Markets, Information and Communication

Austrian perspectives on the Internet economy

Edited by Jack Birner and Pierre Garrouste

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Part IV

Networks and communication

8 The small world of business relationships

Guido Fioretti

Introduction

Curiously, theorizations and models produced within economics generally assume that any agent may interact with any other. Interactions are thought to take place in a homogeneous space where different agents are uniformly distributed, so in the end the outcome of interactions can be averaged and complex economies populated by multitudes of different agents can be subsumed by the behaviour of a few representative individuals, if not a single one. In this way, the existence of structures is assumed away.

Ultimately, this approach is assuming institutions away (Birner 1999). Modes of interaction, historical accidents that shaped the habits of peoples along centuries of agreements and quarrels, organisms for collective governance, all this is neglected by a fantastic jump from the microeconomics of an isolated utility maximizer to the macroeconomics of a single representative utility maximizer.

On the contrary, I am claiming that structures do matter for the generation of collective behaviour, and that a few economists who pointed to concrete cases actually highlighted some of the most important issues ever raised in this discipline:

- Keynes' discovery of the possibility of underemployment equilibria, due to insufficient effective demand (Keynes 1936). According to Keynes, equilibrium involuntary unemployment arises when investments are low, because demand is low, because unemployment is high, because investments are low, and so on. In systems theoretic terms, this chicken-and-egg situation can be characterized as an *information circuit*, a loop where information can circulate forever causing a series of economic agents to endlessly repeat the same sequence of actions.
- Chandler's discovery of the organizational shift from multifunctional to multidivisional form that took place in some large American companies in the 1930s and subsequently diffused over most large companies in the world (Chandler 1962).

According to Chandler, organizational arrangements that gather command lines according to functions (e.g. production technologies) are not viable for large companies that produce a number of differentiated goods for a number of different markets. Rather, organizational arrangements that gather command lines according to divisions (e.g. sectorally or geographically distinct markets) are more apt to channel relevant information to management. In organizational terms, Chandler was discovering *information sinks*, i.e. structures that aggregate information for particular decision-makers.

- Nelson and Winter's work on routines, modes of behaviour that are peculiar to specific firms and that eventually reproduce and propagate in the process of business replication, mutation and selection (Nelson and Winter 1982). Routines can be seen as sequences of operations carried out by individual workers, who eventually may be unaware of being part of a sequence that endlessly repeats itself, as well as of its effects on the firm as a whole. Just like in the case of Keynes' "effective demand", we are dealing with an *information circuit*.
- Axelrod's discovery of the feasibility of islands of cooperation in a sea of competition, if the prisoner's dilemma can be repeated by a population of individuals (Axelrod 1984). Among the many aspects of Axelrod's research, I would like to draw attention on the fact that he was highlighting *information clusters*, a very important and very ubiquitous kind of information structure.
- Kirman's investigations on Marseille gross fish market, which is possibly the most detailed investigation of transactions in a non-financial market (Weisbuch, Kirman and Herreiner 2000). Along years of observation, the Marseille fish market displayed a certain degree of stability of customers around vendors. In structural terms, we could say that vendors act as *information stars* in the net of relationships that take place. In other words, vendors are nodes where information converges and from where it radiates.

Among theoretical viewpoints, Austrian economics distinguishes itself for highlighting the need of taking account of communication, information structures, knowledge formation and cognition. Friedrich von Hayek has been a forerunner in this field, writing a treatise that anticipated modern connectionist models (Hayek 1952) and calling for consideration of information flows in economic theory (Hayek 1937, 1945).

The present contribution suggests the possibility that a widespread structure of interactions among the components of distributed systems (including human societies, neuronal cells, the internet and many others), namely the *small world* topology, regulates business relationships as well. The paper is organized as follows. Firstly, Section 2 explains the basics of small world structures. Subsequently, Section 3 highlights the conditions that make a small-world topology arise in a distributed system. Section 4 proposes methodologies for highlighting a small-world topology in the structure of business relationships and speculates about the event that this structure is actually found. Finally, Section 5 concludes.

A small world

During the 1960s, American psychologist Stanley Milgram discovered the surprising ability by distant people to connect to one another (Milgram 1967). Milgram assigned individuals living in Kansas and Nebraska the task of getting an envelope arrive at an individual located in Massachusetts, with whom they were not acquainted, by means of personal contacts. At each passage, information concerning the person who was receiving the envelope and shipping it forth had to be inserted in the envelope itself. In this way, Milgram could track the geographical and social milieus that were crossed.

To his surprise, completed chains clustered around quite a small number of steps, namely six. Later investigations, aimed to evaluate the effect of changing physical distance and racial groups, highlighted the same clustering feature around seven, rather than six (Korte and Milgram 1970). Since this human ability of finding connections with distant people reminds of anecdotes of people finding unexpected common acquaintances, Milgram called it the *small world* phenomenon.

Clearly, “small world” does not mean that connections between any two individuals have the same length, irrespective of geographical and social distances. Rather, it states that the net of human acquaintances entails long-distance shortcuts.

Sociologist Mark Granovetter (1973) was first to understand the topology underlying the small-world phenomenon. According to Granovetter, the net of human acquaintances is such that clusters of localized connections (*strong ties*, because they describe friends that are all acquainted with one another) are linked by a few long-distance connections (*weak ties*, because they originate from occasional acquaintances) that bridge between cliques.

Notably, since radical change often originates from unexpected connections, weak ties are generally responsible for important breakthroughs in individuals’ lives. More specifically, weak ties can easily explain the occurrence of the small world phenomenon. In fact, although any single individual is unlikely to have the proper long-distance connection in order to reach any other individual by means of a single jump, he can ask people in his clique whether any of them has it. Figure 1 illustrates an example of a small-world topology.

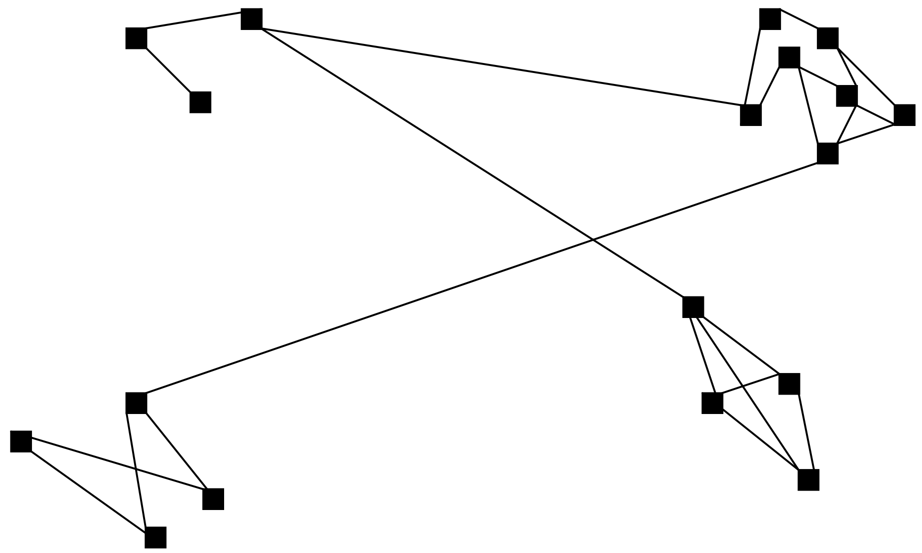

Figure 1
A graph connected according to a small-world topology. Nodes are arranged in tightly connected clusters, that are linked to one another by a few long-distance edges.

Formalization of the notion of small world was not provided until recently, mainly by physicists (Watts and Strogatz 1998; Watts 1999; Marchiori and Latora 2000; Newman 2000; Strogatz 2001). In its simplest formulation, it relies on two magnitudes:

- *Characteristic path length L*, defined as the average number of edges that must be traversed in the shortest path between any two pairs of vertices;
- *Clustering coefficient C*, defined as the average of the ratios of actual immediate neighbours to maximum immediate neighbours for each vertex.

The intuition behind the above magnitudes is that characteristic path length measures the ability of a node to link to a distant one, whereas clustering coefficient measures the amount of local structure in the network.

The above pair of magnitudes characterizes small-world networks. In fact, clustered networks having only local connections will exhibit a high clustering coefficient and a high characteristic path length. On the contrary, random networks (i.e. networks whose connections have been drawn at random) will exhibit a low clustering coefficient and a low characteristic path length. However, small-world networks will exhibit high clustering coefficient *and* low characteristic path length. Thus, simultaneous occurrence of low *L* and high *C* identifies a small-world topology.

Since tools for identifying small-world networks are available, researchers are looking for small-world structures in the most diverse settings. Interestingly, small-worlds seem to be ubiquitous in distributed systems. Small-world topologies have been found in the collaboration graph of feature films extracted by the Internet Movie Database (where *links* have been defined as actors working in the same movie), the Western Power Grid of the U.S., the neural network of the nematode worm *C. elegans*, the Massachusetts Bay underground transportation system, the English language (where *links* have been defined as co-occurrence of words) and the structure of hyperlinks connecting Internet sites (Watts and Strogatz 1998; Adamic 1999; Marchiori and Latora 2000; Ferrer i Cancho and Solé 2001).

Thus, small-world topologies seem to be a general property of the structure of connections between a large number of interacting, autonomous and (to some extent) intelligent agents. Since market economies are precisely like that, one may expect that business relationships are organized according to the same principle as well. However, before examining the possibility that small-world structures regulate economic life it is sensible to ask on what conditions small-world topologies arise, and whether these conditions are likely to hold within economic systems.

An instance of bounded rationality

Small-world topologies are so widespread because they arise out of simple reasons. These are, essentially: i) A generic tendency for each node to establish connections with any other, that is balanced by ii) a constraint on the number of connections that can be entertained, whose localization arises out of iii) greater easiness of establishing links with nodes that can already be reached through indirect paths.

Point (i) is an obvious feature of human societies, and a valuable ability in the world of business (Burt 1992, 1997). Point (iii), meaning that friends of our friends are likely to be our friends as well, is equally obvious (Granovetter 1973). On the contrary, point (ii) is more problematic and will be the subject of the present Section.

Since Simon's pioneering work on *bounded rationality* (Simon 1982), economists have a conceptual alternative to the idea that economic agents are able to make use of all information they get. Models of bounded rationality assume *satisfying*, rather than *optimizing* behaviour. As a rule, satisfying behaviour is modelled by assuming that decision-makers are content to attain certain levels of performance, rather than striving for the best possible performance. The idea is that decision-makers face cognitive limits to their information-processing abilities.

Possibly, a limitation of models of bounded rationality is that no general rule is available to calculate the threshold where cognitive limits put a halt to optimization. In other words, models of bounded rationality do not supply a ready-made decision rule, whereas utility maximization does.

However, if optimizing behaviour is simple but false while satisfying behaviour is correct but difficult, one should look for regularities in satisfying behaviour that would make it easy to employ, rather than sticking on wrong optimization assumptions.

It has long been suspected that cognitive limitations set an upper bound to human circles of acquaintances. Derek De Solla Price, who inspired the creation of the *Science Citation Index*, deemed that scientists gather around informal groups of about 100 people, which he called *invisible colleges* (De Solla Price 1965). Torsten Hägerstrand, a leading figure in cultural and economic geography who carried out extensive analyses of circles of acquaintances, attempted unsuccessfully to find it out by counting the number of references in commemoration books of prominent people (Hägerstrand 2001).

Apparently, the problem lies in separating *stable* acquaintances from occasional ones. However, this problem does not exist if we begin with primitive, simple societies.

By assuming that intelligence developed in order to keep groups of hominids together, evolutionary psychologist Robin Dunbar started to look for a correlation between neocortex size and group size for various species of primates (Dunbar 1996). In order to avoid spurious correlation due to the need of larger animals to have larger brains just in order to control a larger number of muscles, the relevant variable was actually the ratio of neocortex volume to total brain volume. Correlation between neocortex ratio and group size turned out to be high, as illustrated in figure 2.

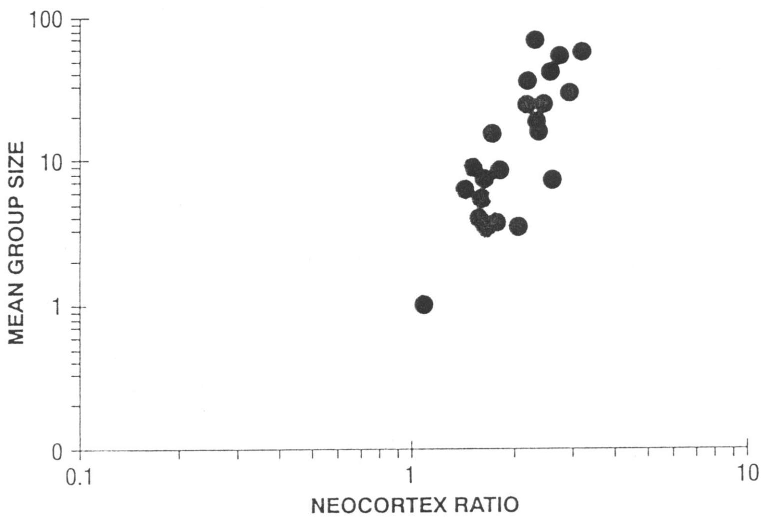

Figure 2
Dunbar's finding of a correlation between neocortex ratio (the ratio of neocortex volume to total brain volume) and mean group size. By courtesy of Robin Dunbar ©.

Most interestingly, this correlation allowed to make an inference on the size of prehistoric human groups. According to Dunbar's calculations, human groups must have counted 150 individuals, approximately.

Dunbar supported his findings with a lot of examples taken from observation of actual human societies. He found out that clans of contemporary primitive societies average almost exactly 150, and that these clans are much less variable in size than any other grouping. Furthermore, he reports that archaeologists have suggested that the villages of the earliest farmers of the Middle East (5000 BC) typically numbered 150 people, just like today's horticultural villages in Indonesia, Latin America and the Philippines.

Possibly, the most interesting evidence collected by Dunbar concerns religious communities in North America. Hutterites live in groups whose mean size is a little over 100. This is because they always split as soon as they reach a size of 150. In fact, the elders claim that once a community exceeds 150 people, it becomes increasingly difficult to control its members by peer pressure alone! Another example is provided by the Mormons. When Mormon leader Brigham Young led his followers out of Illinois into Utah, he chose groups of 150 people as the ideal size.

However, all these examples regard simple societies, where individuals only interact with the members of the group to which they belong. How is it in modern societies, where people typically entertain relationships with many more than 150 fellows? If one counts the number of people with whom each individual interacts, one finds numbers that vary greatly according to profession and can be up to the order of the thousands (De Sola Pool and Kochen 1978). Thus, Dunbar's anthropological constraint eventually holds only for a core of *stable* acquaintances, or, with a more precise definition, only for the number of people with whom an individual, at any given point in time, cares to keep in touch. In its turn this might be a problematic concept, since one could speculate that in modern societies human relationships may take any degree of depth, eventually blurring any distinction between stable acquaintances and occasional ones.

Nonetheless, there exists a bit of anecdotal evidence suggesting that even in modern societies and businesses, humans are subject to constraints as far as it regards the number of people with whom they can interact. Psychologist Nigel Nicholson reports of cellular organizational forms where a large number of semi-autonomous units are kept at an average of 50 employees each (Nicholson 1998). Economists Franco Malerba and Francesco Lissoni, while carrying out a research on the structure of co-authored patents, found out that apart from researchers who are working for large firms, inventors form clusters of a nearly constant size of 80 people (Lissoni 2001).

Notably, these numbers are much lower than 150, and even quite different from one another. Possibly, 150 should be discounted for friends and relatives before yielding an upper limit to the number of business relationships that one can entertain. Furthermore, this figure is likely to be different for different kinds of people, according to profession and inclinations.

Nevertheless, if bounded rationality means – among else – that businessmen cannot entertain relationships with infinitely many people, then even a global *new economy* can expected to retain certain structural features of the old one.

The global network

Admittedly, the little evidence presented in the previous section cannot be deemed to be conclusive in any sense. However, it is interesting to speculate what would happen if business relationships really conform to a small-world topology.

If business relationships are arranged in a small-world structure because of businessmen bounded rationality, then this structure should be invariant with respect to technological paradigms and availability of information and communication technologies. Thus, we should expect structural invariance of business relationships across time and space, in the “old” as well as in the “new” economy.

However, we should not expect that structural invariance is in any way related to physical location. On the contrary, spreading of business relationships all over the globe is a salient feature of the “new economy”. In many cases, it is not even necessary to resort to improving information technologies and falling transportation costs in order to justify this development, since physical distance may bear advantages of its own (Kilkenny 2000; Felsenstein 2001).

Rather, we should expect the clusters of the supposedly small-world network of business relationships to become ever less dependent on physical distance, spreading over continental areas of free trade and eventually, at a later stage, all over the globe. Namely, independence of information clusters from physical distance would be the hallmark of globalization.

Thus, a research agenda could be set out. One could reasonably think of gathering data on business relationships with respect to geographical location, looking for: 1) the existence of a small-world structure, and 2) the changing relation of this structure to physical space.

In order to do this, one would need extensive interviews with managers across industries, space and time. Clearly, a panel of this kind is very unlikely to be realized, particularly because of the requirement to span time and space, besides industries.

Possibly, one may try to use a series of set of regional input-output tables, on the hope that the structure of business relationships did not get blurred in the process of aggregation from managers to firms and from firms to industries. In this case, input-output tables should be discretized, translating their entries into zeros if they fall below a certain threshold, ones if they are above it. Threshold values need not be fixed arbitrarily, since they can be chosen to maximize information entropy (Schnabl 1994).

Note that, if one would find a small-world structure and if this structure would be found to be invariant with technological regimes, then the path of technical progress could no longer be conceived as exogenous. In fact, one could state that the net of inter-firm connections evolves according to precise psychological laws that inhibit combination of too many technologies at a time.

Weird as it might seem at first sight, this is precisely the way natural evolution proceeds. In fact, the overall fitness of an organism generally does not result from simple summation of the fitness of its genes, but rather depends on the extent of interactions between genes as well. In general, mutation of a gene affects overall fitness to a greater extent, the farther-reaching its interactions with other genes are. Up to a certain threshold, greater interaction means that a favourable mutation of a gene increases overall fitness by a greater extent. However, beyond that threshold a favourable mutation of a gene causes overall fitness to fall because of the negative influence that it exerts upon other genes. Thus, there exists an optimal level of genes interaction or, to speak in broader terms, there exists an optimal level of interaction between the components of an evolving system (Kauffman 1993).

Stuart Kauffman proposed to extend these concepts to the economic system, where technologies would take the role of genes and products would take the role of organisms (Kauffman 1988). According to this scheme, innovations would arise out of mutation and recombination of existing technologies (Schumpeter 1911) and, if this metaphor makes sense, one could claim that there should exist a limit to the number of technologies that can be re-combined at any given point in time.

Possibly, this limit lies in cognitive inability to handle infinitely many business relationships at the same time. Bounded rationality, understood as the existence of a limit to the number of relationships that can be entertained with repositories of particular technologies, might shape the set of innovations that can be carried out at any given point in time.

Concluding remarks

Although this short essay did not present definitive results but rather hints and suggestions for future research, its leading theme was that beyond all possible differences between “old” and “new” economy, certain structural invariants are likely to persist. In particular, this contribution focused on a possible psychological invariant, namely a constraint on the number of stable relationships that humans can entertain.

Generally speaking, psychology is seldom accepted in economics. In particular, it is never accepted when one deals with “hard” issues, like technology (Sen 1989).

Yet the main message of this contribution is that, in spite of this prejudice, psychology might command variables that most economic theories take as exogenous. If this would turn out to be true, then the chain of causal links to which economists are accustomed, namely from exogenous technologies towards production and consumption according to exogenous tastes, would close into a double ring where both producers and consumers innovate technologies and habits along anthropological and psychological guidelines, influencing one another in a never ending evolutionary spiral.

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