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The Information Society as a Complex System

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Abstract: We are all very conscious of living through a revolution — one in which the industrial society is being superseded by the information society. Every day brings new evidence of the breakneck pace of the changes that are currently underway. But while broad awareness may be unavoidable, understanding is not so easy. Both the pace of the revolution and its multi-faceted nature make it difficult to gain a clear perspective. But here the new science of complexity can perhaps help. It provides a coherent theory that is directly applicable to the emerging society, potentially providing new insights and new understanding. This paper examines several facets of the current revolution from a complexity perspective, and suggests that the relationship between the emerging science and the emerging society will be a rich one.

Key Words: complexity, information society
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1 Introduction

We live in interesting times — times of rapid and ever-accelerating change. The changes are happening so quickly that it is difficult to keep abreast, much less retain control. Everything seems to be changing at once — the political map, the global economy, our institutions, human society, company structures, business practices, and individual lifestyles. And the changes all seem to be heavily inter-linked. Change triggers change.

2 The World We're Leaving Behind

The world we're leaving behind was highly industrial. It was largely geared towards the manufacture of physical goods. The economics of this world were those of

scarcity, of situations where demand exceeds supply. By definition, physical resources are limited. So the value of a resource depends upon its scarcity — the scarcer the resource, the greater the value.

Since demand often exceeded supply, power rested with the supplier. Customers would not expect goods to be perfectly matched to their needs, but rather would be prepared to purchase any available product or service that came reasonably close. They had no alternative.

So it was a world of mass markets — of the broad notion that 'one size fits all'. Producers regarded their customers as one amorphous and undifferentiated mass, and consciously offered them little or no choice. This stance was perfectly captured in Henry Ford's famous remark that customers for his Model T could have the car in 'any colour, so long as it's black'.

Given the economics of scarcity and a focus on the mass market, the primary concern for producers was efficiency of manufacture and delivery. They organised their supply chains so as to optimise this efficiency. The goal was to achieve mass production and the accompanying economies of scale. So the supply chains were supplier-centric, geared to the needs of the producer. Mass production required that the supply chain should remain stable over periods much longer than the manufacturing time of any individual item — regardless of whether this chain was within a single vertically-integrated company or involved a whole sequence of companies. With this stability, the supply chain could be optimised over time. But the focus of this optimisation was efficient production for the mass market through economies of scale, rather than the specific needs of any individual customer.

In this world of physical resources, efficiency of production and stable supply chains, much of the value of a company lay in its physical assets — in its manufacturing equipment, distribution facilities, buildings and land, inventory and cash reserves. Most of the remaining value then lay in the history of profitability, which was seen as a good indicator of competitiveness, efficiency and future potential. So the entire value always lay in tangibles, whether tangible physical assets or tangible profits.

3 The World We're Entering

The world that we're entering is very different. It's a world that is dominated by information and knowledge, rather than by physical resources. And it is a world in which that information and knowledge is communicated and shared through networks.

Unlike physical resources, knowledge is not limited, either in its extent or its use. The economics of scarcity no longer apply. Instead we have the economics of ubiquity — rather than diminishing, the value of knowledge increases with wider accessibility and use.

So now the value of a product or service lies in widespread availability. As volumes increase, so does value, often on an exponential scale. Internet e-mail provides a good example. When only a few people had e-mail addresses, the value of the service was limited. But as more people subscribed, that value increased. Today, e-mail represents a hugely valuable tool for both business and social communication.

And as more subscribers join, so the value increases, not just for those new subscribers but for all participants.

In a world that is no longer limited by physical resources, supply potentially exceeds demand. Power no longer rests with the supplier — it switches to the customer. And customers begin to expect goods that are precisely matched to their needs.

So the mass market is being superseded by the micro-market. As Alvin Toffler has observed, we are moving from the stance of 'one size fits all' to that of 'one size fits nobody' [Toffler and Toffler 95]. Rather than remaining standardised, products and services are increasingly being customised. Each person is seen as a market of one, as a unique individual with unique personal needs and aspirations. Where once denim jeans were available in only a limited range of sizes, today you can have them made to measure, without any prohibitive increase in price. And as an alternative to pre-packaged musical selections, today we can purchase CDs or download our MP3 player with our own unique sequence of tracks, chosen from huge catalogues. When buying cars, we not only have a choice of colours but often a choice from a wide range of customisation options, so that our own car is heavily personalised. Perhaps in future we shall be able to order whatever colour we like (though some people will still choose black).

To capture and retain some share of these micro-markets, suppliers must be highly customer focused. They must be obsessed with meeting the needs and expectations of their customers on an individual basis. Since those needs and expectations are often dynamic, they must be flexible and innovative. So supplier-centric value chains are being superseded by customer-centric value networks, with the emphasis more on flexibility than on efficiency. Where the old value chains were stable, these value networks are highly volatile — they are formed to meet a transient market need, to occupy a particular niche, and then dismantled. With such volatility, opportunities for analysis and tuning are severely limited; the network must operate effectively from its inception. It must spring into being, work smoothly to satisfy the needs and expectations of its customers on an individual basis, and then simply disappear.

In this world of information, flexible value networks and volatility, much of the value of a company lies in intangibles — in its knowledge, business processes, agility, networking capabilities and brands. By contrast, physical assets become far less important. And even the history of profitability assumes less significance. So companies with no physical assets and that have never made a profit can be valued in billions. New companies come to the market and instantly achieve capitalisation that longer-established companies can only envy. Presumably the markets view these long-established companies as belonging to the world we're now leaving behind, while the newer companies are seen as forging the world to come.

4 The Science of Complexity

These changes that are underway are nothing short of revolutionary. Governments and institutions, companies and individuals all need to gain some insight into these huge changes, to achieve some kind of understanding. Better yet, we would like some

capability to predict and control. But that may be asking too much. Even insight and understanding presents something of a challenge. Fortunately, we have a tool that may help — the new science of complexity [Prigogine and Stengers 84], [Prigogine 80], [Prigogine 97], [Haken 83], [Ruelle 91], [Lorenz 95], [Badii and Politi 97], [Mainzer 97], [Flood and Carson 93], [Weingartner and Schurz 96], [Nakamura et al 97], [FCE 93], [Rhee 99], [Prigogine and Antoniou 99], [Antoniou et al 97b], [Novak 98].

Complexity is the study of emergent properties of systems that are highly non-linear. *Emergent properties* are properties of the system as a whole that cannot be identified by isolated study of its component parts. So, for example, intelligence and consciousness are emergent properties that cannot be understood by analysing the working of the brain's neurons. The beauty of Van Gogh's *Sunflowers* cannot be understood by detailed analysis of its individual brush strokes. And the nature of an ant colony cannot be understood by studying the isolated behaviour of each individual ant. In all these cases, the system must be considered as a whole. Complexity is holistic rather than reductionist.

In *non-linear* systems, instabilities are the keynote: a small change of initial conditions can result in a huge change in the system's behaviour over time. This is in sharp contrast to linear systems, where a small change in initial conditions results in a correspondingly small change of behaviour. So, for example, the simple systems of Newtonian physics like pendula and projectiles are linear. Most interesting systems, however, are non-linear, including, for example, biochemical reactions, electronic circuits, communication networks, ecosystems, weather systems, economic systems and social systems. The emergent properties of non-linear systems are often 'surprising', and it is with these properties that complexity is concerned.

Although a new science, complexity has already had many successes. It has given us new insights and deeper understanding in a wide range of fields, from pattern formation [Walgraef 97] and biological evolution [Novak 98], [Goldbeter 96], [West 90] to traffic flows [Prigogine and Herman 71], [Wolf et al 96]; and from evolutionary economics and stock market trading patterns [Giarini and Stahel 89], [Day 94], [Peters 91], [Day and Chen 93], [Barnett et al 96], [Puu 96], [Mandelbrot 97] to management [Flood and Carson 93], [Baets 99], [Ulrich and Probst 84] and the self-organisation of cities and regions [Prigogine 80], [Allen 97]. It has even contributed to the development of improved instruments for the diagnosis of skin cancer [Antoniou et al 99], [Akishin et al 99].

In many ways, complexity is the science of the Information Society — the two are closely inter-related. IT systems of all kinds are complex systems. The Information Society as a whole is a complex system, with information technologies providing the interconnections and correlations that introduce high non-linearities. Conversely, information technology is an essential tool in the study of complexity. The non-linear equations that characterise complex systems are rarely amenable to solution by analytical methods, and we rely instead on computerised methods involving simulation and searching. So the science of complexity relies upon information technology as an essential tool. But equally, this emerging science may help us gain new insights into the Information Society, and new understanding.

Some of the early trends that will help shape the Information Society are already visible. And we can already identify facets of complexity theory that could yield some insight into those trends. These combinations include:

- new value added services / new relevant variables
- the agile enterprise / non-linearity and rapid structural change
- power to the individual / new stable branches
- virtual communities / self-organisation
- the excluded middle / changing attractors
- the new economics / autocatalysis

5 New Value Added Services / New Relevant Variables

In 1996, Alan Greenspan, Chairman of the US Federal Reserve Bank, made an interesting observation. Apparently, the economic output of the USA today weighs the same (measured in terms of physical weight, tonnage) as it did 100 years ago. Yet during that time, economic output has increased 100-fold in real terms. Clearly the nature of what we produce has changed — from heavy physical goods, to services and intangibles.

In the Information Society, a high proportion of the economy — perhaps 50% or more — will consist of new value added services, in such areas as health, education and leisure. In health, we shall see remote monitoring, diagnosis and treatment. Purely for reasons of financial savings, people may choose to consult a private medical advisor based in India or the Caribbean, rather than one based in their own town. And the specialist surgeon who performs a heart operation may be physically located on the other side of the world from her patient. In education, we shall see an explosion in distance teaching, in life-long self-education, and in 'immersion' learning (whereby one learns from simulated experience rather than from external observation).

So the nature of the world economy has changed dramatically over the past century and will continue to change during the next. Yet our way of measuring the economy has not changed. We continue to use old measures of progress and competitiveness, such as manufacturing output and full-time employment figures.

In the science of complexity, when studying complex systems, the selection of *relevant variables* is recognised as being critical [Prigogine 80], [Haken 83], [Mainzer 97]. Which variables should you use to study the behaviour of the system over time? Often some variables are 'fast' while others are 'slow'. The fast variables highlight the short-term behaviour of the system but provide little indication of longer-term behaviour. Conversely, the slow variables show only longer-term behaviour, not short-term. So selecting both the right kinds of variables — fast or slow — and selecting the right individual variables of those kinds is vital to obtaining the desired insights into the behaviour of the system under study.

Unfortunately, relevant variable selection is currently an art rather than a science — there are no rules. But those who work in complexity are accumulating some experience. They are learning to recognise bad choices of variables more quickly, and

to be imaginative in their search for good variables. Perhaps in time that experience can be applied to the Information Society and the information economy, yielding a new set of economic indicators that are more appropriate than those in common use today.

6 The Agile Enterprise / Non-linearity and Rapid Change

During the industrial era, most organisations enjoyed a relatively stable environment and, consequently, believed in the value of 'planning for progress and profit'. The heyday of such planning was the 1960s. Just as many nations had five- or seven-year plans, so most medium and large businesses had detailed plans for their own development.

But confidence in planning was short lived. By the late 1970s, dissenting voices could be heard. 'Those who say they make plans and these work are liars. The term planning is imbecilic; everything can change tomorrow.' And by 1993, Professor Henry Mintzberg wasn't limiting himself to the observations that planning didn't work and was therefore useless. He went further and condemned planning as positively harmful. Planning schemes don't just fail to encourage the flexibility that is so necessary for success in modern business — they actually suppress it [Mintzberg 93].

The traditional belief in planning reflected a view that the business world was largely stable and predictable. If one hundred thousand people bought new refrigerators during the second quarter last year, then one hundred thousand people would also buy new refrigerators during the second quarter this year. This notion of stability reflects the traditional view of the universe as mechanistic, deterministic and reductionistic. It essentially represents the Newtonian view, uncritically applied to the world of business.

But the 1970s saw growing recognition that any stability was rapidly disappearing — 'change is the only constant'. And today we have widespread acknowledgement that the rate of change is ever accelerating, driven by constantly increasing consumer demands and constantly increasing competition. Sony provides a striking example. The company's cycle time for the development of new products is incredibly short. In a thirteen-year period following its invention of the Walkman, the company produced 227 different models, about one every three weeks [Brull 92]. The new product cycle time is now shorter than the inventory turnover time of many of its retailers.

Equally, companies who carefully monitor their traditional competitors are increasingly outflanked by innovative newcomers who emerge from nowhere to rapidly capture a substantial chunk of the market — or to completely destroy the existing market by creating some radical new alternative.

So the old notions of planning are increasingly inadequate for modern needs. Complexity theory provides an explanation. The traditional approach to planning reflects the reductionist view of management, the notion that any problem can be addressed by dividing it into a set of self-contained sub-problems. But complexity theory shows that this approach cannot work — it relies on the false assumption that the universe is deterministic and linear. The modern business world is characterised by rich and complex interconnections, between co-operating companies, between

different groups within companies, and between companies, suppliers and customers. These complex interconnections establish very high non-linearities. They in turn give rise to unexpected phenomena like self-organisation and dramatic amplification of innovations that initially appear as small fluctuations in the system. As a result we find inherent limits to predictability and the breakdown of most conventional methods of control. For example, attempts to apply conventional (deterministic) control theory to such systems is doomed to failure; instead we must employ *probabilistic* control [Antoniou et al 97a].

So instead of planning for a stable future, companies world-wide are learning to live with change. They acknowledge that its rate is ever accelerating, driven by constantly increasing consumer demands and constantly increasing global competition. In response, they are abandoning their traditional approaches to planning, and replacing them with an emphasis on learning, flexibility, risk taking and 'churn'. They stress continuous learning, strive to remain lean and agile, and happily accept frequent failures as part of the necessary price for success [Peters 94].

In all of this, the information technologies are central — both in creating the need for constant change, and in giving businesses the tools for handling it. The primary driver of continuous change is ever-increasing competition in the global economy. And that global economy was largely created by the information technologies. Before the advent of these technologies, the world's economies were regional or national, and the interactions between the individual economies were limited. But the widespread adoption of information technologies introduced the rich set of inter-connections and inter-dependencies that transformed the many national economies into a single global economy. Equally, the information technologies provide companies with one of their main tools for handling change. They enable companies to quickly change their organisations, to work more closely with their partners and suppliers, and to rapidly bring new products to market. We see the flattening of traditional hierarchies, the blurring of boundaries between companies, and virtual enterprises that are in constant flux.

In complexity terms, the information technologies support the interconnections and correlations that introduce high non-linearities. They actually help to *create* complexity. But at the same time they enable rapid reaction, allowing organisations to respond to the complexity and even exploit it. The result is accelerated business evolution. So companies must always be prepared for the unexpected — for a changing environment or for new behaviour from their customers, partners or suppliers. They must embrace change, and constantly search for a local optimum that will allow them to survive and prosper.

They must therefore replace their old rigid planning with flexible, open and adaptable approaches based on evolutionary strategies. These are now under development within the science of complex systems, along with a new mathematics for evolutionary planning [Flood and Carson 93], [Baets 99], [Ulrich and Probst 84], [Antoniou and Suchanecki 97], [Bojadziev and Bojadziev 97], [de Caluwe 97], [Refenes 95]. That new mathematics will in turn be supported by soft computing. Once this work reaches fruition, we shall have new planning approaches that recognise and respond to the challenges of ever-accelerating change.

But of course, a new approach to planning is only part of the story. A planning approach that emphasises flexibility must be matched by company structures and strategies that provide flexibility. Hence we witness a trend in the structure of organisations that is now well-established:

- *from* rigid hierarchies, vertical integration, functional divisions, central control
- *to* fluidity, flat structures, process orientation, networking, and distributed autonomy.

In complexity terms, the rigid hierarchies reflect a deterministic view of the world while the flexible networks reflect a probabilistic view. The deterministic view subscribes whole-heartedly to a belief in cause and effect. It believes that events are completely determined by previous causes rather than being influenced by free will or other uncontrolled factors. So a strict hierarchy that is able to manage the causes and thereby obtain the desired goal is seen as appropriate. By contrast, the probabilistic view rejects the notion of a clear and stable goal and of a known path for reaching that goal. Instead it takes the stance that many outcomes are possible and that each is subject to some probability, never certainty. So the appropriate organisational structure is the fluid network with its inherent capabilities for self organisation and self adaptation. In the new science of complexity, the probabilistic view is central. With any complex system, we are unable to make firm predictions but we can make probabilistic predictions [Prigogine 97], [Antoniou and Suchanecki 97].

In all these trends from rigid hierarchies to fluid networks, the main enabler is again information technology. Without those technologies, the kinds of changes now taking place — all of which require great flexibility, close co-operation amongst separate groups and superb communications — would simply not be possible. [It is also interesting to note that IT catalysed the development of the mathematics of complex systems. Some of the central characteristics of complexity, including instability and chaos, were known to both Maxwell and Poincaré. But they lacked the mathematical tools to make any progress with these topics. Only with advances in IT was it possible to develop the new mathematics that the science of complexity requires.]

7 Power to the Individual / New Stable Branches

Once fully established, the Information Society will be one of personal empowerment. To quote Taylor and Wacker, we shall all have four key freedoms: to *know*, to *go*, to *do*, and to *be* [Taylor and Wacker 97]. The freedom to *know* comes with open access to continuing self education and to all kinds of information. For the first time in history, our ability to know will not be constrained by wealth, caste or nationality, but only by the limits of our personal desires. The freedom to *go* comes from unconstrained mobility — a world of truly global citizens, unrestrained by national boundaries, who are able to travel and to live wherever they choose. The freedom to *do* comes from the option and obligation to take personal initiatives, to take responsibility for one's own life rather than relying on others. And the freedom to *be*

comes from unconstrained choice, the chance to be whoever one wants to be and live however one wants to live. Lifestyle will no longer be determined by factors outside the individual's control — whether nationality, social class, region of birth, regional customs and cuisine, or whatever — but solely by personal choice.

From a complexity perspective, this personal empowerment emerges as natural and necessary. In the conventional physics of closed systems, all evolutionary strategies have a global goal. They are directed at the gradual minimisation of some global system property — this is the famous *Least Action Principle* that governs equilibrium physics. But in a complex system, far from global equilibrium, this principle breaks down. There is no global goal. Instead there is self-organisation, with the various parts of the system constantly exploring and constantly searching for attractors, for stable branches representing local equilibria [Prigogine and Stengers 84], [Prigogine 80]. In the Information Society each individual person is a distinct part of the overall system, with a unique set of personal goals. Each individual is empowered to pursue those goals and, in some sense, obliged to do so. And the Information Society presents individuals with new stable branches, new avenues to personal progression, that previously were unattainable.

While the Information Society is empowering people in both their working and personal lives, it is also blurring the distinction between the two. For example, we see a massive increase in the number of people working from home. Already one American in five works from home for at least part of the time, and the numbers are steadily growing. Studies have shown a number of benefits, including increased job satisfaction and lower stress. A trial by Northern Telecom in 1994 showed a 30% increase in productivity when employees worked from home for at least three days a week. While an experiment by British Telecom found that home-based directory enquiry operators were more reliable than their commuting counterparts [Cairncross 97].

Another change comes with the increased range of services available in the home, including full financial services, education and health care. Already many of us use credit cards or electronic money to shop from home for all kinds of products and services. In the near future we shall be able to continue our education on any subject at any level, contribute to a political debate, vote for the candidates of our choice, consult legal advisers, and do a thousand other things.

With more people working from home and more services available in the home, the role of both the office and the city will change. Observing that one disadvantage of working from home is a loss of direct personal contact with colleagues, Charles Handy has suggested that the traditional office will become more like a 'club' [Handy 98]. People will no longer do most of their work there, but rather will use it as a meeting place where they can hold informal conversations, brainstorm and build teams. Similarly, the absence of millions of commuting workers will change the face of cities, and they will return to being centres of culture, entertainment and leisure.

The combined impact of all these changes is a lifestyle that has more in common with the agrarian era than the industrial. Days will be far less regimented. The distinction between working time and leisure time will be blurred. Enforced travel to reach work will be eliminated, but personal travel for holidays and leisure will increase. Above all, people will be empowered to make their own decisions and to

live the life that they choose to live. The available selection of stable branches and local optima will be huge.

8 Virtual Communities / Self-organisation

Traditionally, the vast majority of communities have been defined, and constrained, by geographical proximity. People felt a sense of community with their neighbours, with other people in the same village, town or neighbourhood. This geographical proximity fostered common interests, for example in the local environment, schools, healthcare, employment opportunities, shopping facilities, local transport, and so on. And those common interests would in turn reinforce the community. But the original source lay in geographical proximity.

Of course, there are notable exceptions. Newton was a member of a scientific community that spanned, at least, Western Europe. National and international medical communities have existed for centuries. And many of us have participated in various communities associated with our work, whether in the arts, the sciences, or engineering. But these notable exceptions largely serve to prove the rule — that the vast majority of communities have been governed by geographical proximity.

But now the information technologies are demolishing the barriers of distance [Cairncross 97]. Already, communicating with somebody on the other side of the globe is no more difficult than communicating with somebody in the next street. In many cases — such as when using Internet e-mail — it is also no more expensive. And with established trends in communications costs, it will soon be close to free.

So in the information society, people will be able to create new communities that are not determined by geographical location but only by common interests. Some will be work-related, uniting people in a particular profession. Others will be related to the home and family. Others to leisure interests and hobbies. And others to culture or ethnic origins. These virtual communities will not displace existing physical communities, but will be a rich addition to them.

To a large extent this has already happened. The Web is host to a huge range of communities representing every conceivable interest and orientation. So we have communities of mothers. Communities of people who are concerned with a specific disease or medical condition. Communities of people interested in one particular make of motorcycle. A community of the members of an ancient Scottish clan who now happen to be scattered across the four corners of the globe. The list goes on and on. And all these communities function and interact solely via computer networks. The members rarely, if ever, meet face to face.

This explosion will continue. Many of the existing communities will thrive and grow. Others will emerge, reflecting new interests and concerns. Some will be transient — formed to address one particular issue and allowed to evaporate once the issue has been resolved. Others will be permanent and unite people for life. And as the computing and communications technology improves, so the shared community experience will become richer.

Some people have voiced fears that the information society could destroy normal human social life. But the reality is that, through virtual communities, our social life

will be enriched and enhanced. Most important, the single digital space will provide entirely new opportunities for people to meet and interact, regardless of geographical distance, physical disabilities or restrictions on movement. Those who lack face-to-face social skills sometimes find that they are more relaxed in cyberspace and better able to communicate. The experience from letter writing and the telephone suggests that new opportunities for communication do not replace established forms of human contact, but rather supplement and enhance them. And the same will be true of the new communication opportunities provided by the single digital space and virtual communities.

In complexity terms, virtual communities represent a new phase in the self-organisation of our society, enabled by the information technologies. There is no centralised control over the many existing communities — they have been self-forming and self-regulating. Once the technologies were in place to support them, these communities simply sprang into existence. And new ones continue to appear, like mushrooms. This is a classic example of self-organisation reflecting the non-local correlations in complex systems.

9 The Excluded Middle / Changing Attractors

If the industrial era favoured large manufacturing organisations, it also favoured the middle-man. Many companies enjoyed great success simply by acting as intermediaries between manufacturing companies and their end customers. Lengthy supply chains were common.

However, with customers becoming more demanding and competition becoming fiercer, both manufacturing and service companies have been forced to 'get closer to their customers' and become more responsive to their individual needs. Often this has required the shortening of supply chains and, in particular, the by-passing (and elimination) of intermediaries.

The trend is now well established. Undoubtedly it has been accelerated by the success of the Web. Microsoft's Bill Gates has suggested that the information technologies will completely eliminate intermediaries by creating 'friction-free capitalism'. He argues that 'the Internet will extend the electronic marketplace and make it the ultimate go-between, the universal middleman'.

So are all intermediaries doomed to perish? In one sense, probably yes. Historically, many intermediaries have prospered from necessity rather than desirability. They have been a necessary link in the supply chain, in that their involvement has been essential to the delivery of the product or service from the producer to the customer. But from the customer's perspective they have not added value to that product or service — they have simply made it available exactly in the form in which it left the original producer.

Any such intermediary, who adds cost but no value, is obviously vulnerable. Once an alternative delivery route becomes available — whether through the telephone, interactive television, the Internet, or whatever — it will be adopted. From the perspectives of both producer and consumer, it's a pure win: the new delivery route offers cost savings without in any way reducing the value of the product or service.

But some intermediaries do add value. An obvious example is the travel agency staffed with seasoned travellers who can advise on the potential pitfalls of some proposed itinerary and suggest a better alternative, all based on personal experience. Other examples arise when there are many possible alternatives and masses of data to be sifted in order to make an informed decision — such as, for example, when making investment decisions. In such cases, the intermediary between the original supplier and individual consumer is not simply adding cost. By bringing specialist knowledge to the situation, the intermediary is also adding real value. And these intermediaries can continue to thrive, even in an age when the technologies would allow them to be by-passed.

Indeed, the information age could even see a boom in this sort of intermediary. One concern that is often expressed about the Information Society relates to information overload. Individuals may be bombarded with so much information that they are unable to handle it all and simply collapse under the weight. In this context, the knowledgeable intermediary has a real role to play — sifting the information, sorting the wheat from the chaff, and offering informed and reliable advice.

So the overall impact may not be the complete elimination of intermediaries as Bill Gates suggests. While we will certainly see the demise of those who add costs without adding value, we shall also see the growth of a whole new industry — intermediaries whose knowledge and skill add real value for the customer, and for whose services we shall all be happy to pay.

However, the demise of intermediaries who fail to add value is just one example of a more general trend towards the exclusion of the middle. We see other examples with the disappearing layer of middle management and with the changing role of the nation state.

Middle management has of course largely disappeared in many companies as a result of re-structuring and downsizing. While such exercises may perhaps be triggered by a desire to cut costs, they also aim to create an organisation that is more flexible and more responsive. Middle management structures are often seen as rigid and slow-moving, and therefore as attractive candidates for re-organisation or removal.

And the middle layer of government, the nation state, may also be challenged. With modern communications and transport, people's horizons extend beyond their national boundaries. And their focus has polarised. There is a tendency for people to feel strong local affinities, to their own town or city or region, or to a local ethnic group. But also, many people now feel strong 'global' affinities — they think of themselves more as a citizen of Europe, or even the world, than of any particular nation state. Increasingly people have global reach while retaining strong links to local communities.

One wonders how the nation state will fare in between. Its position is not wholly strong. It is often a relatively new artefact — if one watches an animated political map of Europe from the 18th century onwards, the boundaries change with bewildering frequency before finally stabilising somewhat in 1918. It is also an artificial one. The world is real, the local community is real, but the things in between are unreal — they are defined only by lines drawn on the map, which often appear to

be rather arbitrary. So the nation state is likely to come under increasing pressure as people's affinities switch increasingly to the local and the global.

From the complexity perspective, all these examples of the excluded middle reflect exploration and self organisation. The various parts of the complex system are continually searching for attractors that represent a local optimum and for the best ways of achieving their local goals [Prigogine and Stengers 84], [Prigogine 80], [Haken 83], [Lorenz 95], [Mainzer 97]. They are not constrained by their established co-operation patterns, but are prepared through continuous interaction to seek out and establish new partners to help in meeting the goals. As a result, intermediaries that don't add value are by-passed — they are no longer attractors. But the new arrangement is stable only for as long as it represents a local optimum. Should new and better opportunities emerge, they will be seized as a normal part of the ongoing process of exploration, self organisation and self-adaptation.

10 The New Economics / Autocatalysis

The Information Society is changing the rules of business economics. At one time, the dominant goal was to sell your main products and services for more than they cost. The value of a business lay in tangible assets and profitability. But increasingly companies are giving products and services away, for free — witness such companies as Netscape and Yahoo. The business value no longer lies in tangible assets and profits, but rather in knowledge, brand and market presence.

This new strategy exploits the *law of increasing returns* — one of the new rules of the network society [Kelly 98]. In the industrial era, the accepted wisdom was the law of *diminishing* returns. According to this law, much of the value of a product or service lies in its scarcity. When production volumes increase, the scarcity value is reduced. But the network economy turns this law on its head. Many products and services are now subject to a law of *increasing* returns — the more widely available, the greater the value. We see this with the fax machine, with mobile phones, and with many of the services now available on the Internet.

With the law of increasing returns, priorities change. The first priority is to achieve critical mass, as rapidly as possible. Beyond that critical mass there is a beneficial feedback effect and market share then accelerates. Which in turn can generate accelerating profits. So the *first mover advantage* — the benefits of being first to market with a new innovation — is greatly amplified. In complexity terms, this is a case of high non-linearity and small perturbations producing big changes. If the innovation can find a place in the market, the demand can rapidly become massive. But timing is all.

So the economics have changed. Traditionally, company value was a function of tangible assets and profitability. But with the new rules, company value is a function of intangible assets — such as imagination and creativity — and market presence. With ubiquitous presence, the value is high even if the profits have not yet started to roll. So the *relevant variables* for measuring businesses have changed — from 'hard' measures such as tangible assets to 'softer' measures like brand or market share.

These new economics are well illustrated by recent changes in the FTSE 100 Index of the leading companies on the London Stock Exchange, as measured by market capitalisation. The broadest ever changes in this long-established index saw nine companies leave, to be replaced by nine new entrants. The companies that left the index were from traditional sectors such as brewing, the utilities, construction and foodstuffs. They were all household names — Wolseley, Thames Water, Scottish & Newcastle, Imperial Tobacco, Whitbread, Hanson, PowerGen, Associated British Foods and Allied Domecq. All had strong track records of profitability and growth.

By contrast, the nine new entrants are all from new economy sectors: computers and the Internet, pharmaceuticals and the media. The list of names — Freeserve, Thus, Cable & Wireless Communications, Baltimore Technologies, Psion, Celltech, Nycomed Amersham, Capita and Emap — include several that are perhaps unfamiliar. To take just one as an example, Freeserve is Britain's leading Internet Service Provider by number of users, but has never made a profit and expects to be loss-making for the next three years. It is fascinating to see that such a company can now displace one like Hanson, which deals in tangibles, has a good profit record, and has long been regarded as one of the FTSE's strongest performers.

In complexity terms, the law of increasing returns reflects *autocatalysis*, a feedback effect whereby the presence of some product itself stimulates further production of that product [Prigogine and Stengers 84], [Prigogine 80]. And autocatalysis is in turn a significant driver of self organisation in complex systems.

11 The Science of the Information Society

This paper has examined several major trends in the information society and suggested that the science of complexity provides a unifying perspective and a coherent theory that aids understanding of all those trends. Massive changes in the global economy, with new value added services overtaking traditional manufacturing in economic importance, calls into question the validity of the established economic indicators and suggests the need for identifying new *relevant variables*. For the enterprise, the increasing need for agility invalidates traditional planning approaches based on deterministic control and demands their replacement by *probabilistic* control. For the individual, enhanced opportunities for exploration lead to new *stable branches* offering unprecedented levels of personal freedom and choice. New means for *self organisation* in the information society are encouraging the emergence of new virtual communities. The continual search for new *attractors* results in the by-passing of intermediaries of all kinds — business intermediaries, middle management, and perhaps the nation state. And the positive feedback effect of *autocatalysis* is re-writing many of the established economic rules of supply and demand.

Each of these individual trends raises many questions. As just a few examples:

- what economic models and indicators should we use to measure progress and wealth in the information society?

- what new kinds of business and decision support tools should organisations employ?

- what will be the social impact of growing personal freedom — how does this express itself at the community level?

- what will the new roles of our main institutions in the information society?

- what will be the impact on levels of inequality between the different regions of the world?

Equally, for each of the trends, the science of complexity provides its own perspective and offers the promise of new insight. Even more significant, complexity provides a coherent theoretical framework for understanding the Information Society as a whole. The relationship between the emerging society and the emerging science will be a rich one.

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