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Communication Networks and the Rise of an Information Elite: Do Computers Help the Rich Get Richer?

Marshall van Alstyne
Massachusetts Institute of Technology

Erik Brynjolfsson
Massachusetts Institute of Technology

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Marshall van Alstyne
Erik Brynjolfsson
Sloan School of Management
Massachusetts Institute of Technology

Abstract

Under certain circumstances, the presumption that universal access to information infrastructure leads to greater equality of resources is incorrect. In fact, greater inequality can occur. This argument and several related propositions are explored through a formal theoretical model built on four simple assumptions: one cannot converse with everyone at the same time, information can be shared without loss, private information resources are not all the same, and agents can create new information in proportion to how much they know. The model rigorously explains how inter-agent infrastructure can be used to help the "rich get richer" and also why "it's not just what you know but whom you know." This theoretical framework is extensible and readily applied to real situations.

1. INTRODUCTION

In the United States in 1994, approximately 27.5 million people had access to electronic mail with 3.5 million reaching the Internet to browse and gather information (Quarterman 1994). Computer use correlates strongly with income and education in households and varies with industry sector in business.[1] These statistics suggest that digital resources are not distributed uniformly. But what if access were universal? If each enterprise and individual were granted a digital portal onto the National Information Infrastructure, would equal access to channels mean equal access to information?

The question merits a considered response particularly in light of the Commerce Department's declared policy of "universal access." Everyone is to be enfranchised in order to provide equal opportunity to gain from widespread information: "As a matter of fundamental fairness, this nation cannot accept a division of our people among telecommunications or information 'haves' and 'have-nots'." (NTIA 1993, p. 10). The policy, per se, also receives active support from several technologically sophisticated groups including the Electronic Frontier Foundation and Computer Professionals for Social Responsibility. Moreover Schickele (1993) presents an excellent case for the possibility of market failure and the potential for government subsidy. This research seeks to stimulate an information infrastructure policy debate by formalizing intuitions about the creation of opportunity relative to the concentration of resources. It demonstrates that universal access in a voluntary exchange economy with private information can produce *less* equality not more.

A model overview shows how a hierarchy of agents, characterized by different levels of access to information, might emerge as exclusive networks within a larger population. Even with universal access to communications technology, a subset of agents will endogenously gain superior access to resources. The model's major propositions stem from four basic assumptions: agents cannot converse with everyone at once, information can be shared without loss, different agents have different private information, and agents can create new information in proportion to how much they already know.

Information resources are not created equal and several interesting phenomena arise from an agent's efforts to gather better information. First, human information processing limitations (i.e., "bounded rationality") causes information seekers to focus on the best sources from among several of differing quality. Once an open communication channel is established, dialogue will generally be preferred to monologue leading to two-way information transfers (Kofman and Ratliff 1991). In addition, implicit "know-how" trading will often account for a non-trivial share of information propagation (von Hippel 1988). Because dialogue requires the consent of both parties, the agents with the most valuable knowledge, the "information elite," will often find it advantageous to focus their limited attention on each other. Such voluntary collaboration will concentrate knowledge to a greater extent than if agents had less flexibility in choosing communication partners.

Second, differences in channel access, both favorable and unfavorable, can be self perpetuating. If an agent has an adequate endowment to join a network of peers but lacks the network connections, then his resources will grow more slowly, disqualifying him from joining that network in future periods. Similarly, if an agent has few resources but manages to connect to a network with high quality information, then his resources may rapidly catch up to those of the new peer group and support his future participation. Third, the level of information sharing among partners can affect growth in the network's overall information resources. To the extent that information systems infrastructure facilitates this sharing, it can profoundly affect one network's resource growth vis-a-vis that of another.

2. AN ILLUSTRATION

To provide an intuitive overview of the model, this section considers one interaction among a subset of the key variables.[2] Agents or institutions are designated I, j, k $\in \{1, 2, \ldots I\}$. Each agent has access to a private endowment of information resources e_i. These endowments are heterogeneous so that $e_1 - e_2 - e_3$ etc., implying that agents do not have access to the same information. Agents have a finite number of channels, C, which they may use to access the endowments of other agents. Limiting the number of channels proxies physical, temporal, or cognitive capacity constraints among agents. They may also share information with one another but they need not share everything at once, instead revealing their private information according to a sharing parameter $\sigma \in [0, 1]$. Thus if agent I shares with j, then j gains access to σe_i, but since I may share without loss, e_i is not reduced by I granting access to j. Each agent, acting in his own self-interest, pursues a strategy of maximizing his resource access by attempting to network with other agents who have information. Importantly, however, all agents have veto power and may deny access to others offering too little reciprocal value.

For illustrative purposes, we now consider the choices and network behaviors in the specific case of one hundred agents and four communication channels per agent. Without loss of generality, we renumber the agents, sorting them on the basis of their endowments. The largest endowment corresponds to rank 1 and the smallest to rank 100, thus agent I has more information than j for I closer to 1. All agents prefer to communicate with the first agent since $e_1 > e_2 \ldots > e_{100}$. Since agent 1 only has C channels and because he has veto power, he chooses only to communicate with agents 2 through C+1 = 5 whose shared resources offer the greatest return. Agent 2, having C-1 channels remaining, chooses the next best agents 3 through 5. With one fewer channels still, agent 3 repeats this process, choosing agents 4 and 5. The first network therefore contains only agents 1 through 5. As the first five agents are now unavailable, agent 6 becomes the most attractive partner. Filling all channels for the next four most attractive candidates constitutes the second network inclusive of agents 6 through 10 or C+2 to 2C + 2. This process repeats for agents 2C + 3 to 3C + 3. Networks one through twenty[3] emerge:

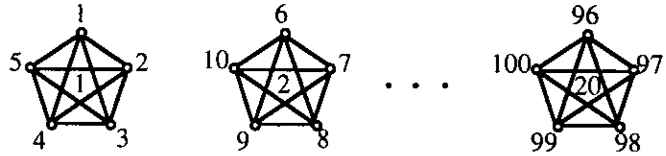

Figure 1. Given Limited Channels, Agents Will Form Exclusive Networks

Prior to network formation, the fifth agent is as elite as afterwards — no one has changed rank on the basis of newly shared resources. The gap between the fifth and sixth agents, however, has increased from $e_5 - e_6$ to

$$e_5 - e_6 + \sigma[(e_1 + e_2 + e_3 + e_4) - (e_7 + e_8 + e_9 + e_{10})]$$

since the fifth agent has access to higher endowment sources. Although the gap between agents five and six increases with network formation, note that the gap between agents four and five, as given by $(e_4 - e_5)(1 - \sigma)$, diminishes for any σ above complete secrecy. Other members of their joint network are the same.

The example illustrates intuitive results about voluntary association and access which we develop as formal propositions in this abstract's companion paper. The intuitions of the model are supported by case studies and also business and economic literature. The practice of exclusive network formation, for example, appears to be supported by evidence on the Internet (Chao 1995). Principles implied by the model regarding when to share and when not to share information are supported by a case study of groupware technology (Orlikowski 1992). That information can be shared without loss also implies resources may grow considerably faster in the presence of greater sharing rates. Evidence of this occurring in a regional economy appears in Saxenian (1994). It is interesting to note that the growth in information resources appears to be increasing at an increasing rate. This "information explosion" is one of several properties explicitly captured in the model that mimic historical events.

Published volumes may potentially understate the growth in information resources, but evidence suggests an increasing growth rate for most of this century. A shorter study (Pool 1983) found that electronic media exhibited a similar pattern from 1960 to 1975. Although the model draws from a small set of variables and assumptions, it appears to offer reasonably good explanations for certain stylized events.

3. POLICY CONSIDERATIONS

In general terms, the model suggests that the impacts of lower cost technology and improved access may not be entirely consistent with conventional wisdom. Others have argued that

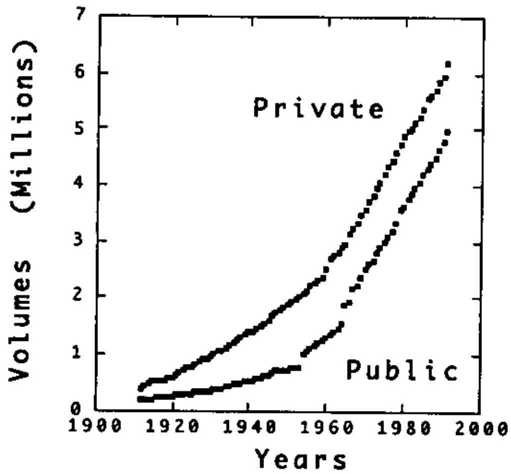

Figure 2. Growth in Volumes at Twelve Research Libraries Continues to Increase (Cummings et al. 1992)

access to information technology is a great equalizer and that lowering access barriers to good sources of information reduces resource gaps. Our model does not support this argument insofar as valuable private information remains publicly inaccessible. New communication technology might equalize information access for the resource starved in cases where a person or firm gained entry to information networks others had already joined. A more significant impact, however, may be the formation of new networks among the resource rich such that universal access leads to an increase in inequality. The model offers two reasons why this might occur.

The principal reason is that not all information resources are public. Owners of private resources may choose with whom they wish to share and those with the most valuable resources can expect the greatest returns. If returns are measured as access, then the information elite will leverage their existing holdings to secure greater access to each other. Increased disparity follows. One policy implication is the need for an improved incentive system for public disclosure. Patent law illustrates this principle, for example, since a temporary monopoly is granted in exchange for public revelation — a dissemination of information resources which can improve general welfare.

A second reason for increased disparity is that universal access interacts with "bounded rationality" and capacity constraints. Until infrastructure, including human and computer processing and channel capacity, permits unbounded resource transfers, not just access, agents will find it privately advantageous to concentrate their channels only on the most valuable sources for reasons of efficiency. In a voluntary system, this leads to the formation of multiple networks with a consequent differentiation of resources by network based on member contributions. People with a great deal to contribute are welcomed by the group and have a better choice of groups; people with lesser contributions are excluded.

The model also implies that differences in channel access can be self-perpetuating; networks exhibit inertia due to friction while reconfiguring membership. New members who initially exceed or fail to meet a network's standards will ultimately assimilate into that network if their endowments still fall within certain boundaries. Access to higher level network resources can boost the endowment of a less qualified candidate who is pulled up into the network. Exclusion, on the other hand, can stunt their endowment's growth, preventing them from ever joining. The policy implication is that if information technology reduces friction such as switching delays or the costs of changing partners, it might reduce inertia.

A final point of the model is that most behaviors exhibited by networks of information channels stem from the assumption of information as a non-rival good, that is, one which may be shared without loss. Since traditional resources do not exhibit this property, many standard intuitions may need to be revised. The owner of a high value asset has no incentive to trade it for a low value asset when the trade nets a loss. But when exchanging access makes new resources available at no cost to the old, incentives to trade greatly improve. In a marketplace of information transactions, the question becomes not whether to trade but with whom to trade first. The role of an information infrastructure might then be to facilitate such transactions in order to realize a greater abundance of information resources.

4. ACKNOWLEDGMENTS

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6. ENDNOTES

1. Of capital base in retail, ½%; 5% in chemicals, 15% in data processing (Brynjolfsson and Hitt 1996).

2. Time dependent variables, in particular, are not included to simplify the example.

3. If $I/(C + 1)$ is not an integer, the final network is incomplete.

The full paper and a software demonstration are available from the WEB at URL

http://www.mit.edu:8001/people/marshall/home.html

or from the authors at: MIT Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts 02139