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Small networks, evolution of knowledge and species longevity: Theoretical integration and empirical test☆

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ABSTRACT

How do small groups play pivotal roles of invention and innovation in (human) organizations and cultures? Economic theories of human capital, i.e., knowledge-skills—provide classic formulations. The economic theories of human capital as intrinsic to societal development and physical survival have direct connections to small group theory of learning through communication and socioemotional interaction. These theories have important parallels in biological theories of the evolution of human intelligence. They are supplemented by social exchange theory and the ecological dominance-social-competition model. These theoretical approaches are common to the overlapping disciplines of social anthropology, sociology and the social psychology of small group behavior.

However, even these theories, while plausible and mutually reinforcing, do not fully account for the extraordinary influence of small groups in the invention and innovation process. A crucial moment of invention and innovation is the psychological stress involved in expression/presentation (even to oneself) of a new idea (on an important subject) that is contrary to accepted (i.e., conventional) wisdom. In this article the argument is made that the social support function of small groups, discussed extensively in the epidemiological literature, facilitates that presentation by: (1) reality testing, i.e., confirmation of the validity (truth value), significance and usefulness of abstract or empirical discovery/creation; (2) emotional support moderating the effects of anxiety or threat; and (3) material support of the discoverer/discovery through financing or provision of significant social contacts.

Thus, we observe trends in human knowledge and consequent economic development: (1) continuous enlargement of the base of knowledge through specialization and differentiation of disciplines and employment, where disciplinary knowledge is embedded in the structure of employment. (2) Sustainable economic development results in expanded human longevity—minus the losses through employment and income inequality.

The impact of economic growth on species survival, engendered by small-group-mediated innovation, can be observed in a statistical model over the beneficial impact of economic development on global cardiovascular mortality. The statistical model also demonstrates the harm to cardiovascular health brought about by employment losses and income inequality associated with world-wide automation.

1. Introduction

The basic constituents of human organization are small networks. This is true of continuously-enlarging organizations: emotional (e.g., friendship) or task (work) groups, families, firms, institutions [1] or systems [2], occupations, industries, civil society, political parties, nations, religions, and racial/ethnic cultures. The evolution of human group organization is, classically, from small to increasingly larger units: herding and gathering to agricultural, to urban and industrial, and from there to the endlessly expanding service industries, stimulated by the communication sectors and, pointedly, the internet and social media.

This evolution of overall organization size reflects the enlargement of the human knowledge base through the continued specialization of scientific disciplines propelled by the innovativeness of individuals via small groups involving both task and socioemotional efforts. Small networks continue to be the sources of invention, and industrial innovation through the process, theoretically formulated by Arrow in economic theory, of "learning by

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doing" [3] and interactively through "learning by using" [4]. This set of small network-initiated processes occurs through the self-correcting process of scientific development followed by the small group-mediated innovation process.

Starting in the 1990s, industrial organizations, through restructuring, and automation, become flatter. Both technological development and automation were stimulated by the development of small multidisciplinary expert teams of R & D in large firm settings. This continuation more sharply reduces employment of low-skilled workers through automation, thus "hollowing out" the lower middle class and substantially enlarging economic inequality in the industrialized countries. Thus, the processes of diffusion of science and diffusion of innovation involve combined knowledge and industrial processes through the initiation and diffusion of small networks. This diffusion process has now been radically magnified through the internet.

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Small networks have therefore become more instrumental in scientific and technological development—enhanced by the digital era. Society therefore appears to be moving from small to large and again to small network influences on economic development. The offset to large-scale employment loss and inequality due to global automation and globalization can occur through entrepreneurial small groups with internet augmentation [5]. This could mitigate the potentially damaging effect on life expectation in the longer term.

2. Small networks and the process of knowledge expansion

It is generally assumed in the field of economics that economic growth is the foundation of the living standard represented by national income (GDP). In recent decades it has become conventional to assume that economic growth, largely influenced by productivity, is dependent on technological change or, more broadly, knowledge development [6]. The standard of living, in turn, is fundamental to expansion of the length of life in human populations. This leads us to the question of the origins of technological change and the diffusion of knowledge. In this paper the argument is made that a large part of new knowledge creation occurs in the context of small group interaction and then, again through small group processes and intergroup interactions, diffuses throughout regional, national and ultimately the global population. The creation of knowledge and its diffusion occurs in three steps: (1) discovery, (2) invention and (3) innovation.

The foundation of theory as to the intrinsic components of human society being small groups lies in the imagery of small group networks as component parts in all forms of human organization and culture. Therefore the largest systems of culture encompass increasingly smaller units—from nations to regions, institutions, organizations, small groups (and the interaction of individual persons composing them). This arrangement of interwoven and interlocking systems from large to elementary small primary groups can be seen as analogous to the system of fractals in many scientific disciplines including physics, biology, economics, sociology, social and individual psychology.

The intragroup (i.e., within small group) processes describing discovery are different from those concerning invention and innovation. But they have in common the fundamental internal conflict that seems to appear in virtually all groups undertaking a task [7]. The process involves conflict among the members regarding both the dominance of ideas and the creation and maintenance of social hierarchies arising from the structuring and consensus building over these ideas. Thus both conflict [8] and emotional maintenance [9,10] are necessary in these small group processes in order to maintain group cohesion and the solidity and continuity of the emergent ideas.

These ideas are indeed emergent in the sense of "emergent properties" as theorized in evolutionary biology [11,12]. They arise out of group interaction and therefore relationships, rather than the singularity of any idea attributable to one or more distinctive persons. They are therefore "group properties" which are now characteristics of the group architecture itself—despite the fact that they are stimulated by the concepts initiated by individual persons [13,14]. The process of idea formation in the intragroup setting represents, at the same time, a sufficient consensus that has the strength of a new norm and will therefore be confidently diffused to other groups and, thereby, to the larger society [15,16].These ideas involve every manner of human thought and inventiveness including the basic sciences, the applied sciences, the arts and moral disciplines, political philosophy, economic theory and moral ideologies. This variety of ideas as they enter their new reality, cannot possibly do so in a piecemeal manner. Instead they emerge in clusters and structured sequences and are thus referred to as "emergent properties" because there appears to be no logic or causal sequence that engenders these clusters of new ideas.

Since these ideas represent the foundations of human knowledge, they enter society in competition with alternative ideas—competition for dominance of cultural norms. The criterion for success in this competition is ultimately the betterment of human life—the increase in comfort and pleasure and the decline in mental and physical pathology and mortality. It is shown in this paper that an increased human knowledge base operating via economic processes in small group settings both decreases risks to human health and improves the likelihood of human adaptation to its environment. This is demonstrated in a model for world societies focused on cardiovascular mortality. At the same time it should be noted that the effort by the human species to control its environment, in order to preserve its own existence, can also bring considerable harm to that environment and thus, in a vicious backlash, damage the human structures and lives that are the raison d'être for that adaptation.

In the field of epidemiology we are able to see relationships between risk and benefit factors and mortality outcomes that pertain to samples of individual persons. We now know that the principles of risk to health that arise out of these samples pertain to human groups at every level from the small group to the work organization, the overall society and, finally, world societies. Thus we see that the importance of the economic unit, which embodies the evolution of technological culture shows a relationship to health that is a microcosm of what can be measured globally. Simply put, the micro is a partial reflection of the intermediate and the macro. The reason it is only a partial reflection is that at each incremental level of societal complexity new phenomena emerge as "contextual" factors.

3. Discovery, invention and innovation

The processes of discovery, invention and innovation have in common that they bring a new idea into reality that others can observe and use. These new phenomena were created under conditions of tension or stress that relate to the fact that they are contrary to what exists at that time—or, in other words, the status quo. The individual or persons who are constructing the new idea face a world of tension in which the idea may only exist in the mind of a person or group and, in order to survive, must demonstrate a utility that others will appreciate and want to employ. In