The New ICT Ecosystem

The ICT sector is crucial as a driver of economic and social growth. Not only is it an important industry in its own right, it also provides the information and communication infrastructure without which modern economies could not function. How does this sector work? Why is it stronger in some countries than in others? What should companies, governments and regulators be doing to enhance its contribution? In *The New ICT Ecosystem*, Martin Fransman answers these and other questions by developing the idea of the ICT sector as an evolving ecosystem. He shows that some components of the ICT ecosystem, particularly the innovation process, work better in some countries and regions (e.g. the USA) than in others (e.g. Europe and the developing world). This enables policy-makers and regulators to understand why some parts of the ICT ecosystem are underperforming and what can be done to enhance their performance.

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Implications for Policy and Regulation

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Preface

The importance of the ICT ecosystem*

Contribution of the ICT sector

The ICT (information and communications technologies) sector plays a crucial role in the modern economy and society. The ICT sector includes computer hardware and software, telecommunications, consumer electronics, and Internet-based contents, applications and services.

From a long-run historical perspective, it is clusters of new technologies that have driven economic and social growth and change. New technologies drive growth and change by creating new opportunities for consumption and investment. The ICT cluster of technologies emerged around the time of the Second World War and since then they have been the most important driver of global economic and social growth and change. Earlier clusters were based on textile machinery in the late 1700s, the steam engine (including railways and steam ships) in the early 1800s; electricity and steel in the late 1800s; and the internal combustion engine, oil and petrochemicals in the early 1900s.

In most industrialised countries the ICT sector is one of the largest in the economy, accounting for around 10 per cent of GDP. However, its contribution to economic growth is even more important than this. According to the OECD up to some 20 per cent of all economic growth is attributable to the ICT sector. The same source reports that about one-third of all business research and development (R&D) is done by the sector (Fransman 2009).

Significantly, the ICT sector provides one of the most important and ubiquitous infrastructures of the modern economy and society,

* This section draws on the author's paper for the OECD's Innovation Strategy (Fransman 2009).

the infrastructure that facilitates information processing and storage and communications. Together with electricity and transportation networks the ICT sector provides the infrastructural basis on which all human activity depends.

The role of the ICT sector in the global crisis of 2007 –

The ICT sector has a key role to play in dealing with the global crisis of 2007 – This crisis has two components. The first is the *global downturn in economic activity*, the proximate cause of which was the global financial crisis sparked off by the sub-prime crisis. The second is the *global environmental crisis* caused by global warming. The ICT sector will be important in dealing with both of these.

The ICT sector will contribute to the reversal of the global downturn in two related ways. The first is by creating the innovations – both incremental and radical – that motivate and incentivise consumption and investment. It is consumption and investment that are the most important components of gross domestic product (GDP). By incentivising consumption and investment, ICT innovations complement Keynesian countercyclical policies. The second is through creating an improved ICT infrastructure that will stimulate the economic and social activities that depend on it. An example is high-speed fixed and mobile communications networks and the improved computing facilities that facilitate related economic activity. It is this same ICT infrastructure that will contribute to the global environmental crisis by making possible more environmentally efficient ways of working that will help to reduce global warming.

However, in order to play this constructive role the ICT sector will need to both *innovate* and *invest*. Innovation and its related investment must, therefore, be the central objective of the players who make up this sector and benefit from its output – corporate players, private consumer-users, government policy-makers and regulators.

But this raises three key questions:

- What do we mean by the ICT sector and how does it work?
- How does innovation happen in the ICT sector?
- What should be done by government policy-makers and regulators?

It is these three questions that are analysed in this book.

Ecosystems thinking

Catastrophic collapse versus reasonable performance

The contrast between the performance of two sectors of the economy in the global crisis of 2007 has been remarkable. While the financial services sector catastrophically collapsed, the ICT sector on the whole performed well. Clearly, very different things have been happening in these two sectors, but how should these differences be explained? More specifically, how should we think about the dynamics of sectors?[1]

The ecosystem metaphor and the creation of knowledge

Marshall and Darwin

Change has long been on the agenda of economics, although not all economists have gone as far as the nineteenth-century Cambridge economist, Alfred Marshall, who insisted that economics be 'concerned throughout with the forces that cause movement' and the corollary that 'its keynote [must be] that of dynamics, rather than statics'.[2]

How should we think of the forces that cause movement in the socio-economy? Marshall had little hesitation in answering this question. 'The Mecca of the economist', he said, 'lies in economic biology . . . the central idea of economics . . . must be that of living force and movement.'[3] However, while this was Marshall's meaning, he was forced to compromise when it came to choosing his method. The reason, Marshall reluctantly accepted, was that 'biological conceptions are more complex than those of mechanics'. He therefore decided to accept that 'a volume on Foundations [of economics] must therefore give a relatively large place to mechanical analogies; and frequent use is made of the term "equilibrium", which suggests something of [a] statical analogy'. The question is whether this method corrupted Marshall's meaning.

[1] This book provides a detailed analysis of the dynamics of the ICT ecosystem. Although reference is made in various places to the financial services ecosystem it is not discussed in detail here. However, the general conceptualisation here of sectoral ecosystems is relevant for all sectors, including the financial services sector. For a similar approach to the financial services ecosystem to that taken here to the ICT ecosystem, see Lo, (2004: 15–29).

[2] This statement comes in the preface to the 8th edition of Marshall's *Principles of Economics* originally published in 1890 (1962: xiii).

[3] *Ibid.*: xii–xiii.

For Darwin, change was evolutionary, and the force behind evolutionary change was the interaction between the generation of variety and selection from that variety. Darwin's understanding of variety was considerably enriched by the subsequent development of genetics, including the understanding of mutation. Populations of organisms, or species, interacting in a natural environment constituted Darwin's evolving ecosystem. This Darwinian conception, we now know, has yielded rich insights in the natural sciences.

But is the ecosystem metaphor helpful in understanding the forces that cause movement in the socio-economy? Certainly, the idea of interacting organisms in a constant process of change is more appealing than that of a mechanical system settling into equilibrium, if the aim is to understand living force and movement. But before deciding whether or not to employ the ecosystem metaphor, some basic questions must be answered. The first of these is: What are the 'organisms' that are interacting in a socio-economic ecosystem?

The interacting organisms in the socio-economic ecosystem

The first set of organisms in the socio-economy consists of *firms*. But 'the firm' is a strange organism in that it is made up of other organisms, namely people. Nevertheless, we tend to think of a firm as a single organism, internally united in its goal under a single hierarchical chain of command. However, for some purposes this abstraction is inappropriate. 'Firms' seldom have one view of the world, since different leaders of the firm may have different understandings. Furthermore, there is a fragmentation of knowledge within the firm as a result of the intra-firm division of labour (which co-evolves with the inter-firm division of labour). It cannot be assumed that all those within the firm are fully dedicated to achieving its stated purposes, raising issues of *motivation* and *incentive* as well as the *forms of organisation* that might facilitate them. Nevertheless, for most social scientists the firm remains a necessary analytical unit of analysis since it is a key locus of ownership, decision-making, resource allocation and innovation – knowledge creation.

However, firms have to be disaggregated if their interactions are to be understood. Two disaggregations in particular are important:

- The first disaggregation is into *competing firms*. Firms compete not only in product markets but also in factor markets. Competitive rivalry is one form of inter-firm interaction. (In the Darwinian

schema, the metaphorical parallel is the struggle for survival between species, Darwin drawing on Thomas Malthus' *An Essay on the Principle of Population* (1798) in his elaboration of this theme.)

- But also important, and interacting with competitive rivalry, are cooperative symbiotic interactions between *interdependent firms*. The word 'symbiosis' comes from the Greek meaning living together. Firms always live with other firms and the effectiveness with which they do so is an important determinant of their ability to survive and thrive in the socio-economic ecosystem. On this basis, two primary symbiotic relationships may be identified – namely that between a firm and its suppliers and a firm and its partners. A third relationship is between a firm and its competitors. Although at one level not a collaborative relationship, at another level firms often learn from and imitate their competitors, benefiting from the rivalry relationship. However, from the perspective of the firm which loses its ability to appropriate returns from its knowledge, the flow of knowledge to competitors appears as an externality, a spill-over from which it is unable to reap a reward.

There is another crucial set of symbiotically interacting organisms that needs to be added to the ecosystem picture. These are *final* consumer-users. They must be distinguished from *intermediate* consumer-users – firms that use the output of other firms (such as a producing firm that uses equipment made by a supplying firm). Both final and intermediate consumer-users interact symbiotically with their suppliers, acquiring knowledge through using the products and services they have bought and, in various ways, feeding this knowledge back to the suppliers. They constitute the fourth primary symbiotic relationship.

One group of supplying firms is particularly important – the financial firms that provide their customers with financial services. They are also part of a distinct sectoral ecosystem, the financial services ecosystem (the catastrophic failure of which since 2007 is teaching us more about how this ecosystem has worked in the past, and what happens when it fails). However, this is not the place for further discussion of the financial services ecosystem.

Symbiotic interactions and the creation of knowledge

While the first basic question asked in employing the ecosystem metaphor dealt with the organisms of the ecosystem, the second relates to

the nature of the *interactions* between the organisms. The key point here is that these interactions are processes that are continually ongoing, forever changing as learning, exploring and adapting take place through the symbiotic interactions. The interactions are the antithesis of static states of affairs where the parties involved in the interactions have optimised their objectives and have settled into a state of equilibrium. It is in understanding these dynamically changing interactions that the wisdom of Marshall's insistence that we comprehend 'living force and movement', rather than stationary mechanical states, becomes apparent.

So far, we have ignored one key dimension of the symbiotic interactions, a dimension that produces the most important 'forces that cause movement'. This is the generation of *new knowledge* through the symbiotic interactions between knowledge creators and users. It is the creation of new knowledge that puts the final nail into the coffin of the static mechanical analogy, rendering it inadequate as a framework to explain change.

Not all symbiotic interactions involve the creation of knowledge. An example is the interaction between the supplier of an unchanging machine and the firm that uses it. The ongoing interaction – involving initial supply, maintenance and repair – may be crucial for both firms. And it is possible that little new knowledge is created in the process. However, as has long been apparent, the symbiotic interactions between the users and producers of machinery frequently result in the creation of new knowledge. In some cases the users have also been the producers of machinery.

Writing in 1776 at the start of the first industrial revolution Adam Smith observed that 'A great part of the machines made use of in those manufactures in which labour is most subdivided, were originally the inventions of common workmen, who, being each of them employed in some very simple operation, naturally turned their thoughts towards finding out easier and readier methods of performing it' (1910: 9). Smith went on to note that 'All the improvements in machinery, however, have by no means been the inventions of those who had occasion to use the machines. Many improvements have been made by the ingenuity of the makers of the machines, when to make them became the business of a peculiar trade' (1910: 9). He could have added that the specialist makers of machinery do not improve their machinery in a vacuum. Rather, their efforts are spurred by the

feedback they get from the users of their machinery (that may include users within their own firm) through *their* symbiotic interactions.

Symbiotic interactions between the creators and users of knowledge provide the interacting parties with the knowledge and information on the basis of which further knowledge is created (by both parties). It is this knowledge that injects novelty into the ecosystem, (in the words of Joseph Schumpeter) creating the new and destroying the old. It is this creation of new knowledge that, to return to Marshall, is the main force that causes movement in the socio-economic ecosystem. In particular, as Schumpeter emphasised, it is new innovation-knowledge – that is, new knowledge embodied in new products and services, new processes and technologies, new forms of organisation and new markets – that challenges the status quo, forcing learning and adaptation on the interacting organisms in the ecosystem and making capitalism the restless system that it is.

But it is also with the creation of new knowledge that the biological conceptualisation of an ecosystem reaches its limits insofar as its applicability to the socio-economic realm is concerned. The reason is that it is the human mind – more specifically, *interacting* human minds – that is the most important cause of movement in the socio-economic ecosystem. Although new knowledge is created within the *context* of evolving symbiotic interactions, knowledge creation does not happen automatically or costlessly. Furthermore, it may not happen at all. Context does not determine in a predictable way the content of new knowledge, but by determining the conditions under which human minds may create new knowledge, context may influence content.

Ultimately it is the creative leap of the human mind – as new associations, inferences and connections are made – that constitutes a rupture from the past and causes movement in the socio-economic ecosystem. But this creative leap does not have a counterpart in the biological or physical worlds. It cannot be equated with the mutations and chaotic non-linear interactions that drive change in the natural world, even though there may be some similarities in their systemic consequences. The human act of creation is not a mutation but a regular part of the functioning of the human mind.

Other components of the socio-economic ecosystem

The ecosystem comprises more than symbiotically cooperating and competing firms and final consumer-users. Crucially, these players are

embedded in institutions. Institutions have been defined by Nobel Laureate Douglass North as the 'rules of the game'. One example, important for our later discussion, is the regulations that determine what firms can and cannot do. The legal framework defined by legal institutions is another example (including the laws of property and contract and intellectual property rights (IPRs)). A *de facto* rule of the game is the macroeconomic conditions under which players interact, including the availability of finance, and interest and exchange rates. These conditions affect interactions within the sectoral ecosystem as a whole (although direct interactions between firms and the other financial firms that provide them with financial services are treated here as an example of the symbiotic relationship between firms and their suppliers).

Other non-firm organisations also play an important role in the ecosystem. These include universities that provide research and skilled person-power and perhaps entrepreneurs. Firms may develop a symbiotic relationship with universities. However, the interface between firm and university may be quite different from that between firms as a result of the different ways of organising the production of knowledge in these two kinds of organisation. Government research institutes (such as those embedded in hospitals) and standards-setting bodies are two other examples of institutions that may also have an influence on the workings of the ecosystem.

Finally, government policy-makers may also have an important impact in many ways that will not be elaborated upon here. (Both regulation and government policy are considered in more detail in connection with the ICT ecosystem in chapters 5 and 6 of this book.)

Platforms, architectures and networks

Symbiotic interactions may also be shaped by *platforms*, and in recent years a rich stream of literature has emerged exploring the implications of this development.[4] Gawer (2009) defines a platform as 'a building block, which can be a product, a technology, or a service, that acts as a foundation upon which other firms can develop complementary products, technologies, or services.'[5] In an earlier

[4] For a recent contribution see Gawer (2009).
[5] *Ibid.*: 3–4.

work Gawer and Cusumano (2006) refer to 'the modern high-tech platform – an evolving system made of interdependent pieces that can each be innovated upon.'[6]

Platforms – defined here as systems that support complementary economic activity – vary greatly in terms of complexity and the level of the ecosystem at which they exist. For example, the Internet – a complex system of systems – serves as a platform at the sectoral level of the ICT ecosystem. The Internet as a platform has facilitated the rise of the Internet content and applications providers (ICAPs) who now comprise an important group of players in layer 3 of the ICT ecosystem (the content and applications layer, as shown in chapter 3 of this book). These companies include Google, Yahoo!, eBay, Amazon, Skype and Facebook.[7]

But the Internet is not only a network of networks; it is also a platform of platforms. For instance, the personal computer (PC) and smart mobile phone are platforms within the Internet platform. But platforms exist at even more disaggregated levels. Some writers have analysed platforms at the level of PC operating systems (e.g. the Linux open source operating system or Windows)[8] and microprocessors (e.g. Intel microprocessors).[9]

Platforms shape symbiotic interactions. Apple's iPhone may be taken as an illustration. The iPhone depends on the platform provided by the mobile communications network without which it would not work. But the iPhone itself serves as a platform for contents and applications. This architecture of interdependencies shapes the co-operative symbiotic relationships between four actors – the mobile network operator, Apple and its suppliers and partners, the independent creators of content and applications for the iPhone, and those who compete with the iPhone. This dynamic set of evolving symbiotic interactions is but one part of the broader set of interactions that constitutes the mobile communications industry.

[6] Gawer and Cusumano (2006: 2–3).
[7] Significantly, virtually all the globally dominant ICAPs are from the USA. The explanation of this fact lies at the sectoral rather than the firm level. See appendix 7 (p. 123) for an explanation of the success of the US ICAPs.
[8] See, for example, Eisenmann *et al.* (2008).
[9] Gawer and Cusumano (2006).

Globalisation and performance

Sectoral ecosystems have simultaneously both a global and a local existence. In any country the players of the ecosystem are embedded in *local* (national and/or regional) interactions with other players under the influence of local institutions. (Institutions are shaped by what North called *organisations* – consisting of groups of people with common objectives. Organisations include firms, political parties and trade unions. Organisations have the power to change institutions at the same time as they themselves are influenced by them. Institutions, therefore, are inherently political constructs and politics still largely occurs within the realm of the nation state, even though the actions of states may be influenced by global determinants.)

But many of the players also have an *international* ecosystem existence. Some players are globally dominant, with involvements in the sectoral ecosystems of many countries, and also involved in global trade and financial activities. Significantly, much of the knowledge created in national sectoral ecosystems will diffuse through many channels and in many different ways and influence other national systems. (All knowledge, however, is in the first instance created within a particular local context – that is, the place where its creators are – under a specific set of circumstances.)[10]

Important questions arise regarding the shifting positions of national sectoral ecosystems within the global ecosystem. These questions deal, for example, with the processes of catch-up or falling behind, as some national systems improve or deteriorate in terms of their relative performance. The dynamics of sectoral ecosystems are important in explaining these differential performances. (In the case of the ICT ecosystem the catch-up of East Asian countries – such as Japan, Korea, Taiwan and China, discussed in appendix 8 of this book – was a global system-changing event.)

A key problem lies in explaining inter-ecosystem performance differences. One example, discussed in appendix 7 of this book, is the Internet content and applications part of the ICT ecosystem. US companies dominate this part of the system globally – companies such as Google, Yahoo!, Amazon, eBay, Skype, Facebook and MySpace. Why is this the case? Why have European and Asian Internet

[10] For a detailed elaboration of this important point see Fransman (2009).

companies (Skype excepted) not featured in this space? Symbiotic ecosystem thinking is used in appendix 7 to provide an answer.

The new ICT ecosystem: implications for Europe

This book covers some of the same ground as the author's *The New ICT Ecosystem – Implications for Europe*, (Fransman 2007b) which was awarded the 2008–10 Joseph Schumpeter Prize. Although that book was written with a European audience in mind the analysis and supporting empirical evidence is relevant for all national ICT ecosystems, whether the ecosystem in question is in Britain, Brazil, or Botswana. Every country has an ICT ecosystem, although the players, their symbiotic interactions and the institutions in which they are embedded will be different. The task of national policy-makers and regulators in all countries is to understand how their ICT ecosystem works, its strengths and weaknesses, and what might be done to improve its contribution. The analytical and empirical tools provided in this book will help them in this task.

In a few places, the references to Europe in the earlier work have been removed in order to accentuate the generality of the argument. But for the most part the book addresses essentially the same questions.

A further comment is necessary regarding the division of the book into chapters and appendixes. The proportion of the book devoted to appendixes is unusual, but was intentional. The rationale was to make the argument of the book – pitched largely at corporate players, government policy-makers and regulators – succinct, leaving background material, evidence and supporting detail as far as possible to the appendixes. This does not mean that the appendixes are relatively unimportant: indeed, several of the commentators on the earlier book have stated that some of them contain important novel contributions. This applies in particular to appendix 7 (Why do US Internet companies dominate in layer 3?) and appendix 8 (How did East Asia (Japan, Korea, Taiwan and China) become so strong in layer 1?).

Abbreviations and acronyms

ADSL	asynchronous digital subscriber line
BCR	benefit-cost ratio
BIOS	basic input–output system
BT	British Telecom
capex	capital expenditure
CATV	cable modems
CDMA	code division multiple access
CEO	chief executive officer
CNC	computer numerically controlled
DB/km	decibels per kilometre
DRAMS	dynamic random access memories
DRM	digital rights management
DRPT	dominant regulatory paradigm in telecoms
DSL	digital subscriber line
DWDM	dense wave division multiplexing
ELM	ICT ecosystem layer model
EPZ	export processing zone (Taiwan)
Esprit	European Strategic Programme for R&D in Information Technology
FCC	Federal Communications Commission (USA)
FTSE	Financial Times–Stock Exchange (100 Share Index)
FTTP	optical fibre to the premises
GDP	gross domestic product
GSM	global system for mobile communication
IAP	Internet access provider
ICAP	Internet content and applications provider
ICT	information and communications
IP	intellectual property
IP	Internet Protocol (inter-network protocol)
IPO	initial public offering
IPR	intellectual property rights

IS	innovation system
ISDN	Integrated Services Digital Network
ISO	International Standards Organisation
ISP	Internet service provider
IT	information technology
ITU	International Telecommunications Union
JETRO	Japan External Trade Organisation
LAN	local area network
laser	Light Amplification by the Stimulated Emission of Radiation
LED	light-emitting diode
LLU	local loop unbundling
LRIC	long-run incremental cost
M&A	mergers and acquisitions
MIC	Ministry of Internal Affairs and Communications (ministry-regulator) (Japan)
MII	Ministry of Information Industry (China)
MITI	Ministry of International Trade and Industry (Japan)
MNC	multinational corporation
MPT	Ministry of Posts and Telecommunications (China)
MSN	Microsoft network
NGN	next-generation network
NIE	new ICT ecosystem
NIE–IS	new ICT ecosystem–innovation system
NMT	Nordic Mobile Telephony
NRA	National Regulatory Authority
OECD	Organisation for Economic Cooperation and Development
OEM	original equipment manufacture
ONP	open network provision
OSI	The Open System Interconnection Model
PAS	Personal Access System (China)
PC	personal computer
PHS	Personal Handy Phone System (China)
R&D	research and development
Race	R&D for Advanced Communications in Europe
ROE	return on equity
ROIC	return on capital invested

SEEP	Schumpeterian Evolutionary Economics Paradigm
SITC	standard industrial and trade classifications
SME	small and medium-sized enterprise
SMP	significant market power
SOE	state-owned enterprise
TCP/IP	Transmission Control Protocol/Internet Protocol (inter-network protocol)
TELRIC	Total Element Long-Run Incremental Costs
TSLRIC	Total Service Long-Run Incremental Cost
VoD	video-on-demand
VoIP	voice-over-IP
VSLI	very large-scale integrated circuit
WAP	Wireless Application Protocol
WCDMA	wideband code division multiple access
WiFi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WTO	World Trade Organisation
www	World Wide Web