-effective reduction, the more textured (though less computable) information typical of social relations can provide better reasons for action than the persistent (though futile) search for crisply computable courses of action represented by pricing or managerial commands. Moreover, social sharing has the capacity to capture a cluster of social and psychological motivations that are not continuous with, and may even be crowded out by, the presence of money. Social sharing, particularly when it pools large numbers of small scale contributions to achieve effective functionality—where transaction costs would be high and per-contribution payments must be kept low—is likely to be achieved more efficiently through social sharing systems than through market-based systems. It is precisely this form of sharing—on large scales, among weakly connected participants, in project-specific or even ad hoc contexts—that is my central focus.

Social sharing is becoming a common modality of producing valuable desiderata at the very core of the most advanced economies—in information, culture, education, computation, and communications sectors. Free software, distributed computing, ad hoc mesh wireless networks, and other forms of peer production offer crisp examples of such large-scale, measurably effective sharing practices. I suggest that the highly distributed capital structure of contemporary communications and computation systems is largely responsible for the increased salience of social sharing as a modality of economic production in that environment. By lowering the capital costs required for effective individual action, these technologies have allowed various provisioning problems to be structured in forms amenable to decentralized production based on social relations, rather than through markets or hierarchies—whether state or firm-based.[4] While recently gaining in salience as a modality of economic production at the core of the advanced economies, sharing is hardly a new social phenomenon.[5] The claim is not, therefore, that

[4] This is different from capital intensity. The activity may be capital intensive—like distributed computing—when you consider the total capital cost of the computers, networks connections etc. required for an effective unit of production, by comparison to labor. The capitalization is, however, highly distributed, which is the key characteristic that enables individual agency in the production process.

[5] The anthropological literature on sharing and the gift has been vast, starting with Bronislaw Malinowski's Argonauts of the Western Pacific (1922) and Marcel Mauss, The gift; forms and functions of exchange in archaic societies (1925) (trans. 1954). A combination of a broad intellectual history and a major contemporary contribution to this line is Maurice Godelier, The Enigma of the Gift (1997); see also James G. Carrier, Property and Social Relations in Melanesian Anthropology, in Hann, supra, note 2 (providing brief intellectual history of the literature); C.M. Hann, Introduction, in Hann, *supra*, note 2, at 23-34 (providing same). As an alternative antithesis to the competition of all against all model of human society, an early manifestation of a focus on mutual aid and cooperation as a possible path for contemporary societies was Peter Kropotkin, Mutual Aid (1902).

we live in unique moment of humanistic sharing. It is, rather, that our own moment in history suggests a more general observation: that the technological state of a society, in particular the extent to which individual agents can engage in efficacious production activities with material resources under their individual control, affects the opportunities for, and hence the comparative prevalence and salience of, social, market, and state production modalities. The capital cost of effective economic action in the industrial economy shunted sharing to its economic peripheries—whether to households in the advanced economies, or to the kinds of global economic peripheries that are the subject of the anthropology of gift or the common property regimes literatures. The emerging restructuring of capital investment in digital networks—in particular the phenomenon of user-capitalized computation and communications capabilities—are at least partly reversing that effect. My claim is not, of course, that technology determines the level of sharing. But it does set threshold constraints on the effective domain of sharing as a modality of economic production. Within the domain of the efficaciously feasible, the actual level of sharing practices will be culturally driven and cross-culturally diverse.

The policy implications of recognizing the relative importance of sharing-based solutions to economic problems are significant. In the immediately foreseeable future, we can see that radio and communications technologies have reached a point where our policy focus should be on how to build an institutional framework that facilitates markets in shareable goods—wireless devices and systems—rather than imposing regulatory prohibitions on whole classes of systems and devices in order to create markets for reselling wireless transport capacity generated by large-grained systems like those that typified twentieth-century radio systems. The music copyright debate around peer-to-peer file sharing can also be explained in terms of the change in the type of goods used in distribution, from large-scale capital goods to mid-grained shareable goods. Understood in these terms, solving this problem by squelching peer-to-peer sharing becomes implausible—both descriptively and prescriptively. In addition to its possible effects on formal policy, recognizing the systematic availability of sharing as a mode of structuring productive cooperation offers a new solution space for engineers concerned with designing services that require cooperation, and can inform long-standing debates into problems such as the introduction of per-packet pricing into the internet protocol.

Yet current policy analysis largely disregards how institutional changes will affect existing or emerging practices of sharing that may substitute for, or compete with market-based production. If indeed we live in an economic system made up for price-based, state-based, and sharing-based modalities of production, if it is true that optimizing our institutional system for price-based production undermines productivity in the sharing modality, and if it is true that our communications, computation, and information sectors are undergoing such a technological change, then we are making systematically mistaken decisions not on the peripheries of our economies and societies, but at their very engines.

II. Case Studies: Carpooling and Distributed Computing

The two motivating case studies share the following characteristics. First, they involve large scale sharing practices among individuals who are either only weakly related along other social dimensions, or complete strangers. Second, they involve

sharing of private economic goods, owned by individuals for their own use. Third, in each case, there exist market models through which the excess capacity of these private goods could be, and sometimes is, cleared. Fourth, the output of the sharing practice in both cases is a rival good—it could be put to uses other than those that the participants in the sharing practice have put it to, and their using it for one purpose rivals the availability of the particular units shared to pursue other practices. In these characteristics car pooling and distributed computing are like peer-to-peer networks, or ad hoc wireless mesh networks, or like the labor individual programmers put into free software development. They provide us with a basic context through which to begin to work towards an understanding of the micro-level motivations and transactional characteristics that underlie the use of these social sharing systems, rather than the available, substitutable market mechanisms.

Carpools

Carpooling is the second largest commuter transportation system in the United States. It accounts for one-sixth to one-eighth of work-related trips (17% to 12% of trips, depending on study)—twice as much as all other modes except solo driving (75.4%) combined.[6] In the United States, carpooling came to prominence during World War II, when oil and rubber shortages made car-sharing a policy goal.[7] It re-appeared as a national priority in the mid-1970s, responding to the oil crisis, but appears to have been on a declining trajectory since 1980[8]— declining from 19.7% to between 12% and 16.8% in 2000-2001.[9] Despite its contraction, carpooling remains much more significant than public transit, which accounts for only 3.7% of work related trips. Transit use drops even further to 1 or 2 percent for non-work related trips, while carpooling rises to account for over 50%.[10] Because non-work related carpools often are comprised only of family members, and I am concerned primarily with non-intimate social sharing practices, I focus here on work-related carpools, where a majority of sharing appears to occur among non-household members.[11]

The most important characteristic of carpooling from the perspective of the present paper is that money or explicit barter may be present or absent, and money, where

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[6] John Pucher & John L. Renne, *Socioeconomics of Urban Travel: Evidence from the 2001 NHTS*, 57 TRANSPORTATION Q., at *? tbl. 3 (forthcoming?) (2003).
[7] Erik Ferguson, *The Rise and Fall of the American Carpool: 1970-1990*, 24 Transportation 349, 349 (1997).
[8] *Id*.
[9] According to Census data, the number is approximately 12%. *See* Pucher & Renne, *supra* note 6 at *4 tbl. 1 (citing U.S. Decennial Census, Supplemental Survey: Journey to Work, various census years, 1960 to 2000, as tabulated by Alan Pisarski and reported in ALAN PISARSKI, COMMUTING IN AMERICA III (2003)) According to NHTS data, the decline was more moderate, to 16.8% of more clearly commute-related trips, defined as trips in urban areas for distances shorter than 75 miles. See Pucher & Renne, at 8.
[10] *Id*., Pucher & Renne, *supra* note 6, Table 3.
[11] How large a majority is not entirely clear. Pucher & Renne, claims that "family members are often passengers on car trips for shopping, recreation, church, and school, while they seldom accompany each other to work."), *supra* note 6, at 10. An older study reported that more than 40% of work-related carpools include members of the same household. Roger F. Teal, *Carpooling: Who, How and Why*, 21A TRANSPORTATION RESEARCH 203 (1987).

present, is usually limited to explicit cost sharing rather than used as a price. A central concern of this paper is comparison of instances where prices are the primary source of information about, and incentive for, resource allocation, to instances where non-price based social relations play those roles. Taking a co-worker to work, rather than another person who is willing and able to pay more is an instance of social production, not of price-based market production. This is true whether or not part of the social interaction includes sharing the cost of gas and parking—because the market-defined social cost is the unavailability of the seat to the higher bidder, not the operating cost of the vehicle.

Carpool-like arrangements where seats are sold for a price are rare relative to non-price based carpools. They include mostly jitneys,[12] which may follow pre-defined routes like buses, or offer door-to-door services, and "car sharing" services, which are club-like arrangements where members pay on a per-use basis in addition to the membership fee.[13] But price-based car sharing is the exception, not the rule. The vast majority of carpooling occurs without pricing, though it does often include either explicit barter or cost sharing. Carpools often involve some exchange–*X drives Mondays, Y drives Tuesdays*,[14] or *Passenger A gets a ride from Driver B, Driver B gets to use the HOV lane*.[15] Money does not typically mediate this type of transaction.[16] Rotating driving and car-provisioning responsibilities is one major form of barter in this area,[17] but money does not appear to be used to balance divergent costs or values—the owner of the fuel-efficient sub-compact does not compensate the owner of the comfy gas-guzzler with more money or added driving days. There is also some macro level data that could, with further refinement, suggest that reciprocity plays an important role in carpooling.[18]

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[12] *See* Isaac K. Takyi, *An Evaluation of Jitney Systems in Developing Countries*, 44 TRANSP. Q. 163, 170 (1990); Nicole S. Garnett, *The Road from Welfare to Work: Informal Transportation and the Urban Poor*, 38 Harv. J. on Legis. 173 (2001) (discussing jitney operations in New York City and Miami and their potential to further help poor communities if allowed to operate legally).

[13] Franz E. Prettenthaler & Karl W. Steininger, *From Ownership to Service Use Lifestyle: The Potential of Car Sharing*, 28 Ecological Economics 443, 445 (1999). The pricing model follows remarkably well Berglas's version for efficient pricing of club goods. See Eitan Berglas, On the theory of clubs, 66 Am Econ. Rev., 116-121 (1976).

[14] Aloise B. Heath, *The Sociology of the Carpool*, 12 National Review 360, 360 (1962).

[15] *See* Marcela Kogan, *Slugs and Body Snatchers*, 29 Government Executive 39 (1997).

[16] Ferguson, *supra* note 7 at 352 ("Most carpools do not involve any financial transactions"). The academic literature on carpooling rarely mentions money.

[17] *See, e.g.*, Patricia A. Adler & Peter Adler, *The Carpool: A Socializing Adjunct to the Educational Experience*, 57 SOCIOLOGY OF EDUCATION 200 (1984); Heath, *supra* note 14; F.W. Davis, Jr. et al., Department of Transportation, 1 Increased Transportation Efficiency Through Ridesharing: The Brokerage Approach 57 (1977) [hereinafter Efficiency Through Ridesharing] (describing the "general norm of reciprocity" by which carpoolers alternate driving days and "repay their driving days" if illness or holiday disrupts the rotation schedule). The report presents a Department of Transportation survey of 4,500 Knoxville, TN-area carpoolers in 1974-75.

[18] The relevant data point is the correlation between the number of automobiles a household owns and the percentage of automobile-based trips that are carpools. Carpooling increases by 56% as a percentage of all trips a person takes, if a person is a member of a household with one automobile, relative to individuals whose household owns no automobile. Carpooling further increases by an additional 16% for members of households with 2 automobiles, and declines by about 9% for households with 3 or more cars. Pucher & Renne, *supra* note 6, Table 7. One hypothesis that could explain these data is reciprocity—one needs one in order to participate, hence the practices *increases* as households move from zero to one to two cars. The usefulness of the data at this stage is limited, however, because they do not do not differentiate whether

Money changes hands more frequently in non-rotational work-related carpools. Money in these contexts is still, however, not structured as marginal cost pricing—that is, by willingness and ability of putative riders to bid on seats. Rather, full-time riders may pay drivers for a portion of explicit operation costs, such as contributions to cover gas, tolls, and parking costs, and sometimes wear and tear and maintenance in formally negotiated cost sharing arrangements.[19] In terms of organization and governance, practically all carpool arrangements are decentralized. Carpooling can be divided into two stages of activity: 1) formation and scheduling, and 2) behavior of participants while carpooling. Other than scattered government-, employer- and non-profit-run ride-matching programs focused primarily on improving information about available rides and riders,[20] carpool formation and scheduling appears to be highly decentralized. Carpools for work-related trips usually are comprised of co-workers who live in rough proximity, rather than of neighbors who work in rough proximity.[21] More generally, household members, co-workers, and parents whose children have common transportation needs typically contact potential carpooling partners and arrange a carpool without government or market involvement.[22] In highly organized, regularized systems, *e.g.*, a carpool in which multiple parents drive children to and from after-school activities according to a

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carpooling and car ownership are correlated because they correlate independently to distant suburban and exurban living, where public transit it weak, whereas no car ownership may correlate to living in an urban center where carpooling is crowded out by transit. Number of cars would then be indicative of a high demand for private automobile-based travel, rather than for a practice of reciprocity. This latter point is suggested by the fact that walking is also strongly associated with an absence of a car, and drastically declines for households with one car or more. *Id.* On the other hand, this does not explain why social carpooling, rather than market-based Jitneys and taxis, fill this demand.

[19] *See, e.g.*, P. W. Daniels, *Vehicle Sharing for the Journey to Work by Office Employees*, 15A Transp. Research 391, 391 (1981) (noting regular, negotiated contributions by passengers to trip costs). An informal survey of postings 250 postings on in the San Francisco Bay Area revealed that in 30% of postings money is not mentioned, and in the vast majority of postings that do mention money, the request or offer modulates the money as being for "gas" or "tolls," etc. Only 10% of postings state a fixed price for a ride, while only 6% state a price without modulating the price by characterizing its purpose as cost sharing. The majority of users, whether money is asked or offered or not, also specify social characteristics they desire in potential carpooling partners, such as being "good company" or having "good tunes." Review of anonymous postings, Craigslist San Francisco Rideshare bulletin board, Nov. 6, 2003, *at* http://www.craigslist.org/rid/. (on file with author).

[20] Craig N. Oren, *Getting Commuters Out of Their Cars: What Went Wrong?*, 17 Stan. Envtl. L.J. 141, 141 (1998). Oren provides an in-depth analysis of the Employee Trip Reduction mandate, the single most ambitious government effort to promote carpooling to date. Oren concludes that the mandate fell short—it did not come close to producing the desired gains in alternatives to solo driving and in air pollution reduction—because it followed the structure of traditional technology-forcing environmental regulations, failing to account for the complexities inherent in changing individuals' commuting behaviors or for the breadth of factors affecting carpooling; *See, e.g.*, D.J. Dailey et al., *Seattle Smart Traveler: Dynamic Ridematching on the World Wide Web*, 7 Transportation Research Part C 17 (1999); Roberto W. Calvo et al., *A Distributed Geographic Information System for the Daily Car Pooling Problem*, COMPUTERS & OPERATIONS RESEARCH (forthcoming), *available at* www.sciencedirect.com. The Microsoft Access-based system optimizes the composition of carpool groups and carpooling routes for employees of a large Italian employer and communicates with users via SMS, e-mail and the Internet.

[21] Teal, *supra*, note 11, at 204 (citing A.J. Richardson & W. Young, *The Spatial Structure of Carpool Formation*, paper presented at 1982 meeting of the Transportation Research Board).

[22] *See Efficiency Through Ridesharing*, *supra* note 17; Heath, *supra* note 14.

written rotation schedule,[23] trip scheduling is an integral part of carpool formation but is typically conducted by participants. Sporadic, ad hoc carpools—*e.g.*, two roommates who decide to carpool to work on a given morning, or carpool pick-up spots—do not require organized scheduling at all.[24]

One of the most rarified forms of carpool formation and scheduling, observed in Northern Virginia and the San Francisco Bay Area, is ad hoc or dynamic carpooling. Ad hoc carpooling—in California called "casual carpooling"[25] and in Virginia, "slugging"[26]—involves solo drivers picking up strangers in well known meet points, to form a carpool sufficiently large to and take advantage of HOV lanes.[27] The practice has been described as follows:

> [One driver] now has the system down cold. Between 7 and 7:15 a.m., she drives to a slug line in the parking lot of a closed . . . home-improvement store in her Northern Virginia suburb. [She] waits her turn behind other cars. When her car gets to the front of the line, the next slug in line comes up to her window and asks [her] where she's going. The slug then shouts the destination to the others in line and gets in the car if he or she wants to go in that direction. The next couple of people in line headed in the same direction climb aboard, too. Usually, [she] swipes someone within five to ten minutes.[28]

The Northern Virginia terminology suggests a tension between this form of carpooling and public transit—the drivers are called "body snatchers"; the riders "slugs" (reportedly named after passengers who drop slugs instead of legitimate tokens into a bus's fare-box.).[29] Indeed, a recent study of the practice in Northern Virginia documents substitution between dynamic carpooling and transit use,[30] and suggest also that dynamic carpools depend on transit as a fallback option at least for one leg, in case the ad hoc carpool fails to form in both directions.[31] Body snatchers can also find slugs, however, at non-transit pick-up spots, which may be marked as dedicated carpool pickup stands, or unmarked–e.g., street corners, parking lots–and may be designated by a centralized authority or by custom.[32] While individual drivers and passengers may see each other on

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[23] *See* Heath, *supra* note 14.
[24] *See* Kogan, *supra* note 15.
[25] A list of casual carpooling locations on a San Fracisco website devoted to casual carpooling lists both BART and shopping mall-type locations. http://ridenow.org/carpool/#locations (last visited April 16, 2004).
[26] The community is a fountain of information about itself, see http://www.slug-lines.com
[27] Kogan, *supra* note 15.
[28] Kogan, *supra*, note 15.
[29] *Id*.
[30] F. Spielberg & P. Shapiro, *Mating Habits of Slugs: Dynamic Carpool Formation in the 1-95/1-395 Corridor of Northern Virginia*, 1711 Transportation Research Record 31 (2000).
[31] *Id*., at 33.
[32] *Id*. A list of casual carpooling locations on a San Fracisco website devoted to casual carpooling lists both BART and shopping mall-type locations. http://ridenow.org/carpool/#locations (last visited April 16, 2004).

more than one occasion, body snatchers and slugs are typically strangers, and participants of the same functional type are fungible.[33]

Dynamic carpooling appears to be a highly egalitarian activity: body snatchers seem to take slugs regardless of gender, race, or occupation in order to fulfill their quota and gain access to HOV lanes.[34] One set of regularities, however underscores an obstacle that dynamic carpool must overcome, and offers a surprising hypothesis about impersonal social cooperation. The deviation from the gender-neutral pickup practices is that solo women will not usually enter a car with two men already in it. "Unrelated" slugs on a line, however, will match up, whether male or female, irrespective of the gender of the driver.[35] First, this underscores the fact that personal security fears may be a serious obstacle to carpooling with strangers.[36] The matching practices suggest that security is achieved by the fact that generally more than one rider will join a solo driver, and the riders themselves are not pre-organized in groups. Each pair thus provides each individual with some security against an aggressive stranger. The importance of strength in numbers *and* lack of personal relationship is indicated by the fact that solo women will join two men in a car if the woman and man were both on line and no relationship between the two men is indicated.[37] Carpoolers on this model seem to assume a prevalence and distribution of aggressive proclivities in the population that places a low probability on two randomly associated individuals cooperating aggressively. Given such a model of the prevalence and distribution of aggressive tendencies, fully impersonal cooperation can then be seen as safer than partially impersonal cooperation, where some subset of participants have a pre-existing relationship. Another aspect of the same problem is "solved" by etiquette, as described in the "etiquette" page of the Northern Virginia-oriented website lists: "the line does not leave a woman standing alone….. Either a man forfeits his place in line so that he is left standing, or the ride is declined until another slug arrives. Or, it is acceptable to ask the driver if he will take more slugs in order to clear the line. Whatever the situation, the intent is not to leave a woman standing alone on the street, especially at night."[38]

As the reference to the etiquette indicates, though decentralized, ad hoc carpooling is not entirely unregulated; social norms seem to play an important role in the process. A list of such rules is found on the Northern Virginia site,[39] and includes interesting insights. Slugs do not talk—at least, not unless the driver initiates. This

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[33] *Id*.
[34] Spielberg & Shapiro, *supra* note 30, at 33. The article reports results of a survey of more than 3,000 drivers and passengers using an HOV lane to commute from Northern Virginia to Washington, DC. Of 28,000 commuters using HOV lanes during morning commute, the survey counted 3,100 slugs. *Id*. at 34.
[35] *Id*.
[36] The Californian description of the parallel issue is: "As far as anyone seems to know, over the history of East Bay casual carpooling, there have been no untoward incidents. The "three-per-car" requirement has helped. A little caution and common sense also have helped. Passengers can always decline a ride. For example, female passengers have been known to decline rides in two-seat cars. They simply let another passenger go first, and wait for a larger vehicle." http://ridenow.org/carpool/what.htm.
[37] Spielberg & Shapiro, *supra*, note 30.
[38] http://www.slug-lines.com/Slugging/Etiquette.asp.
[39] *Id*.

appears to be the rule in San Francisco as well.[40] No money, gifts, or tokens of appreciation are ever offered or requested. No smoking or eating by driver or slug. No going out of line—either for slugs to push ahead, or drivers to "snatch" slugs before the line, except that drivers can call out to a particular friend they see on line. The slug does not adjust the radio station or the heat.[41]

Dynamic carpooling is an entirely impersonal, ad hoc, practice with no perceptible socially stable set of participants. Yet participants do not use market mechanisms to clear seats. They rely instead on pure short-term mutual interest with no price—seats for eligibility for the HOV lane—together with social norms and practices—to get body-snatchers and slugs together.[42] Behavioral controls may be somewhat more formal, but these are rules of etiquette that are under the control of the driver, largely.[43] The decentralization of governance is paralleled in the normal case of carpools, where key behavioral decisions – for example, driver rotation, seating arrangements, smoking prohibitions, waiting policy in case of tardiness – appear largely informal: participants follow loose norms or ad hoc decisions rather than explicit, articulated rules.[44]

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[40] http://ridenow.org/carpool/what.htm.

[41] http://www.slug-lines.com/Slugging/Etiquette.asp.

[42] Dynamic carpools cannot quite be presented as "proof" that social provisioning is more efficient or desirable, because there is ambiguity as to the legal status of a similar arrangement that would instead operate on, for example, a spot-auction model. At least in some jurisdictions, such a practice could require licensing as a taxicab or otherwise a vehicle for hire. But in the Northern Virginia corridor, the ambiguity is limited. The Alexandria, VA Code, for example, covers only taxicabs and vehicles for hire that are "maintained for hire". See Alexandria Code of Ordinances, Sec 9-12-1(7), (14). While not impossible, it is highly unlikely that a vehicle used, even a few days a week, for one or two trips where money changes hands out of an entire weekly schedule, would be defined as "maintained for hire." Slightly more ambiguously, the Arlington, Virginia relevant ordinance, states that a "*Taxicab or other motor vehicle performing taxicab service* means any motor vehicle having a seating capacity of not more than six (6) passengers and not operating on a regular route or between fixed terminals used in the transportation of passengers for hire or for compensation." This definition would seem to include carpooling for compensation, unless the sporadic use for carpooling would not designate the *vehicle* in general as a taxicab, but rather as falling under the category of an "other motor vehicle performing taxicab services". "Taxicab services," in turn, "means and includes the operation of any motor vehicle upon any street or highway, on call or on demand, accepting or soliciting passengers indiscriminately for transportation for hire between such points along streets or highways as may be directed by the passenger or passengers so being transported." The requirements of indiscriminate acceptance of solicitation, and the structure of the contract as one where the passenger directs the destination and route, would seem to exclude carpooling, including even dynamic carpooling. Arlington County, Code of Ordinances, Chapter 25, section 25-2. (Available http://livepublish.municode.com/LivePublish/newonlinecodes.asp?infobase=11749). The San Francisco ordinance, on the other hand, sweeps more broadly and probably would capture dynamic carpooling in its scope. San Francisco Code of Ordinances, Article 16, Section 1076.

[43] *See* Kogan, *supra* note 15. Kogan reports that "etiquette rules inside the car are pretty much up to the driver. 'Certain drivers will not talk,' says one federal lawyer. 'Others won't shut up. You are under their control; you are bumming a ride. Certain people will tell drivers to change the radio station, which I think is bold.'" *Id* A 1977 Department of Transportation of commuters in Knoxville, Tennessee posits a general rule: the fewer and more intimate the participants in a carpool, the less formal the arrangements for carpool behavior. See *Efficiency Through Ridesharing, supra*, note 17, at 57, but it is not entirely clear what is meant by "formal," or what the source of the formal rules is.

[44] *See id*. When asked how they established rules for their carpools, study participants "indicated that they had briefly discussed [the issues] on the phone or at work before forming the pool, or when they were initially riding together. There appears to be considerable reluctance to meet formally and discuss what will

Surveys of carpoolers show that carpoolers have a wide range of motivations for carpooling, and wide variation between carpoolers and solo drivers in attitudes towards the costs and benefits of the practice. Carpoolers report that they carpool in order to take advantage of HOV lanes,[45] to reduce individual driving burdens,[46] to reduce costs of automobile use and maintenance,[47] for the company,[48] to be socially and environmentally responsible, and to teach their children sociability.[49] A review of the existing research suggests that carpooling behavior does not vary by socioeconomic or demographic characteristics,[50] but does correlate with beliefs that carpooling is good because of all these desiderata,[51] and with a discount on concerns with freedom to choose your time and route, to be in peace, etc, typical of solo drivers.[52] Whether these attitudinal differences are a reason for the different behavior or a coherence-seeking realignment of the

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and will not be appropriate in a carpool. . . . When there are only two or three carpoolers, the riders frequently indicate there are not set rules among 'friends.'" *Id*. at 56.

[45] *See, e.g.*, Kogan, *supra* note 15; Lior J. Strahilevitz, *How Changes in Property Regimes Influence Social Norms: Commodifying California's Carpool Lanes*, 75 Ind. L.J. 1231, 1237 (2000); Spielberg & Shapiro, *supra* note 30, at 33; Joy Dahlgren, *High Occupancy Vehicle Lanes: Not Always More Effective than General Purpose Lanes*, 32 TRANSPORTATION RESEARCH-A 99, 100 (1998).

[46] *See, e.g.*, Heath, *supra* note 14 ("A carpool, after all, has only one *raison d'etre*: to drive as seldom as is necessary to get your own child to school and back every day.")

[47] *See Efficiency Through Ridesharing*, *supra* note 17, at 56 (reporting that surveyed carpoolers cited the price of gas and the price of parking as two of the top three reasons they carpooled); Ferguson, *supra* note 7, at 359 ("[F]alling real marginal fuel costs 'explain' a third of the observed decline in American carpooling between 1970 and 1990"). Consistent with the importance of costs savings, carpooling propensity appears to increase with commuting distance, *see* David T. Hartgen & Kevin C. Bullard, *What Has Happened to Carpooling: Trends in North Carlonia, 1980 to 1990*, 1390 Transportation Research Record 50, 58 (1993); Teal, *supra* note 11, at 209. In areas where HOVs are excused from paying tolls during rush hour *See, e.g.*, Golden Gate Bridge Highway and Transportation District, *Golden Gate Bridge Toll Rates*, *available at* http://www.goldengatebridge.org/fastraktolls/ (last visited Nov. 2, 2003) carpooling offers additional cost savings. See also Edward P. Weber et al., Understanding urban commuters: how are non-SOV commuters different from SOV commuters?, 54 Transportation Q. 105, 110-11 (2000); Ferguson, *supra* note 7, at 371 (citing decline in fuel costs as major determinant in carpooling decline); Teal, *supra* note 11, at 207 (finding that commuting cost burden correlates strongly with carpooling).

[48] *Efficiency Through Ridesharing*, *supra* note 17, at 56.

[49] Adler & Adler, *supra* note 17, 208-09 (asserting that carpooling is one of the first regular contacts a child has with adults and children outside the immediate family and arguing that the carpool acts as an extremely important socializing arena for children).

[50] The 2001 NHTS suggests a minor income effect: carpooling is slightly less prevalent among households with annual income less than $20,000, and has little if any correlation with income above $20,000.*See* Pucher & Renne, *supra* note 6, at 19 tbl. 8. Income, education and gender seem to have little effect on carpooling practices, *see* Ferguson, *supra* note 7, at 363. This does not mean that carpooling is entirely divorced from economic consideration. Trip cost reduction is a consideration many commuters report as a consideration, see *supra* note 47, and trip/fuel cost and vehicle availability do show some correlation to commuting behavior. Ferguson at 371; Teal, *supra* note 11, at 207.

[51] *See* Norbert Oppenheim, *Carpooling: Problems and Potentials*, 33 Traffic Q. 253, 259 (1979); Abraham D. Horowitz & Jagdish N. Sheth, *Ride Sharing to Work: An Attitudinal Analysis*, 637 Transportation Research Record 1 (1978) (concluding that only attitudinal factors – in contrast to socioeconomic and demographic factors – are significant in explaining the carpooling behavior of 800 surveyed commuters).

[52] Weber, et al., *supra* note 47, at 110-11; Horowitz & Sheth, *supra* note 51, at 5. *See also* Paul A. M. Van Lange, et al., *A Social Dilemma Analysis of Commuting Preferences: The Roles of Social Value Orientation and Trust*, 28 J. of Applied Social Psychology 796 (1998).

carpoolers' preferences with their practices[53] is not obvious. What matters for our purposes, however, is that people report these desiderata to be important to them, and to be reasons they give to themselves as to why they carpool.

To conclude, carpooling is a deeply decentralized system, controlled by millions of individual decisions rather than by government, market actors, or other institutional players. It is organized largely without the use of prices or bureaucratic instructions to clear seats, and is usually interpreted and explicitly described by its participants as a social act, even when money does change hands to share explicit costs.

Distributed Computing

The phenomenon of "distributed computing" reflects an economically driven technical trend in computation, coupled with a social innovation. The first thing to understand is the idea of parallel computing. Imagine that I have a computational problem that can be solved by performing 100 mathematical operations. I could solve it in one second using a computer that could perform 100 operations in one second, or I could solve it by dividing the operations to be performed into two batches of 50 operations, and run them simultaneously on two computers, each capable of performing 50 operations per second (assuming, for the moment, that the division of the problem and collation of the results were costless). If the cost of improving the computation speed of a single processor increases super-linearly (that is, it costs more than twice as much to build a computer capable of 100 operations per second than a computer capable of 50 operations per second), then I can achieve the same result at lower cost by lashing together two cheaper processors than I can achieve by building a faster processor. Parallel computing is not costless. One must break up the problem into well-designed pieces that can run simultaneously, rather than having one processor wait for the other to finish, and there is overhead in managing the information input and output flows to and from the processors, both to each other and to the system memory. The tradeoff therefore becomes slightly more complex, but is fundamentally unchanged. Parallel computing will achieve similar results to a single processor at lower cost, if the total amount of overhead lost to parallelization is less than the cost differential for building the added computation capacity into one computer. Imagine that doubling the processing capability of a single processor quadrupled its cost, so that the 100 operation computer cost as much as four 50 operation computers. Imagine that the overhead involved in parallelization imposed a 30% loss of computation capacity "wasted" on parallelization. Taking the same problem as before, one could still lash together three cheaper processors, achieve a net 105 operations per second (after overhead), at a price of three processors, while the single processor would cost, by assumption, as much as four processors. This simplified explanation describes more or less why, by the end of the 20th century, most supercomputers were made of thousands of simple processors lashed together, and parallelization became an increasingly important field of computer science.

[53] Dan Simon, *A Third View of the Black Box: Coherence Based Reasoning in Law*, Univ. Chi. L. Rev. (*forthcoming* 2004).

Parallelization in supercomputing set the stage for the next step, Internet-based distributed computing. As Shirts and Pande noted in 2000,[54] supercomputers can lash together thousands of computers at a cost of tens of millions of dollars. But connected to the Internet there are millions of computers, and one can lash together hundreds of thousands of processors, rather than thousands, using their spare cycles, if one can overcome the quite substantial design problems involved in structuring problems so that they can efficiently be solved by very large numbers of processors with highly variable availability and orders of magnitude slower communications than those possible among processors located in arrays designed for, and dedicated to working together in, a single physical machine.[55] Once the problem is defined, however, it can be approached by designing new algorithms that trade off processing for communication, and focus on algorithms that restructure the description of solutions to problems assuming much lower constraints on the number of processors and much tighter constraints on communications than those used in mainstream supercomputers.[56] While designing an algorithm to achieve such scaling is difficult, it is not impossible, and the organizer of a project obviously has the incentive to develop such algorithms in order to benefit from the potential to mobilize distributed computing to solve his or her problems.[57]

SETI@Home is the paradigmatic internet-based distributed computing project. It harnesses idle processor cycles of about 4,500,000 users around the world. The users download a small screen saver. When the users are not using their computer, the screen

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[54] Michael Shirts and Vijay Pande, Screen Savers of the World Unite!, 290 Science 1903-04 (2000)

[55] The overarching ambition of connecting all the computation and storage resources connected to the network in a capacity grid is also known as "grid computing." See, *e.g.*, Leon Erlanger, *Distributed Computing: An Introduction* (April 4, 2002) available at http://www.extremetech.com/print_article/0,3428,a=25002,00.asp; Brian Hayes, *Collective Wisdom*, 86 American Scientist 118, 118 (1998), available at http://www.americanscientist.org/template/AssetDetail/assetid/20836; Ian Foster, Carl Kesselman, and Steven Tuecke, *The Anatomy of the Grid* available at http://www.globus.org/research/papers/anatomy.pdf (draft of version in Intl. J. Supercomputer Applications, 2001).

[55] Ian Foster, *What is the Grid? A Three Point Checklist* (July 20, 2002) available at http://www-fp.mcs.anl.gov/~foster/Articles/WhatIsTheGrid.pdf.

[56] See, e.g., Michael Shirts and Vijay Pande, Mathematical Analysis of Coupled Parallel Simulations, 86 Physical Review Letters 4983-87 (2001) (explaining how to use a statistical algorithm to scale the speed of folding deducible from a computer simulation linearly with the number of processors added); D. Laforenza, Grid programming: some indications where we are heading, 28 Parallel Computing 1722-52 (2002). See also Stefan M. Larson, Christopher D. Snow, Michael Shirts, and Vijay S. Pande, Folding@Home and Genome@Home: Using distributed computing to tackle previously intractable problems in computational biology (p. 11 of the working paper), available at http://folding.stanford.edu/papers/Horizon_Review.pdf.

[57] The primary oddity from a rational choice perspective is that scientists would not develop the algorithm unless thought that users would contribute their processing cycles, should the algorithm be developed. In theory, given that there is no easy story to tell about why contributors would volunteer their excess capacity, scientists should not develop these algorithms. Note, however, that there is nothing irrational about the actual scientists' beliefs that led them to design these systems. It is perfectly coherent for an agent to have a belief that others are like the agent, and to hold the belief that conditional upon the agent's behaving in a trusting reciprocal way, others will behave similarly. Given that for the scientists who develop these algorithms have no need to believe that any particular individual agent will cooperate, but only that there is some set of motivated others who would behave as the scientist would and cooperate, building the project is not only permissible for a rational agent, but represents a high likelihood of finding cooperators.

saver starts up, downloads problems for calculation—in the case of SETI@Home, radio astronomy signals to be analyzed for regularities as part of the search for extraterrestrial intelligence—and calculates the problem it has downloaded. Once the program calculates a solution it automatically sends its results to the main site. The cycle continues for as long as, and every time that, the computer is idle from its user's perspective, so that the screensaver is activated. Using this approach, SETI@Home became the fastest "supercomputer" in the world, capable of performing as of the summer of 2003 calculations at a speed 60% faster than the NEC Earth Simulator, formally the fastest supercomputer in the world at the same time, four times as fast as the next fastest supercomputer, and *seven times* faster than the following three fastest supercomputers, [58] including the fastest supercomputer that IBM had built at that point in time.[59] The simple fact of the existence and success of SETI@Home and similar projects, coupled with the fact that only a tiny fraction of the world's processors participate in similar projects[60] suggest that there is, and will continue to be in the foreseeable future, a significant amount of idle computation resources extant in the world.[61]

Another of the largest and best known distributed computing projects is Folding@home. As of late November 2003, a snapshot of its usage statistics reveals that it had amassed contributions of over 572,000 CPUs, of which about 20% were active at a given moment, contributed by 272,000 users, some of whom were self-organized into over 28,000 teams.[62] The contributions were concentrated largely in the United States, Western Europe, Japan, and Southeast Australia.[63] SETI@Home and Folding@Home provide a good basis for describing the fairly common characteristics of such projects. First, these are non-commercial projects, engaged in a pursuit understood widely as scientific, for the general good, seeking to harness contributions of individuals who wish to contribute to such larger-than-themselves goals. Like SETI@Home, Folding@Home,

[58] SETI@Home statistics showed a speed of over 54 Teraflops per second. The more traditional supercomputers,—where a single firm or organization builds on computation cluster from processors under its ownership or control achieved 35.8 Teraflops for the NEC Earth simulator, 13.9 Teraflops for the HP ASCI-Q at Los Alamos National Laboratories, the Linux Network with 7.6 Teraflops, and the IBM ASCI White mentioned in the preceding note, both at Lawrence Livermore Laboratories. See Top 500 Supercomputer Sites, at http://www.top500.org/list/2003/06/. These numbers and relationships offer, of necessity, a snapshot. When looked at again five months later, the mainstream supercomputers remained similar, but the number for SETI@Home had increased to over 64 Teraflops.

[59] IBM ASCI White, at Lawrence Livermore Laboratories, could perform 7.3 Teraflops, See Top 500 Supercomputer Sites, at http://www.top500.org/list/2003/06/, as compared to 54 Teraflops calculated by SETI@Home.

[60] There is no hard technological block to, for example, using microwave ovens for computation on this model. It is more a question of connectivity and engineering. But as we move to a more highly interconnected environment of pervasive computing, the number of connected computers per person in the industrialized world will be very large. Many of these are unlikely to require their full computation capacity any more often than microwave ovens do, when you happen to call on their services automatically to select the time and power of heating your dinner.

[61] SETI@Home is now also providing the development and deployment of a platform for the potentially next-generation improvement—the development of a cross-project common platform called BOINC, the Berkeley Open Infrastructure for Network Computing, that would allow many projects and many users to be matched dynamically, as needs and capacities changed, rather than having every user dedicate his or her computer to helping one project or another and downloading project-specific software for each project.

[62] For daily stats see http://folding.stanford.edu/cgi-bin/serverstats.

[63] See http://www.stanford.edu/group/pandegroup/folding/maps.html.

Fightaids@Home, Genome@Home etc. appeal to broad other-regarding concerns. Other sites, like those dedicated to cryptography or math, have a narrower appeal, but are also "altruistic", or perhaps hobbyist, in their basic motivational appeal. The absence of money is, in any event, typical of the large majority of active distributed computing projects.[64] Less than one fifth of these projects mention money at all. Most of those that do mention money refer to a share of a generally available prize for solving a scientific or mathematical challenge, and mix an appeal to hobby and altruism with the promise of money. Only two of almost 60 projects active in November, 2003 were built on a pay-per-contribution basis.[65]

In the SETI@Home internal survey,[66] the project found that users respond to the question "what is your main reason for running SETI@Home" with a strong emphasis on "good of humanity" (58%), or "keep my computer productive" (17%), and a little more than 5% focused on answers that tended to suggest a search for fame or explicit recognition, like getting one's name on the top 100 list of the site. While far from scientific, the SETI survey offers some texture as to the motivational self-descriptions of participants, albeit within a choreographed questionnaire, and certainly reflects the assumptions of those running the site about the kind of motivations for which they design their sites. Similarly, the organizers of Folding@Home and Genome@Home describe their design assumptions, reflecting a belief that users contribute their cycles because they are motivated by lay interest in the project, a desire not to waste computing resources, or by an amateur interest in either computers or the science involved.[67]

The assumptions about the motivations of contributors are translated quite clearly into both the client interface design and the websites supporting the project. Interfaces are explicitly designed to provide participants with feedback about their own contribution, information about the scientific context and output of their contributions, and a platform for both competitive and mutually supportive social interaction. The SETI client shows users how their own processing component is going, as well as offering a graphic representation of the data processed, which is aesthetically pleasing but relatively opaque as an explanation of the science or the results. Folding@Home offers a

[64] The aggregate descriptions are based on observations made November, 2003, of 57 projects linked to on http://www.aspenleaf.com/distributed/distrib-projects.html, a site dedicated to collecting links to all distributed processing sites.

[65] These sites, Gomez Performance Networks, and Capacity Calibration Network, differ functionally from distributed computing projects. The service they offer is running network traffic analysis by placing queries from topologically-diverse locations. They require their user's topological diversity, not their processing power. Therefore not all PCs are equal in their eyes. The specificity of the requirements, which generates the need to reject many putative contributors, likely contributes to the difficulty of attracting volunteers, in addition to the divergent social meanings of calls to "help organizations solve their business problems" as compared to "help fight AIDS". Money then steps in as a reasonably well understood motivational source for a project ill-suited to mobilize contributors socially. Because both projects were not trying to aggregate as many users as possible, or crunch as many numbers as possible, aggregate "success" of these projects, is not qualitatively comparable to SETI@Home or similar projects.

[66] http://setiathome.ssl.berkeley.edu/polls.html

[67] Larson et. al., *supra* note 56, at 2 (of the working paper). They do not explain how lay interest is different than amateur interest, but one suspects that these stand in for different levels of engagement and hobbyist-enthusiasm.

visualization of the actual calculation performed on the computer as a screen saver, providing an intuitive, if still analytically opaque, visualization of the work done. Climateprediction.net, a project focused on simulating climate change, takes a different approach. Each user downloads a whole "run", so that the world they run is a complete single run of what happens if CO_2 levels double from pre-industrial levels while a variety of other parameters are tweaked. The screen saver allows the participants to see how the world they are running is changing in the simulation. The site offers people the ability to compare "their" world to those of others and to a baseline run, providing greater opportunity for individual participation in reading the results.

Most of the distributed computing projects provide, on the server side, a series of utilities and statistics intended to allow contributors to attach meaning to their contributions in a variety of ways. The projects appear to be eclectic in their implicit social and psychological theories of the motivations for sharing. Sites describe the scientific purpose of the models and the specific scientific output, including posting articles that have used the calculations. In these components, the project organizers seem to assume some degree of taste for generalized altruism and the pursuit of meaning in contributing to a common goal. They also implement a variety of mechanisms to reinforce the sense of purpose, so there are aggregate statistics about total computations performed. But the sites also seem to assume a healthy dose of agonistic giving, as well. For example, most of the sites allow individuals to track their own contributions, to see their effect accumulating, but some also provide "user of the month" type rankings—displaying who contributed the most cycles and similar statistics. An interesting characteristic of quite a few of these is the ability to create "teams" of users, who in turn compete on who has provided more cycles or work units. SETI@Home in particular taps into ready-made nationalisms, by offering country level statistics. Some of the team names on Folding@Home also suggest other, out-of-project bonding measures, such as a national or ethnic bonds, (*e.g.*, Overclockers Australia or Alliance Francophone), technical minority status (*e.g.*, Linux or MacAddict4Life), organizational affiliation (University of Tennessee or of Alabama), as well as shared cultural reference points (Knights who say Ni!). In addition, the sites offer platforms for simple connectedness and mutual companionship, by offering user fora to discuss the science and the social participation involved. It is possible that these sites are shooting in the dark, as far as motivating sharing is concerned, but it is also possible that they have tapped into a valuable insight, which is that people behave for all sorts of different reasons, including all sorts of different reasons to act generously, and that at least in this domain adding reasons to participate—some agonistic, some altruistic, some reciprocity-seeking—does not have a crowding out effect. Research on the presence and pattern of crowding out between different sharing patterns would be useful in the design of such projects.[68]

III. Lumpiness, granularity, and shareable goods

The case studies are intended simply to motivate the analysis. They show us that there are large scale sharing phenomena in the world that successfully provision material desiderata through social sharing practices. These practices involve the sharing of private

[68] On crowding out between money and non-monetary rewards see *infra*, Part IV.B.

goods—automobiles and personal computers—as inputs. They involve rival outputs—seats in cars going from point *a* to point *b*, or computer processor cycles devoted to problem *a* rather than to problem *b*. They exist alongside market mechanisms for delivering substitutable functionality. And they work well; in some cases, better than market mechanisms. The questions that this part and the next will seek to answer within an economics-based framework are why this happens, why it is sustainable, and when is it efficient. This part is dedicated to describing a class of characteristics that, in combination, define a situation where it is likely that individuals will over-invest in capacity-generating goods—like PCs and automobiles—which will then have excess capacity, widely distributed in smallish dollops among large numbers of individuals in a society. The next part will be dedicated to explaining why this excess capacity may better be distributed by social sharing than by secondary markets (or administrative allocation). While the goods I call here "shareable goods" could be understood as a sub-class of "club goods"[69] or "common pool resources,"[70] the additional specification more precisely isolates individually owned goods that have excess capacity and are available for sharing.

The basic intuition is simple. There are goods that are "lumpy," by which I mean that given a state of technology, they can only be provisioned in certain discrete bundles that offer discontinuous amounts of functionality. In order to have any computation, for example, a consumer must buy a CPU, which in turn only comes in certain speeds or capacities. Lumpy goods can, in turn, be fine-, medium-, or large-grained. A large-

[69] See James Buchanan, An economic theory of clubs 32 *Economica* 1-14 (1965); Mancur Olson, The Theory of Collective Action (1965); Eitan Berglas, On the theory of clubs, 66 Am. Econ. Rev., 116-121 (1976). A current description of the state of the theory is available in R. Cornes & T. Sandler, The Theory of Externalities, Public Goods, and Club Goods (2d ed. 1996).

[70] An early and broad claim in the name of commons in resources for communication and transportation, as well as human community building—like roads, canals, or social-gathering places—is Carol Rose, The Comedy of the Commons: Custom, Commerce, and Inherently Public Property, 53 U. Chi. L. Rev. 711 (1986). Rose's observations on commons in waterways, highways etc. had far more radical implications in the long term than the direction that the bulk of the literature took over the course of the 1990s, because it focused on cases where commons *superseded* areas that had previously been private property—like turnpikes or private property over which public paths were later recognized. As such, it suggested that there were areas where commons were strictly superior to private property, that these commons existed at the very heart of our commercial system, and that many of the most important of these commons—like the highways and waterways—were not limited common property regimes, but were in fact open for anyone to use under very general usage rules. Condensing around the work of Elinor Ostrom, a different, narrower and less threatening literature developed over the course of the 1990s. It was concerned with showing that there were places where non-property regimes, or more accurately, common property regimes, were sustainable and stable over long periods of time. This line of literature was less radical and threatening than Rose's original claims, because it inverted the signs of all three radical implications of her claims. Common property regimes were shown to be stable, not claimed to be more efficient. They were studied on the peripheries of the main economies, and could be understood as stable holdovers, rather than as strictly more efficient alternatives that superseded preexisting private property regimes. And they were, in fact, a property regime, except that the outer boundary of the property included many participants, among whom proprietary interests were divided through governance mechanisms rather than through property and contract. The condensation point of this literature was Elinor Ostrom, Governing the Commons (1992); another seminal study was James M. Acheson, The Lobster Gangs of Maine (1988). A brief intellectual history of the study of common resource pools and common property regimes can be found in Charlotte Hess & Elinor Ostrom, Artifacts, Facilities, And Content: Information as a Common-pool Resource, (paper for the "Conference on the Public Domain," Duke Law School, Durham, North Carolina, November 9-11, 2001).

grained good is one that is so expensive that it can only be used by aggregating demand for it. Industrial capital equipment, like steam engines, is of this type. Fine-grained goods are of a granularity that allows consumers to buy precisely as much of the goods as they require of the functionality they deliver. Mid-grained goods are small enough for an individual to justify buying for her own use, given their price and her willingness and ability to pay for the functionality she plans to use. If enough individuals in society buy and use such mid-grained lumpy goods, that society will have a large amount of excess capacity "out there," in the hands of individuals. The problem of how to harness that excess capacity and use it to provision the requirements of others is the problem that Part IV deals with. If you are comfortable with this simple intuitive explanation, you may wish to skip the remainder of this part and go directly to that part. What follows here is a more-or-less careful working out of lumpiness and granularity, and the conditions under which we should expect there to be large scale excess capacity in the hands of individual owners of goods that become the opportunity for large-scale sharing practices.

A few assumptions and terms run throughout this part. Resources or goods have a usable lifetime—which can be of any length—once put in service. Owning a resource is not intrinsically utility generating. Use of the resource over its lifetime is what generates value to the agent. The welfare-producing use that a resource enables is its "functionality". Agents value a resource or good at the utility that use of its functionality is expected to generate over the lifetime of the resource. The degree to which the functionality of a resource can be used is its capacity. A good has a lifetime capacity, which is the total amount of functionality it can deliver over its usable life. This may or may not be separate from, and greater than, the good's usable capacity, which is the capacity it can deliver within the timeframe necessary for use of the functionality to generate the welfare sought by users. Capacity is technologically given. People purchase, make, or otherwise invest in putting into operation units of goods or resources that are not themselves the utility sought, but rather are resource packages that have the capacity to produce functionalities. I begin with two special cases that are easily grasped intuitively, and then generalize.

Renewable resources

Renewable resources are resources that can deliver their functionality within a given time frame, and are then capable of delivering that functionality again at a later time. A perfectly renewable good is capable of delivering exactly the same amount of functionality over time, irrespective of whether its functionality was used in full at a prior moment in time. Its expected lifetime is unaffected by use. An imperfectly renewable good either delivers some, but not all, of the amount of its functionality with each successive use, or loses expected lifetime with each use. A nonrenewable good is one that can deliver its functionality once.

"Spectrum" is a perfectly renewable good. Dining tables, computer processors, and automobiles, are slightly less perfectly renewable, but still almost perfectly renewable. Rubber bands, soccer balls, lithium ion batteries, etc., are imperfectly renewable. Apples, matches, etc., are strictly nonrenewable. Renewability is equivalent

to nonrivalry along the time dimension. A perfectly renewable good is like a nonrival good as among all and only those uses that can be timed to occur asynchronically without loss of value. Perfectly renewable goods are, in this sense, an impure public good, where the limitation on their use by marginal users is their requirement that time pass before they can deliver additional units of desired functionality. Another way of thinking about them is that they are club goods with a zero maintenance cost, as to which congestion is measured as the likely divergence, for a reference agent, between the desired time for delivery of the functionality and the actual time at which functionality is available given the sequencing or queuing algorithm used to synchronize use of the resource.

An individual will decide whether to put a unit of a good into service by comparing the value of its functionality over time, discounted, to its price. Imagine a good that expires after a year in service, irrespective of how it is used. The individual plans to use the functionality once a week, for an hour; a use that the individual values at v, and which the individual cannot replicate except by owning a unit of the good. The individual will be willing to pay up to $52v$ for a unit of the good (ignoring discount). Where, as in this case, an individual's demand for functionality is variable over time and the functionality can be delivered by a renewable good, the individual has an overcapacity to deliver the functionality. This overcapacity is precisely the extent of the divergence between the time necessary for renewal of the good's capacity to provide the functionality and the time lapse between instances where the individual demands the capacity. In the example, assuming the good is perfectly and immediately renewable, the individual owns an overcapacity of $8684v$, reflecting the availability of the unit to be used by someone other than the owner for 24 hours a day for six days, 23 hours the seventh day, for 52 weeks, which is the life of the unit (assuming for simplicity that others value the use as much as the individual).

Intuitively, take a renewable resource like a lithium ion battery. Sometimes, the owner of a camcorder or camera will need more power than a full battery can offer, and will need it again as soon as it has recharged. In that setting, the good provides less functionality than desired by its owner, because the time for its renewal is greater than the time demanded for additional capacity. The degree to which this will be common, the lost utility from not having power, and the price of a second battery will determine whether the owner will put a second, backup unit in service. Sometimes, the owner will be able to let the battery lie in the device for weeks, not needing power at all because lacking in opportunities to shoot videos or photos. During that period, the battery has excess capacity—if held by another, it could have delivered its power, and renewed, before its owner would require it again—multiple times. With batteries, our experience may resist this example because we know that they are not infinitely rechargeable. With computer processing cycles that is less the case.

Rapidly decaying resources

A resource is rapidly decaying when the rate at which it decays is greater than the rate at which one user can consume its capacity. Once a user decides that the capacity he can in fact extract before the good decays is high enough to justify putting a unit into

operation, the functionality is over provisioned as to that individual, and excess capacity is created for the short lifetime of the resource. Unless that capacity is used by others—who may borrow or buy it—it will be wasted.[71]

A single trip in a car (unlike the car itself, which is highly, but not perfectly renewable) is a rapidly decaying good. Once the owner of a car decides to travel from home to work, the good "four seats going from *a* to *b* on Tuesday morning" has been created, and will last only for the length of the trip. Carpooling is in this instance a practice of sharing a rapidly decaying good. (In this carpooling is different from lending a car to a friend for the weekend or for a trip to the grocery shop, which uses the car's renewability, not the rapidly decaying character of a trip the owner is about to undertake.) The parallels between rapidly decaying goods and renewable goods may help to explain why ova are treated like renewable tissue—sperm or blood—for purposes of egg donation, rather than like nonrenewable tissue, like livers or hearts, that are not similarly over-provisioned. It is also consistent with observations of some behavioral ecologists, who claim that sharing is particularly common in large-package foods—for example, the observation that in the same community, hunters will share widely the meat from a large sea turtle, but will net no more of finer-grained foods, like small lagoon fish, than they need within the household, and then will not share these in the broader community that would normally share in the turtles.[72]

Lumpiness in general

The two special cases of renewable resources and rapidly decaying resources can be generalized to describe "lumpy" resources of mid-grained granularity. A lumpy resource is one that delivers utility in discrete packages, rather than continuously. Physically, any resource is "lumpy", including rice or even water (at the molecular level). So "lumpiness" is intended as a concept in economics, not physics. It describes a relationship between technically attainable package size and extant demand by agents. It refers to a divergence between the package size (of each unit or of any cost-effective aggregation of units) and the extant demand of individual agents for the functionality produced by the good. One might therefore think of the "lumpiness" of a resource as reflecting the capacity of a single unit of a resource to provide a functionality, and the probability that that amount of utility or functionality supplied by any physically

[71] Interestingly, Locke bases his praise for money precisely in terms of its capacity to store the value of a rapidly decaying good in the sense described, thereby giving the provisioning agent the value of his labor, while avoiding the predicament that a laborer takes from the common and then wastes what he took. Locke, Second Treatise paras 36-38, 46-50.

[72] See R. L. Bliege Bird and D.W. Bird, Delayed Reciprocity and Tolerated Theft, the behavioral ecology of food-sharing strategies, 38 Current Anthropology 49-78 (1997). While the fact may explain the origins of the sharing practices, it does not explain its continued persistence—given that the studied people already have refrigeration. *Id.* It is important to note also that the bulk of anthropological study of sharing practices is not limited to goods with these characteristics, and may relate to abundant goods, as in the case of potlatch societies, as well as to scarce and unique goods that are do not rapidly decay and are not "shareable" in the sense I describe here, like the objects of *kula* rings. See Godelier, Enigma of the Gift (1997) for one of the most important recent contributions to this literature, as well as an intellectual map of its origins.

obtainable number of discrete units of the resource in a time frame will diverge from the amount of functionality demanded by an agent in that time frame.

An agent will invest in owning a unit[73] of a lumpy resource if the utility the agent achieves over the lifetime of the resource is greater than the price of the unit for its lifetime. The fact that a resource is capable of producing more utility over its lifetime than the agent needs over that lifetime is irrelevant to the individual's decision whether to invest in a unit or not. That decision is made purely on the comparison of the value over lifetime, expressed as the capacity to produce a functionality flow, and the cost of a unit (bracketing, for now, the possibility of a secondary market or sharing system.)

In order to give lumpiness some persistence, both supply and demand of the functionality must be in discrete units. If we were to define the agent's demand as capable of fulfillment incrementally, for example, that by provisioning a unit of a resource that offers 90% of what the agent requires the agent could fulfill 90% of the agent's demand, the analysis would collapse back into smooth demand and supply curves. The assumption must be, then, that, like functionality supply, demand comes in discrete units. Fulfillment of 90% of the requirement is no fulfillment at all. Intuitively, an automobile without a gas tank or missing a wheel cannot get one to work, even if the rest of the car is there. Agents, then, will not provision units capable of providing less than some threshold of demanded functionality.

The discrete unit of demand, however, remains the single agent. It is possible for agents to aggregate their demand in order to co-provision a very large-grained lumpy good, that is, one whose functionality is multiple times greater than the requirements of any agent, so that it can serve the demand of multiple agents. The obvious example of this is where labor market provisions the power of a steam engine or other large machine to a number of workers on an assembly line, or where farmers' cooperatives provision harvesters. But I am concerned here with finer-grained goods that need not require aggregation of the demand of multiple agents to provision a single unit.

Because demand is discrete, units that under-produce functionality below some required threshold (automobiles without wheels or gas tanks) will not be provisioned. Units that will be put into operation are therefore a subset of those that are lumpy in the general sense defined earlier. That subset consists of those units whose capacity equals or exceeds the threshold functionality demanded by the agent who put them into service, in that timeframe. The total social capacity for provisioning the functionality in a given timeframe will be the sum of capacity capable of being provisioned by all units of the resource put into operation in that timeframe by the agents who have provisioned units. The excess capacity of the units in operation at a given time relative to the requirements of their owners is the "slack" of this resource set. Note that "slack" here refers not to the

[73] For simplicity of exposition, I will treat a collection of small but discrete units that cannot be aggregated into precisely the amount of functionality desired, as a single lumpy unit that delivers functionality in an excess amount equal to the divergence caused by the last incremental unit. This does not change the analysis, but simply obviates the need to talk about units that are small grained, but still lumpy in the sense that no combination of obtainable units will deliver precisely the amount of functionality desired.

claim that there will necessarily be overcapacity at an aggregate social level, all social demand for the functionality considered, but rather that there will be some capacity that would be unused if only the owners of units use the capacity generated by the units they own. Recall that we assume for now no transfers of excess capacity. The amount of excess capacity will be the sum of all capacity of units in operation at a given time, less the amount required by all owners of units in that time frame discounted for each owner by the probability that the unit placed in operation by that owner will produce either exactly as much capacity as she will require or less (in which case the owner of the unit would capture all the capacity produced by the unit she owns).

If units have a technically predefined capacity and agents have variable demand for the functionality, then the larger the number of agents who put units into operation, the higher the probability that some of the agents will own resources that have slack as to their needs, and the higher the probability that the universe of agents who own units will have excess capacity among them. The probability that each agent requires exactly as much capacity as his or her unit can supply in the relevant time frame becomes very small as the number of agents who own units increases. Because of the lumpiness, then, the total set of resources or goods that have these characteristics will usually exhibit slack capacity to produce the functionality. This slack will exist unless the excess capacity is somehow transferred to fulfill the demand of non-owners. Because of the relationship of the increase in the likely available slack to the number of unit owners in society, the extent to which a good will be "mid-grained," and shareable in the sense I describe here, or "large grained," like a steam turbine, will depend on the extant wealth in a society and its distribution—that is, how many people are able, as well as willing, to pay its price. A PC is a shareable good in North America, Europe, etc., but may be a large-grained capital good in an Indian or Brazilian village.

The intuitive response, at least for economists, to such endemic "overcapacity" of functionality is to create a secondary market in excess capacity. For large-grained lumpy goods, like steam engines or hotels, this could take the form of a labor market or a hotel room market, respectively, where the excess capacity (from the perspective of an individual agent) is not excess capacity at all, but rather the demand is aggregated so as to match it to the capacity and "smooth" out the lumpiness. For mid-grained goods the answer would be a secondary market in capacity so as, once again, to smooth out the lumpiness by aggregating and disaggregating the demand side of the incongruence between functionality provisioned and functionality demanded on a per unit/owner basis. Yard sales and eBay would be the relevant intuitive examples of such secondary markets. Part IV will consider the reasons why we might nonetheless see the sharing systems that we in fact observe.

Before we outline the relative advantages of secondary markets or sharing systems, however, their introduction requires an explication of the dynamic effect of any type of transferring excess capacity to non-owners. The more efficient the sharing or secondary market for excess capacity will be—that is, the smaller the difference in the value of functionality that can be acquired by owning a unit relative to acquiring it from the market or social sharing system in excess capacity—the less of an impetus there will

be for marginal users to put new units of the functionality-producing goods into service, rather than acquiring functionality from the secondary market or sharing system. As the motivation to provision the marginal unit declines, however, units will end their life cycle, total social capacity will decline, and the difference between owning a unit and acquiring capacity from units owned by others will grow, increasing, in turn, the attractiveness of putting an additional unit into service for the marginal user. The degree of efficiency with which a system of secondary market or sharing will pass through excess capacity without degradation of functionality will therefore be the degree of efficiency of that system relative to an ideal perfect market, considering the total cost of provisioning the capacity and the total functionality value utilized by users.

If there were a perfect secondary market in capacity, the deadweight loss created by the overcapacity would be eliminated. Enough units that would generate enough capacity to satisfy demand *for the functionality* would be purchased, but no more, and their excess capacity would be reallocated to individuals who valued some functionality, but not enough to purchase an additional unit. Consider the following simple numerical example. Imagine that the marginal cost of a unit is the equivalent of the value of a degree of functionality designated as 4*f*, but that because of the technical lumpiness, each unit generates a functionality flow of 6*f*. Imagine further that the demand for the functionality in society is as follows: Five individuals demand a functionality flow of 5*f*, five demand 4*f*, five demand 3*f*, and five demand 2*f*. Total social demand for the functionality would be 70*f*. If there were no secondary market or sharing system, total social demand for capacity generating units would be 10 units (demanded by the ten individuals whose demand equals or exceeds the cost of a unit, 4*f*). Total social supply of functionality from these units would 60*f*, but only 45*f* would be consumed by unit owners, and 15*f* would be wasted, while individuals who demand 25*f* would remain unserved. With a perfect secondary market, 12 units would be put into operation, generating a total social capacity of 72, and all users who value functionality would be served, with the total social capacity exceeding demand by 2*f*. Now, imagine that technology was such that each unit generated functionality of 10*f*, some of those who bought units under the first assumption would refrain from doing so, acquiring units instead from the secondary market, and only 7 units would have been put in operation. The basic point is obvious. Even if the units are lumpy, if functionality can be transferred costlessly and perfectly from unit owners to non-owners, there will be no over capacity.

Markets are not, however, perfect. And in Part IV, I will describe in detail how transaction costs in general and information shortfalls in particular can be integrated into the analysis. The overarching intuition is this. Secondary markets and social sharing systems are alternative systems for transferring the excess capacity of units that are in service at a given time. They differ in the transaction costs associated with the use of each, and in particular they differ in the quality of information they generate. Which one will more efficiently pass through its excess capacity to non-owners will determine which will be more efficient as a system for managing resources that have these technological characteristics.

* * *

Goods that meet the focused definitions I offer for sharable goods are not rare events in our daily lives. Automobiles come with standard packages of seats; PCs with CPUs and disk storage well beyond what most users will use. Beyond these examples, one can look at many others. Books (rather than their content), are an excellent example. In order to read a book one can borrow it from a library, or buy it. Once purchased, the book has much more capacity to deliver its primary functionality—communicating its content—than a single non-obsessive individual can consume. This overcapacity is the source of the second-hand book market (market provisioning), the public library (state provisioning), or the widespread practices of lending books to friends (social provisioning). Houses and apartments are a ubiquitous, though muted, instance of shareable goods. In the first instance, they are shared within families and non-family households, like roommates.[74] Rooms are sometimes disposed of through markets, as in the case of bed and breakfasts, sometimes through social exchange systems, as when guests come to stay overnight, or invited to use one's bathroom (itself a nested shareable good). The complex systems of market and social provisioning of renewable tissue like blood and sperm, or rapidly decaying over-provisioned tissue like ova, can also be understood in terms of these forms of tissue having the characteristics of shareable goods, capable of being provisioned and exchanged either through markets or through social systems. Finally, toys have similar characteristic, and provide the first and central mode of cultural transmission of the values of sharing the excess capacities of one's possessions. Anyone who sits in a New York City playground can only marvel at the paradoxical phenomenon of Wall Street traders admonishing their children to "share nicely," and will appreciate the deep cultural commitment we have to sharing some subset of our private, rival possessions as a mode of social provisioning.

IV. Sharing and markets: transaction costs and motivations

The price system (whether engaged in directly by agents or through hierarchical firms),[75] the state, and social relations provide different transactional frameworks through which individuals can act.[76] Each has different set up costs. Each has different marginal

[74] See Robert C. Ellickson, The Law & Economics of the Household (draft).

[75] A methodological (or perhaps metaphorical) note is due. One often hears people speaking of "a market in reputation" or "a market in which people compete for esteem." It is important to recognize that such statements are metaphors. Markets as actual institutional forms are a very particular information process, generating information in a very particular form—prices. Other modalities of allowing unorganized individuals to decide on their actions without hierarchical coordination, even if they are fully distributed and atomistic in style, but that rely on other institutional forms and social practices, are not "a market," except metaphorically. The metaphor is a bad one if it leads us to ignore the fact that on any given question of institutional design, there may be different answers depending on whether we think that the most effective system would utilize prices or, for example, esteem.

[76] Note that this tri-partite typology is similar to, but not the same as the tripartite description of organizations one finds in the discussion of non-profits. See, note 3, *supra*. The difference is that investor firms, nonprofits, and government agencies are all organizational forms of action. My focus here is more general, and applies to individual domains of action. Nonprofits of the type Hansmann calls "commercial," *See* Hansmann, *supra* note 3, can work through markets, such as by selling services in competition with for profits. For profit firms can use social relations, by leveraging the social capital of their employees. *See* James S. Coleman, Social Capital in the Creation of Human Capital, 94 Supp. Am. J. Soc. S95, S106 (1988); Nan Lin, Social Capital: A Theory of Social Structure and Action 19-28 (2001).

transaction costs. Each also, independently but cumulatively, has a different reward structure. This part works through first the transaction costs analysis of the choice, and then the question of motivation.

A. Transaction Costs

1. Choosing a transactional framework

An agent considering whether or not to allow others to use his or her resources must go through a decision patterned as described in Figure 1. Each decision can be understood as a cost benefit analysis that considers (a) the transaction costs involved under given technological and legal conditions in the act of complete or partial exclusion, and (b) the comparative opportunity costs of inclusion and exclusion, in each case under any of the modalities of organizing the use and exchange of resources—market, state, and social relations. Because I am concerned here with the decisions of agents with regard to privately owned goods and resources, I will ignore the state-based options for disposition, although the shape of the comparative analysis is similar. The tree illustrates that the basic decision of whether or not to transact based on a comparison of the transaction costs and the likely benefits of transacting involves not one choice between two options (transact/not transact), but a series of choices among a variety of actions ranging from no exclusion at all to perfect exclusion with no transaction at all, and proceeding through a variety of alternatives for partial exclusion. Different options for exclusion and different strategies for inclusion will entail different transaction costs.

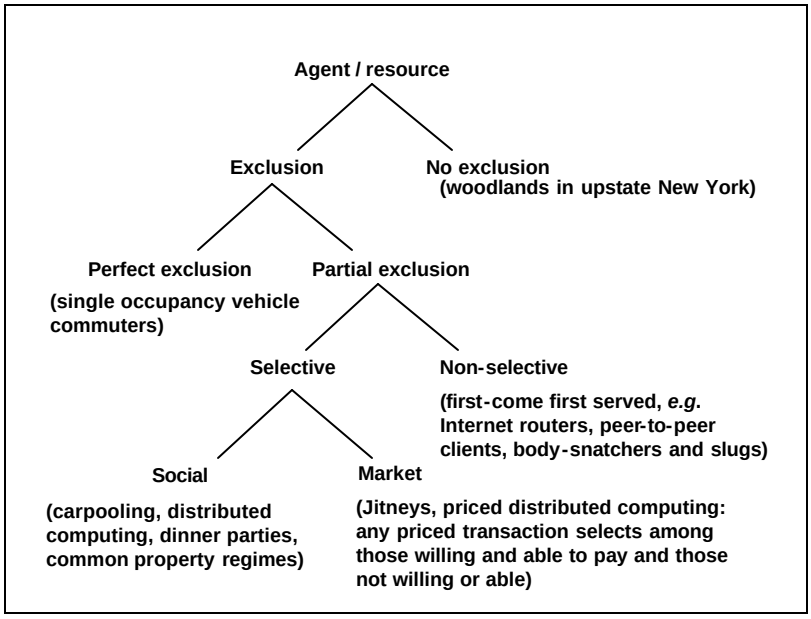

Figure 1. Decision to exclude

The first choice point is between exclusion and no exclusion.

No exclusion. Simply leaving the resource open to anyone's use is likely to be the lowest transaction cost option. No fences, no guards, no contracts, etc. However, it is likely to be the highest cost alternative in terms of congestion costs—opportunity costs incurred by the owner whenever her failure to exclude anyone from the good causes her not to have her unit of the good available to her for her own use. These may be high or low, depending on the nature of the good and the pattern of demand for the good. Privately owned woodlands in New Hampshire or upstate New York may be sufficiently abundant, use by hikers and hunters sufficiently sparse, and fencing sufficiently costly that de facto open access policies may be most efficient for individual landowners to adopt. Otherwise, the owner will choose some form of exclusion.

The second choice is between perfect exclusion and partial exclusion.

Perfect exclusion. Under perfect exclusion, the owner allows no one else to use his goods. The direct transaction costs of perfect exclusion are likely higher than those of no exclusion, but may be higher or lower than for partial exclusion. Perfect exclusion may be cheaper than partial exclusion, where, for example, one need only build a strong fence, and then all are excluded, while partial exclusion would require a guard at the gate admitting and excluding different people. Perfect exclusion may, however, be harder to achieve than partial exclusion, if every discrete act of exclusion requires an independent investment. For example, if a hunter in a hunter gatherer society needs to fend off each new claimant to the spoils of the hunt, then partial exclusion may be cheaper than perfect exclusion. This characteristic underlies the claims of the tolerated theft model in behavioral ecology, which suggests that sometimes hunters or foragers permit others to share in their catch not within a social framework of sharing and gift giving, and without expectation of reciprocity or the acquisition of social status. Instead, there is "tolerated theft," in the sense that others take from the good with no expectation of retaliation and no expectation of reciprocation. This occurs, within that framework of analysis, when the cost of exclusion is higher than the gains from exclusion.[77] This descriptive phenomenon is also recognized—though not interpreted through the prism of methodological individualism—as "demand sharing" by anthropologists who study sharing practices from a cultural perspective.[78] This form of sharing becomes a form of partial sharing, rather than of "open access," because not everyone will be tolerated, only those within a group that is sufficiently large to prevent outsiders from accessing the shared good.

Whether or not perfect exclusion is more expensive to implement than partial exclusion, it is clear that one of the costs of perfect exclusion is the opportunity costs of partial inclusion. In the case of shareable goods of the type we discuss here, that have an

[77] See N. Blurton Jones, A selfish origin for human food sharing: Tolerated theft, 5 *Ethology and sociobiology*, 1-3 (1984); N. Blurton Jones, Tolerated Theft: suggestions about the ecology and evolution of sharing, hoarding and scrounging, 26 Social Science information 31-54 (1987); B Winterhalder, A marginal model of tolerated theft, 17 ethology and sociobiology, 37-53 (1996), R. L. Bliege Bird and D.W. Bird, Delayed Reciprocity and Tolerated Theft, the behavioral ecology of food-sharing strategies, 38 Current Anthropology 49-78 (1997), David Sloan Wilson, Hunting Sharing and Multilevel Selection, The Tolerated theft model revisited, 39 Current Anthropology 73-97 (1998).

[78] See James G. Carrier, Property and social relations in Melanesian anthropology, *in* Property Relations, Renewing the Anthropological Tradition (C.M. Hann ed.) (1998), 85-103.

overcapacity relative to the individual owner's needs, the owner has an opportunity to benefit if she can get *any* positive utility from allowing access to the excess capacity. This is so whether the sharing provides economic returns in a secondary market, cost avoidance by permitting open access, social and psychological returns in social sharing arrangements, or the simple pleasure of fulfilling a taste for altruism.

Partial exclusion. This represents a cluster of strategies that are the most interesting from our perspective. These entail permitting some set of others, who are not the owner, to use the resource, but nonetheless limiting the set of permitted users to some number less than anyone who wants it.

Nonselective partial exclusion. This option refers to the simplest approach to partial exclusion—nonselective partial exclusion. Under this category, the selection criterion is independent of the characteristics or choices of the owner or the users permitted to use the good. Instead, the total amount shared is set by the capacity of the good, the demand of the owner—which together determine the amount of unused and available capacity—and some non-specific selection criterion. First come, first served is a simple example of such a sharing algorithm. The Northern Virginia corridor practice of body-snatchers and slugs are a form of nonselective partial exclusion on a first come, first served basis. Similarly, the Internet transmission control protocol, TCP, manages the capacity of routers on a non-selective, partial exclusion basis, by forwarding all packets on a first come first served basis, and dropping later packets if they arrive when it is overloaded, causing the senders to back off and slow down or try other routes. Other, more elaborate algorithms can be defined, but will still be non-selective as long as they do not rely on characteristics that are specific to individuals who are seeking permission to use the excess capacity. That the individuals need not be determined on a case-by-case basis is likely to lower the transaction costs involved in instantiating the partial permission framework. The primary cost of nonselective partial exclusion is the opportunity cost of the utility that could be gained from selective exclusion.

Selective exclusion.

Market selection. This is the secondary market option. The owner of the unit that produces welfare enhancing functionality allows those who pay market prices to gain access to the functionality, and excludes those who do not pay. This option is typified by the costs commonly associated with market transactions. These include defining the property and use rights, specifying the uses permitted and contracting for them, metering the functionality used, and monitoring and enforcing compliance. We have long understood transaction costs to be sufficiently nontrivial to affect the choice of how the economy organizes access to and use of resources.[79]

Social selection. Under this option, the owner excludes many putative users of the functionality, and permits use only to those who meet the owner's social criteria. This

[79] This is, after all, the point for which Ronald Coase was awarded the Nobel Prize in economics. Ronald Coase, The Nature of the Firm, 4 Economica 386 (1937); Ronald Coase, The Problem of Social Cost, 3 J L & Econ. 1 (1960).

obviously includes the lobster gangs in Maine that Acheson described in the early common property regime literature,[80] and the socially-selective swimming pools and golf clubs often analyzed in the club goods literature.[81] They also include wide ranges of normal human experience, like sharing the refrigerator with one's household members and invited guests, but not with others, inviting an acquaintance, but not a stranger, to share one's usufruct in the table at the café, etc. Once one begins to define the various forms of temporary or stable proprietary-type interests we have in the things in the world around us, and to couple them with the pervasive social sharing practices we use—some of which may be purely redistributive, some reciprocal, some voluntary, some obligation-based within a given set of social understandings, one sees that social sharing of is ubiquitous in everyday life.

Like markets, social exchange systems entail transaction costs. These may include the definition of social norms, the definition and policing of social group boundaries—who is in and who is out—the monitoring and enforcement of the terms of social sharing, which has been the subject of much empirical literature on the willingness of individuals to incur costs to enforce reciprocity and compliance with other social expectations,[82] etc. Just as we have pervasive, long standing investments in enabling markets—like building and maintaining a legal system, a fiscal system, physical marketplaces, etc., so too we have standing investments in social sharing. Ranging from widespread cultural schooling in socially acceptable and desirable behavior—like teaching children to share their toys in the sandbox—to the gossips who shame individuals into compliance.

2. The general shape of transaction costs-based choice among frameworks

It is now fairly simple to outline the shape of (though not necessarily to perform) comparative transaction costs analysis of the choice among these various strategies towards disposing of the excess capacity of shareable goods.

When any form of exclusion is more costly than permitting anyone to use the resource, owners will simply allow others to use the goods or resources they own. When the costs of either permitting everyone to use the resource or good or sharing it are greater than the cost of simple perfect exclusion, owners will simply exclude everyone from the good. Given that "the cost" includes opportunity costs caused by congestion, and that for perfectly private—rival and nonrenewable—goods "congestion" means loss of the full value of the good to its owner, this condition would obviously be fulfilled for perfectly private goods that are more valuable than the cost of exclusion. This also

[80] See Acheson, *supra*, note 70.
[81] See *supra*, note 69.
[82] See Ernest Fehr and Klaus M. Schmidt, Theories of Fairness and Reciprocity, Evidence and Economic Applications, Institute for Empirical Research in Economics, University of Zurich, Working Paper No. 75 (February 2001); Bruno S. Frey and Stephan Meier, Pro-Social Behavior, Reciprocity, or Both? Institute for Empirical Research in Economics, University of Zurich, Working Paper No. 107 (February 2002); Ernest Fehr and Armin Falk, Psychological Foundations of Incentives, Schumpeter Lecture, Annual Conference of the European Economic Association 2001; Samuel Bowles and Herbert Gintis, Social Capital and Community Governance, 112 The Economic Journal F419-F436 (2002); Kahan, *supra* note 2.

includes the Coasean insight that where entitlements were inefficiently defined initially, but the cost of implementing selective market exclusion to find the more efficient allocation is greater than the cost, including opportunity cost, of perfect exclusion—that is, of retaining entitlements where they began—perfect exclusion will be chosen and entitlements will remain where initially assigned. But it also maps the limitation of that insight that characterizes the social norms literature. The fact that the *market* transactional framework may be too costly for transacting around inefficiently delineated entitlements does necessarily mean the same is true of social relations-based transactional frameworks. Social norms may shift around the entitlements if transacting around the entitlements through the social system is less costly than doing so through the market, in which case the inefficiency need not be solved by state/judicial intervention to reallocate the entitlements.[83]

When the costs of refusing to exclude anyone, or refusing to permit anyone to use the good, in both cases including the opportunity cost of failing to permit or exclude some, are greater than the costs of one or the other form of selective exclusion, selective exclusion will occur. When the cost of market selection are greater than the costs of social selection, social sharing will occur, and when the costs of social sharing are greater than the costs of market selection, market selection will occur.[84]

The problem of understanding how to harness the excess capacity exhibited by shareable goods is to compare perfect exclusion to partial exclusion, and then to decide among nonselective and selective market and social partial exclusion. That is, to answer why and when it may be more costly for people not to share at all, and then to answer why and when it may be more or less costly to exclude on some nonselective model, as opposed to sharing socially or participating in a secondary market for excess capacity.

First, recall that there is some subset of agents who own shareable goods, who only use up part of the capacity of their goods and do not require or cannot absorb more of it. Giving that excess capacity away is costless to them, except for the transaction costs of giving the excess capacity to others. This means that they should prefer to have their excess capacity used rather than be idle whenever there is any positive utility to them from the fact that the excess capacity is used, net of the cost of sharing/reselling it. If the costs of perfect exclusion were equal to the costs of partial exclusion, then the owners of shareable goods would choose to exclude only partially whenever there was any positive utility to sharing. It is trivial that if we assume that the cost of perfect exclusion were always higher than the cost of partial exclusion, whether selective or not, then the owner would permit some use of his or her good as long as the disutility from sharing was no greater than the difference in exclusion costs. And where the costs of partial exclusion are higher than the costs of perfect exclusion, the owner will share or

[83] Indeed, this has been a core claim of the social norms literature for almost 20 years. See Robert C. Ellickson, Of Coase and Cattle, Dispute Resolution Among Neighbors in Shasta County, 38 Stan. L. Rev. 623 (1986).

[84] See Henry E. Smith, Exclusion vs. Governance: Two Strategies for Delineating Property Rights, 31 J. Legal Studs. S453 (2002) (describing prevalence of commons-based systems and property-based systems as a function of comparative transaction costs in each).

resell his or her excess capacity when the utility from sharing or reselling will exceed the difference in cost between partial exclusion and perfect exclusion.

Second, we have fairly extensive studies of the costs of the two forms of selective exclusion. The transaction costs literature analyzes the sources and types of transaction costs.[85] The cluster of literatures concerned with various non-market mechanisms—social trust and reciprocity,[86] common property regimes,[87] the gift and exchange anthropology literature[88]—offers us insight into the sources and scope of "transaction costs" associated with social selective exclusion. I assume that selective partial exclusion will always have higher information costs than nonselective partial exclusion, because the former will always require more information about specific transactions in order to implement the selection criterion, whereas any nonselective algorithm that can be applied mechanically will require the minimal amount of information—that a transaction is sought to be had. Selective partial exclusion will therefore only outperform nonselective partial exclusion when the selectivity provides some positive return as compared to nonselective partial exclusion. This is trivial in the case of markets, because the selection criterion is willingness and ability to pay, and payment must be more than the cost of selecting for those willing to pay more from those willing to pay less. Similarly, the social rewards of selectivity must exceed the added cost of selection in the social exclusion model. Bestowing a benefit on loved ones is probably the most common benefit for social selectivity, as we prefer our family and friends to strangers when we decide to whom we will lend our car or book.

Imagine a 200 square foot swimming pool in a back yard. The cost of perfect exclusion is the cost of building a fence at the perimeter (given a background investment in legal enforcement of and respect for property rights.) This is nontrivial but not high. This cost is higher than the direct cost of permitting free access by not putting up a fence. Given congestion costs, displacement, dirt, risk of liability etc., the option of open access is probably more costly than the option of perfect exclusion. The cost of partial exclusion includes (1) the cost of perfect exclusion plus (2) the cost of selective admission. It is, then, greater than the cost of perfect exclusion. Selective admission will nonetheless be granted when its return is higher than the added cost. Admitting friends and family members is relatively low cost. It is easy to identify and differentiate those who have permission from those who do not, and requires little or no additional monitoring, contracting, enforcement costs because it relies on a preexisting set of social relations that exist independently of the decision to admit to the swimming pool. The rewards are

[85] See, *e.g.*, Ronald Coase, The Firm, the Market, and the Law 6 (1988) (defining the relevant costs as search and information costs, bargaining and decision costs, policing and enforcement costs); Robert C. Ellickson, The Case for Coase and Against "Coaseanism," 99 Yale L. J. 611, 614-16 (1989) (offering a functional taxonomy of transaction costs, including get-together costs, decision and execution costs, and information costs). Calabresi & Melamed point out explicitly that exclusion costs are a part of negotiation costs—leaving unstated but obvious that enforcing the pre-bargaining entitlements is crucial to defining what is to be gained and transferred in the transaction itself. Guido Calabresi and Douglas Melamed, Property Rules, Liability Rules, and Inalienability, One View of the Cathedral, 85 Harv. L. Rev. 1089, 1095 (1971).
[86] See *supra*, note 82.
[87] See *supra* note 70.
[88] See *supra*, note 5.

social psychological in nature, and perhaps reciprocal for in kind exchanges. Admitting strangers who are willing to pay is more expensive. It requires identification, contracting, collection, enforcement, etc. Rewards are, obviously, monetary. Given the small size of the pool and its likely rapid congestion, there is a low ceiling on the monetary rewards obtainable from market-based admission. While thoroughly culturally and class-specific, the example offers an intuitive sense of the shape of the analysis involved.

A similar framework can be mapped onto our motivating problems: car-pooling and Internet-based distributed computing. In both cases, the marginal cost of perfect exclusion for any given time frame is negligible. Both types of goods come with exclusion mechanisms built in as part of the lumpy "unit"—be they door locks or an operating system that requires a user's initiation to run programs on the CPU. Both could suffer substantial congestion costs as well as degradation if given over to open sharing. Both are therefore only likely to be shared, if at all, on a partial exclusion basis. In both cases the primary perceived cost of nonselective partial exclusion is security—be it picking up hitchhikers on a first come, first served basis, or allowing anyone who wishes to run any program they wish on one's computer. Otherwise, the comparative costs of selective versus nonselective partial exclusion are more ambiguous. Which of the two approaches will fill three or four empty seats in a commuter car more efficiently? Will a habit of picking up at one or two meet points lower the marginal coordination cost such that it will be lower than stopping for the first hitchhiker, and will it be sufficiently low cost to outperform a stable set of commuting relationships, as is the case with body snatchers and slugs? Which will require greater intervention on the part of the computer's owner to assure that the resource is shared up to, but not beyond, the excess capacity? In the case of WiFi access points, for example, it is simple for the owner to set the gateway to full sharing, enabling any user to connect automatically. Selectively admitting only some users requires the owner either to select a password and provide it to all whom the owner wishes to admit, and for those others to change their configuration to meet this one access point, or to get unique identifying numbers of each admitted user and exclude others. Both for automobiles and for personal computers, then, perfect exclusion is a simple and cheap choice, open sharing is not a strong contender, and partial exclusion, is possible both on a nonselective (picking up any hitchhiker or slug on a first come first served basis, leaving one's WiFi gateway on the default "sharing" setting) and selective basis, which can occur both on a market and social basis: car-pooling and taxis, project-specific CPU cycle donations like SETI@Home or Folding@Home, more or less explicit reciprocity-based file-sharing system designs, such as Gnutella or Kazaa, as well as cybercafés and commercial WiFi hotspots.

3. Transaction costs analysis of markets and sharing

Both markets and social exchange are forms of selective exclusion. They share many of the basic costs of physical exclusion, given by the technology relating to the resource in question and its use. The primary systematic differences between these two forms of selective exclusion in terms of transaction costs are related to information and enforcement costs. There are two distinct differences in terms of information costs between markets and states, on the one hand, and social relations based production, on

the other hand. The first is the degree of crispness of the boundary of each transaction. The second is the information opportunity cost of each approach—which largely trades off texture for computability. A third information advantage is one enjoyed by decentralized systems more generally—whether for sharing or through eBay-like mechanisms—as compared to more centralized systems like firms and bureaucracies. That is the fact that they have fewer communications requirements, and fewer opportunities to lose information or to delay action. This information advantage trades off information for control—and hence declines as the conditions within which a resource will be deployed become more stable and predictable. The other main transaction cost difference between markets and social sharing system are enforcement costs. Assuming the information has been generated in each system—which is the subject of most of this subsection—markets rely more heavily (though not exclusively) on formal enforcement, while social relations rely on informal enforcement mechanisms studied in the literature on social norms and reciprocity. Which will be more costly depends on how costly punishing in the social system is relative to the enforcement process for property and contract claims in the particular market, how well developed the market/legal system are relative to the relevant social system, etc. These are largely empirical questions that I will not further pursue here.

Crispness

A market transaction, in order to be efficient, must be clearly demarcated as to what it includes, so that it can be priced efficiently. That price must then be paid in equally crisply delineated currency. Even if initially a transaction may be declared to involve sale of "an amount reasonably required to produce the required output", for a price "ranging from *x* to *y*," at some point what was provided and what is owed must be crystallized and fixed for a formal exchange. The crispness is a functional requirement of the price system, and derives from the precision and formality of the medium of exchange—currency—and the ambition to provide refined representations of the comparative value of marginal decisions through denomination in the exchange medium that represents these incremental value differences.

Social exchange, on the other hand, does not require the same degree of crispness. As Maurice Godelier put it, "the mark of the gift between close friends and relatives … is not the absence of obligations, it is the absence of 'calculation.'"[89] There are, obviously, elaborate and formally ritualistic systems of social exchange, both in ancient societies and modern. There are common property regimes that monitor and record calls on the common pool very crisply. These tend to resemble markets and market-based firms as the crispness increases.[90] In many of the common property regimes one finds mechanisms of bounding or fairly allocating access to the common pool that more coarsely delineate the

[89] Godelier, *supra*, note 5, at 5.

[90] An extreme classic case of a system described as a "commons" type arrangement that seemed to be more of a market in scrip than a common property regime was the case of water scrip in Alicante. As Ostrom described that irrigation system, water availability was divided up into increments of fractions of minutes of open irrigation gates, represented by paper scrip, for which there was a perfectly liquid market, facilitated by both auctions and two-party exchanges, and which were used as collateral and as an otherwise fungible medium of exchange. See Ostrom, Governing the Commons, *supra* note 70, at 78-82.

entitlements, behaviors, and consequences.[91] In modern market society, where we have money as a formal medium of precise exchange, and where social relations are more fluid than in traditional societies, social exchange certainly occurs as a fuzzier medium of exchange. Across many cultures, generosity is understood as imposing a debt of obligation, but neither the precise amount of value given, nor the precise nature of the debt to be repaid, or its date of repayment, need necessarily be specified.[92] Actions enter into a cloud of good will or membership, out of which each agent can understand him or herself as being entitled to a certain flow of dependencies or benefits in exchange for continued cooperative behavior. This may be an ongoing relationship between two people, a small group like a family or group of friends, and up to a general level of generosity among strangers that makes for a decent society. The point is that social exchange does not require defining: "I will lend you my car and help you move these five boxes on Monday, and in exchange you will feed my fish next July," as it would require "I will move five boxes on Tuesday for $100, six boxes for $120," etc. This does not mean that social systems are cost free; far from it. They require tremendous investment, acculturation, maintenance etc. This is true every bit as much as it is true for markets or states. Once functional, however, social exchanges require less crispness at the margin.

Both social and market exchange systems require large fixed costs—the setting up of legal systems, enforcement systems, etc. for markets, and the setting up of social networks, norms, and institutions for the social exchange. Once these initial costs have been invested, however, once both background systems are in place, market transactions systematically require a greater degree of precise information about the content of actions, goods, and obligations, and greater precision of monitoring and enforcement on a *per-transaction* basis than do social exchange systems.

Because the difference in cost is at the margin per-transaction, it increases linearly with the number of discrete transactions necessary to obtain a sufficient quantum of functionality flow to achieve the goals of a person relying on functionality flows from the owners of units. In other words, imagine that in order to run one computation one needs the excess capacity of only one computer, and the difference in transaction costs between using market based clearance and social exchange is $*x*. If, instead, in order to run one computation the person seeking to use excess capacity of others needs to pool the excess processing power of two idle computers, then the cost difference is $2*x per computation*,

[91] Acheson's classic study of the Lobster Gangs of Maine, James M. Acheson, The Lobster Gangs of Maine (1988), for example, describes a much coarser and collectivist system of entitlements than those of Alicante, described in the preceding note. There, harbor gangs' entitlements were collective to a fishing area broadly defined. Internal division was usufruct-based, leaving substantial room for internal allocation on a combination of unilateral action and social standing. Similarly the time-division techniques used in Swiss pastures that Ostrom describes have a coarser outline than the Alicante scrip system, or even the other, more closely policed Spanish irrigation systems she describes. Ostrom, Governing the Commons, supra note 69 at 61-65.

[92] See. *E.g.*, Joseph Henrich, Robert Boyd, Samuel Bowles, Colin Camerer Ernst Fehr, Herbert Gintis, and Richard McElreath, Cooperation, Reciprocity and Punishment in Fifteen Small-scale Societies, Am Econ. Rev. (2001) (suggesting that this type of indebtedness is responsible for an unusually high rejection rate of offers in a wide ranging dictator game experiment, in those cultures where receiving gifts was most clearly associated with unpredictable indebtedness).

and so forth. This pattern suggests that when slack capacity is located in small dollops distributed among many owners, it becomes increasingly more costly to harness that excess capacity through markets than through social exchange systems. Given that the interest of each individual owner to buy as little excess capacity as technically feasible places a downward pressure on the expected amount of each unit's excess capacity, shareable goods are likely to have this characteristic—widespread distribution of excess capacity in smallish dollops. This is precisely the domain in which shareable goods become very interesting as objects of social sharing, rather than market exchange, and in which they describe well carpooling, distributed computing, file sharing, or ad hoc mesh wireless networks.

Rendering requirements and lossiness

Both markets and state based production have rendering requirements that are lossy by comparison to social production and exchange systems. They lose information in the translation from the way the world is perceived by the agents most immediately affected by it and capable of acting, to the language in which the decision must be rendered given the requirements of the decision mechanism used to direct the action.

Each modality of production has its own ways of encoding, storing, and transmitting information from those observing the conditions and opportunities for action, to those who are doing the calculation of the comparative attractiveness of possible actions and the decision as to what action should be taken—be they centralized or distributed, be it from the eyes to the brain or from the sentries to the general. This takes the form of prices in the market or of administrative reports in the state or firm. In both cases, the actual richness of the world is transposed into formally structured modalities of representation whose logic is defined by the internal requirements of representation and processing in the system into which the information is fed—be it price in the market or bureaucratic decision making in the state.

Information about social relations relies not on formal structure, but on tacit, learned and culturally reproduced capacities to read and interpret social settings. This may well present problems of clarity, comparability, and formal computability of problems, but it allows more "analog," storytelling-like modalities of communicating information with great subtlety and nuance. Social communications are more textured than the more formal systems of organizing information in market and state production. The texture can come from direct express communication about details, as opposed to translation into prices or formal categories, or from narratives that tap into culturally accessible reasons for action ("help fight AIDS", "find extraterrestrial life"). It can also come from observation of others or of the context of action filtered through a common cultural filter that allows the observer to treat the actions or observed facts about the world as legible and intelligible cues about context, reasons for action, and desirability of action. Texture also comes from practice and the tacit learning or information acquisition that occurs as part of practice in and adaptation to the social and material environment.

The tradeoff between formal clarity and computability, on the one hand, and texture on the other hand, suggests that social systems will be relatively weaker in organizing actions for which there are clear, computable, but fine differences between alternative courses of action. Conversely, such systems will be particularly valuable as information processing systems where the context, precise nature of the alternative possible actions, and range of possible outcomes are persistently vague or difficult to specify formally.[93] To the extent that information about production opportunities, cooperative actions, and motivational inputs can be represented effectively through social communications systems, it would represent a more complete statement of the factors relevant to agent's decisions than could information available in systems—like the state and the market—that require formalization of the data so that they can be represented adequately for the particular process of computation defined as necessary to a decision in those systems.[94] This is particularly important under conditions of persistent uncertainty (where uncertainty cannot be eliminated at an acceptable cost). Presumably, there will be ranges where decisions could be improved by formal representation and computation, ranges where these will systematically fail to represent all factors relevant to an agent,

[93] The value of nonmarket systems in the presence of high uncertainty is not original here. Arrow mentions it in Kenneth Arrow *Gifts and Exchanges*, 1 Phil. & Pub. Aff. 343, 351-55 (1972), as an explanation of Titmuss's finding that market-based blood was more tainted than donated blood. For a more complete discussion of the Titmuss-Arrow debate see *infra*, Part IV.B. Arrow also mentioned it as a reason that nonprofit hospitals may be better than for profit hospitals in Kenneth Arrow, *Uncertainty and Welfare Economics of Medical Care*, 55 American Economic Review 941 (1963). This latter position was developed into a full blown theory of the comparative advantage of nonprofits by Henry Hansmann in Hansmann, The Ownership of Enterprise 228 (1996) (explaining that "nonprofit firms commonly arise where customers are in a peculiarly poor position to determine, with reasonable cost of effort, the quality or the quantity of the services they receive from a firm. As a consequence, assigning ownership to anyone other than these customers would create both the incentive and the opportunity for the customers to be severely exploited. Yet at the same time, the customers are so situated that the cost to them of exercising effective control over the firm are unacceptably large relative to the value of their transactions with the firm. The solution is to create a firm with no owners—or, more accurately, to create a firm whose managers hold in trust for customers. In essence, the nonprofit form abandons any benefits of full ownership in favor of stricter fiduciary constraints on management.") These claims about nonprofit and nonmarket donation and uncertainty are different from my own focus in one crucial way. Both Arrow and Hansmann locate the "fix" that nonprofits or nonmarket actors provide in the alignment of incentives of the agents and "principals" or "customers." In the case of nonprofits, the nondistribution constraint means that no class of "owner"-patrons governs the firm *and* can capture the gains from exploiting the ill-informed class of patrons, and hence there is no class whose interests are severely misaligned with the potentially-exploitable class. In the case of Arrow and blood donation, without an ability to be paid for one's tainted blood, the donative motivation to help others no longer drives the person with disease-carrying blood to provide it. My own focus here is not on the alignment of incentives when operating through a market (though nothing in my approach denies this effect), but on the idea that embedding an uncertain transaction in social exchange introduces social signals into the transaction, thereby reducing uncertainty and the information asymmetry—it is not alignment of incentives only that is at stake, but freeing the transaction from the strictures of price-mediated information exchange that improves the quality of action in the face of uncertainty.

[94] Note that, to the extent that a nonprofit is run like a firm, and interacts with its "patrons" as a firm would, it would not have this uncertainty reduction characteristic. It is when non-market behavior occurs through social interactions among individual participants that socially-legible information can be communicated. A market-based actor who can communicate socially (a "chic" nightclub) will reduce uncertainty (as to whether to go into this club or that, or whether to go to a club or stay at home), while a non-market actor communicating bureaucratically or through market-pricing will not.

and ranges where any two or three of the systems could render the decisions clearly enough for a decision—easy cases—where their comparative advantage must be found elsewhere.

Decentralized systems and information

Finally, the phenomenon I focus on in this article is systematically decentralized. Shareable goods are private goods controlled by their private owners, shared in broad social patterns among more or less weakly related individuals—much as an idealized market (or actual one, like eBay) might work. In this, they are different from many actual market-based or state-based production systems—which tend to be more centralized or firm/bureaucracy based.

The "centralized/distributed" distinction as I use it here is not binary. It is a range property of systems of human action in context. It describes the distance between the occurrence of an opportunity for human action in an environment and the authority for directing whether and how the agent confronted with the opportunity will act on it. "Distance" describes any parameter that separates the authority from the capacity to identify the presence of, and act on, the opportunity. This may describe organizational and institutional characteristics, geographic distance, technical constraints of information and authorization flow, etc. The point to see is that the more a system is organized centrally, the more room there is for information loss between the actual state of the world as perceived by those agents closest to the opportunity for action and the perceptions of agents with authority to decide that an action should be undertaken, and vice versa. Any system, whether a market based firm, a state based bureaucracy, or a social organization like the Catholic Church, can be centralized. So too can there be distributed models of production in each, though the formal constraints of accountability and legal authority of the state makes true devolution of power to individual agents who act on behalf of the state difficult. To the extent that shareable goods in fact are shared in practices that are closer to the distributed end of the spectrum, it adds an additional reason to think that sharing in social production systems loses less information: distributed systems lose less information. This overarching claim about sharing systems captures within it the many empirical claims about local knowledge, active monitoring and enforcement, etc. that have been made on behalf of common property regimes and community-production systems in the literature that has described and explained the sustainability and, indeed, efficiency, of these non-market based organizational forms.[95]

B. Motivation

Transaction costs-based institutional analysis normally stops here—identifying and comparing transaction costs across institutional settings. There is, however, another, independent dimension to understanding sharing—that of motivation. The organizers of distributed computing projects, for example, focus explicitly on how to motivate contributions.[96] Practitioners of free software development[97] as well as the academics

[95] See Ostrom, *supra* note 70.
[96] See *supra*, text accompanying notes 66-67

who study them[98] similarly spend a good bit of energy studying motivations. One question is what is the source and form of non-monetary rewards. The other is the question of crowding out—that is, whether the presence of market-based, monetary rewards for an action undermines or improves non-monetary motivations for that action.

The theoretical and empirical debate over whether monetary motivations and some set of social-psychological motivations crowd each other out emerged initially in the debates of the early 1970s over blood policy. Until the early 1970s, the vast majority of blood donors in the United States were compensated in cash or indirectly, via some type of blood exchange or insurance system.[99] In a major work, Richard Titmuss compared the U.S. and British blood supply systems, the former largely commercial at the time, organized by a mix of private for-profit and non-profit actors, the latter entirely voluntary and organized by the National Health Service. Titmuss found that the British system had higher-quality blood, as measured by the likelihood of recipients contracting hepatitis from transfusions,[100] less blood waste, and fewer blood shortages at hospitals. Titmuss also attacked the U.S. system as inequitable, arguing that the rich exploited the poor and desperate by buying their blood. He concluded that an altruistic blood procurement system is both more ethical and more efficient than a market system, and recommended that the market be kept out of blood donation to protect the "right to give."[101] Titmuss's argument came under immediate attack from economists. Most relevant for our purposes here, Kenneth Arrow agreed that the differences in blood quality indicated that the U.S. blood system was flawed, but rejected Titmuss's central theoretical claim that markets reduce donative activity.[102] Arrow reported the alternative hypothesis held by "economists typically", that if some people respond to exhortation/moral incentives (donors) while others respond to prices and market incentives (sellers), these two groups likely behave independently – neither responds to the other's incentives.[103] Thus the decision to allow or ban markets should have no effect on donative behavior—though removing a market could in fact remove incentives of the

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[97] See Eric Raymond, The Cathedral and the Bazaar, (1998), available at http://www.tuxedo.org/~esr/writings/cathedral-bazaar/; Eric Raymond, Homesteading the Noosphere, (1998), available http://www.firstmonday.dk/issues/issue3_10/raymond/.

[98] See, *e.g.* Josh Lerner and Jean Tirole, Some Simple Economics of Open Source, 50 *J. Indus. Econ.* No. 2 (2002). Eric von Hippel in particular has provided both theoretical and empirical support for the importance of the use value gained by users in a user-driven innovation environment, both in software and elsewhere, see *e.g.*, Eric von Hippel, Innovation by User Communities: Learning from Open Source Software 42 *Sloan Management Review* 82 (2001).

[99] RICHARD M. TITMUSS, THE GIFT RELATIONSHIP: FROM HUMAN BLOOD TO SOCIAL POLICY 94 (1971); s*ee also* DOUGLAS STARR, BLOOD: AN EPIC HISTORY OF BLOOD AND COMMERCE 174-75 (1998) (explaining that replacement fees were approximately $25 per pint in the late 1940s).

[100] In the UK, this rate was less than 1%, and in one study was as low as 0.16%. TITMUSS, *supra* note 99, at 154-55. In the U.S., the rate may have been as high as 3.6%. *Id*. at 145-46.

[101] TITMUSS, *supra* note 99, at 245-46. At least one contemporary historian casts some doubt on Titmuss's analysis:

> In retrospect, Titmuss's critique was unfair. His thesis largely ignored the American Red Cross, which accounted for about 40 percent of the blood collected in America. . . . Instead, he focused on the booming plasma industry and the rising number of for-profit blood banks. What he criticized was not the complex reality of America's blood resource, but a caricature . . . . Titmuss's book hit a public nerve.

STARR, *supra* note 99, at 225.

[102] Kenneth J. Arrow, *Gifts and Exchanges*, 1 PHIL. AND PUB. AFFAIRS 343 (1972).

[103] *Id*. at 350-51.

"bad blood" suppliers to give blood, thereby improving the overall quality of the blood supply.[104] Titmuss's had not established his hypothesis analytically, Arrow argued, and its proof or refutation would lie in empirical study.[105] Theoretical differences aside, the United States blood supply system did in fact transition to an all-volunteer system of social donation since the 1970s.[106] In surveys since, blood donors have reported that they "enjoy helping" others, experienced a sense of moral obligation or responsibility, or exhibited characteristics of reciprocators after they or their relatives received blood.[107]

A number of scholars, primarily in psychology and economics, have attempted to resolve this question both empirically and theoretically.[108] The most systematic work within economics is that of Bruno Frey and various collaborators.[109] Frey imports a model of motivations from psychology[110] and combines it both with analytic modeling and empirical evidence to show that the introduction of money, or prices, for an activity, may in fact lower the level of that activity. He calls this "the crowding out effect."

A simple statement of this model is that individuals have intrinsic and extrinsic motivations. Extrinsic motivations are imposed on individuals from the outside, taking

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[104] *Id*., 351-55. This was similar to Robert Solow's critique. Solow took issue with much of Titmuss's empirical work and ascribed the UK's advantage over the U.S. in part to the "the tight little island['s] . . . tradition of civic-mindedness." Because hepatitis had to be self-reported – no hepatitis test existed at the time – Solow found the lower quality of blood in the U.S. system to be largely unsurprising: compared to voluntary blood donors, blood sellers are 1) more likely to have hepatitis and 2) face incentives to conceal their illness. Robert M. Solow, *Blood and Thunder*, 80 YALE L.J. 1696, 1705 (1971).

[105] Arrow *Gifts and Exchanges*, at 351.

[106] *See* Kieran Healy, *Embedded Altruism: Blood Collection Regimes and the European Union's Donor Population*, 105 AM. J. OF SOCIO. 1633 (2000); JANE A. PILIAVIN & PETER L. CALLERO, GIVING BLOOD: THE DEVELOPMENT OF AN ALTRUISTIC IDENTITY 1 (1991) (explaining that the Department of Health, Education, and Welfare announced a policy strongly discouraging blood sales in 1973; a subsequent regulation requiring differential labeling of blood from voluntary and paid donors also contributed to the "virtual elimination of commercial whole-blood banks"); American Association of Blood Banks, Frequently Asked Questions, http://www.aabb.org/All_About_Blood/FAQs/aabb_faqs.htm. Since the 1970s there has been essentially no commercial collection of whole blood in the U.S., and insurance-based individual responsibility systems are becoming rarer. *See* STARR, *supra* note 99, at 219. In 2001, 8 M volunteers donated 15 M units of whole blood and red blood cells in the U.S. http://www.aabb.org/All_About_Blood/FAQs/aabb_faqs.htm. This likely represents more than 5% of the age-eligible population. PILIAVIN & CALLERO, *supra* note 106, at 2, and [a]pproximately 40% of age-eligible Americans have given blood at some point in their lives. *Id*. At 24. European countries also appear to collect whole blood exclusively from voluntary donors, following an official European Union policy announced in 1989. *See* Healy, *supra* note 99, at 1638. Survey research shows that blood donors are common in some European countries, e.g., France, where 44% of age-eligible residents have given blood, and much rarer in others, e.g., Luxembourg, where only 14% of age-eligible residents are donors. See *id*.

[107] PILIAVIN & CALLERO, *supra* note 99, at 35 (describing motivations of first time donors); *id*., at 181-90 (describing social norms around donation).

[108] See Bruno S. Frey and Reto Jege, Motivation Crowding Theory: A Survey of Empirical Evidence, 15(5) J. Economic Surveys 589 (2001) (surveying the literature).

[109] See Bruno S. Frey, Not Just for Money (1997); Brnuo S. Frey, Inspiring Economics 52-72 (2001).

[110] He traces the origin of the line of psychology literature he follows to Edward L. Deci, Effects of Externally Mediated Rewards on Intrinsic Motivation, 18 J. Personality and Social Psychology, 105-15 (1971). Ironically, then, at least one answer to Arrow's critique of the lack of theoretical causal mechanism for crowding out already existed, but in another field. The line of literature is crystallized in Edward L. Deci and Richard M. Ryan, Intrinsic Motivation and Self-Determination in Human Behavior (1985).

the form of either offers of money for, or prices imposed on, behavior, or threats of punishment or reward from a manager or a judge for complying with, or failing to comply with, specifically prescribed behavior. Intrinsic motivations are reasons for action that come from within the person, such as pleasure or personal satisfaction.[111] Extrinsic motivations are said to "crowd out" intrinsic motivations because they (a) impair self-determination—that is, people feel pressured by an external force, and therefore feel over-justified in maintaining their intrinsic motivation rather than complying with the will of the source of the extrinsic reward; or (b) impair self-esteem—they cause individuals to feel that their internal motivation is rejected, not valued, and as a result individuals reduce their self-esteem, causing them to reduce effort.[112] It is not self-evident in Frey's own rendition why offering to pay money for an activity that an agent is free to forego has the same psychological effect of impairment of self-determination or self-esteem as the imposition of a penalty/price on the agent's failure to act, which the agent cannot avoid, but the intuition is not difficult to explain. It depends on a culturally-contingent notion of what one "ought" to do if one is a well-adjusted human being and member of a decent society. Being offered money to do something you know you "ought" to do, and that self-respecting members of society do, implies that the offeror believes that you are not a well-adjusted human being or an equally-respectable member of society. An alternative causal explanation is formalized by Roland Benabou and Jean Tirole, who claim that the person receiving the monetary incentives infers that the person offering the compensation does not trust the offeree to do the right thing, or to do it well of their own accord, and the offeree's self-confidence and intrinsic motivation to succeed are reduced to the extent that the offeree believes that the offeror—a manager or parent, for example—is better situated to judge the offeree's abilities.[113]

A substantial empirical literature, including field and laboratory experiments, econometrics, and surveys—has tested the hypotheses of this model of human motivation, and found substantial evidence that, under some circumstances, adding money for an activity previously undertaken without price compensation reduces, rather than increases, the level of activity.[114] The work has covered contexts as diverse as employees supplying labor[115] or sharing their knowledge with team members,[116] willingness of communities to accept locally undesirable land uses (NIMBY behavior increasing, rather than decreasing, with the addition of incentives rather than common weal arguments),[117] or punctually picking up children from daycare centers (parents come

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[111] See Frey, Not Just For Money, *supra* note 109, at 13-14; Frey, Inspiring Economics, *supra* note 109, at 55.

[112] See Bruno S. Frey and Reto Jege, Motivation Crowding Theory: A Survey of Empirical Evidence, 15(5) J. Economic Surveys 589 (2001) (pp. 8-9 of working paper version).

[113] Bénabou, R. and J. Tirole (2000). Self-Confidence and Social Interactions. NBER Working Paper W7585 (March, 2000).

[114] See *id*.

[115] T.F. Bewley, A Depressed Labor Market as Explained by Participants, 85 Am Econ. Rev. 250 (1995) (providing survey data about managers' beliefs about the effects of incentive contracts).

[116] See Margit Osterloh and Bruno S. Frey, Motivation, Knowledge Transfer, and Organizational Form, 11 Organization Science 538 (2000).

[117] Bruno S. Frey and Felix Oberholzer-Gee, The Cost of Price Incentives: An Empirical Analysis of Motivation Crowding-Out, 87 *Am Econ. Rev*. 746 (1997); H. Kunreuther and D. Easterling, Are Risk-Benefit Tradeoffs Possible in Siting Hazardous Facilities? 80 Am. Econ. Rev. 252-256 (1990).

later, rather than earlier, when a price is imposed on coming late).[118] The results of this work strongly suggest that some displacement, or crowding out, can be identified, across various domains, between monetary rewards and non-monetary motivations. This does not mean that offering monetary incentives does not increase extrinsic rewards. It does, and where extrinsic rewards dominate, this will increase the activity rewarded as usually predicted in economics. But the effect on intrinsic motivation, at least sometimes, operates in the opposite direction. Where intrinsic motivation is an important factor, because pricing and contracting are difficult to achieve or because the payment is relatively low, the aggregate effect may be negative. Inducing transfers of tacit knowledge from employees to the teams they work with is a good example of the former type of condition;[119] while low payments for otherwise volunteer-based activities are an example of the latter.[120]

Frey's psychologically-based extrinsic/intrinsic motivation distinction is helpful, and the empirical evidence is powerful. The psychological construct does not, however, seem fully to account for motivation in social sharing frameworks. As Frey himself implies, recognition by friends is plainly a form of extrinsic motivation,[121] and it is trivial that the attainment of wealth is not purely functional and extrinsic, but as Veblen explained long ago, plays a role in providing social recognition,[122] which in turn is likely quite central to people's sense of intrinsic satisfaction. In the social capital literature, social interactions are very often understood in functional, rather than symbolic and psychological terms—their value is in providing future access to information, resources, and opportunities for action.[123] This social-functional thesis of why people might behave sociably and share does not need a psychological explanation, but might still have a similar relationship with money—where paid cooperative behavior demands less non-monetary reciprocation than uncompensated cooperation. Such an interpretation would equally, if not better, explain empirical findings that payments crowd out reciprocating cooperation.[124] The social capital literature, in any event, seems to assume that what can be attainable through social position and relations is not substitutable, at least not

[118] Uri Gneezy and Aldo Rustichini, A Fine is a Price 29 J. Legal. Stud. 1 (2000) (finding that introducing a fine for tardy pickup increased, rather than decreased, tardiness by parents).
[119] See Osterloh & Frey, *supra* note 116.
[120] See Frey & Jege, *supra* note 112.
[121] See Frey, Not Just for Money, *supra* note 109, at 14.
[122] Thorstein Veblen, The Theory of the Leisure Classe, Chapter 4 (1902) (explaining conspicuous consumption).
[123] See, *e.g.*. Lin, *supra*, not 76, at 150-51 (Making the claim that "there are two ultimate (or primitive) rewards for human beings in a social structure: economic standing and social standing," and elaborating a thesis where in both cases these represent relational standing, in terms of capacity to mobilize resources, some that can be mobilized by money, others those that can be mobilized by social relations. Coleman, *supra* note 76, similarly is focused on the functional characteristics of social networks, as are other major versions of social capital literature, such as Mark Granovetter, The Strength of Weak Ties, 78 Am. J. Sociology, 1360-80 (1973); Mark Granovetter, Getting a Job (1974); Yoram Ben-Porath, The F-Connection, Families, Friends and Firms and the Organization of Exchange, 6 Population and Development Rev. 1 (1980).
[124] In particular, studies that focus on crowding-out of reciprocity, are supportive of a social causal theory. See, *e.g.*, Ernst Fehr and Simon Gechter, Do Incentive Contracts Undermine Voluntary Cooperation? IERE Zurich Working Paper, No. 34, (April 2002) (describing laboratory experimental results for the effects of incentives on cooperation).

perfectly, with what can be bought. That is what makes social relations a form of capital distinct from financial capital.

For purposes of my analysis here it is not necessary to pin down precisely the correct and most complete theory of motivation, or the full extent and dimensions of crowding out. All that is required to outline the framework for analysis is recognition that there is some form of social-psychological motivation that is neither fungible with money, nor simply cumulative with it.[125] Transacting within the price system may either increase or decrease the social-psychological rewards (be they intrinsic or extrinsic, functional or symbolic).[126]

The intuition is simple. Leaving a $50 bill on the table after one has finished a pleasant dinner at a friend's house would not increase the host's social and psychological gains from the evening. Most likely it would so diminish them such that one would never again be invited. A bottle of wine or bouquet would, to the contrary, improve the social gains. And if dinner is not intuitively obvious, think of sex. The point is simple. Money-oriented motivations are different from socially oriented motivations. Sometimes they align. Sometimes they collide. Which of the two will be the case is historically and culturally contingent. The presence of money in sports or entertainment reduced the social psychological gains from performance in late 19th century Victorian England, at least for members of the middle and upper classes. This is reflected in the long-standing insistence on the "amateur" status of the Olympics, or the status of "actors" in that society. This has changed dramatically over a century later, where athletes' and popular entertainers' social standing is practically measured in the millions of dollars their performances can command.

The relative relationships of money and social-psychological rewards are culturally- and context-dependant. Similar actions may have different meanings in different social or cultural contexts. While I have elsewhere offered more detailed descriptions,[127] one example could illustrate how these components interact. Consider three lawyers contemplating whether to write a paper presenting their opinion. One is a practicing attorney. The second is a judge. The third is an academic. For the first, money and honor are often, though not always, positively correlated. Being able to

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[125] One sees this assumption in operation in the non-profit literature. See Dennis Young, Entrepreneurship and Behavior of nonprofit Organizations: Elements of a Theory, in The Economics of Nonprofit Institutions (S. Rose-Ackerman, ed.) at 161 (1986) (describing non-profit sector precisely in terms of motivational profiles of non-profit entrepreneurs); Weisbrod, *supra* note 3, at 31-33 (describing motivational profile of nonprofit entrepreneurs, and providing empirical evidence that the non-profit sector draws individuals with different motivational profiles than for profit sector).

[126] Crowding out may not, however, be an important effect in the relationship of government provisioning to volunteer donation. Susan Rose-Ackerman has shown that the relationship is ambiguous, and that government provisioning may not crowd out private donation, but merely change is focus and shape. Susan Rose-Ackerman, Do Government Grants Reduce Private Donations, in The Economics of Nonprofit Institutions *supra* note 114, at 313. See also Burton A. Abrams and Mark D. Schmitz, The Crowding Out Effect of Governmental Transfers on Private Charitable Contributions, in Economics of Nonprofit Institutions, *id*, at 304, 311 (finding somewhat ambiguously a partial displacement of private contributions by public funding.)

[127] Benkler, Coase's Penguin, or Linux and the Nature of the Firm, 112 Yale L. J. 369 (2002).

command a very high hourly fee for writing the requested paper is one mode of expressing one's standing in the profession. And yet, there are modes of acquiring esteem—like writing the paper as a report for a bar committee—that not only are not improved by the presence of money, but are in fact undermined by it. This latter effect is sharpest for the judge. If a judge is approached with an offer of money for writing an opinion, not only is this not a mark of honor, it is a subversion of the social role and would render corrupt the writing of the opinion. The intrinsic "rewards" for the judge from writing the opinion when matched by a payment for the product would be guilt and shame, and the offer therefore an expression of disrespect. Finally, if the same paper is requested of the academic, the presence of money is located somewhere in between the judge and the practitioner. To a high degree, like the judge, the academic who writes for money is rendered suspect in her community of scholarship. A paper clearly funded by a party, whose results support the party's regulatory or litigation position is practically worthless as an academic work. But in a mirror image of the practitioner, there are some forms of money that count towards adding to an academic's social psychological rewards, peer-reviewed grants and prizes most prominent among them. Pursuing those reinforces, rather than undermines, the academic's social psychological rewards.

A comparison of market and social systems for organizing production utilizing shareable goods in terms of motivation, then, will see money (or any other expression of market-exchange value) and social-psychological rewards as alternative sources of motivation, where the pursuit of one sometimes complements, but sometimes undermines, the value of the action as measured in terms of the other. What the relationship of the two will be is culturally and historically contingent. Capturing the potential for human action that could be motivated by the exchange of love, status and esteem,[128] a personal sense of worth in relations to others, is the strong suit of social production (and sometimes to a greater, and sometimes to a lesser extent, depending on time and context, the state—as in "Uncle Sam Wants You!"), which rewards action either solely in these forms, or if it adds money, organizes its flow in such ways that at least does not *conflict* with and undermine the quantum of self-confidence, love, esteem, social-networking value etc., obtained by the agent from acting.

c. Motivation and Information

To compare the attractiveness of market and social exchange systems, then, we should compare (a) transaction costs of using one or the other system of exchange, and (b) the likely reward flows to individuals from participating in one or the other of the two systems. The two considerations are independent of each other. If one chooses to be concerned with welfare optimization, then what needs to be optimized is the combined effect of both. Comparing each is a context specific, empirical exercise that depends on the characteristics of the good, the use, and the extant social and market practices and institutions in the society for which the two are compared. The answers may be different for apples than for oranges,[129] for economists than for Melanesian Islanders.[130] These

[128] See Richard H. McAdams, The Origin, Development, and Regulation of Norms, 96 Mich. L. Rev. 338 (1998).
[129] The latter have lower transaction costs for sharing, because of their morphology.

questions provide rich grounds for empirical observations as to sharing and secondary market practices, but do not give us an approximate general intuition about the direction that exchange of excess capacity generated by shareable goods will take, except in one instance of central importance.

What the analysis does suggest is that where shareable goods result in excess capacity being widely distributed in small dollops, social sharing will outperform secondary markets. This is so because of both transaction costs and motivation. The difference between the transaction costs of a secondary market and those of a sharing system increase linearly with the number of transactions necessary to collect a usable amount of functionality. The smaller the amount of excess capacity held by each unit owner relative to the total amount required for the functionality, the higher the number of transactions necessary to achieve the functionality, and the larger the gap in transaction costs between market-based clearance and social sharing. Furthermore, the smaller the amount of excess capacity each unit owner owns, the smaller the payment that each owner can be paid. It is precisely where payments are low that their introduction is likely to have a small positive effect on contributions, and therefore to leave the crowding out effect to dominate the overall level of participation. Fewer owners will be willing to sell their excess capacity cheaply than to give it away for free, and the transaction costs of selling will be higher than those of sharing.

At a broad policy level, one could be concerned with one of two goals. The first goal is relevant where we are able to say with some degree of confidence that a particular problem is particularly amenable to solution within one or another of the systems of production. It would be focused on providing stronger institutional guides towards funneling the behavior into a market, or a social production system, respectively. The second, more widely applicable goal until we have learned more about the contours of social production and exchange, is to study changes in law and policy so as to avoid tipping the production system towards one or another of these competing systems—in particular in favor of the one with which we are more familiar, the market—before we have good reason to think that the preferred system is the better one.

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[130] Melanesian Islanders have appeared as all but the personification of gift economies ever since Malinowski's Argonauts of the Western Pacific, *supra* note 5. Economists, by contrast, have been the subject of claims that they systematically behave less pro-socially than students of other disciplines. See Marwell Gerald and Ruth E. Ames (1981). Economists Free Ride, Does Anyone Else? Experiments on the Provision of Public Goods IV. *Journal of Public Economics* 15. 295-310.; Carter, John R. and Michael D. Irons (1991), Are Economists Different, and If So, Why? *Journal of Economic Perspectives* 5, 171-177; Frey, Bruno S., Werner W. Pommerehne and Beat Gygi (1993). Economics Indoctrination or Selection? Some Empirical Results, *Journal of Economic Education* 24, 271-281; Frank, Björn und Günther G. Schulze (2000). Does Economics Make Citizens Corrupt? *Journal of Economic Behavior and Organization* 43 (1). 101-113; Frank, Robert H., Thomas Gilovich and Dennis T. Regan (1993). Does Studying Economics Inhibit Cooperation? *Journal of Economic Perspectives* 7, 159-171; Frank, Robert H., Thomas Gilovich and Dennis T. Regan (1996). Do Economists Make Bad Citizens? *Journal of Economic Perspectives* 10, 187-192. This observation may, however reflect a selection bias—that is, it is more likely that selfish people self-select into the discipline than that the exposure to the discipline causes selfishness. See Frey & Meier, Pro-Social Behavior, *supra*, at 14-16 & Table 6.

The basic point is that for any given resource that exists in an institutional-cultural space at a moment in history, there will be different costs to move from no sharing to either a secondary market system or a social exchange system. These costs partly depend on the technological characteristics of the good. Some things are very small, aggregation requires many transactions with many individuals, and the higher transaction costs of markets will likely rule out efficiency-seeking policy through secondary markets. Partly, however, the costs depend on social practices and cultural values held by the people in the relevant society. For example, if market institutions are prevalent, and people are culturally attuned to making every penny they can, then moving to a secondary market will require (a) lower fixed transaction costs for institution building and repurposing, (b) fewer attitudinal and social practice adjustments, and (c) will hit the right motivational pitch to which people in this society are attuned. And vice versa—a society where sharing or otherwise non-market cooperation among non-kin is widespread, where social institutions, attitudes etc., are more readily available to support a sharing system for impersonal interactions, the transition costs from perfect exclusion to social sharing will be lower than the transition costs from the same perfect exclusion, keeping technological characteristics constant, to secondary markets. When we are faced with policy proposals for institutional changes that affect practices involved in production and exchange, we should consider their effects not only on market production, but also on social production. To the extent policy is properly concerned with increasing production of a given desideratum, it should be driven by an analysis of how the policy change will affect total production, in both systems—or all three, including state-based production—not only on how it will affect one of the systems.

V. Sharing as a modality of production

Up to this point the article has been focused on sharing of material goods that appear to be "traditional" economic goods—rival and private—but nonetheless are amenable to sharing. We can now integrate these observations with work done in a number or related areas of study, as well as with my own earlier work on peer-production online, to consider sharing at a broader level of abstraction as an alternative modality of economic production. In this part I will attempt to outline what "sharing" as a modality of economic production might mean, how we could think of locating its role in the economy. The last part will be devoted to outlining how recognizing sharing as an important form of production can affect some contemporary policy debates.

The claim is that sharing is a pervasive modality of economic production. By "economic production" I mean the provisioning of goods and services that people value. By pervasive, I mean that it is an approach to organizing economic production that we use as an integral part of many daily contexts—whether we think of them or not.

Under certain technological circumstances, practically-feasible opportunities for action are distributed in such a pattern that they are amenable to execution by a class of approaches to organizing production that rely on sharing. These are typified by (a) radical decentralization of the capacity to contribute to effective action and the authority to decide on the contribution, and (b) reliance on social information flows, organizational

approaches, and motivation structures, rather than on prices or commands, to motivate and direct productive contributions.

Most practices of production—social or market-based—are already embedded in a given technological context. They present no visible "problem" to solve or policy choice to make. We do not need to be focused consciously on improving the conditions under which friends lend a hand to each other to move boxes, make dinner, or take kids to school, and feel no need to reconsider the appropriateness of market-based-firm production of automobiles. However, in moments where a field of action is undergoing a technological transition that changes the opportunities for sharing as a modality of production, understanding that sharing *is* a modality of production becomes more important, as does understanding how it functions as such. This is so, as we are seeing today, when prior technologies have already set up market- or state-based production systems that have the law and policy-making systems already designed to fit their requirements. While the prior arrangement may have been the most efficient, or even may have been absolutely necessary for the incumbent production system, its extension under new technological conditions may undermine, rather than improve, the capacity of a society to produce and provision the goods, resources, or capacities that are the object of policy analysis. This is, today, true of wireless communications regulation, or "spectrum management" as it is usually called; of the regulation of information, knowledge, and cultural production, or "intellectual property," as it is usually now called, and it may be true of policies for computation and wired communications networks, as distributed computing and the emerging peer-to-peer architectures are suggesting. I will consider these policy areas in Part VI.

Sharing is common and underappreciated as a modality of production

There is a curious congruence between the anthropologists of the gift and mainstream economists today. Both treat the gift literature as being about the periphery, about societies starkly different from modern capitalist societies. As Godelier puts it, "What a contrast between these types of society, these social and mental universes, and today's capitalist society where the majority of social relations are impersonal (involving the individual as citizen and the state, for instance), and where the exchange of things and services is conducted for the most part in an anonymous marketplace, leaving little room for an 'economy and moral code based on gift-giving."[131] And yet, sharing is everywhere around us in the advanced economies. The past two decades or so have seen an increasing focus, in a number of interrelated literatures, on production practices that rely heavily on social, rather than price-based or governmental policies. These include, initially, the literature on social norms[132] and social capital, or trust.[133] Both lines of

[131] Godelier, *supra* note 5, at 106.

[132] In the legal literature Robert Ellickson, Order Without Law: How Neighbors Settle Disputes (1991) is the *locus classicus* for showing how social norms can substitute for law. For a bibliography of the social norms literature outside of law see Richard H. McAdams, The Origin, Development, and Regulation of Norms, 96 Mich. L. Rev. 338, footnotes 1 and 2. Early contributions were Edna Ullman-Margalit, The Emergence of Norms (1977); James Coleman, Norms as Social Capital, *in* Economic Imperialism, (Gerard Radnitsky and Peter Bernholz, eds. 1987) 133-55; Sally E. Merry, Rethinking Gossip and Scandal, in Toward a Theory of Social Control, Vol 1., Fundamentals, (Donald Black, ed. 1984) 271-302.

literature, however, are statements of the institutional role of social mechanisms for enabling *market* exchange and production.[134] More direct observations of social production and exchange systems are provided by the literature on social provisioning of public goods—like the literature on social norm enforcement as a dimension of policing criminality,[135] and the literature on common property regimes.[136] The former are limited by their focus on public goods provisioning. The latter usually limited by their focus on discretely identifiable types of resources—common pool resources—that must be managed as among a group of claimants while retaining a proprietary outer boundary towards non-members.[137] The broadest set of claims similar to those I make here comes from Bowles and Gintis, who describe "community governance" as a complementary system for solving problems, some of which take the form of production problems, some that take the form of public goods provisioning.[138] Their claim is that communities can have advantages in incentives to cooperate because of the prevalence of repeat interactions, in the acquisition of information about past, present, and likely future behavior of other participants, and by providing organizational space for the utilization of the empirically tested fact that many people have a taste for enforcing against anti-social behavior. Along these dimensions, they claim that community governance systems exist alongside, and complement, markets and states, where their relative advantages make them better than market and states at solving the governance problems faced by agents that make up the community.[139] My own aim is to generalize this claim, such that we understand "community governance" aimed at production as a special case of social

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[133] Bowles and Gintis trace the argument that social trust compensates for market failures in enabling cooperation to Kenneth Arrow, *Political and economic evaluation of social effects and externalities*, in Frontiers of Quantitative Economics, 22 (1971) "In the absence of trust… opportunities for mutually beneficial co-operation would have to be foregone… norms of social behavior, including ethical and moral codes (may be) … reactions of society to compensate for market failures."

[134] The ranchers of Shasta County in Ellickson's classic study were producing *norms* socially. They were not producing beef in response to social motivations or signals, in the same way that, for example, the participants in SETI@Home produce computation socially, or the programmers who co-author free software projects do. They were provisioning governance through social mechanisms. The governance issues they tackled were the conflicts that arose from their *market-based* behavior. The problem that has been the focus of economic claims about social capital was that trust relations provide an important social context for markets, in lowering transaction costs and improving production in market systems. But they are in the first instance understood as means of smoothing the operations of a market production and exchange system (and these are to be distinguished from the political claims about the relationship between social capital and democracy, which were central to Putnam's treatment, see Robert Putnam, Bowling Alone (2000)..

[135] See, *e.g.*, Robert C. Ellickson, Controlling Chronic Misconduct in City Spaces: Of Panhandlers, Skid Rows, and Public-Space Zoning, 105 Yale L.J. 1165, 1194-1202 (1996); Dan M. Kahan, Between Economics and Sociology: The New Path of Deterrence, 95 Mich. L. Rev. 2477 (1997).

[136] See *supra* note 70; see also Carol M. Rose, The Several Futures of Property: Of Cyberspace and Folk Tales, Emission Trades and Ecosystems, 83 Minn. L. Rev. 129 (1998). Carol M. Rose, Left Brain, Right Brain and History in the New Law and Economics of Property, 79 Org. L. Rev. 479 (2000).

[137] See Ostrom, supra note 70, at 91-92 (listing clearly defined boundaries as crucial to success). Clearly, however, the provisioning of a dam in Ostrom's description of the Phillipine *zanjeiras*, *id.*, at 82-88, organized around claims to the resulting water flow, none of which is price-based or legal fiat-based, describes a richly detailed social production system. Ostrom, Governing the Commons.

[138] Samuel Bowles and Herbert Gintis, Social Capital and Community Governance, 112 The Economic Journal F419-F436 (2002).

[139] *Id*.

sharing, one that gains robustness because it involves tightly connected social groups. But social sharing is a broader phenomenon that includes cooperative enterprises that can be pursued by weakly connected participants or even by total strangers, and yet function as a sustainable and substantial modality of economic production. Indeed, in the context of the digitally networked environment, it is this type of sharing and cooperative production among strangers and weakly connected participants that holds the greatest economic promise.

The most visible set of practices that typify this broader claim are what I have called commons-based peer production—large-scale cooperative efforts where the thing shared among the participants is their creative effort, or labor.[140] Most prominent among these is free software. An approach to software development that is sharing-based, free software or open source software depends on many individuals contributing to a common project on a variety of motivations, and then sharing their respective contributions without any one entity or person asserting a right of exclusion to either the contributed components or the resulting whole. In order to avoid the joint product being appropriated by any single party, participants usually retain copyrights in their contribution, but license them to anyone—participant or stranger—on a model that joins a universal license to use the materials with constraints that make its re-appropriation by either the contributor or a third party difficult, if not impossible. While there have been many arguments about how widely the provisions that prevent appropriation should be used, the practical adoption patterns have been dominated by forms of licensing that prevent re-appropriation of the contributions or the joint product.[141] Free software has played an important role in the recognition of peer production, because software is a functional good with measurable qualities. It can be more or less authoritatively tested, quantitatively, against its market-based competitors. And in many instances free software has prevailed. Over 60% of webserver software, in particular for critical e-commerce sites, runs on the Apache webserver, free software.[142] More than half of all back office email functions are run by one free software program or another.[143] These are mission critical applications for the

[140] See Benkler, Coase's Penguin, *supra*, note 127; James Boyle, The Second Enclosure Movement and the Construction of the Public Domain, 66 L. & Contemp. Probs 33, 44-49 (2003).

[141] Josh Lerner & Jean Tirole, The Scope of Open Source Licensing, Harvard NOM Working Paper No. 02-42 (2002) (identifying roughly 85% of the licenses in active projects on SourceForge, the biggest site for clearance of free software development projects, as having "restrictive" or "very restrictive" licenses—that is, largely speaking, to be copylefted.)

[142] Netcraft Web Survey, http://news.netcraft.com/archives/web_server_survey.html.

[143] Email server surveys are less common and regularized than webserver surveys. For much of the 1990s, the dominant email server was Sendmail, See Glynn Moody, Rebel Code (2001), which was distributed mostly under a BSD license, and is currently available under that license to all but those who intend to be commercial redistributors of the software when unaccompanied by its source code. See ftp://ftp.sendmail.org/pub/sendmail/LICENSE. In the past few years, Sendmail has lost market share, partly to other free software projects, and partly to a new proprietary email server, iMail, which seems to have risen in usage to around 19%. Compare Credentia, Email Server Results for April 2003, http://www.credentia.cc/surveys/smtp/latest/, (8.4%) to Falko Timme, Mail Server Survey March, 2004, http://www.falkotimme.com/projects/survey_smtp_032004.php (18.75%). At the same time, however, a free software project supported by IBM, Postfix, also rose from 2.53% to 20.55%. Compare Credentica, *id*. to Falko, *id*. Postfix is a particularly interesting case, because it was developed as an alternative to sendmail, but also self-consciously as in competition with qmail, see http://www.postfix.org/motivation.html. qmail, in turn, was developed as an alternative to sendmail, and for

organizations that adopt them, applications that most organizations would not jeopardize to save a few thousands of dollars for licensing fees. Google, Amazon, and CNN.com, for example, are not running their webservers on the GNU/Linux operating system[144] in order to save licensing fees at the risk of higher failures for their core business. The measurable efficacy of free software has made dismissing the phenomenon harder. The centrality of software to production in the information and communications environment has made its success impossible to ignore and important to preserve and emulate.

While free software is the most visible instance of peer production, with areas of measurably superior performance, it is not the only locus of peer production. I have described these other phenomena in detail elsewhere, but will encapsulate one example here.[145] Slashdot is a technology news site co-authored by a quarter of a million users. It is far from perfect, but it has become something of a must-read for anyone seriously interested in information and communications technology, be they professional, amateur, or commercial journalist. The site allows its hundreds of thousands of users to scour the Internet for news, to identify what is relevant and what is not, and to post links with commentary for others to read. Users then engage in a system of commentary and elaboration, which itself is peer reviewed by other users through a system of technologically-mediated recording of quality judgments. The peer reviewers are themselves reviewed by other users periodically, and may be removed if a sufficient number of other users find their judgments lacking. The whole system of posting of stories, commentary on stories posted, and recursive peer review of the commentary and of the quality of the peer reviewers runs on a free software platform. Together these provide an example of an identifiable information good, co-produced by many users, in a manner that is efficacious, and yet based on social motivations and structures of participation, not on prices or hierarchical commands. The users contribute and share in each other's time and judgments as to what is relevant to this community of interest, and about how to evaluate the events of the day in its fields of coverage. In this case, the "shareable good" involved is the time, education, and effort of the users who participate, it is combined with a public good—existing information—to form what is itself a public good—a topical news and commentary source. Other similar endeavors provision an encyclopedia co-authored by a few thousand volunteers,[146] a comprehensive human-edited directory of websites, on the model of the Yahoo directory, but provisioned by over 40,000 volunteers,[147] and many other examples.[148]

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a while was believed to be developed by Daniel Bernstein for release as free software. Bernstein, however, has chosen to release the software at no charge, but under terms that give him strong authorial control, see http://cr.yp.to/qmail/dist.html. Qmail's use declined dramatically between the two surveys cited above, suggesting a preference in the community of adopters for free software over software that is at no charge, but nonetheless controlled.

[144] The operating system used by a website can be obtained by querying the site. A simple tool is available at http://www.netcraft.com. The three sites are selected purely for anecdotal intuitive reasons, with no special claim to being representative of broader usage statistics.

[145] See Coases Penguin, *supra* note 127, at 381-400.

[146] www.Wikipedia.org

[147] The open directory project, www.dmoz.org

[148] See Benkler, Coase's Penguin, *supra*, note 127.

Creative labor in the context of peer production can be harnessed when a project is broken up into discrete modules, whose granularity is varied and sufficiently fine-grained to allow individuals with diverse motivations to engage in the effort at levels appropriate for their motivations, but still provide stable contributions to the whole.[149] In this, the modularity and granularity of the individual effort and time required by a project allow individuals to segment their own day/week/month such that they can find "excess capacity" that they can contribute to the common effort. The relative efficiency of peer production to markets, as with the case of social sharing of shareable goods, is analyzed in terms similar to those offered here—concerning information, transaction costs, and motivations—but with changes appropriate for the case of human creative labor, which is different in many ways from the material goods that were the subject of the first four parts of this paper.

These lines of literature point to an emerging understanding of social production and exchange. This phenomenon is not limited to public goods, to exotic out of the way places like surviving medieval Spanish irrigation regions[150] or the shores of Maine's lobster fishing grounds,[151] or even to the ubiquitous phenomenon of the household.[152] Nor, as SETI@Home and the body-snatchers and slugs of Northern Virginia suggest, is it necessarily limited to stable communities of individuals who interact often and know each other, or expect to continue to interact personally. Social production of goods and services, both public and private, is ubiquitous, though unnoticed. It sometimes substitutes for, and sometimes complements, market and state production everywhere. It is, to be fanciful, the dark matter of our economic production universe.

Consider the way in which the following sentences are intuitively familiar, yet as a practical matter describe the provisioning of goods or services that have well defined NAICS categories,[153] whose provisioning through the markets is accounted for in the economic census, but that are commonly provisioned in a form consistent with the definition of sharing—on a radically distributed model, without price or command.

NAICS 624410624410 [Babysitting services, child day care]

> "John, could you pick up Bobby today when you take Lauren to soccer? I have a conference call I have to make."
>
> "Are you doing homework with Zoe today, or shall I?"

NAICS 484210 [Trucking used household, office, or institutional furniture and equipment]

> "Jane, could you lend a hand moving this table to the dining room?"
>
> "Here, let me hold the elevator door for you, this looks heavy"

NAICS 484122 [Trucking, general freight, long-distance, less-than-truckload]

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[149] *Id*., at 400-43.
[150] Ostrom, *supra* note 70.
[151] Acheson, *supra* note 70.
[152] See The Household Economy, Reconsidering the Domestic Mode of Production (Richard R. Wilk, ed. 1989); At the Interface: The Household and Beyond (David B. Small and Nicola Tannenbaum, eds. 1999); Ellickson's, Households, *supra* note 74.
[153] NAICS stands for North American Industry Classification System, the new classification system developed by the U.S. Census Bureau to describe economic activity.

"Jack, do you mind if I load my box of books in your trunk so you can drop it off at my brother's on your way to Boston?"

NAICS 514110 [Traffic reporting services]

"Oh, don't take I-95, it's got horrible construction traffic to exit 39"

NAICS [Newspaper columnists, independent (freelance)]

"I don't know about Clark, he doesn't move me, I think he should be more aggressive in criticizing Bush on Iraq."

NAICS 621610 [Home healthcare services]

"Can you please get me my medicine? I'm too wiped to get up."

"Would you like a cup of tea?"

NAICS 561591 [Tourist information bureaus]

"Excuse me, how do I get to Carnegie Hall?"

NAICS 561321 [Temporary help services]

"I've got a real crunch on the farm, can you come over on Saturday and lend a hand?"

"This is crazy, I've got to get this document out tonight, could you lend me a hand with proofing and pulling it all together tonight?"

NAICS 71 [Arts, entertainment, and recreation]

"Did you hear the one about the Buddhist monk, the Rabbi, and the Catholic priest?..."

"Roger, bring out your guitar…."

"Anybody up for a game of…?

The litany of examples generalizes through a combination of four dimensions that separate them from the current foci of the literature. First, they relate to production of goods and services, not only of norms or rules. Social relations provide the very motivations for and information relating to production and exchange, not only the institutional framework for organizing action that itself is motivated, informed and organized by markets or managerial commands. Second, they relate to all kinds of goods, not only public goods. In particular, the paradigm cases of free software development and distributed computing or carpooling involve labor and shareable goods—each plainly utilizing private goods as inputs, and in the case of carpooling and distributed computing, producing private goods as outputs. Third, at least some of them relate not only to relations of production within well defined communities of individuals who have repeated interactions, but extend to cover baseline standards of human decency that enable strangers to ask one another for the time or for directions, that enable drivers to cede the road to each other, and that enable strangers to collaborate on software projects, on co-authoring an online encyclopedia, or on running simulations of how proteins fold. Fourth, they may either complement or substitute for market and state production systems, depending on the social construction of mixed provisioning. What weight social and sharing-based production has in the economy is hard to measure. Our intuitions about capillary systems would suggest that the total volume of boxes or books moved or lifted, instructions given, news relayed, meals prepared, etc., by family, friends, neighbors, and minimally decent strangers would be very high relative to the amount of substitutable activity carried on through market exchanges or state provisioning. Measuring the actual relative weight would be difficult.

Sharing is technology-sensitive, because individual efficacy is subject to capital constraints

A threshold requirement for social sharing to be a modality of economic production, as opposed to one purely of social reproduction, is that sharing-based action be effective. Efficacy of individual action depends on the capital requirements for action to become materially effective, which, in turn, depend on technology. When effective action requires very low physical capital requirements, so that every individual has, by natural capacity, "the physical capital" necessary for action, social production or sharing can be (though may not in practice become) ubiquitous. Voice cords to participate in a sing-along, muscles to lift a box, etc., are obvious examples. When the capital requirements are non-trivial, but the capital good is widely distributed and available, sharing can similarly be ubiquitous and effective. This is true whether the shared resource or good is the capacity of the capital good itself—as in the case of shareable goods—or some widely distributed human capacity capable of being made effective through the use of the widely distributed capital goods—as in the case of human creativity, judgment, experience and labor that is shared in online peer production processes, for which participants rely on the widespread availability of connected computers to participate. When some larger-scale capital requirement is a threshold requirement of effective action, we should not expect to see widespread reliance on decentralized sharing as a standard modality of production. Industrial production of automobiles, steel, plastic toys, etc., is not the sort of thing that is likely to be produced on a social sharing basis, because of the capital constraints. This is not to say that even for large-scale capital projects, like irrigation systems and dams, social production systems cannot step into the breach. We have those core examples in the common property regime literature, and we have worker-owned firms as examples of mixed systems. But those systems tend to replicate the characteristics of state or market production—be they rule-based production that uses quotas, scrip systems, formal policing by "professional" officers, court-like systems for adjudicating disputes, or mid-level management within worker owned firms.[154] By comparison, the lobster gangs of Maine,[155] or fishing groups in Japan,[156] where capital requirements are much lower, tend to be more social-relations based systems, with less formalized or crisp measurement of contributions to, and calls on, the production system.

It is important to emphasize that technology imposes *threshold* constraints on effective sharing, but cannot unilaterally determine the level of sharing practiced in a society. At any given level of technically feasible sharing, societies may differ in their cultural practices and tastes. These differences can be expressed in the approach I offered in Part IV as (a) the level of background investments in any one of the alternative

[154] See Ostrom, 69-82 (describing the governance mechanisms of the complex irrigation systems); Hansmann, Ownership of Enterprise (describing worker-owned firms as simply a species of firm ownership).
[155] Acheson, *supra*, note 70.
[156] See Jean-Phillipe Platteau and Erika Seki, Community arrangements to overcome market failure: pooling groups in Japanese fisheries, in Communities and Markets in Economic Development (M. Hayami and Y Hayami, eds.) (2001) at 344-402.

transactional frameworks and (b) the shape of the demand for social-psychological rewards. Differences in these elements would result in different levels of sharing in societies that share a technological state, but differ in their culture of sharing. A change in technology, however, will increase the supply of opportunities for sharing, and should, other things being equal, increase the prevalence of sharing practices. Of course, if culture is endogenous, then the taste for sharing will also change with the increase in feasible opportunities for sharing. For example, one possible interpretation of the survey data about preferences of carpoolers[157] is that they are an indication of coherence-seeking attitudinal changes towards the benefits of sociability, time saving etc. that carpoolers adopt to make their practice cohere with their beliefs, rather than of attitudinal priors that individuals hold as an antecedent to participating in the practice.[158] If this were so, and we believed that by practicing sharing people come to value it more, or come to learn to trust other participants, then an increase in opportunities to share will dynamically increase the taste for sharing as well, which will increase sharing practiced, forming a virtuous cycle, at least from the perspective of anyone who holds that a society that practices trust and sharing is normatively more attractive than a society where agents treat each other at arms length.[159]

To say that sharing is technology-dependent is not to deny that it is a ubiquitous human phenomenon. Sharing is so deeply engrained in so many of our cultures, that it would be difficult to argue that with the "right" (or perhaps "wrong") technological contingencies, it would simply disappear. My claim, however, is much narrower. It is that *the relative economic role of sharing changes with technology*. There are technological conditions that require more or less capital, in larger or smaller packets, for effective provisioning of goods, services, and resources valued functionally. As these conditions change, the relative scope for social sharing practices to play a role in production changes. When goods, services, and resources are widely dispersed, they allow their owners to choose to engage with each other through social sharing, instead of through markets or a formal state-based relationship, because individuals have available to them the resources necessary to engage in such behavior without recourse to capital markets or the taxation power of the state. If technological changes make the resource necessary for effective action rare or expensive, individuals may wish to interact in social relations, but they can now only do so ineffectively, or in different fields of endeavor that do not similarly require the high capitalization. Large packet, expensive physical capital, draws the behavior into one or the other of the two modalities of production that can concentrate financial capital. Nothing, however, prevents change from happening in the opposite direction. Goods, services, and resources that, in the industrial stage of the information economy required large scale capital investment to provision, for example, now are being subject to a changing technological environment that can make sharing a better way of achieving the same results than can states, markets, or their hybrid, regulated industries.

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[157] See *supra*, notes 51-52 and accompanying text.
[158] Se Simon, *supra*, note 53.
[159] See Helen Nissenbaum and Yochai Benkler, Commons Based Peer Production and Virtue, (draft manuscript)

Music in the 19th century was a relational good.[160] It was something people did in the physical presence of each other: in the folk way through hearing, repeating, and improvising; in the middle-class way of buying sheet music and playing for guests or attending public performances; or in the upper class way of hiring musicians. Market-based production depended on performance through presence. It provided opportunities for artists to live and perform locally. With the introduction of the phonograph, a particular relationship to played music was made possible, one that was more passive, in reliance on the high capital requirements of recording, copying, and distributing instantiations of recorded music. What developed was a concentrated industry, based on massive investments in preference formation, which crowded out some, but not all, of the sharing practices, and many of the presence-performance based markets, though not all of them (jazz clubs, piano bars, wedding bands, etc.). As computers became more music-capable and digital networks became a ubiquitously available distribution network, we saw the emergence of the present conflict over the regulation of cultural production—the law of copyright—between the twentieth-century, industrial model recording industry and the emerging system of amateur distribution systems coupled, at least according to supporters, to a re-emergence of decentralized, relation-based markets for professional performance artists.

Radically decentralized, relatively impersonal sharing-based and peer production has economically attractive characteristics as a mode of organizing production

The kind of social interaction typified by peer production like free software development, or by distributed computing, has remarkably "market like" characteristics that make it particularly attractive as a social modality of production from the perspective of economic efficiency. The decentralization of these processes underlies the capacity of agents to retain a great degree of individual autonomy within the social interaction This autonomy—to choose to participate, to select opportunities for action, and to act when the participant wishes and in the fashion that she chooses—is central to the informational advantage of peer production efforts over firms. Individual agents can act—by contributing labor or a unit of excess capacity—without need for formalization of their role, or contribution, either for contracting or for managerial assignment. The modularity—of the incremental material contributions in shareable goods or of the work tasks in peer production—keeps individual actions discrete and fairly fine-grained. This again allows individuals to make decisions at the margin, for each contribution or cluster of contributions, without undermining the whole, without incurring high social costs. These characteristics make the availability of resources—labor or material—relatively fluid. The weakness of the social relations, usually thought harmful to the sustainability of cooperation in the absence of property rights or managerial oversight, improves the fluidity of deployment of goods and actions, and improves the degree of agent autonomy in the relationship.

This does not mean that individuals do not get emotionally and socially engaged in peer production projects. They do. This does not mean that participants do not derive

[160] Eben Moglen, The dotCommunist Manifesto: How Culture Became Property and What We're Going to Do About It, Lecture available http://www.ibiblio.org/moglen/

a sense of meaning and connectedness to others from participation. They do. It does, however, mean that the particular shape of this form of social production is relatively fluid, leaving tremendous room for autonomous individual action, in concert with others but not subject to it. The normative implications of these characteristics of peer production and large-scale social sharing behaviors are ambiguous. To a communitarian, the relative fluidity, the capacity to be in many projects at once, to ratchet one's participation up or down on an ad hoc basis, and to cabin the cooperative enterprise in one small or large compartment of one's life would render this mode relatively unattractive. To liberals, libertarians, and post-modernists, various characteristics of this modality of production should be very congenial—autonomy respecting, and allowing for the creation of varied and diverse social relations of production, relatively free of the structuring effects of property rights and the distribution of wealth. Irrespective of one's position on the normative attractiveness of peer production compared to, Amish barn raisings, functionally it allows larger scale participation, by many more people, who can shift their efforts and contributions dynamically as need and interest arise and change. It is, in other words, likely to be more economically effective and efficient on larger scales.

The claim, then, is that phenomena I describe here and elsewhere—sharing of material shareable goods and peer production of software, information, and cultural goods more generally—resemble an ideal market in their social characteristics, but with social cues and motivations replacing prices to generate information and motivate action. They rely on relatively impersonal cooperation, generally focused on a particular functional project, and are based on quite radically decentralized action. Their impersonality is what allows them to scale to very large groups that could nonetheless maintain effective action, because intimacy, and even strong familiarity, is highly limited by each individual's time, memory, and emotional capacities. Their relatively project-specific pattern is what allows for moderately impersonal exchange to suffice. Increasing the relational scope, which would require greater dedication from each individual, would make participants more vulnerable to each other and require greater stability and control over inputs and outputs. These characteristics make them attractive as a modality of production, because they allow greater flexibility and liquidity in the deployment of resources—whether human or material—through these systems, more so than systems that depend on more centralized organizational infrastructure or that claim broader scope over the participation of participants.

Part VI. Some Areas of Current Policy Implications

What are the policy implications of recognizing sharing as a sustainable and potentially efficient modality of economic production? Where is there a policy battle between market-based, hierarchical organizations and social production through sharing that is being fought? I will note here three areas with substantial implications for how our society produces, records, and communicates information, knowledge, and culture.

A. Wireless communications regulation

Perhaps the most counterintuitive policy shift, yet the one most likely to see a fundamental change in our approach to provisioning a basic resource, is in the area of wireless communications. Early in the first decade and a half of radio, radios were relatively specialized, but not sophisticated. Wireless communications capacity, such as existed, was therefore relatively decentralized. Marconi operated large shore to ship stations on a monopoly service model, alongside much small-scale experimentation of the type that would come to be known as amateur radio. From the middle of World War I and through the mid-twenties, improvements in the capacity of expensive transmitters and a series of strategic moves by the owners of the core patents in radio transmission—GE, RCA, AT&T, and Westinghouse—led to the emergence, by 1926, of the industrial model of radio communications that typified the 20th century. Radio came to be dominated by a small number of professional, commercial networks, based on high-capital cost transmitters, supported by a regulatory framework tailored to making the primary model of radio utilization for most Americans passive reception, with simple receivers, of commercial programming delivered through high-powered transmitters. This development crowded out the more widely distributed, local infrastructure of non-market broadcasting that blossomed before the mid-1920s in the United States.[161]

The industrial model, that assumes a large-scale capital investment in the core of the network and small scale investments at the edges, optimized for receiving what is generated at the core, imprinted on wireless communications systems both at the level of design and at the level of regulation. When mobile telephony came along, it replicated the same model, using relatively cheap handsets oriented towards an infrastructure-centric deployment of towers. The economic analysis of wireless communications adopted the same model, and spent four decades criticizing the incumbent approach only

[161] A condensed version of this history can be found in Yochai Benkler, Overcoming Agoraphobia: Building the Commons in the Digitally Networked Environment, 11 Harv J. L. & Tech. 287, 301-14 (1998). The most comprehensive history on which this story is based is 1 Erik Barnouw, A History of Broadcasting in The United States: A Tower In Babel (1966). There are, needless to say, other historiographies of this period, some covered in *Overcoming Agoraphobia, supra*, 298-301. The most distinctly different story, focusing more on the politics of ground roots activism versus corporate corruption of the process and locating the origins of the systems in the mid-30s instead of the mid-20s is Robert W. McChesney, Telecommunications, Mass Media, & Democracy: The Battle for the Control of U.S. Broadcasting, 1928-1935 (1993). While McChesney's history is a gripping and important one, it is consistent, rather than inconsistent, with the hypothesis that the US system was "tipped" by 1926. The power of the networks, which had captured the political process in the 1930s, is rooted in the business history of the first half of the 1920s. The story McChesney tells is therefore a story of how that earlier moment, when we were locked into the regulated, concentrated commercial industry model, worked itself out over almost a decade, rather than describing a moment of true openness and missed opportunity. The stakes of this interpretation for understanding Internet policy today are high. My version, the version I ascribe to Barnouw, requires an immediate focus on economic and technical structure as long as the technological and business organization of the Internet communications environment are open. Time is of the essence, and structural regulation is the objective. His version would suggest that political action to attain regulatory control of an already-embedded technical-business structure is potentially effective. Time is a little looser, and behavioral regulation is a feasible path of reform.

on the basis that it inefficiently regulated the legal right to construct a wireless system by regulating spectrum use, instead of creating a market in "spectrum use" rights.[162]

By the time that legislatures in the United States and around the world had begun to accede to the wisdom of the economists' critique, however, it had been rendered obsolete by technology.[163] In particular, it had been rendered obsolete by the fact that the declining cost of computation and the increasing sophistication of communications protocols among end-user devices in a network made possible new, sharing-based solutions to the problem of how to allow users to communicate without wires. Now, instead of having a regulation-determined exclusive right to transmit, which may or may not itself be subject to market re-allocation, it is possible to have a market in small scale

[162] The *locus classicus* of the economists' critique was Ronald Coase, The Federal Communications Commission, 2 J. L. & Econ. 1 (1959). The best worked-out version of how these property rights would look remains Arthur S. De Vany et al., A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study, 21 STAN. L. REV. 1499 (1969). While those works were deeply revolutionary for their time, and cohered with the then-prevailing technological-economic conditions and the state of the radio engineering discipline, the position that "spectrum" had to be "managed" by someone, and that that someone must be either the government or an owner of property rights defined in RF frequency bands, turns out, in hindsight, to have been technologically contingent rather than generally stable.

[163] For the full argument see Yochai Benkler, *Some Economics of Wireless Communications*, 16 Harv. J L & Tech. 25 (2002); and *Overcoming Agoraphobia*, *supra*. For an excellent overview of the intellectual history of this debate, a detailed explanation of the emerging business models around sharing radios, and a contribution to the institutional design necessary to make space for this change see Kevin Werbach, Supercommons: Towards a Unified Theory of Wireless Communication, *forthcoming*, Texas L. Rev. (2004). The policy implications of computationally intensive radios using wide bands were first raised, to my knowledge, by George Gilder in *The New Rule of the Wireless*, Forbes ASAP, March 29th, 1993, and by Paul Baran, *Visions of the 21st Century Communications: Is the Shortage of Radio Spectrum for Broadband Networks of the Future a Self Made Problem?* Keynote Talk Transcript, 8th Annual Conference on Next Generation Networks Washington, DC, November 9, 1994, available http://www.eff.org/pub/GII_NII/Wireless_cellular_radio/false_scarcity_baran_cngn94.transcript. Both statements focused on the potential abundance of spectrum, and how it renders "spectrum management" obsolete. Eli Noam was the first to point out that, even if one did not buy the idea that computationally intensive radios eliminated scarcity, they still rendered spectrum *property rights* in spectrum obsolete, and enabled instead a fluid, dynamic, real time market in spectrum clearance rights. See Eli Noam, *Taking the Next Step Beyond Spectrum Auctions: Open Spectrum Access*, 33 IEEE Comm. Mag. 66 (1995); later elaborated in Eli Noam, *Spectrum Auction: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism. Taking the Next Step to Open Spectrum Access*, 41 J. Law & Econ. 765, 778-80 (1998). The argument that equipment markets based on a spectrum commons, or free access to frequencies, could replace the role planned for markets in spectrum property rights with computationally intensive equipment and sophisticated network sharing protocols, and would likely be more efficient even assuming that scarcity persists, is Benkler, *Overcoming Agoraphobia*, *supra* note 161. Lawrence Lessig, CODE (1999) and Lawrence Lessig, THE FUTURE OF IDEAS (2001) developed the argument that relied on the parallel structure of innovation in the original Internet end-to-end design architecture and of open wireless networks, offering a rationale based on the innovation dynamic in support of the economic value of open wireless networks. David Reed, *Why Spectrum is Not Property, The Case for an Entirely New Regime of Wireless Communications Policy* (February 2001) available at http://www.reed.com/dprframeweb/dprframe.asp?section=paper&fn=openspec.html and David Reed, *Comments for FCC Spectrum Task Force on Spectrum Policy*, filed July 10, 2002 and available at http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6513202407 crystallized the technical underpinnings and limitations of the idea that spectrum can be regarded as property. Comments to the Task Force generally were the first substantial set of public comments in favor of a spectrum commons.

capital goods—smart radio equipment owned by individuals, much like automobiles and PCs—which embed in the devices the technical ability to share capacity and cooperate in the creation of capacity. These radios can cooperate by relaying each other's messages, or by temporarily "lending" their antennae to neighbors to help them decipher messages of senders who are not entitled to exclusive use of the spectrum.[164] Described in terms of this paper, radio and computer technology has changed so as to make radio transceivers shareable goods with an excess capacity to generate wireless transport capacity, which, like distributed computers and like automobiles, their owners can share so as to produce wireless communications systems. The reasons that the owners share are relatively straightforward in this case. Users want to have wireless connectivity all the time, to be reachable and immediately available everywhere. But they do not actually want to communicate every few microseconds. They will therefore be willing to purchase and keep turned on equipment that provides them with such connectivity. Manufacturers, in turn, will develop and adhere to standards that will improve capacity and connectivity. Given that "cooperation gain" is the most promising source of better-than-linear capacity scaling for distributed wireless systems,[165] these standards should gravitate towards interoperability and mutual awareness of requirements. Whether there are technically robust ways of "cheating" on a standard to improve performance by not cooperating is debatable,[166] but it is doubtful that, even if achievable in principle, cheating could be done on a commercial scale without detection and in compliance with interoperability standards. Users, then, have incentives to keep systems turned on, manufacturers have incentives to "share nicely," and defections from sharing are likely to be reasonably identifiable. What remains for consideration in the regulatory process is how much, if any, background regulation of systems is necessary to constrain specifically strategic defections from cooperative standards, and in what flavors—as pre-certification rules, as liability rules, etc. This is a hard problem that will not likely be solved theoretically, but rather through practical experimentation with different regimes in different parts of the already-regulated spectrum.

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[164] A reasonably accessible description of the various techniques is Andrea Goldsmith and Stephen Wicker, Design challenges for energy-constrained ad hoc wireless networks, 9 IEEE Wireless Comm. 8 (2002).

[165] See Benkler, *Some Economics*, *supra* note 163, at 44-47 (providing definition and underlying technical citations). The term "cooperation gain" was developed by David Reed, see Reed, Comments to FCC, *supra* note 163, to describe a similar, but somewhat broader concept to what is known as "diversity gain" in multi-user information theory.

[166] Compare D. P. Satapathy and J. M. Peha, "Spectrum Sharing Without Licenses: Opportunities and Dangers," in "Interconnection and the Internet," book of Selected Papers From The 1996 Telecommunications Policy Research Conference, (G. Rosston and D. Waterman (Eds.) 1997) pp. 49-75 (modeling defection in unlicensed wireless systems) with Timothy Shepard, Comments to the FCC Taskforce, FCC ET Docket (02-135), available at http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6513201206 and additional comments at http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6513405081. Shepard, who was the first theoretical engineer to build a workable model of municipal-level scalable networks in a mesh architecture, see Timothy Shepard, Decentralized Channel Management in Scalable Multi-hop Spread Spectrum Packet Radio Networks (1995) (unpublished Ph.D. dissertation, MIT, on file with the MIT library), explains why adding power—the quintessential strategy that would lead to tragedy, and require regulation, is not the only, and indeed not the most desirable, mechanism of dealing with increased power by anti-social neighbors.

Cooperative, sharing-based wireless connectivity can emerge if it is not illegal for the vendors of wireless equipment to produce and sell the machines that let people share their capacity and help each other to communicate. The past few years have seen at first slow, and more recently quite dramatic, change in the United States in the extent to which the FCC and Congress have recognized this opportunity and have begun to make regulatory space for its development. Indeed, in the past year and a half alone, a major shift has occurred, and what have been called "commons-based" approaches to wireless communications policy have come to be seen as a legitimate, indeed a central, component of the FCC's wireless policy.[167] We are beginning to see in this space the most prominent example of a system that was entirely oriented towards improving the institutional conditions of market-based production of wireless transport capacity as functionality flows—connectivity minutes—shifting to enable the emergence of a market in shareable goods—smart radios—designed to provision transport on a sharing model.

B. Information, knowledge, and cultural production policy

Another area of policy where sharing and market/firm-based production based on a particular regulatory environment are coming into conflict, and one where regulation has quite systematically weighed in to support the continued prevalence of market- and firm-based production, is in cultural production.[168] The story of music that I told in the prior section is the paradigmatic case of pressure that the ubiquity of networked computers is placing on our understanding of how information, knowledge, and culture are produced, of the potential these networks have for increasing the relative role of sharing systems in that production process, and of efforts to use law to squelch the technological conditions and practices of sharing and social production of distribution.

In many senses, it is odd to think of this area as one that ever came to be thought of as "dominated" in any useful meaning of the word by market production. As an analytic matter, information is a public good and could not, in principle, be provisioned efficiently by markets alone.[169] As a practical matter, we have always relied heavily on organizational and institutional forms that were insulated from both state and markets to produce information, knowledge, and culture. That is what the university and academic freedom are centrally about. That is what underlies the heavy reliance of the arts on philanthropy and on a culture of esteem and status as crucial motivating forces. That is what public schools and libraries are about. Our understanding of information, knowledge and culture as "public goods" in the formal economic sense should have immunized us from mistaking the presence of important market-based approaches for the whole, or even the core, of the story of information and cultural production. And yet, it does seem that our perception of where information generally, and culture in particular,

[167] See Michael Powell, Broadband Migration III: New Directions in Wireless Policy (Oct 30, 2002), available http://www.fcc.gov/Speeches/Powell/2002/spmkp212.html; Spectrum Policy Task Force Report to the Commission, November 2002, available http://www.fcc.gov/sptf/reports.html.

[168] The conflict is brilliantly described and engaged in Lawrence Lessig, Free Culture (2004); Jessica Litman, Digital Copyright (2001); Siva Vaidhyanathan, Copyrights and Copywrongs (2001).

[169] Kenneth J. Arrow, Economic Welfare and the Allocation of Resources for Invention, in The Rate and Direction of Inventive Activity: Economic and Social Factors 609, 616-17 (National Bureau of Economic Research, 1962).

come from came to be dominated over the second half of the 20th century by a vision of Hollywood and the recording industry.

As the story of music suggests, the rise of Hollywood and the recording industry is a function of the happenstance of the 20th century economics of film and music recording and distribution. It is the relative capital intensity of these industries—involved in recording, distribution, and production—that underlies the industrial structure of these industries. This structure, in turn, and the political force of its industries, underlies the steady but inexorable changes in copyright law, from a relatively brief period of statutory exclusivity over commercial distribution at the turn of the 20th century, to a practically perpetual and broad right over almost any use of the information, knowledge, or cultural materials covered by the close of that century.

On the background of the iconic role of movies and recorded music in framing how we understand our cultural production system, Napster emerged towards the close of the century as the counter-icon of the technological shift that radically disrupted that model. In the legal battles that have followed, the industry has ever more virulently invoked the powers of the state to squelch the use of this technology and its attendant social-cultural attitudes. In these battles the revolutionary effect of peer-to-peer technologies and of sharing as a modality of production—in the case of music, of distribution, relevance, and accreditation—have been overshadowed.[170]

Free software development, and peer production more generally, combine two features that make them the polar opposite of Hollywood and the recording industry. First, they decentralize the legal privilege to decide to act upon information resources in pursuit of information production projects. One needs no permission to participate in a peer production project, to use any particular piece of software as input, or to combine it with any other. Second, the capital costs necessary to obtain, rework, and communicate the products of one's work to others with whom one is cooperating in production are low, and already owned for a variety of reasons by the participants. Neither capital nor legal rights provide a condensation point for hierarchical or property-based relations.

The policy conflict between these modes of production has emerged in two domains. First, and more immediately tractable to policy, is the question of government procurement policy vis-à-vis free software. Led by Microsoft,[171] some software producers who depend on copyright have fought a battle to persuade governments to eschew free software in their procurement policies, as against an opposite political move

[170] For an overview of the state of music and film industry in the twentieth century, and of the battles since its closing years between the industrial producers and the emerging online technologies see William W. Fisher, Promises to Keep: Technology, Law, and the Future of Entertainment (2004).

[171] See Dave Newbart, Microsoft CEO take launch (sic) break with the Sun-Times, June 1 2001 pg 57, (quoting Microsoft CEO Steve Ballmer: "The only thing we have a problem with is when the government funds open source work. Government funding should be for work that is available to everybody. Open source is not available to commercial companies. The way the license is written, if you use any open source software you have to make the rest of your software open source. If the government wants to put something in the public domain, it should. Linux is not in the public domain. Linux is a cancer that attaches itself in an intellectual property sense to everything it touches. That's the way that the license works.")

to embrace free software—whether as a strategy to lower government software costs, as a development policy to allow local programmers to develop skills in, and opening towards, free software markets,[172] or as a strategy to assure diversity of sources for mission critical applications.[173] An understanding and appreciation of the ubiquity and stability of social sharing based production is important as an input into this debate.

More complex is the debate over the industrial structure of cultural production, in particular music and movies. Unlike the peer production enterprises I mention here, Napster and its successors from Gnutella to KaZaa are not involved in the creation of music. In what way, then, are Napster and KaZaa "productive"? They are productive in the same sense that the recording industry deems its role in stamping CDs, promoting them on radio stations, and placing them on distribution chain shelves productive. That is, they produce both the physical and informational aspects of the distribution system collaboratively, on a social sharing basis. This is what Eben Moglen called anarchist distribution, and for which he claimed the perfectly plausible advantage that it put the music people wanted into the hands of those who wanted it most, based on the six degrees of separation principle.[174] Jane's friends and friends of friends are more likely to know exactly what music would make her happy than are recording executives trying to predict which song to place, on which station and which shelf, to expose her to exactly the music she is most likely to buy in a context where she would buy it.

So KaZaa produces *distribution* of music on a sharing modality. Distribution is indeed a separate economic good from music *creation*, and yet was centrally tied to the way the production of music and movies has been paid for throughout the 20th century. The ties were so close, in fact, that in displacing industrial *distribution*, peer-to-peer distribution is thought both by its critics and by some of its adherent to be likely to undermine the very possibility of industrial *production* of music. Now, there are some artists who welcomed this development, understanding that the model of production they were part of was industrial, and believing that artistic expression was being constrained by it.[175] But others were perfectly happy with industrial distribution, and the millions of dollars that they either did, or believed that they might one day, reap from it. Certainly there are recording industry executives whose roles have no existence outside of the industrial organization of music production and distribution.

Needless to say, it is not my purpose here to "solve" the question of peer-to-peer networks and their effect on the music industry. As the Northern Virginia "slugs" have taught us, social provisioning through sharing can at least partially displace market provisioning, and we have no reason to believe that it could not in principle crowd that modality out entirely—despite the current ambiguity as to whether peer-to-peer sharing

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[172] See text of Peruvian proposed bill, and its explanations, available Peruvian Bill, available at http://www.opensource.org/docs/bill-EngTrans.php.

[173] President's Information Technology Advisory Committee, Developing Open Source Software to Advance High End Computing, October, 2000. http://www.ccic.gov/pubs/pitac/pres-oss-11sep00.pdf.

[174] See Moglen, *supra*, note 160.

[175] See, *e.g.*, Courtney Love, Courtney Love Does the Math, in Salon, June 14, 2000, available http://dir.salon.com/tech/feature/2000/06/14/love/index.html; see The Future of Music Manifesto, http://www.futureofmusic.org/manifesto.

indeed crowds out CD sales.[176] Is there a future for sharing-based music distribution? Is the displacement of industrial distribution by sharing-based distribution necessarily the end of market-based music production? Much of the actual flow of revenue to artists—from performances and other sources—are stable even assuming a complete displacement of the CD market by peer-to-peer distribution, suggesting that there will still be room for musicians to play for their dinner. Perhaps there will be fewer millionaires. Perhaps fewer mediocre musicians with attractive physiques will be sold as "geniuses", and more good musicians will be heard than otherwise would have, and will as a result be able to get paying gigs instead of waiting tables or "getting a job". In any event, no one seriously claims that the market in *distribution* cannot be sustained on a radically decentralized mode. As long as songs—intrinsically public goods—are encoded in digital bits that are non-scarce, as long as users have computers that allow them to share their playlists and hard-drives, temporarily, with others, sharing will be sustainable, indeed likely more efficient, as a means of distributing music.

As for creation, it would be silly to think that music, a cultural form without which no human society has existed, will cease to be in our world because we shall abandon the industrial form it took for the blink of an historical eye that was the 20th century. Music was not born with the phonograph, nor will it die with the peer-to-peer network. The terms of the debate, then, are about cultural policy; perhaps about industrial policy. Will we get the kind of music we want in this system, whoever "we" are? Will American recording companies continue to get the export revenue streams they do? Will artists be able to live from making music? Some of these arguments are serious. Some are but a tempest in a monopoly-rent teapot. What is clear is that a technological change has rendered obsolete a particular mode of distributing information and culture. Distribution, which used to be the sole domain of market-based-firms, now can be produced by decentralized networks of users, sharing instantiations of music they deem attractive with others, using equipment they own and generic network connections. That is, users combine public goods (songs) with shareable goods (storage media and bandwidth) to provision the core good that was the bread and butter of the traditional industrial producers of music.

Policy is concerned now with whether and to what extent it should try to squelch this new modality of production to preserve the operating conditions of the old. Understanding the causes of the challenge suggests that three powerful elements will have to be, practically speaking, regulated away in order to preserve the old industrial structure. The newly emerging modality of production relies on (a) the most fundamental technical characteristics of digital communications networks—their flexibility and adaptability, (b) a technological-economic trend towards lower cost, higher capacity processors that has been a stable feature of the computer industry for four decades, and (c) the ubiquitous and deeply engrained cultural practices and social-psychological mindsets that form the transactional framework for an enormous amount of productive activity in our society, on and off line—sharing. The practices of, and taste for, sharing are not epiphenomenal to the economy. They are not a new hip thing kids are doing,

[176] See Felix Oberholzer and Koleman Strumpf, The Effect of File Sharing on Record Sales, (working paper) available at http://www.unc.edu/~cigar/papers/FileSharing_March2004.pdf.

which will pass like any fad.[177] They are as much a part of capillary production—"Jack, could you put the brown box on the high shelf"—as the incentives of money and the contract and property systems are central to the arteries—"Allied Vans, could you move the brown box to the bedroom in California." It is breathtaking to imagine that all this would be legislated away in order to preserve the margins of two industries with revenues of 76 billion dollars a year.[178] The solution must assume that peer-to-peer file sharing is here to stay. Once we understand that, we can focus our energies on the range of solutions that have been suggested—from government funding to tipjars and performances.[179]

C. Network design for a network of shareable goods

Not all policy is legal. As Larry Lessig has taught so many of us so well, so is the architecture of "code."[180] A large domain of communications policy operates at the level of network architecture, and the assumptions engineers make about what practices are sustainable, socially, inform their design choices. If engineers believe that people can be made to cooperate only through pricing, then where a network calls for cooperation, they will seek to implement a pricing mechanism. If they believe that social sharing is possible and sustainable, they could build networks to assume that possibility, and to facilitate social sharing. The actual practice of Internet design has been ambivalent on this question. The basic Internet protocol design itself does not include a possibility for prioritizing traffic using pricing. It relies exclusively, at the transmission control protocol layer—that is, at the congestion control mechanism—on best efforts, undifferentiated service. Predictions that the Internet would therefore melt down were followed by assiduous development of pricing schemes for traffic prioritization at the packet level.[181] And yet, pricing has not been implemented, and the Internet has not melted down. Users have not adopted any of the many more-or-less sophisticated pricing schemes proposed over the past decade or more. Instead, ever more demanding applications for real-time

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[177] On the centrality of sharing as a modality of cultural production on the Net, and its conflict with the notion of "stealing" music see Jessica Litman, Sharing and Stealing, (draft) available at http://www.law.wayne.edu/litman/papers/sharing&stealing.pdf.

[178] See 2002 Economic Census, Table 1: Advance Summary Statistics for the United States, NAICS Category 512, available http://www.census.gov/econ/census02/advance/TABLE1.HTM.

[179] Two state-oriented solution based on taxing devices and remunerating artists and labels, are Fisher, *supra* note 169, Chapter 6, and Neil W. Netanel, Impose a Noncommercial Use Levy to Allow Free Peer-to-Peer File Sharing, 17 Harv. J. L. & Tech. 1 (2003). Artists themselves seem focused on building on a variety of self-help mechanisms based on their relationships with fans, ranging from live performances to web-based distribution on a tip jar model. See the now-classic John Perry Barlow, The Economy of Ideas, Wired 2.03 (March 1994), available http://www.wired.com/wired/archive/2.03/economy.ideas.html; Love, *supra* note 174, at 5. Future of Music coalition, for example, provides artists with instructions on how to implement tip jars, see http://www.futureofmusic.org/tipjars/index.cfm.

[180] Lawrence Lessig, Code and Other Laws of Cyberspace (2000).

[181] Jeffeey Jackie Mason and Hal Varian, *Economic FAQs About the Internet*, 8 J. Econ. Persp. 75 (1994); S. Shenker, D. Clark, D. Estrin, S. Herzog, Pricing in computer networks: reshaping the research agenda, 20(3) Telecomms. Policy (1996); Andrew Odlyzko, Paris metro pricing, The minimalist differentiated services solution, AT&T Labs Research report (1997); F.P. Kelly, A.K. Maulloo, D.K.H. Tan, Rate control for communications networks: shadow prices, proportional fairness, and stability, 49 J. of Operational Research Society 237-252 (1997); Peter B. Key and Derek R. McAuley, Differential QoS and Quality in Networks: where flow-control meets game theory, IEEE Proceedings Software, March 1999.

streaming, and even the most latency-sensitive of applications—like voice over internet protocol (VoIP), have begun to be implemented without introducing pricing. I suggest that this may be occurring because communicating through the internet systematically involves using shareable goods, and that when this is so, algorithms designed to let people share their capacity and balance load among units that have overcapacity when they have overcapacity offer a better solution than algorithms designed to enable the millions of transactions necessary to achieve a comparably efficient network service. Demand for units with overcapacity increases capacity over time, and sharing and load-balancing allocate extant capacity in the short term. Let me illustrate with one VoIP application, which makes quite clear the possibilities of generalized, impersonal social exchange as a means of provisioning network resources over a price-insensitive network made of shareable goods.

The application is Skype.[182] It is proprietary software provided by the makers of KaZaa, currently the most popular peer-to-peer music sharing platform.[183] There are no published performance studies of this network relative to the telephone network and other pc-to-pc voice telephony over internet applications. As of early 2004, however, while still in beta-testing, the software was downloaded by over ten million users, and used at any one time by over 300,000. Anecdotally the software seems to function well, offering voice quality and reliability—again, anecdotally—on par with cordless phones, if not quite plain old telephone service. What is fascinating about this application, if it proves capable of scaling technically (leaving the business model to one side), is that it relies on a peer-to-peer network. The capacity used to deliver the service is purely combined from capacity-generating components that have the characteristics of shareable goods. Users put these components into service for reasons other than voice-grade telephony, but

[182] http://www.skype.com.

[183] The following description is drawn from Peter Biddle, Paul England, Marcus Peinado, and Bryan Willman, The Darknet and the Future of Content Distrubtion, available http://crypto.stanford.edu/DRM2002/darknet5.doc; Clay Shirky, PCs are the Dark Matter of the Internet, http://www.shirky.com/writings/dark_matter.html. Skype runs on a structured decentralized peer-to-peer network on the model of KaZaa. The first major peer-to-peer network, Napster, relied on a centralized server to store information about which peer had what music. While peers then communicated directly with each other and downloaded music one from the other's computer from one end of the network to another, no peer could communicate directly with the other without first identifying the relevant other by reference to a central listing. This made the communications protocol simple to design and execute, but the system vulnerable to attack and failure. The particular attack on that server was legal action, and the failure was a court ordered closure. But the weakness was architectural—there was a single point of attack that could bring the system down. The response of the community of technology developers was to treat the legal attack like any other failure, and to design around it. The result was Gnutella and a class of approaches to peer-to-peer network design that avoided creating a center that would be vulnerable to attack, but had very high overhead, because it had no central clearing point about who had what information stored where. FastTrack, with its best known clients Morpheus and KaZaa, introduced Supernodes, which added structure to the network of peers, but still was insufficiently centralized, to suffer the failure of Napster. The software dynamically assigns to users "Supernode" status based on their available resources, and instead of every node telling every other node everything it had and everything it wanted, every node told these things to its nearest supernode, and supernodes told each other, keeping network traffic and information overhead low, while retaining redundancy, flexibility in the distribution of the location of information, load balancing among nodes with more or less free capacity, and flexible rerouting around points of failure. The result is a system that is much more popular than Napster was, but offers no single point of failure for attack.

Skype allows them to share their overcapacity so as to co-provision a telephony system. (We can afford to leave the business model aside because Skype is an architecture and some software, not a physical network. It hence could, in principle, be developed on a free software model should one company or another fail.) In an always-on or even mostly-on universe, where PCs have large amounts of unused memory and bandwidth, and a client like Skype's runs in the background taking up proportionally miniscule amounts of CPU power, bandwidth, and electricity, there will be little need to provide incentives to avoid shirking. The interest every user has in being reachable by his or her friends should provide enough incentive to keep one's client on and connected. Except for rare people who speak for more hours than they do not in any given 24 hour period, and who are capable of using their computer to its capacity while at the same time talking, so that they take resources from the VoIP network without contributing at least as much back into it in their own excess processing, caching, and bandwidth capacities, the system capacity should scale well from the perspective of willingness of participants to contribute as much as they take or more.

The policy point of the Skype story is fairly simple. VoIP is one of the most demanding applications, insofar as QoS assurance is concerned, because we have such remarkably low tolerance for latency in voice communications. VoIP has therefore been the primary excuse for schemes aimed at implementing pricing at the transmission control protocol level, so as to introduce pricing to manage congestion. Skype suggests that pricing is unnecessary if the machinery necessary for VoIP is sufficiently widespread and is a shareable good. PCs and broadband connections in the advanced economies indeed have the core characteristics of shareable goods. They are provisioned by individuals for their individual purpose in lumpy units that mostly exhibit substantial overcapacity. Given that requirements for human voice communications are limited by human capacity to comprehend and engage in real time communications, but capacity is generated by demand for a much wider host of applications, most of them allowing asynchronous use, the lumpiness of these units should persist. Given also that one needs to have such an overcapacity-generating good or resource to participate in pc-to-pc communications in the first place, demand will outstrip capacity only in the very unlikely case that the total demand for capacity by all owners of units will systematically outstrip total capacity of all units put in place by owners, even though the units are put in service only if they indeed provide some threshold capacity that equals or exceeds the requirements of the owner of the unit. This is not theoretically impossible,[184] but is probabilistically insignificant. In parallel to my observations about open wireless networks, if the devices necessary to take advantage of a functionality have the characteristics of shareable goods, it is possible that a market in capacity generating units with overcapacity, sold on a per unit basis, coupled with a technical platform that allows them to share their overcapacity and balance the load among units, will increase capacity better than an approach that assumes a fixed capacity provisioned through a market in capacity flows.

[184] The units meet prior demand exactly, skype adds exactly so much demand that it overwhelms the system capacity, but not enough added demand to make enough people buy enough new units with even greater over-capacity to achieve sufficient total capacity in the new state.

VI. Conclusion

This paper has two primary goals. The particular goal is to identify a class of resources or goods that are amenable to being shared within social sharing systems rather than allocated through markets. The general goal is to suggest that the particular observation, together with a growing body of literature on social norms, social capital, common property regimes, and the emergence of peer production outline the contours of social sharing as a third mode of organizing economic production, alongside markets and the state.

I suggest in this paper that there is a class of resources or goods that are lumpy and of medium granularity. These goods exhibit systematic overcapacity, which is often subject to sharing practices. Lumpiness is a technologically determined characteristic of these resources. Granularity is a function of technology and the extant demand and wealth in a society. It describes the divergence between the package size of a unit of a good capable of producing functionality and the demand individuals have for that functionality. Medium-grained lumpy goods are large enough so that each unit has systematically more capacity than one person requires over the lifetime of the good, and small enough that one person can justify putting a unit into operation to serve that person's demand for the functionality over the lifetime of the unit, given that person's ability and willingness to pay. Such units will generally have an overcapacity on an aggregate basis, in the sense that they will be able to deliver more functionality over their lifetime than the owners of units will demand in that time period. Goods with these characteristics will systematically represent a pool of potentially idled resources. The problem to solve for these goods is whether and how these idle resources will come to be used by individuals who gain welfare from using them at a time when their owners do not demand their capacity.

Information and transaction costs, and the practical diversity of individual motivations, limit the efficacy of secondary markets to harness this excess capacity. The comparative efficiency of social sharing systems and secondary markets is a context specific, empirical matter, but one can generalize that markets (a) will have higher marginal transaction costs per transaction, because social exchanges can have systematically fuzzier boundaries than market transactions require, (b) will have less information, organized in a more formally computable form, at the expense of more textured, detail information that can be computed in less formal, culturally-transmitted modalities, and (c) may, by using pricing, crowd out social psychological rewards that would elicit sharing patterns. Sharing is likely to dominate, however, where shareable goods are widely owned and have only small amounts of excess capacity. In those cases, the number of transactions necessary to accumulate the excess capacity into a usable amount of functionality, on the one hand, and the likely low price that small incremental contributions will command, on the other hand, suggest that both transaction costs and crowding out effect will be substantial if a secondary market is used in these situations.

More generally, I suggest that shareable goods are but one instance of a broader phenomenon, outlined by the literature on social norms, social capital, and most directly

common property regimes. The broader claim is that social production and exchange comprises a third system of production, a class of solutions to production problems that is separate from, and can complement or substitute for, the two more commonly studied systems—markets and the state. The relative salience of social production or sharing as an economic phenomenon is technology dependent. In particular, the form of sharing that we are observing today occurring in information and communications production—relatively impersonal, project or function-specific, radically decentralized cooperation—depends on the technologically-contingent capital requirements for effective action. As capital requirements have declined and access to the relevant capital goods has become widely disseminated in advanced economies, the scope of sharing as a modality of production has increased. Understanding this fundamental change in the material conditions of production is important because we find ourselves posed with policy and design questions that assume that the role of market production is fixed, rather than technologically-contingent. We are observing in many contexts policy choices and design impulses that take assumptions appropriate to the capital requirements of industrial economies and are trying to force behavior in the digitally networked economy into the social and market behavioral patterns that were appropriate for that technological stage and capital structure, rather than for the one we live in today.