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Networks:
Innovation, Growth and Sustainable Development

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Abstract

The emergence of the Internet as a measureable manifestation of our social and economic relationships changed the domination of networks in our lives. From about 2000, the internet has allowed us to study and understand the type of networks in which we live, and to model their behaviour. The Internet has fundamentally changed the distribution of wealth. The rich became richer simply because of the larger scale of the trading network and stretched national wealth distributions. Network effects are therefore likely to be responsible for much of the perceived increases in inequalities in the last 20-30 years, and policies to tackle poverty must therefore address the extent to which the poor can engage with society's networks of wealth creation. The greatest challenge to continued growth and prosperity, and therefore to peace and justice, is climate change. The potential cost of inaction on climate change could be as high. Our self-organising social networks have structured our societies and economies, and are now reflected in our technology networks. We can now replicate their evolution in computer simulations and can therefore better assess how to deal with the greatest challenges facing us in the next few decades.

Networks dominate our lives. They dominate our economic and social behaviour, yet until the last few decades we knew little about how they behave and grow.

This changed with the emergence of the Internet, not just as a communications tool, but as a measureable manifestation of our social and economic relationships. From about 2000, the internet has allowed us to study and understand the types of networks in which we live, and to model their behaviour.

These insights have since been transferred across to economics, ecology and biology, providing new insights into the nature of evolution in all areas. There have been numerous valuable successes and these have raised expectations that the science and modelling of networks can make a major contribution to economic policies, sustainable development and medicine. The application that has raised most expectation is in economics. However, there are limits to what can be done. From my experience in the last few decades, let me summarise what we now know, and what we can and can't do.

1. Self-Organising Networks

> *"Computer simulations can never reflect the full complexity of human behaviour and interactions."*

There is now no doubt that social and economic systems have most of the characteristics of one of the four types of self-organising networks: scale-free, "small-world" networks. It is worth reminding ourselves what these characteristics are: A power-law (n^x) relationship between nodes (people, businesses etc) and the number of links between them, and a power-law distribution of other key parameters (wealth, influence, and also fluctuations around dynamic equilibria etc.). Such networks emerge naturally in nature and society, and give rise to the dominance of "hubs" – key individuals and businesses; to the inequalities we know so well as Pareto's 80/20 rule; to "non-linear" responses to change, and to the fluctuations we see in equity markets.

The dynamics of such networks can also now be well modelled. They emerge naturally as a result of simple rules of "preferential attachment" to more connected nodes and are robust to disruption (which is why the Internet was designed this way), and therefore also to deliberate change by policy intervention. Their evolution is also "path-dependent", so the effect of a policy intervention depends on the starting point and previous history. They are in continuous evolution, don't have static equilibria, and are susceptible to "boom and bust cycles".

2. The Challenge to Economic Analysis and Projection

The economic models used by all main-stream economic institutions are still "dynamic stochastic general equilibrium" models. However, the recognition that our economic and social systems are complex dynamic networks requires new modelling approaches, notably "agent-based" modelling, that explicitly recognise the interconnectedness of different agents (people, businesses and parameters). These models can replicate and "explain" many of the characteristics of our economic systems. However, economic and social change can only be studied by letting computer simulations of the interplay of complex interactions "play out", and computer simulations can never reflect the full complexity of human behaviour and interactions. We will therefore need to continue to use a combination of General Equilibrium models for short-term steering of our economic systems, and "agent-based" network models for more long-term analysis of growth, innovation and sustainable development.

3. Boom and Bust in Networks

A first useful insight emerged very quickly with the boom and bust of "Internet-related" companies in the period 1998-2003. PC-based dial-up access to the Internet and GSM mobile telephony are both classic "network" technologies; the value depends on the square of the number of users.* Growth is therefore initially hyperbolic: It follows Metcalfe's law (faster than exponential), but then slows as the utility of additional links and participants diminishes. All growth patterns are self-limiting; network growth also slows and eventually saturates,

* The value of a network is related to the number of participants and number of others they can connect to: the square of the number of participants.

as in the case of the penetration of GSM telephony and PC-internet use, and now seen in social networks such as Facebook. Equity value of Internet and GSM-related companies which had been grossly inflated by extrapolations of ever-faster "exponential growth" collapsed as the growth-rates slowed. A simple model of self-limiting hyperbolic growth well reflected the evolution of technology use, with growth rates following its first differential and equity-values, the second differential. A more complex but analogous pattern underlies the current economic crisis, with its origins in the business, banking and government networks which followed an unsustainable enthusiasm for debt-financed investment.

> *"Smaller national and regional trading networks have a much smaller range of wealth, so globalisation has made the rich richer simply because of the larger scale of the trading network."*

4. Growth, Equity and Poverty

The growth of scale-free complex networks generates inequalities in most of their key parameters. In the internet, this is seen most notably in the number of links per node and the number of visitors per website. These follow "power-law" distributions with large numbers of nodes with few links and a few with many, much like the distribution of wealth in a population. Globalisation fundamentally changed the scale of networks in which we live – more, and more varied contacts, both socially and in trade. The Internet added and complemented this by fundamentally broadening and speeding-up our networks. These changes naturally change the distribution of wealth: Smaller national and regional trading networks have a much smaller range of wealth, so globalisation has made the rich richer simply because of the larger scale of the trading network. In addition, the rich end of the global wealth distribution exists in most countries and stretches national wealth distributions. Faster and wider trading on the Internet opens new opportunities and makes a few people richer faster, and may even increase inequalities, but is unlikely to change the poverty of billions, and puts new downward pressure on the wages of the least skilled in the USA and the EU. Network effects are therefore likely to be responsible for much of the perceived increases in inequalities in the last 20-30 years: Policies to tackle poverty must therefore address the extent to which the poor can engage with society's networks of wealth creation.

Despite a higher probability of large fluctuations than would traditionally be expected (in equity and bond markets), complex networks are fundamentally robust, and their long-term behaviour is therefore relatively predictable. Assessments of probable world growth and prosperity to 2050 by the OECD and the International Futures system, both using "agent-based" simulations, are very similar. Individual countries and regions go through crises, but overall changes in key global parameters such as employment rates, GDP and energy-use are projected to grow continuously over the next 40 years, as they have over the past 40 years: World GDP could be 4-times larger by 2050, but with major increases in Green House Gases concentrations and losses in bio-diversity.

However, the long-term resilience and adaptability pose new challenges to policies for sustainable growth. Because of the interconnectedness of so many parameters, no single policy measure (such as shifts in government expenditure) has a direct and linear impact on outcomes: The system adapts, sometimes in ways that were not intended. It is resilient to change. This makes "impact assessments" of single policy initiatives ineffective, and makes "cost-benefit" analysis a poor basis on which to base policy choices. Only complementary portfolios of policy measures can have significant impact, as we had shown in 2005 with the International Futures simulations. Greater investment in education, innovation, non-fossil energy and social equity could all contribute to greater and more widely-shared prosperity in 2050. A combination of increased investment in research and innovation, notably in "networking technologies"; education, health-care, and non-fossil energies, could significantly improve prosperity, equity and governance by 2050. The most effective long-term policies build around a small number of dominant drivers of change, and complement them with flanking policies to enhance adaptation.

Other policies must now focus on the intensity of links: the connectedness of people and businesses: Trade liberalisation widens and strengthens collaborations and trade, but must be accompanied by coherent regulations – banking rules, labour laws, product-safety specifications etc. The value of such approaches has been demonstrated by the increased connectivity of the European research community as a result of collaborations through EU research programmes. Not only has this reduced the fragmentation of research in the EU, but even small universities now have close links to the world's best researchers. This widens the range of new ideas that can be exploited, increases the number of skilled people that can contribute to leading-edge innovations, and helps provide a critical mass of new investment to take ideas to marketable services.

5. Climate Change: a Game-Changing Threat, but with Network Solutions

The greatest challenge to continued growth and prosperity, and therefore to peace and justice, is climate change: Climate change is already beginning to disrupt regional climate systems and has increased the frequency of disruptive extremes. If these changes continue, large numbers of people will be displaced and large costs of protection and recovery will be imposed on the society. We are heading in this direction.[1] The most recent assessments from the OECD indicate that, with current policies, world energy demand in 2050 will be 80% higher, with still 85% supplied from fossil fuels.[2] This would lead to a 50% increase in greenhouse gas (GHG) emissions, with CO_2 concentrations reaching 650ppm by 2050, and global average temperature rising by 3-6 degrees C by 2100,[*] and worsening air pollution. The OECD report recommends environmental taxes and emissions trading; valuing and pricing natural assets and ecosystem services; removing environmentally harmful subsidies (to fossil fuels or wasteful irrigation schemes), and encouraging green innovation.

Assessments of policy options with the International Futures system in 2005[3] showed that a broader combination of increased investment in research and innovation, notably in "networking technologies"; education, health-care, non-fossil energies together with a global

* The UK Royal Society estimated in 2011 that with 4 degrees warming, half the world's current agricultural land would become unusable, sea levels would rise by up to two metres, and around 40% of the world's species would become extinct.

carbon-emission price, would be needed to stabilise CO_2 concentrations (at about 500ppm) by 2050. However, these measures would have to be implemented by most major countries: Action by the EU alone would have little effect.

More recent assessments with the International Futures system for the European Commission* indicate that a combination of accelerated deployment of "network innovations" (broadband communications and smart-grids), together with a global market price for carbon-emissions, could cut global emissions after 2025 and stabilise CO_2 concentrations (again about 500ppm) by 2050. The OECD assessment indicates that global carbon pricing could be sufficient to lower GHG emissions by nearly 70% in 2050 compared to the baseline scenario and limit GHG concentrations to 450ppm, and would slow economic growth by only 0.2 percentage points per year on average.

The potential cost of inaction on climate change could be as high. The recent assessments of the changes in probability of extreme weather by Jim Hansen show the magnitude of change already experienced. If change continues at the same pace over the next 20 years, extreme weather events will impose a major burden on growth and prosperity by 2030. The assessment by Stern in 2008 indicated the cost could be 5-20% of future GDP. More recently, the OECD estimated that the cost could be 14% of average world consumption per capita by 2050. The "World in 2052" assessment by Jørgen Randers of the Club of Rome, published in 2012, estimates that the world could be 40% less prosperous in 2052 than the simultaneous OECD assessment, largely because of assumed lower population growth and the costs of adaptation to and damage from extreme weather.

So far, most government policies, to slow the growth in greenhouse gas emissions at the national, regional (EU) and world levels, have been too narrowly-based and relatively ineffective. The EU Emissions Trading System is close to collapse from over-generous emission allocations and fraud. In addition, we are now past the time when gradual reduction in emissions can alone keep temperature rises within 2 degrees C. We may soon be in the situation where we need to draw-down GHG concentrations to stabilise the climate. What can we then do to improve the effectiveness of public policies to mitigate climate change? And how do our insights into networks and innovation help?

Sensitivity analyses using the International Futures and OECD systems have shown that the three key drivers of change to economic growth consistent with climate stabilisation are 1) a robust carbon-emission price converging to the cost of capture and sequestration, 2) low-carbon energy networks that can accommodate a variety of variable energy sources and assure reliable and affordable energy for all, and 3) accelerated deployment of innovations such as high-speed communications to most people and businesses to enable structural change in products, services and lifestyles. Infrastructures are the key to effective networks, and the key infrastructures for low-carbon prosperity are:

- A coherent and robust world "carbon-accounting infrastructure" of monitoring, reporting, labelling and trade, with credits for certified sequestrations, tradable

* Using state-of-the-art models and tools for the assessment of ICT impacts on growth and competitiveness in a low-carbon economy: DG-Information Society, November 2009.

against emissions, with market access by billions of land-users and enterprises. This market must be transparent to investors, companies, governments and individual consumers.

- "Smart grids" for electrical power distribution, with real-time pricing to consumers; and
- High-speed social and business connectivity everywhere, affordable for everyone (mobile and fibre access)

The former could build on the agreements brokered by the World Business Council for Sustainable Development and the Carbon Disclosure project of Institutional Investors. The latter can be rolled out on the basis of the 4th Generation of mobile radio-based systems and fibre in most of the developed world by 2015, and could be affordable for over half of the world's population by 2020.

6. Concluding Remarks

Our self-organising social networks have structured our societies and economies, and are now reflected in our technology networks. We can now replicate their evolution in computer simulations and can therefore better assess how to deal with the greatest challenges facing us in the next few decades.

Climate change cannot be allowed to run out of control. Its effects will de-stabilise societies and impose huge costs on our economies. Assessments of the effectiveness of policy options to 2050 indicate that a broadly based portfolio of policy changes will be needed, built around a robust pricing of carbon-emissions engaging most businesses and people in the developed and developing world in a new network of carbon trading, with the price eventually set by the cost of capture and sequestration.

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Notes

1. "Climate Change Report Warns of Dramatically Warmer World This Century" *World Bank* http://climatechange.worldbank.org/content/climate-change-report-warns-dramatically-warmer-world-century
2. *OECD Environmental Outlook to 2050: The Consequences of Inaction* (Paris: OECD, 2012) http://www.oecd.org/document/11/0,3746,en_2649_37465_49036555_1_1_1_37465,00.html
3. Barry Hughes and Peter D. Johnston, "Sustainable futures: policies for global development," *Futures* 37, no.8 (2005): 813-831 http://www.sciencedirect.com/science/article/pii/S001632870500008X