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THE EVOLVING ICT INDUSTRY IN ASIA AND THE IMPLICATIONS FOR EUROPE

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Preface

R&D activity in the Information and Communication Technologies (ICT) industrial sectors is an important factor in boosting the competitiveness of the European economy. The ICT industry and ICT-enabled innovation in non-ICT industries and services is making an increasingly important contribution to economic growth in advanced economies. The ICT sector was highlighted in the EU Lisbon Objectives, and has retained its prominence in the recently proposed **Europe 2020 Strategy**.

The Information Society Unit at IPTS[1] is carrying out a research project on Prospective Insights on R&D in ICT (PREDICT)[2] and has produced a series of annual reports. PREDICT combines, in a unique way, three complementary perspectives: national statistics (covering both private and public R&D expenditures), company data, and technology-based indicators. PREDICT relies on the latest available official statistics delivered by Member States, Eurostat and the OECD.

The first part of each annual PREDICT report gathers the most recent quantitative information on ICT R&D investments in the EU and worldwide. It presents the data by countries, sub-sectors and companies. The second part of each report is dedicated to a specific thematic analysis. In 2010, it focused on the internationalisation of ICT R&D.

As part of these research efforts, IPTS launched in 2006-2007 an early tender for research focused on the ICT sectors and their R&D in East Asian countries in order to gain a better understanding of major ICT capabilities in those parts of the world. The present report provides a synthesis of this study.

This overall research exercise on Internationalisation led to a series of further reports. All of them are available on the IS Unit's website.[3]

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1 IPTS (the Institute for Prospective Technological Studies) is one of the 7 research institutes of the European Commission's Joint Research Centre.

2 PREDICT is co-financed by JRC-IPTS and the Information Society & Media Directorate General of the European Commission.

3 Available on the IPTS website at: http://is.jrc.es/pages/ISG/PREDICT.html

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EXECUTIVE SUMMARY

1. What are the component parts of the ICT Industry? How do these parts interact with one another to form a coherent industrial system? What are the main forces that drive the ICT Industry? How has the ICT Industry been affected by globalisation and the international division of labour?

2. In order to answer questions such as these in Part II of this paper a model is developed and elaborated upon. This is referred to as the Fransman Layer Model (FLM). The basic version of the model is analysed and the model is then extended to include the main sub-sectors of the ICT Industry and, after that, the main companies.

3. In Part III the dynamics of the ICT Industry are examined. This is done through an analysis of the main drivers of this industry. These drivers include innovation (what Joseph Schumpeter called new combinations), economic forces (such as economies of scale and scope, network externalities, the intensity of competition, and evolutionary dynamics). A further driver is institutional influences (such as regulation – particularly important in the network operator layer, standardisation, financial markets, and universities). Entrepreneurialism is another important driver (also emphasised by Schumpeter). Finally, co-evolutionary changes in consumer behaviour, tastes and demand also constitute a significant driver of change in this industry.

4. In Part IV attention is shifted to the role that East Asian countries (specifically Japan, Korea, Taiwan and China) play in the ICT Industry. The role of these countries is analysed, first by extending the Fransman Layer Model to include globalisation and the international division of labour. An analysis is then provided of the relative strengths of these countries in different parts of the ICT Industry. In short, the role of East Asian countries in this industry is first described.

5. Much more difficult, however, is to explain why these East Asian countries have come to possess the international competitiveness that they currently have in different parts of the ICT Industry. At the heart of the explanation that is provided of the success of Japan, Korea, Taiwan and China in the ICT Industry is the process of learning and innovation that has occurred within the specific contextual conditions that have been created in each of these countries. It is shown that these conditions have been fundamentally different in each of the East Asian countries. In all of them the creation and growth of indigenous firms have been fundamental to their success. However, in each country these firms have emerged and grown in very different ways as is shown in detail in the country studies.

6. Although, as shown, government has played a key role in the growth of the ICT Industry in all of these East Asian countries it has been involved in very different ways in each country. Furthermore, the industrial structure is also very different in the ICT Industry in each country. While Japan's and Korea's industrial structure is dominated by large companies (that in most cases also have close ties to other companies in the same group) in Taiwan it is networks of some large and many smaller companies that play the key role. Furthermore, these networks are more tightly integrated into global production chains (that include not only manufacturing but also design activities). In several parts of the ICT Industry China has managed to grow key players that have recently burst onto the

global stage. One example studied in detail is Lenovo that has acquired IBM's PC subsidiary.

7. In Part V, attention is focused on the role of R&D. A number of important conclusions emerge from this study. The first is the extent to which the US dominates total R&D spending by these 300 companies. Second, Japan's total is approximately half that of the US. The third point is the imbalance between the three European countries with Germany the clear European leader, and the UK following a long way behind both Germany and France with less than half the German total. Fourth, both Korea and Taiwan still perform poorly relative to the US, Japan and the European countries. Fifth, motor car companies feature prominently in most of the countries. Sixth, in the US 5 out of the top 10 companies are ICT companies. In Japan the figure is 7, in Germany 3, France 3 and the UK 1. This is roughly in accordance with the relative strength of the ICT Industry in the economy concerned. Seventh, in Korea Samsung far outperforms all the other companies with more than twice the R&D spend of the second company, Hyundai Motor. Eighth, in Taiwan there are only 3 companies above the cut-off point of $0.25 billion, all of which are in the ICT Industry.

   A further contribution is made in Exhibit 17 which locates the world's major ICT companies in the three main layers of the ICT Industry and ranks them according to their R&D expenditures. It is concluded that companies from Japan and East Asia are particularly strong in Layer I. Conversely, they are relatively weak in Layer III. Layer II differs from the other layers in that telecoms services, provided by telecoms network operators, is primarily a national industry provided by national operators. Globalisation has made little impact on Layer II. However, in terms of R&D expenditures Japanese and East Asian companies do relatively well in Layer II.

   The European companies that feature strongly in Layer I include Siemens, Philips, Nokia, Ericsson, and Alcatel, and SAP in software. In Layer II the main telecoms operators from the largest European countries are, unsurprisingly, amongst the largest R&D performers. They include Deutsche Telekom, France Telecom, Telefonica and BT. Their R&D expenditures are dwarfed by those of NTT, however, by far the leader in this layer.

   But, it is in Layer III that US companies are clearly in the lead with little competition from their Asian or European counterparts. This requires an explanation which is provided in the following section.

8. Part VI focuses on the upper layers of the ICT Industry and particularly on those parts that use the Internet as a platform for their activities, namely the New Internet Companies. It is shown that these layers are dominated by US companies, which include firms such as Google, Yahoo!, eBay and Amazon.

   Again, however, the important issue is to explain having described. This is done through a number of case studies that include Skype, Baidu (the Chinese counterpart of Google that dominates Google in the Chinese market), and Jajah (a small Austrian start-up that moved to California in order to get venture capital support). These studies lead to the conclusion that the US dominance in New Internet Companies is largely the result of the effectiveness of US institutions, particularly financial institutions and universities. The case of Skype, however, shows that it is possible for similar results to be achieved in Europe, although the paucity of 'Skypes' in Europe also suggests that these institutions do not at present work as effectively in Europe (or East Asia for that matter) as they do in the US.

9. Finally, the following three policy implications for Europe are derived:
   i) Policy Implication 1: The European Commission, with the support of relevant stakeholders, should select three or four sites in the European Union to be designated as ‘Internet Platform Innovation Sites’
   ii) Policy Implication 2: Far more needs to be done by the European Commission, national governments, and independent analysts (including academics) to benchmark European activities and performance in ICTI (including both private and public activities) against global best-practice wherever it is to be found.
   iii) Policy Implication 3: Europe needs to have a far more public debate about how to deal with the challenges from the US and Asia in ICTI

I. INTRODUCTION

The main aim and contribution of this paper is to examine the implications of East Asian growth in the ICT Industry for Europe. In order to achieve this aim, however, it is necessary to have a more precise idea of what the 'ICT Industry' is. What are the component parts of the ICT Industry? How do these parts interact with one another to form a coherent industrial system? What are the main forces that drive the ICT Industry? How has the ICT Industry been affected by globalisation and the international division of labour?

In order to answer questions such as these the author draws on and extends previous work that he has done in this field which makes use of an original layer model to examine the structure of the ICT Industry.[4] Making use of engineering layer models in the telecoms and computing areas (such as the OSI and TCP/IP models) the present layer model is essentially a description of the set of functionalities that are required in order to provide Internet access and services. This layer model is useful because it allows us, having examined the functionalities, to relate them to the economic sectors and companies involved in providing the elements that generate the functionalities. In addition, globalisation and the international division of labour in the ICT Industry can be examined by analysing specialisation by region in the different layers.

One distinguishing feature of the layer model as used in this paper is the addition of a top layer depicting final consumers. (Intermediate consumers – e.g. telecoms operators who consume telecoms equipment made by equipment suppliers – and their consumption activity exist both between and within layers.) This addition, while breaking with the layer model tradition, highlights the importance of the demand side and the co-evolution of demand.

In this paper the growing international competitiveness of East Asia (specifically, Japan, Korea, Taiwan and China) is both documented and explained. The explanation emphasises the complementarity between the private companies that have emerged in East Asia and the governments that have in many ways supported their growth. It is noted that these countries are particularly competitive in the first layer that produces networked elements (such as semiconductors, computers and computer components, and consumer electronics). These are areas where Europe is becoming progressively weaker.

In this paper no judgment is made regarding whether Europe should abandon particular parts of the ICT Industry to the shifting sands of international competition, instead becoming proficient users rather than producers in these areas. Nevertheless, it is clear that European policy makers will have to bite this bullet eventually. Either Europe will have to regain international competitiveness in those areas in which it is falling behind – but it must be demonstrated, rather than assumed, that this can happen in a cost-effective way – or it will have to consider abandonment. Either way, a challenge awaits.

Finally, this paper also examines some of the reasons behind the US dominance in the area of Internet content and application provision. Clearly, companies such as Google, Yahoo!, eBay,

[4] See Fransman, M (2002) Mapping the Evolving Telecoms Industry: The uses and shortcomings of the layer model, *Telecommunications Policy*, Vol 26, Nos 9/10, October/November 2002; M. Fransman. (2002). Telecoms in the Internet Age: From Boom to Bust to…?, Oxford University Press (winner of the Wadsworth Prize, 2003); and www.TelecomVisions.com

and Amazon are both US companies and dominant in the Internet content and provision space. The question is why. Answers are offered towards the end of the paper.

II. THE STRUCTURE OF ICTI: THE FRANSMAN LAYER MODEL (FLM)

A. Introduction

A Google search reveals how widespread reference to 'ICT' is and even to the 'ICT Industry'. However, such a search does not readily reveal (indeed hardly at all reveals) what is meant by the ICT Industry.

What is clear is that the letters I and C refer to information and communications respectively, and that T refers to technology. However, less clear is what we are meant to understand by the ICT *Industry*: i.e. an industry based on information and communication technologies. What are the component parts of this industry? How do these parts interact with one another? What are the forces that drive change within each of these parts? What drives 'the system' as a whole – consisting of all the interacting parts of the industry; that is how does this industry work? Where are the boundaries of ICTI, separating it from other industries? Despite the widespread reference to ICT the answers to questions like these are still poorly understood.

Further underlining the lack of clarity is the inadequacy of our existing classifications. Leaving aside standard classification systems (such as the standard industrial and trade classifications which are essentially-product based) it is illuminating to look at pragmatic attempts to provide a classification of business activity in this area.

One such attempt is that made in the *Financial Times'* online classification. Here three sectors are to be found that refer most directly (though implicitly) to ICTI: telecommunications (telecoms), IT (information technology), and Internet/Media. However, a perusal through these three separate sectors on any day reveals a significant degree of cross-posting, indicating that the categories are neither water-tight nor mutually exclusive. This begs questions regarding the relationship between these three sectors.

Furthermore, the addition of 'Media' to accompany the Internet adds further complications. While a number of organisations have attempted to define the ICT industry their definitions have tended to focus on telecoms (network operators and equipment suppliers) and computing (hardware and software) and have excluded 'media' (a term that itself is vague, and becoming vaguer as we shall see). How does 'media' fit into ICTI?

The Internet greatly complicates both the attempt to classify the components of ICTI and the attempt to understand the dynamics of ICTI. The Internet has rapidly become a key and ubiquitous infrastructure (its widespread commercial diffusion only occurred from about 1995), paralleling other infrastructures such as electricity and roads and supporting (and shaping) virtually all economic activity. But where does it fit into ICTI and the dynamics of this industry?

These few words of introduction and the questions raised should be sufficient to convince even the sceptical reader that a deeper understanding of ICTI is necessary. But where should the attempt to provide such an understanding begin?

B. The Fransman Layer Model

The approach taken in this paper is to begin with a particular kind of layer model of ICTI. Such layer models (such as the OSI and TCP/IP layer models – see Appendix 1 for further details) originated from the attempt of engineers to define and understand the components and structure of the computer and telecoms industries. Essentially they conceptualise these industries in terms of a number of hierarchically-defined, modularised and interdependent 'layers' of functionality. These layer models have played a crucial cognitive role in facilitating communication and coordination amongst engineers working in these areas.

However, a number of writers and organisations have begun to explore the use of the broad layer model conceptualisation in order to understand other issues, such as industrial and market structure, industrial dynamics, and regulation.[5] The present paper is within this emerging tradition. In this paper specific interpretations and uses are made of the general layer model concept. Collectively these are referred to as the Fransman Layer Model (FLM) to differentiate the present approach from the other layer models used in this area.

What is the Fransman Layer Model?

The Fransman Layer Model (FLM) is a model of the global ICT Industry (ICTI) developed by the present author in order to assist analyses of this industry and to help inform the development of appropriate corporate strategies and government policies. It is a qualitative model that views the entire ICTI as a system. In doing so it incorporates sectors such as the following: semiconductors, computers, software, consumer electronics, telecoms equipment, network operators (including telecoms fixed and mobile operators, cable TV operators, satellite and other operators), broadcasting, media, newspapers, books, music and advertising.

How does FLM differ from other Layer Models?

FLM is an economic-institutional model. It conceptualises ICTI as a set of functionalities. These functionalities are coordinated both by market processes, based on prices and other forms of coordination, and by other institutions. These institutions include regulation and standardisation. As mentioned, other layer models are essentially engineering models. They are extremely useful in the present context because they define a hierarchy of functionalities that together are necessary to make the ICTI system work.

The ICTI system that we are conceiving in FLM has a dual existence. On the one hand it is a technical or engineering system with a set of technical (and modular) interactions defined and determined by a technical architecture. However, on the other hand it is also *at the same time* an economic-institutional system with markets and other institutions (such as regulation and standardisation) that shape how the system and its parts evolve over time. This is the feature that most strongly distinguishes the present FLM from technical or engineering layer models, such as the OSI and TCP/IP models (which are discussed briefly in Appendix 1).

In What Ways is FLM Useful?

Exhibit 1 indicates some of the uses to which FLM may be put. This list is not exhaustive.

[5] For example, see the references in Mindel, J.L. and Sticker, D.C. (2006) Leveraging the EU regulatory framework to improve a layered policy model for US telecommunications markets, *Telecommunications Policy*, Vol. 30, No. 2, March, pp 136-148.

Exhibit 1. Why is the Fransman Layer Model Useful?

1	Allows us to conceptualise the entire ICT Industry (ICTI) **as a system** and understand the interactions between its components.
2	Allows us to identify the role played by **markets, firms** and other **institutions** (such as regulation and standardisation) in **coordinating** the activities undertaken within ICTI.
3	Allows us to analyse **corporate specialisation** and **corporate strategy.**
4	Allows us to analyse different **evolutionary drivers** that shape industrial structure in the different layers.
5	Allows us to examine the effects of **globalisation** and the **international division of labour** (including the role of **government policy**).
6	Allows us to understand companies that have been able to seize **'commanding heights'**, such as Microsoft, Intel, and Google.
7	Allows us to analyse the importance of **co-evolving demand**.
8	Allows us to begin analysing the different **profitability** in different parts of the system.
9	Allows us to understand **interdependencies** and **complex interactions** within the system.

C. The Basic Fransman Layer Model A: A Description of the Structure of the ICT System

The basic layer model, FLM A, is shown in Exhibit 2. It provides a description of the entire ICT Industry, ICTI.

Exhibit 2. The Basic Fransman Layer Model A – Description of the ICT Industry by Functional Layer

LAYER	FUNCTION
Layer VI	Consuming
Layer V	Content, Applications, Services
Layer IV	Middleware, Navigation and Search
Layer III	Connectivity
TCP/IP Interface	
Layer II	Network Operating
Layer I	Networked elements

Source: M.Fransman (copyright).

Layer I: Networked Elements

Layer I consists of networked elements. A fundamental characteristic of the evolution of ICTI is the increasing tendency over time for all the components of this industry to be integrated into networks.

This tendency began with telecommunications networks from late nineteenth century with the integration of transmissions equipment, switches, and customer premises equipment. The tendency continued with the development of computer networks in the post-second world war period. The tendency was given a significant boost from the mid-1990s with mass adoption of the Internet. The Internet became the integrator *par excellence*. It soon became commonplace to observe that almost everything was becoming integrated and networked into the Internet.

In the case of ICTI the networked elements included in Layer I refer specifically to products from the following sectors that are integrated into networks including the Internet: telecommunications equipment (including transmissions equipment, telecoms switches, routers and servers), computers, consumer electronics (including mobile phones, MP3 players, digital cameras, and TVs), semiconductors and other devices embodied in these elements, and the software necessary to make them work.

Layer II: Network Operating

In Layer II the elements produced in Layer I are integrated into information and communications networks and run by network operators. These network operators include telecoms operators (fixed and mobile), cable TV operators, satellite operators, broadcasting operators as well as other operators (such as WiFi operators).

While these networks and their operators were initially separated from one another – and were incorporated into distinct markets – from the 1990s they became increasingly interconnected. As a result their services have become increasingly substitutable (although in some cases they have also become complementary). The term ‘convergence’ is often used to capture this phenomenon. Thus, for example, films and television programmes can be provided to households by telecoms companies using DSL or FTTH connections, by cable companies using coaxial cables, by satellite companies, and by mobile phone companies.

TCP/IP Interface

The advent of the Internet had the most profound impact on the structure and dynamics of ICTI, the effects of which are still uncertain and are still working themselves out. In FLM this is partially represented by the TCP/IP (Transmission Control Protocol/Internet Protocol) interface. As noted earlier, TCP/IP refers to the suite of communications protocols used to connect hosts on the Internet.

An analogy is useful in order to understand the significant implications for the dynamics of ICTI of TCP/IP. The analogy is containerisation in the field of transport. The advent of the container had a major impact on the cost of transport and therefore on international trade and the growth of the world economy. As a result of being able to move containers (as opposed to products) across different transport networks these networks became increasingly interoperable and substitutable. (These networks include air, sea, road and rail networks.) The result was increasing competition between the different networks that contributed to a substantial fall in transport costs. (It is worth noting, however, that it took a significant amount of time and resource for containerisation to be fully implemented. The reason was that big changes in capital goods and infrastructure were needed in order to facilitate the movement and storage of the standard sized containers.)

In analogous fashion TCP/IP facilitates the movement of packets of information across different information and communications networks, also allowing them to become interoperable and to some extent substitutable. This has facilitated the emergence of the Internet as a network of networks.

However, TCP/IP has had another equally profound effect. As shown in FLM it has facilitated the emergence of new layers consisting of new functionalities - Layers III to V. Furthermore, it has allowed a technical separation of Layers I and II from these other upper layers which has made possible the entry of new players into ICTI providing the new functionalities.

Layer III: Connectivity

With the diffusion of TCP/IP new firms were able to enter Layer III and provide internet connectivity. These firms were internet access and service providers (IAPs and ISPs). Significantly, although the incumbent telecoms operators who dominated Layer II also entered Layer III to provide internet connectivity, some of the most successful Layer III players were new entrants.

For example, in the US AOL, that had previously been an online provider of content, adapted its operations to the Internet and quickly became the dominant ISP. In the UK, Freeserve soon came to dominate a host of smaller new entrants after it developed the then novel business model of providing free dial-up Internet access. It was able to do this because, due to a business tie-up with the retail electronics company Dixons and the new entrant telecoms operator, Energis (the telecoms subsidiary of the main English electricity company), it was able to share in the revenue generated by this new Internet traffic. Although BT also entered this market, BT Openworld was only the third player. However, in Germany and France the incumbent dominated the connectivity market through T-Online and Wanadoo respectively.

However, from the point of view of the market structure of Layer III, the key feature was the entry of new competitors into this new competitive market. Later we will see how the advent of local loop unbundling (i.e. the regulatory requirement that the incumbent telcos open the local switches in their local access networks to the equipment of competitors) was to further boost competition in the Internet access market.

Layer IV: Middleware, Navigation and Search

The addition of Layer III to ICTI following on the diffusion of TCP/IP meant that the function of Internet connectivity was provided. However, although necessary, this was not sufficient for people to make use of the growing number of hosts connected in the World Wide Web (based on an innovation made by Tim Berners Lee at the CERN particle-accelerator in Switzerland). Other functionalities had to be provided.

For example, in order to locate information it was necessary to be able to navigate through the ‘cloud’ of hosts that made up the rapidly growing World Wide Web. This required *browsers*. Further required functionalities included things like security software that would safeguard Internet interactions. These functionalities are referred to generically in FLM as middleware. Furthermore, there still remained the need to be able to search for specific information from the huge and rapidly growing number of servers holding this information.

Significantly, it was on the whole new entrants rather than incumbents from other parts of ICTI that came to dominate in the provision of these new functionalities. The partial exception was the area of browsers.[6] Here a brief battle ensued between two contenders. The first was a start up called Netscape, started by Marc Andreeson based on the ideas of Tim Berners Lee. Netscape had its IPO in 1995. However, it was the second, Internet Explorer, championed by Microsoft – which with Intel dominated personal computing – that eventually came to triumph (and be accused of anti-competitive behaviour). In 1999 Netscape was bought by AOL.[7]

In the area of middleware many medium-sized software companies established niches for themselves. For example, a number of Israeli software companies were able to become strong in niche markets for security software such as firewalls.

However, most significantly from the point of view of the future evolution of ICTI, as we shall see later, was the area of *search*. The demand for a search function followed naturally from the rapid commercial diffusion of the Internet and World Wide Web from around 1995. Users needed to search for what they wanted. One of the start-ups that responded to this need was a small firm called Google started by two Stanford University students. It focused narrowly on the search function developing the mathematical algorithms that would facilitate search while constructing a minimalist web site that would help users search quickly and efficiently. As we will later see, from these small beginnings disruptive changes would occur that would transform the Upper Layers of ICTI.

It is important to note that the companies that dominated Layers I and II – that is, the equipment companies and the telecoms operators – had little to do with these events shaping the evolution of Layer IV. Why? Why did the equipment companies and telecoms operators not see the new opportunities opening up in Layer IV and take steps to enter and take advantage of these new markets?

The answer is that although, as FLM clearly shows, the functionalities of Layer IV were closely connected to those in Layers I to III, the competencies and focuses required were quite different. For example, telecoms operators, providing voice and data services and even Internet access had neither the competencies nor the focus necessary for the development of browsers or search engines. Although with their substantial R&D capabilities they probably could, in theory, have developed browsers and search engines, their existing competencies and priority business activities meant that in practice they were precluded from doing so. It was not, therefore, a matter of knowledge, more an issue of organisational focus that prevented them from dominating the activities of Layer IV.

Layer V: Content, Applications and Services

With connectivity and Internet access provided, and with the navigation, search and middleware functionalities in place, it was possible to generate the content, applications and services that consumers would use. These functionalities are provided by the activities undertaken in Layer V.

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[6] Technically, a web browser is a software application used to locate and display Web pages.

[7] For a brief history of Netscape and Andreesen and the browser wars, see: http://en.wikipedia.org/wiki/Marc_Andreesen

The terms 'content, applications and services', although in widespread use, refer to complex economic outputs and different uses of the terms in different contexts can cause confusion. Accordingly, it is useful to spend a little time clarifying their meaning.

Content[1] is a commonly used term with regard to the Internet and other electronic media (e.g., television and DVDs). In its broadest sense it refers to material which is of interest to users, such as textual information, images, music and movies.[8]

An *application*[9] may be defined as a program or group of programs designed for end users. It often refers to software programs (as in the case of applications software). However, in this paper the term applications will also be used to include functionalities such as electronic commerce provided by new Internet companies such as eBay (electronic auctions and trading) and Amazon.com (the electronic selling of books and other commodities).

The best definition of a *service*[10] - that provided by IBM Research – is that of a provider/client interaction that creates and captures value. An elaboration of this definition, from IBM Research, is provided in the Appendix.

It should be noted that contents, applications and services constitute the final output from ICTI for final customers/users. However, it is important to remember that there are also intermediate demand and supply relationships (and therefore markets) that exist both within and between layers. For example, in Layer I systems producers (such as the producers of PCs or mobile phones) demand semiconductors and other devices from component producers; telecoms operators in Layer II demand telecoms equipment from telecoms equipment suppliers located in Layer I; etc.

Furthermore, it should be noted that conceptually the services referred to in Layer V refer to services for final consumers/users. These should be distinguished from services for intermediate consumers/users. For example, new entrant telecoms companies purchasing local loop access services from incumbent telecoms operators under local loop unbundling regulations are conceived of as making an intra-Layer II transaction in the access market located in Layer II. However, in using the local loop access to provide Internet access to final users (such as households) they are conceived of as making a market transaction involving Layers II and V.

While this distinction may seem arbitrary it has the advantage of distinguishing between services and markets according to the kind of customer involved, specifically whether the customer is an intermediate customer (usually a firm or government) or a final customer (usually an individual or household). The importance of distinguishing between these kinds of customers and their tastes, preferences and demands is emphasised by adding a sixth layer to the Fransman Layer Model, namely Layer VI.

In Exhibit 3a, some examples of telecoms services are given together with the corresponding Layers where the markets for these services are located.

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8 http://www.bellevuelinux.org/linmo/content.html

9 Applications are defined in Appendix 2.

10 Services are defined in Appendix 2.

Exhibit 3.a. Some Services and Corresponding Layers

SERVICE	LAYER
Electronic mail (e-mail distributed content)	Layer V (application) Layer V (content)
Voice-over-IP (VoIP)	Layer V (application)
Video services (including TV and video-on-demand)	Layer V (content)
Online Information Services	Layer V (content)
Search Services	Layer III
Leased Line Services	Layer II
Mobile Services	Layer II

Source: FLM and Mindel and Sicker (2006).

Layer VI – Consuming

A key conceptual innovation and advance in the present FLM lies in the addition of Layer VI, a consuming layer. The reason is that this makes explicit the important role played by final consumption and the co-evolution of this consumption. At the same time, the identification of Layer VI also draws attention to the importance of intermediate demand and intermediate markets that exist within and between layers.

The point is a simple one. The ICTI system that we are conceiving in FLM has a dual existence. On the one hand it is a technical or engineering system with a set of technical (or modular) interactions defined and determined by a technical architecture. However, on the other hand it is also *at the same time* an economic-institutional system with markets and other institutions (such as regulation and standardisation) that shape how the system and its parts evolve over time. This is the feature that most strongly distinguishes the present FLM from the technical or engineering layer models discussed earlier, such as the OSI and TCP/IP models.

One key aspect of the market/institutional dimension of ICTI is the role played by consumer demand and crucial questions arise regarding how, within the context of an FLM analysis of ICTI, this demand should be conceptualised.

Consumer Demand

In many economic analyses relating to ICTI *demand is treated as a given*. For example, there are many estimations of demand in many ICTI markets based on econometric or other models. It is not being suggested here that these estimations are either incorrect or valueless. The point, rather, is that they are by conceptualisation and definition *ex post*. That is, the estimations are made after the said demand has already come into existence. However, what often matters (though not in all circumstances) is how demand *emerges* and the *expectations* that different players have about this emerging demand. Understanding this requires an *ex ante* perspective on demand.

In order to make this rather abstract and theoretical argument clearer we will later examine the evolving demand for content within the context of the evolving Internet. There we will see more accurately what is meant by the *co-evolution of demand.*

D. Other Layer Models– OSI and TCP/IP

The Open Systems Interconnection (OSI) model is a seven-layered description of open (non-proprietary) communications and computer network protocols. It was established in the 1980s by the International Standards Organisation (ISO). The definitive account of this model is provided in ISO (1994).[11] The original intention of the OSI model was to understand the hardware and software that comprise a network.

The basic OSI model is shown in Exhibit 3b.

Exhibit 3.b. The OSI Model

LAYER	OSI STACK
7	Application
6	Presentation
5	Session
4	Transport
3	Network
2	Data Link
1	Physical

The TCP/IP model deals with the communications protocols that are used to connect hosts in the Internet. These protocols are expressed in a modular set of layers. A description of the part played by TCP/IP in the development of the Internet is provided by Cerf (1989).[12] A recent discussion of the OSI and TCP/IP models is to be found in Mindel and Sicker (2006).[13]

The TCP/IP model is shown in Exhibit 3c.

Exhibit 3.c. The TCP/IP Model

LAYER	TCP/IP STACK
4	Application
3	Transport
2	Internet
1	Network Interface

[11] ISO (1994). Information technology – open systems interconnection – Basic Reference Model: The Basic Model. URL: http://www.iso.org/iso/en/CatalogueListPage.CatalogueList?ICS1=35&ICS2=100&ICS3-01

[12] Cerf, V. (1989). *The Internet Activities Board.* Internet Engineering Task Force (IETF), Network Working Group, Request for Comments: 1120.

[13] Mindel, J.L. and Sicker, D.C. (2006). Leveraging the EU regulatory framework to improve a layered policy model for US telecommunications markets, Telecommunications Policy, 30, 136-148.

E. Elaborations of the Fransman Layer Model

In what follows, two elaborations of FLM will be developed. The first involves adding various sectors in ICTI to FLM while the second involves an identification of some of the major firms that have specialised in these sectors.

The Fransman Layer Model B: Adding Selected Sectors

How do the various sectors of ICTI map onto the FLM?[14] In Exhibit 4 a selection of some of the more important sectors of ICTI are shown.

Exhibit 4. The Fransman Layer Model B: Layer, Function, and Sectors

LAYER	FUNCTION	SELECTED SECTORS
Layer VI	**Consuming**	
Layer V	**Content, Applications, Services**	1. Content 2. Applications 3. Services
Layer IV	**Middleware, Navigation and Search**	1. Middleware 2. Navigation (browsers) 3. Search
Layer III	**Connectivity**	1. Internet access providers
	TCP/IP LAYER	
Layer II	**Network Operating**	1. Core Network Operators a. Telecoms operators (fixed & mobile) b. Cable TV operators c. Broadcasters (terrestrial, satellite) d. Others (e.g. electricity firms) 2. Access Network Operators a. Fixed b. Cellular mobile c. Other Wireless
Layer I	**Networked elements**	1. Devices: a. Microprocessors b. Memories c. Other
		2. Systems: a. Telecoms Equipment b. Computer h/w & s/w c. Consumer Electronics

Source: M. Fransman (copyright)

We start upstream, that is from Layer 1 which includes networked elements. Here we have made a distinction between devices on the one hand (mainly semiconductors of various kinds)

[14] **A note on terminology is important**. The term '**industry**' in this paper is reserved for the ICT Industry. '**Sector**' refers to sub-divisions within this industry.

and the systems into which they are incorporated on the other. These systems include telecoms equipment, computers, and consumer electronics. What these systems have in common is that they are all increasingly networked through the Internet.

Moving downstream we come to Layer II which contains network operators. Here we make an important distinction between *core network operators* on the one hand and *access network operators* on the other. The main reason for this distinction is economic rather than technical. A key economic characteristic of the telecoms sector is that it is relatively easy to facilitate *facilities-based competition* in the core network (either *intra-modal competition* where competitors use the same technology, or *inter-modal competition* where they use different technologies – e.g. wireless versus fixed networks). The reason is that the core network carries substantial traffic and therefore the potential for significant revenue that can pay for the high fixed network investment costs.

However, the situation is very different in the access network (the figurative 'last mile' that connects the home or business to the local telecoms network). Here the cost is high relative to the revenue generated from the individual home or business. (It is for this reason, for example, that already-depreciated copper cable remains in use in the local loop rather than superior optical fibre to the home, FTTH). For this reason the local access network is often referred to as a *'bottleneck' network* frequently controlled by a network operator that has '*significant market power*'.

As shown in Exhibit 4, in addition to telecoms operators, Core Network Operators also include cable TV operators, broadcasters, and other network operators (such as electricity companies which, in countries like Japan, have begun to compete in telecoms services markets). The process of *convergence* – based largely on IP (Internet Protocol) technology – has meant that these different companies - previously from different, unconnected sectors – are now able to compete with one another. One arena for competitive rivalry is the 'triple play' market (packaging voice telephony with Internet access and TV/video).

It is worth noting that *cellular mobile operators* are included in Exhibit 4 as local access operators. This is because in effect the cellular mobile network connects individual users and aggregates their traffic which then passes over the fixed (largely optical fibre) core network until it reaches the receiver's end (when, if the called party is on a mobile phone, the call is terminated over a cellular mobile network or, if the party is on a fixed phone, it ends on the fixed local access network).

It is also worth noting that there are other wireless technologies that are alternative to the cellular mobile network. These include WiFi and Wi Max which provide a wireless radio connection to the end user and may completely by-pass the cellular mobile network. As this description makes clear, operators using these alternative technologies may compete with one another, although there are also possibilities for complementarity.

Moving further downstream we come to Layer III where connectivity is provided. Essentially, this is where the *Internet access providers* are located. Again, there are a range of technologies that may be used e.g. ADSL over copper, FTTH (optical fibre to the home), wireless (such as fixed wireless access, WiFi or Wi Max), cellular mobile, or even Internet access through electricity cables (called power line). Usually, incumbent telecoms operators have vertically-integrated their activities in Layers II and III, although there is also a group of independent Internet access providers in Layer III (such as AOL and Tiscali).

Layer IV is where middleware, navigation and search are provided. Essentially, *middleware* refers collectively to all those services and products (mainly software based) that allow users to receive their content, applications and final services. Examples include security software such as firewalls and authentication systems. These are offered by a host of large firms or SMEs, themselves constituting a fairly heterogeneous software sub-sector.

Navigation is provided primarily by browsers, beginning with Mosaic that turned into Netscape and Microsoft's Internet Explorer.

Search, based largely on mathematical algorithms that track key words in a site as well as the links made to that site, has in recent years been dominated by Google. More is said about the search market in the following section that examines companies in FLM.

Going even further downstream we come to Layer V that provides *contents, applications and services* (the latter two are defined more closely in the Appendix). Content is an entire sector in its own right. Until the advent of the Internet it has been dominated by so-called traditional media (including TV, newspapers, book publishers, Hollywood and other film companies, and music publishers). However, as will be seen in more detail when we examine the dynamics of ICTI, the widespread diffusion of the Internet and the development of broadband Internet is fundamentally transforming the whole content sector.

Having briefly examined the sectors in FLM and ICTI we turn now to some of the major companies that dominate these sectors. These are shown in Exhibit 5.

The Fransman Layer Model C: Adding Companies

Exhibit 5. The Fransman Layer Model C: Layer, Function, Sectors and Companies

LAYER	FUNCTION	SECTORS/COMPANIES
Layer VI	**Consuming**	
Layer V	**Content, Applications, Services**	Hollywood, media companies, Amazon, eBay, Yahoo!, News Corp
Layer IV	**Middleware, Navigation and Search**	Google, Baidu
Layer III	**Connectivity**	Internet Service Providers, BT Openworld, Wanadoo/Orange, AOL, Tiscali
TCP/IP LAYER		
Layer II	**Network Operating**	**1. Core Network Operators** AT&T, Verizon, NTT, BT, Deutsche Telecom, France Telecom, Telefonica, TelMex **2. Access Network Operators** **a. Fixed** Core network operators (see above), CATV companies, LLU operators **b. Cellular** Vodafone, NTT Docomo, Verizon Wireless, Cingular, Orange, T Mobile, Telecom Italia Mobile **c. Other Wireless** WiFi operators, fixed wireless operators
Layer I	**Networked elements**	**1. Devices**: **a. Microprocessors** Intel, AMD, Texas Instruments, **b. Memories** Samsung, NEC, Toshiba **c. Other**
		2. Systems: **a. Telecoms Equipment** Alcatel/Lucent, Nortel, Ericsson, Nokia **b. Computer h/w & s/w** Microsoft, Dell, Lenovo, **c. Consumer Electronics** Sony, Matsushita, Samsung, LG, Sharp

Source: Martin Fransman (copyright).

Since Exhibit 5 is largely self-explanatory, no more will be said about it here.

III. THE DYNAMICS OF ICTI

In order to more readily elaborate on the dynamics of ICTI and ease exposition it will be useful to simplify FLM by aggregating so that the six layers become four. This is done in Exhibit 6.

THE FOUR-LAYER FLM MODEL

Exhibit 6. The Four-Layer FLM Model

LAYER	FUNCTIONALITY
IV	Consumption.
III	Contents, applications, services, navigation, middleware.
II	Network operation.
I	Networked elements, including telecoms equipment, computer hardware and software, and consumer electronics.

Source: M. Fransman (copyright).

The aggregation to get the Four-Layer FLM Model from the Six-Layer FLM involves two separate aggregations. The first is the aggregation of Layers II (network operation) and III (connectivity) in the Six-Layer model in order to get Layer II in the Four-Layer model. The second is the aggregation of Layers IV (navigation and middleware) and V (contents, applications and services) in the Six-Layer model in order to get Layer III in the Four-Layer model.

The reason for the first aggregation is that connectivity has been vertically-integrated by most telecoms operator incumbents even though there are also independent ISPs (Internet service providers) who also contest this market (such as AOL in the US and Tiscali in Europe). Furthermore, new entrants who have entered on the basis of LLU (local loop unbundling) also contest this market but their activities are the result of the regulation of the telecoms operator incumbents.

The reason for the second aggregation is that, as we will see later in this paper, the activities of navigation (as typified by Google's offerings) – which were in Layer IV of the Six-Layer model – are intimately connected with the provision of contents, applications and services. Furthermore, middleware products are increasingly also being provided by firms involved in navigation, contents, applications and services. It therefore makes sense to include them in one layer.

THE DYNAMICS

Having examined the structure and architecture of ICTI in the first section of this paper through the use of FLM, here in the second section we turn to an analysis of the dynamics of ICTI. What is to be understood by the term 'dynamics'?

By dynamics we mean change and the causes of change. But what are the 'engines' of change in ICTI (to use Joseph Schumpeter's word)? Schumpeter asked precisely this question, but of the entire capitalist system, not only of one industry. But his answer is equally valid for a single industry. **Schumpeter's answer was that 'new combinations' constitute the engine of change.**

A. New Combinations

Schumpeter identified four new combinations: new products/services, new processes, new forms of organisation, and new markets. In Exhibit 7, we identify some of the new combinations changing ICTI that have emerged over the last decade.

Exhibit 7. Some New Combinations over the Last Decade

NEW COMBINATION	EXAMPLE
New Products/Services	• Mobile voice/data services. • Internet search. • Voice over the Internet. • Music and film downloads. • Blogging.
New Processes	• Broadband (e.g. ADSL, FTTH). • Wireless (e.g. Wi Fi, Wi Max).
New Forms of Organisation	• Internet (e.g. social creation of knowledge as in Wikipedia, new patterns of work and collaboration, online business).
New Markets	• New content markets (e.g. active users and user-generated content) • Social-networking based markets.

Source: M. Fransman (copyright)

These new combination, in turn, have caused further change, largely through substitution and complementary effects. Examples are given in Exhibit 8.

Exhibit 8. Impact of New Combinations

IMPACT	
Substitution	• Mobile v fixed telephony • VoIP v fixed telephony • Email v fax, telex and letters • Online v print • Blogs v newspapers • iTunes v CDs v tape recorders • Online classified ads v newspaper ads
Complementary	• Fixed + mobile convergence • e-commerce + payment mechanism (e.g. eBay + Pay Pal) • Search + advertising (e.g. Google + Google Ads) • Selling books + music + videos (e.g. Amazon) • Internet use + security software

Source: M. Fransman (copyright).

B. Economic Forces

However, there are also other forces at work that play an important role in any attempt to explain the dynamics of ICTI. These are best described as economic forces and are shown in Exhibit 9.

Exhibit 9. Economic Forces for Change in ICTI

ECONOMIC DRIVER	DESCRIPTION
1	Economies of scale (stemming from high fixed costs)
2	Economies of scope
3	Low marginal costs
4	Network externalities
5	Industry evolutionary patterns (e.g. new technology – over-abundant entry – shake-out – consolidation).
6	Intensity of competition

Source: M. Fransman (copyright).

The first of these is *economies of scale*. Essentially, these stem from the very high fixed costs that exist in parts of ICTI (e.g. in Layer II where full-facilities-based network operators face high fixed investment costs and in Layer I where semiconductor producers have high fixed costs in connection with fabrication facilities).

High fixed costs imply that as scale increases so unit costs fall. This gives an advantage, all other things equal, to larger firms and those that are first able to achieve greater scale. It is economies of scale that lie behind the natural monopoly argument that until the mid-1980s provided the dominant ideology in Layer II, suggesting that telecoms operation should be left to national monopolies.

However, at the current time economies of scale also lie behind the process of consolidation that has occurred in the rich countries, leaving three across-the-board network operators in Japan, two in the US, and one each in the European countries. This is shown in Exhibit 10.

Exhibit 10. Consolidation amongst Major Network Operators

COUNTRY	NUMBER OF MAJOR OPERATORS	COMPANY NAMES
Japan	3	NTT, KDDI, Softbank
US	2	AT&T, Verizon
UK/France/Germany/Italy	1	BT/France Telecom/ Deutsche Telecom/Telecom Italia

Source: M. Fransman (copyright).

Economies of scope are the second economic force at work in ICTI. They occur when it is cheaper to produce and distribute two or more products by the same firm than it is to produce them separately by separate firms. Economies of scope may reinforce the effect of economies of scale, giving advantages to the larger firms.

Low marginal costs in many parts of ICTI are the third economic driver. They refer to the additional cost involved in producing the last product or service. Examples include the additional cost to a network operator of providing the last phone call, the additional cost of producing an extra semiconductor chip or CD, or the additional cost to a consumer of sending one more email or downloading an additional song.

The problem with low marginal costs – as economic theory demonstrates – is that the greater the degree of competition in a market the more market prices tend to be driven down towards marginal cost. In competitive markets with high fixed costs this can cause serious problems since some firms may have difficulty recovering their costs and making a profit. This may lead to cycles with waves of entry followed by bouts of shake-out.

Network externalities are the fourth economic force. They occur when the benefit to users of a network increases the more members there are of that network. Network externalities drove the adoption of the original telephone: the more subscribers there were the greater the benefit to existing and new subscribers who could contact more people. They explain the snowballing effect as more subscribers join the network, their benefit-cost ratio of so doing continually increasing. More recent examples include Windows and social-networking sites like MySpace or YouTube (where the more people who join the greater the user-generated content available and the greater the enjoyment of the users, thus explaining the extremely rapid rate of growth of sites such as these).

Patterns of industry evolution are the fifth force. There appears to be a good deal of consistency across different industries – including the sectors included in ICTI – regarding evolutionary path. The starting point is often a radical technical change. This is followed by a wave of new entry, firms focusing particularly on the new product or service. However, as time passes so the priority shifts from product to process and economies of scale become important. Costs may fall as process innovations are produced but entry barriers may rise as fixed costs rise. Less efficient firms may be forced to exit. The result may be shakeout and consolidation possibly resulting in an oligopolistic market structure (at least until the next wave of technical change stirs things up again).

Incumbents may lose their dominance to be replaced by new entrants. This has happened, for example, in Layer I in the computer industry where IBM, dominating mainframes, was later replaced by firms such as Microsoft, Intel and Dell who dominated PCs.

However, in some cases the incumbents may not be displaced. In Layer II, for instance, the shakeout following the Telecoms Bust resulted in a reinforcement of the dominant position of the incumbent telecoms operators and a weakening (and even exit) of many of the new entrants. High fixed costs and low marginal costs were the culprit making it expensive for new entrants to enter and to generate sufficient compensating revenue. For a while, during the Telecoms Bubble, exuberant financial market were prepared to plug the gap between costs and revenue but with the coming of the Bust this plug was pulled and many new entrants in Layer II were weakened or destroyed. In contrast the incumbent telecoms operators could still rely on their core revenues from services such as fixed telephony, although later (as we shall see below) these were threatened by other factors.

Intensity of competition is the sixth and final economic force identified here. Essentially, the more intense the competition the greater the pressure put on competitors to change. It is not simply a question of numbers of competitors or their market shares. In some cases the animal spirits of entrepreneurs lead them to develop extremely aggressive strategies, even when the small number of competitors gives them the option of not rocking the boat. What is clear, however, is that when competition is intense a powerful force for change is produced.

C. *Institutional Shapers*

Institutions – that may be thought of as constraints that determine de facto rules of the game for players – also play an important role in shaping the change that occurs in ISTI. Four examples of institutions that are important are shown in Exhibit 11.

Exhibit 11. Some Institutional Shapers in ICTI

NUMBER	INSTITUTION
1	Regulation
2	Financial markets
3	Standardisation
4	Universities

Source: M. Fransman (copyright).

Regulation

Regulation is particularly important in Layer II where telecoms operators, particularly the incumbents, are regulated in all countries. However, regulation – or more precisely the decision either not to regulate at all or to opt for light-touch regulation – is also crucial for the operation (both nationally and globally) of the Internet.

In general, the aim of telecoms regulators is to intervene where it is believed that market competition is not working properly, particularly where an operator is judged to possess 'significant market power'. (Telecoms regulation is sector-specific and is also usually *ex ante*, whereas competition law, also intended to remedy defects in market competition, is *ex post*. One of the aims of the European Union is to place increasing emphasis on competition law where possible, reducing the influence of telecoms regulation.)

However, although often not sufficiently acknowledged, telecoms regulators are frequently caught on the horns of a dilemma. On the one hand they are seeking competitive outcomes, but on the other they are forced to confront the consequences of high fixed costs, economies of scale and scope, and low marginal costs (discussed in the last section), forces which tend to produce oligopoly or even monopoly.

Currently, this dilemma is highlighted in the area of Next Generation Networks (NGSs). These are the next generation of all-IP (Internet Protocol) networks that will replace the current legacy network, the PSTN (or public switched telecoms network). NGSs are both much cheaper and more flexible and there is therefore a strong incentive for both network operators and governments/regulators to adopt them. However, they are very expensive. Furthermore, it is usually only one or two incumbents who are in a position to provide nationwide NGNs.

And this is where the dilemma crystallises. Government/regulators want the incumbent telecoms operator to invest in NGNs. However, they also want competition. But if competitors to the incumbent (unwilling or unable to invest in duplicating NGN infrastructure) are to be given access to the incumbent's NGN at reasonably low access prices, then this reduces the incentive for the incumbent to make the NGN investment in the first place: a regulatory contradiction.

How have regulators in the rich countries dealt with this dilemma? The answer is inconsistently. In short, there has been a divergence in regulatory responses. Briefly, at the one extreme is Japan where the regulator has taken an aggressive stance against the incumbent, NTT. At the other extreme (at least amongst the large countries) is the US where the FCC over the last few years has increasingly opted for lighter-touch regulation, counting to a greater extent on competition between telecoms operators and cable TV companies who are coming head-to-head in converging markets.[15] However, it is not yet clear which kind of approach will deliver the goods.

Financial Markets

This is a topic that the present author has dealt with extensively elsewhere and the details will not be repeated here.[16] Suffice it to say here that financial markets are an important institution (as defined above) shaping the dynamics and evolution of ICTI. The reason, simply, is that the decisions taken in financial markets to provide funding (or, equally important, to deny funding) to ICTI companies has a significant bearing on both the way these companies work and their performance.

However, the matter becomes all the more complex once it is realised that financial markets are not responding automatically to objective and unambiguous rates of return generated in different parts of ICTI. Rather, as John Maynard Keynes shrewdly observed, expectations of future financial performance are generated under conditions of uncertainty and under these conditions psychology and ideology are also important determinants. Under such conditions financial booms and busts, especially when associated with radical systemic innovations – such as the advent of the Internet – are the rule rather than the exception.

Standardisation

Little observed in the financial and popular media, standardisation is another key institution in ICTI. One of the main architectural characteristics of ICTI is its modular nature. Indeed, the structure analysed in the Fransman Layer Model (FLM) should be thought of as a modularised, hierarchical structure.

Modularisation, as the Nobel Prize-winner Herbert Simon has observed, facilitates coordination. It also economises on knowledge and enables specialisation to take place. Each module in a system, by definition, is relatively autonomous. This means that specialists working in that module have little need for detailed knowledge regarding other modules. All they need to know is how to interface their module with the other modules that together are essential for the system's functioning. This facilitates the division of knowledge, part of the broader process of the division of labour, and the creation of further knowledge.

This is where standards enter. Standardisation allows the creators of modules to coordinate their efforts in achieving inter-modular interoperability.

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15 These include so-called triple-play markets: voice telephony, Internet access, and TV/video.

16 Fransman, M (2002) *Telecoms in the Internet Age: From Boom to Bust to…?* Oxford: Oxford University Press. Winner of the 2003 Wadsworth Prize. (Review, *Financial Times*, October 16, 2002) Fransman, M (2004) The Telecoms Boom and Bust 1996-2003 and the Role of Financial Markets, *Journal of Evolutionary Economics*, Vol 14, No 4, October 2004, 369-406.

But the creation and adoption of appropriate standards cannot be taken for granted. Sometimes incentive issues stand in the way. For example, having mastered a potential standard and holding key property rights in the area a company may have an interest in other companies adopting its standard. However, the cost-benefit calculation from the perspective of these other companies may look very different.

For this reason government agencies have traditionally played an important role in the standardisation process, such as the ITU (International Telecommunications Union) and ETSI (the European Technical Standards Institute, in Europe which played a major role, for example, in developing the GSM mobile standard). De facto standards, emerging through the market where the different interests of different players are resolved (if not reconciled) are also common in ICTI (e.g. the Wintel standard in PCs).

Universities

Significantly, universities (and also government research institutes) since about the 1960s have played a less important role as sources of technical change than in other industries such as biotechnology and the life sciences. Although before and immediately after the Second World War universities and government research laboratories were important in areas such as semiconductors, computers and telecoms equipment the main locus of research in these areas soon moved into companies. (As noted earlier in this paper, within the private sector R&D activity has moved from the 1980s increasingly from telecoms operators in Layer II to equipment suppliers in Layer I.)

However, universities have played a far more significant role in ICTI as seedbeds for entrepreneurial activity. Indeed, in many famous cases entrepreneurial activity has owed its institutional origin to universities. This is considered in the following section.

D. Entrepreneurial Drivers

Entrepreneurs play a key role in Schumpeter's explanation of the 'restlessness' of capitalism. The reason is that it is entrepreneurs who introduce the new combinations that drive the dynamics of capitalist change. In *The Theory of Economic Development* Schumpeter stressed the role of the individual entrepreneur but later, in *Capitalism, Socialism and Democracy*, he emphasised that increasingly it is the R&D divisions of large companies that are responsible for new combinatorial innovations. Entrepreneurs have been difficult to fit into economic models, largely because their role is a disruptive one, seeing opportunities for profit that others do not see and disturbing the equilibrium on which many of the conclusions of these models rest.

In Exhibit 12 a few of the key entrepreneurs who have played important roles in ICTI are mentioned.

Exhibit 12. Some Key ICTI Entrepreneurs

ENTREPRENEUR	COMPANY
Berners Lee, Tim	CERN (world wide web)
Bezos, Jeff	Amazon (e-trading, books etc)
Brin, Sergey (Page, Larry)	Google (search)
Gates, Bill	Microsoft (windows, PCs)
Grove, Andy	Intel (microprocessors, PCs)
Jobs, Steve	Apple (iPod, iTunes)
Murdoch, Rupert	News Corp (media)
Omidyar, Pierre (Whitman, Meg)	eBay (auctions, e-trading)

Source: M. Fransman (copyright).

E. Co-Evolving Consumer Behaviour, Tastes and Demand

Since this topic has been discussed later earlier in this paper in the analysis of the layer model the discussion will not be repeated here.

IV EAST ASIA IN THE GLOBAL ICTI

This section contains two subsections. The first of these describes East Asian international competitiveness in the global ICTI (as well as the competitiveness of other dominant regions/countries). The second explains this East Asian competitiveness.

A. EAST ASIAN INTERNATIONAL COMPETITIVENESS IN THE GLOBAL ICTI

In Exhibit 13, the Fransman Layer Model is used to describe East Asian competitiveness in the different sectoral subdivisions of the five production layers.

Exhibit 13. The Fransman Layer Model D: Globalisation and the International Division of Labour

LAYER	FUNCTION	SECTORAL SUB-DIVISIONS	DOMINANT COUNTRIES
Layer VI	**Consuming**		
Layer V	**Content, Applications, Services**	1. Content 2. Applications 3. Services	1. US 2. Various 3. Various
Layer IV	**Middleware, Navigation and Search**	1. Middleware 2. Navigation (browsers) 3. Search	1. Various 2. US 3. US
Layer III	**Connectivity**		Various
TCP/IP LAYER			
Layer II	**Network Operating**	1. Core Network Operators 2. Access Network Operators a. Fixed b. Cellular c. Other Wireless	1. Various 2. Various
Layer I	**Networked elements**	1. Devices: a. Microprocessors b. Memories c. Other	a. US b. Japan, Korea c. Various
		2. Systems: a. Telecoms Equipment b. Computer h/w & s/w c. Consumer Electronics	a. Europe, US, Japan b. E. Asia (h/w); US (s/w) c. E. Asia, US

Source: M. Fransman (copyright).

Exhibit 14 further describes East Asian international competitiveness in ICTI.[17] It contrasts four areas of considerable strength (all in Layer 1 – telecoms equipment, semiconductors, computers, and consumer electronics) with the medium strength of selected East Asian companies in the upper layers (Layer III).

Exhibit 14. East Asian Global Competitiveness in the ICT Industry

COUNTRY	TELECOMS EQUIPMENT	S/CONDS	COMPUTERS	CONSUMER ELECTRONICS	UPPER LAYERS
JAPAN	*** e.g. NEC, Fujitsu	*** e.g. NEC, Toshiba, Hitachi, Fujitsu	** e.g. Fujitsu, NEC, Toshiba, Hitachi,	*** e.g. Sony, Matsushita, Sharp, Sanyo	* e.g. NTT DoCoMo (i-mode)
KOREA	* e.g. Samsung, LG	*** e.g. Samsung, LG		*** e.g. Samsung, LG	* e.g. SK Telecom (Cyworld)
TAIWAN		*** e.g. TSMC, UMC	*** e.g. Acer, Peripherals manufacturers	** e.g. OEM producers	
CHINA	** e.g. Huawei, ZTE, Datang		** e.g. Lenovo, Great Wall	* e.g. OEM producers	* e.g. Baidu

Global Competitiveness: * = very strong, ** = strong, * = medium**

Source: M. Fransman (copyright)

As can be seen from Exhibits 13 and 14, Japan is very strong in terms of global competitiveness in telecoms equipment, semiconductors (particularly memories), and consumer electronics. Furthermore, it is strong in computers. In the upper layers, however, Japan is of medium strength (NTT DoCoMo's i-mode mobile Internet service, which is very strong, being an example of a significant exception).

Korea is very strong in semiconductors (including displays) and consumer electronics. However, despite major government initiatives in the 1980s, Korea has not been able to establish a significant competitive advantage in computers (although more recently companies like Samsung have begun once again to contest the small computer market). In telecoms equipment, despite some notable exceptions (e.g. Samsung's wireless broadband, Wi Bro, products), Korea is not particularly strong. In the upper layers there are some examples of Korean international competitiveness (such as SK Telecom's Cyworld, that is similar to the US virtual reality website, Second Life) although in general the country's competitiveness here is medium.

[17] These qualitative indications of competitiveness represent the author's estimates based on his knowledge of data sources such as market share by company and country. A larger and more detailed study than the present one would collect and analyse this data in a more detailed way. Exhibits 13 and 14 in this paper are simply meant as summaries.

The big success stories in Taiwan have been in computers (mainly computer peripherals such as monitors, keyboards, mice and motherboards although companies such as Acer have overall strengths) and in semiconductors (dominated by two large companies, TSMC and UMC, but with many medium-sized companies involved in semiconductor design activities). In consumer electronics Taiwanese companies are strong but not as strong as their Japanese and Korean counterparts. As in computers they tend to specialise in consumer electronic sub-systems. However, in the upper layers there is little evident Taiwanese strength.

China is strong (and has growing strengths) in telecoms equipment and computers. In the former area the outstanding success story is Huawei that is currently making a significant impact on global telecoms equipment markets. Other notable companies in this field include ZTE and Datang as well as Ningbo Bird in mobile phones. In computers the success story is Lenovo that has acquired IBM's PC subsidiary. China is rapidly becoming stronger in consumer electronics, partly as a result of the migration to China of production in this area from Japan, Korea and Taiwan. A number of local medium-sized firms have emerged and are battling to find market niches in China, and accumulate the competencies and innovativeness that will allow them to compete in the Chinese market with more sophisticated East Asian and Western companies.

However, while it is relatively easy to *describe* East Asian international competitiveness in ICTI (as has been done in Exhibits 13 and 14) far more difficult is to *explain* why and how this competitiveness has emerged. This is done in the following section.

B. EXPLAINING EAST ASIAN COMPETITIVENESS IN ICTI

Very different development trajectories in ICT have been followed by the four East Asian countries examined in this paper. In some cases the differing trajectories have resulted in international competitiveness in the same sectors; in other cases the trajectories have conferred on the countries concerned distinctive strengths and weaknesses. These trajectories are summarised in Exhibit 15.a. Similarly, industrial structures are also very different in the four countries as we shall shortly see.

Exhibit 15.a. ICT Trajectories in East Asian Countries

COUNTRY	TRAJECTORY
JAPAN	**<u>Evolving from Communications Infrastructure</u>** • Late Nineteenth Century: telegraph & telephone. • Ministry of Communications (Teishinsho) + Japanese universities (e.g. Imperial University of Tokyo). • Indigenous equipment suppliers: e.g. NEC (Western Electric), Fujitsu (Siemens), Hitachi, Toshiba (GE). • Post-war entry into semiconductors and computers (with assistance from MITI). • Distinct consumer electronics companies e.g. Matsushita, Sony, Sharp, Sanyo (for dates see text).

COUNTRY	TRAJECTORY
KOREA	**<u>Bottom-Up Learning from Consumer Electronics</u>** • Korean companies begin assembling simple consumer products such as radios and black and white TVs e.g. LG, Samsung, Daewoo, Hyundai (1950s and 1960s). • Industrial Structure: conglomerates (chaebol). • Strong State: pre-1960s protection of infant-industry learning; from 1960s emphasising exports and incentives and government research institutes (e.g. ETRI, KAIST). • Suited to consumer electronics and semiconductors (esp. memories) but not to computers or software; relatively weak in telecoms equipment. • Post-1990s: highly dynamic Korean ICT Industry e.g. greatest broadband penetration in the world facilitating equipment innovation (e.g. Samsung's WiBro broadband wireless); dynamic services market, e.g. SK Telecom's Cyworld.
TAIWAN	**<u>Bottom-Up Learning from Consumer Electronics</u>** • Taiwanese companies begin as low-cost assemblers for US and Japanese firms (1950s and 1960s). • Government plays key role: pre-1960s protecting infant industry learning; after 1960s incentivising exports, helping to insert Taiwanese firms into global production chains particularly in computers (peripherals) and semiconductors; creating supportive R&D institutes (e.g. ITRI, ERSO and III). • Industrial Structure: flexible networked SMEs inserted into global production chains but increasing their capabilities (e.g. in design) and in some cases own-brand design and manufacture (e.g. Acer in PCs) (from 1980s). • Post-1990s: increasing integration into mainland China.
CHINA	**<u>Top-Down Learning from Government strategic scientific research institutes</u>** • Chinese companies in computers and telecoms equipment evolve from government scientific research institutes (e.g. under Chinese Academy of Sciences) established after 1949. • Based on dynamic Chinese market some achieve international competitiveness (e.g. Lenovo in PCs and Huawei in telecoms equipment) largely from 1990s. • Many less prominent Chinese firms emerge contesting the domestic market in areas like consumer electronics (e.g. DVDs) and mobile phones (e.g. Ningbo Bird). • China developing its ICT firms under a more liberal trade regime than the other E Asian countries due to WTO membership; but large domestic market gives additional policy tool. • In telecoms services four state-owned Chinese companies create dynamic infrastructure and services (i.e. China Telecom, China Mobile, China Netcom, China Unicom). • The big question: how can Chinese companies become more innovative (creating internal capabilities) and achieve international competitiveness.

Source: M. Fransman (copyright).

In the following sections the different trajectories and development patterns in the four East Asian countries are analysed.

Japan[18]

The birth of the Japanese ICT industry can be traced back to the Nineteenth Century communications sector, beginning with the telegraph and later the telephone. It was the powerful Ministry of Communications (Teishinsho) that assumed responsibility for the provision of this (and other) important infrastructure.

However, from the very beginning the Ministry decided that while government would play the role of network operator (it was only after the Second World War that responsibility for the telecoms network was allocated to a spun-off state-owned company, namely NTT) the necessary equipment would be provided by the private sector. Moreover, it was decided that several companies – rather than one – should manufacture this equipment.

It was in this way that the so-called Den Den Family was born. At the head of this family was the Ministry of Communications (and later, NTT). Its role was to take the lead in defining, standardising, and designing the equipment that was needed, in procuring it, in constructing the networks, and delivering services over them to final customers. The other family members would cooperate with the Ministry in the definition, standardisation and design of the equipment but would assume sole responsibility for the manufacture and supply of this equipment.

From the Ministry's point of view there were a number of important advantages that followed from this form of industrial organisation. First, there was a degree of competition between the equipment supplying companies (what the present author has called 'controlled competition'). This provided an incentive for the companies to make innovative improvements. (Significantly, in the US AT&T vertically integrated its major equipment supplier, Western Electric, which was fully owned. This removed the degree of competition that existed in Japan.) Secondly, the large market provided by the Ministry provided a further incentive for the companies to give of their best. Thirdly, close coordination and standardisation was facilitated by this arrangement.

In order to provide further incentives while cementing the basis for cooperation the Ministry (and later NTT) tacitly agreed that the Den Den Family would be closed to outsiders. While this eliminated the threat of competition from new entrants it provided an incentive for the equipment suppliers to make high sunk cost investments. Since the Ministry/NTT controlled the purse strings it was in command and used its position of considerable strength to insist on innovation, quality, cooperation, and timely delivery. As my book, *Japan's Computer and Communications Industry*, shows in detail (in areas such as switching, computing, and optical fibre) this mode of industrial organisation allowed Japan to catch-up rapidly with the US and Europe and make some important innovations.

The four equipment suppliers in the Den Den Family were NEC, Fujitsu, Hitachi and Oki. With the exception of Hitachi, the other firms established close links with prominent Western counterparts which facilitated an effective mode of technology transfer and learning. NEC, which quickly became the strongest of the suppliers, was established in 1899 by Iwadare, a Japanese businessman who entered into a joint venture with AT&T's Western Electric. In the

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[18] This section draws on Fransman, M (1995) Japan's Computer and Communications Industry: The Evolution of Industrial Giants and Global Competitiveness. Oxford: Oxford University Press. (603 pages).

early 1900s, Fujitsu was established as a joint venture between its parent, Fuji Electric, and Siemens which was the main German telecoms equipment supplier (as well as being a major producer of electrical equipment).

However, the Japanese companies were not simply passive consumers of technology supplied by their far stronger Western partners. Rather they actively learned, using every opportunity to increase their own technological and innovative capabilities. The fact that they had majority ownership and control of their companies created the incentive. Their goal was to stand on their own two feet as soon as possible and to reap the financial rewards of so doing.

But apart from government procurement, which was crucial, they were also helped by the Japanese state in other ways. One example was the high quality engineers they were able to employ who had been trained by some of the centres of excellence that had been established in Japanese universities, such as the Imperial University of Tokyo (later Tokyo University). Since the Meiji Restoration from 1868 Japan had given high priority to the establishment of high quality engineering faculties, originally with Western staffing and training, and they provided the skill base for these and other Japanese companies. Another example was government protection and nurturing of infant industry learning through the imposition of quotas and tariffs and other protective instruments.

Apart from the Den Den equipment suppliers – NEC, Fujitsu, Hitachi and Oki – there were a number of other companies that also became prominent. Foremost amongst these was Toshiba that established a partnership with General Electric in the US and became a major electrical equipment supplier. Toshiba was established in 1939 through the merger of two companies: one established in 1875 that was one of the first manufacturers of telegraph equipment and the second set up in 1890 as a producer of incandescent electrical lamps. Another example was Mitsubishi Electric which was spun-off in 1921 from the Mitsubishi Group's shipbuilding company (now called Mitsubishi Heavy Industries) in order to focus on ship-related electrical products.

There were also smaller telecoms equipment suppliers, a sort of second tier membership of the Den Den Family, including Sumitomo Electric, Furukawa and Fujikura. Non-telecoms companies established in the pre-war period that would go on to become important players in the ICT industry included Canon. Canon was established in 1933 by Goro Yoshida and his brother-in-law Saburo Uchida. The original aim was to develop camera technology and in 1934 the company developed its first camera.

Significantly, the consumer electronic companies evolved in an entirely different context. Here the leading company was Matsushita (that produced the National and Panasonic brands). The company was founded by Konosuke Matsushita in 1918. His first product was a light socket. In 1927 the company produced its first real success, a bicycle lamp, sold under the National brand name. Another consumer electronics company was Sharp, founded in 1912 by Tokuji Hayakawa. Its first major product was a mechanical pencil invented by its founder. When the factory was destroyed by the Kanto earthquake in 1923 it was relocated to Osaka and began producing the first Japanese radio sets.

It was around the time of the Second World War that the ICT Industry proper would emerge, totally transforming all the companies discussed here. This was the result of two radical and increasingly interconnected innovations: computers and semiconductors. Although these innovations originated in the US and Europe, the indigenous capabilities of these Japanese companies made them fertile ground for the adoption and mastery of these innovations. In so doing their efforts were greatly assisted by the supportive efforts of the Japanese state.

In the field of telecommunications NTT continued the work of the pre-war Ministry of Communications. In the fields of computers and semiconductors the Ministry of International Trade and Industry (MITI) played a key role providing trade protection, subsidised credit, assistance from government-funded research institutes (such as its Electro-Technical Laboratory, ETL), inter-firm coordination (where this was not precluded by strong inter-firm competitive rivalries), and help in entering foreign markets (through JETRO, the Japan External Trade Organisation).

Under the stimulus of post-war reconstruction and a rapidly-growing domestic economy (particularly after the 1960s), the new opportunities created by the waves of Schumpeterian change in ICT and other areas, and a growing international competitiveness enabled these companies to forge ahead. After the war they were joined by a number of new companies, particularly in the consumer electronics area.

One of these was Sony. Sony was started in 1945 when Masaru Ibuka began a radio repair shop in a Tokyo that had been destroyed by war-time bombing. The following year he was joined by Akio Morita. One of their first successful products was an electrical rice cooker. But both men had good backgrounds in electrical engineering, skills that they were able to enhance in carrying out their war-time army duties. These skills were in evidence when in the early-1950s they visited AT&T's Bell Laboratories, eventually managing to persuade the company to license use of the transistor (that had been invented in Bell Labs by Shockley and his associates in 1948). While the Bell Labs researchers were sceptical that the transistor - invented as an outcome of an attempt to improve telecommunications transmission technologies - would have useful applications in the field of consumer goods, Sony went on to develop the first commercially-successful transistorised radios.

Another post-war consumer electronics company was Sanyo which was founded in 1947 by Toshio Iue, the brother-in-law of Konosuke Matsushita and a former employee of the Matsushita corporation. Sanyo followed the same path as Matsushia, beginning as a bicycle lamp manufacturer. In the 1950 the company diversified its product range into plastic radios and washing machines.

With this corporate structure in place and with the capabilities that had been accumulated in these Japanese companies the country was excellently positioned to take advantage of the new opportunities that would unfold in the ICT Industry from the 1960s to the present day.

Korea

Korean economic development also owes a great deal to the ICT Industry. In both consumer electronics and semiconductors (largely memories) Korea is amongst the top few countries in the world. However, the evolutionary path that Korea followed was in many respects very different from that taken in Japan.

In ICT there have been three undisputed corporate leaders in Korea: Samsung Electronics, LG Electronics and Hynix (originally Hyundai Electronics). The rise to global prominence of Samsung in particular has been rapid and remarkable.

This is illustrated by data provided in the Appendix. For the present study the author has selected the main ICT companies from the US, Japan, Europe and East Asia (i.e. Korea, Taiwan and China) from the *Financial Times* Top 500 Global Companies in 2006. As can be seen from the table, Samsung comes sixth after Microsoft, Cisco, IBM, Vodafone and Intel, ahead of any Japanese company. Samsung's market capitalisation (the basis on which the Top 500 are ranked) was $107 billion compared to $114 billion for Intel, and $133 billion for Cisco. Although outperformed by Samsung, LG has also been a major success story in areas such as displays, memory semiconductors and mobile phones. In semiconductors (mainly memories) Hynix is the second Korean company, after Samsung, in the world's top 20.

How was this remarkable performance achieved? To answer this question it is necessary to begin with the companies that have been the engine.

Samsung was founded in 1938 by Byung-Chull Lee in Taegu, Korea, as an export business selling dried Korean fish, fruit and vegetables to Manchuria and Beijing. But it was only from the 1950s after the Second World War, when Japan was forced to end its colonial occupation of Korea, and after the Korean War that Samsung was able to start growing rapidly through diversification. Early diversification included sugar manufacturing, flour milling, confectionary machinery and insurance. By the time the Samsung Corporation (established in 1951) entered the ICT field in 1969 it was already an established rapidly growing conglomerate. In 1969 Samsung established Samsung Electronics, originally as a joint venture with the Japanese company Sanyo.

LG was originally established by Koo Inhoe in 1947. The company, named Lucky Chemical Industrial Corp, originally produced a cosmetic called Lucky Cream. During the Korean War the company entered the plastics field, originally producing plastic lids for cosmetic bottles. Soon the product range was extended to include items such as combs, soap containers, toothbrushes and tableware. Later toothpaste was added to the list. In 1958 the company diversified into radios establishing Goldstar (later LG Electronics) which produced Korea's first radio in 1959, exactly ten years before Samsung Electronics started.

The processes by which Samsung and LG entered the ICT Industry are relevant.[19] For LG the story is one of a creative entrepreneurial decision to begin producing locally a product – Korea's first vacuum tube AM radio – that was in growing demand. But how does a company involved in the areas just outlined diversify into the completely new field of radios? Two events clinched the entry. The first was the decision to employ an experienced German engineer in order to broaden and deepen LG's technological capabilities. At around the same time the company's president arranged to visit several leading electronics firms in Japan, Europe and the US. These two events led to the decision to enter this field. A Japanese AM radio served as a model and was reverse engineered.

While Korean companies, led by the largest mentioned here, constituted the engine of the emerging ICT Industry it was the Korean state that created the supportive environment that made their efforts both feasible and profitable. Determined that the country should pull itself up by its own bootstraps Korean government officials developed industrial policies designed to facilitate the process.

[19] This account draws on Linsu Kim's excellent *Imitation to Innovation: The Dynamics of Korea's Technological Learning,* Harvard Business School Press, 1997. I am indebted to the late Professor Kim for many discussions over the years about the process of Korea's economic development.

Until the mid-1960s Korean industrial policy relied largely on import substitution policies aimed at providing a protected local market for Korean companies. Strict controls were enforced limiting the ability of foreign companies to compete in these markets. In some sectors – including cars, steel, shipbuilding and agriculture – high effective rates of protection (i.e. protection on value added) led to rapid industrialisation. In electronics, however, progress was slower until the late-1960s.

From the mid-1960s the Korean government (along with the Taiwanese government) began increasingly to incentivise exports. Crucially, however, the high rate of protection of the prioritised sectors was maintained. This policy of walking on two legs – emphasising both export-orientation and at the same time import-substitution – allowed the government to create high-powered incentives for Korean companies to accumulate necessary capabilities in the protected domestic market while at the same honing their international competitiveness in international export markets. An additional raft of measures added to the incentives, including the granting by state-owned financial institutions of subsidised credit at below market rates to companies that performed well in export markets, tax concessions and foreign loan guarantees. These incentives in effect forced Korean firms to become internationally competitive while they enjoyed protection in the local markets.[20]

The Korean government was also quick to realise that the ICT Industry had particularly important potential for the development of the country. In 1969 the government passed the Electronics Industry Promotion Act accompanying this with the Long-term Electronics Industry Promotion Plan and the Electronics Industry Promotion Fund which gave preferential funding at subsidised rates to electronics companies.

It was within this context that the Samsung Corporation made its decision to enter the ICT Industry with the establishment in 1969 of Samsung Electronics. Subsequently, Hyundai and Daewoo, two other large Korean conglomerates, also entered.

In the mid-1960s the Korean ICT companies began to produce black and while TV sets, often relying initially on Japanese and US technology. Later they moved on to colour TV, microwave ovens, semiconductors and displays. As they became an increasing competitive threat to their erstwhile technology suppliers so the Korean companies were forced to turn to alternative sources of technology such as smaller US high-tech companies and Korean engineers living in the US. At the same time they accumulated their own R&D capabilities building increasingly sophisticated R&D organisations.

Over the succeeding years a number of important government research institutes were created that worked closely with Korean ICT companies, encouraging them to cooperate where possible (although fierce rivalry between these companies often limited cooperation) and offering them both technology and trained person-power. These institutes included the Korea Institute of Science and Technology (KIST), the Korea Institute of Electronic Technology (KIET), the Electronics and Telecommunications Research Institute (ETRI), and the Korea Advanced Institute of Science and Technology (KAIST). These institutes played an important role from the 1970s to the early-1990s, although thereafter, with significantly increasing R&D capabilities both in Korea and abroad, the large Korean ICT companies came to rely less and less on R&D from government institutes.

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[20] It is worth noting that for a long time influential organisations such as the World Bank failed to understand the true significance of Korea's industrial policy, choosing instead to focus exclusively on the export-orientation side of government policy while ignoring the protection that went with it.

By the early-1990s Korea had become the fourth largest producer of electronic products in the world and was second in consumer electronics after Japan. However, this success did not extend to all parts of the ICT Industry. While the large Korean conglomerates (chaebol) proved adept in becoming internationally competitive in areas such as consumer electronics, memory semiconductors, displays and, later, mobile phones they found it more difficult to make their mark globally in fields like computers and software. Nevertheless, their areas of strength in ICT were sufficient to make Korea a major global power in this industry.

Taiwan[21]

Taiwan's main ICT success has been in the area of computer hardware. By the mid-1990s Taiwan produced 72% of the world's computer mice, 65% of keyboards, 65% of computer motherboards, 64% of scanners, 57% of computer monitors and 27% of notebook PCs (the largest market share in the world). How was this remarkable market share achieved?

In the 1950s, as in Korea, a number of small Taiwanese firms began to produce simple electronic products such as radios. However, it was from the 1960s that substantial production of these kinds of products took off. The initial stimulus was foreign companies, largely big Japanese electronics companies, including Matsushita and Sanyo, sourcing assembly and some component production in low-cost Taiwan. US companies such as Texas Instruments and General Instruments also became involved in Taiwan at this time.

From the late-1970s a few Taiwanese firms began assembling imported PC kits. However, it was in the 1980s - after the world PC market began growing rapidly following the launch in 1981 of the IBM PC and the emergence of IBM-clones - that the production of computer components became a substantial business in Taiwan. Again, the driving force was foreign multinational corporations searching for a low-cost production base. It was these companies that became the engine of growth, unlike in Japan and Korea where large indigenous firms played that role.

Taiwanese small and medium-sized entrepreneurs responded enthusiastically to these new business opportunities. They set up as suppliers and subcontractors to the multinationals. Many of them – like Stan Shih, the founder of Acer, which would become Taiwan's largest computer company – had received engineering training in Taiwanese universities and had already engaged in the production of simple electronic products. (Shih had developed Taiwan's first electronic desktop calculator and designed a watch pen.) Others furthered their training in the multinational corporations operating in Taiwan and then left to establish firms to supply their former employers.

Although this response from Taiwanese small and medium-sized firms was entrepreneurially driven the Taiwanese government played a crucial supportive role. From as early as the 1960s, sensing that an important new area of economic activity was emerging, the government created incentives for the infant suppliers. These included subsidised credit from government financial institutions as well benefits provided in export processing zones.

From the late-1970s a powerful new government impetus was provided by K T Li who had been Minister of Finance and was Minister of Economic Affairs. He prioritised both the computer and semiconductor sectors, recognising their potential as engines of Taiwan's growth. With his support several well-funded government programmes were launched aimed

[21] This section draws on Dedrick and Kraemer (1998) *Asia's Computer Challenge*, Oxford: Oxford University Press.

at supporting the Taiwanese small and medium sized companies involved in these sectors. In addition, he cemented ties with foreign multinational corporations, persuading some of their leading executives to join his advisory panel. This helped to ensure that Taiwan would become an even more suitable base for these multinationals.[22]

A further crucial role played by the Taiwanese government involved government R&D institutes. Of these the most prominent was a remarkable institute, the Industrial Technology Research Institute (ITRI). Government owned and funded the role of ITRI is to support the technical and innovative capabilities of Taiwanese small and medium-sized companies, not only in the ICT area but also in other fields such as computer numerically controlled (CNC) machine tools (where the institute played a crucial role in facilitating Taiwanese international competitiveness[23]).

ITRI evolved in order to overcome a significant weakness in Taiwan's industrial structure. This weakness stemmed from the small and medium size of most Taiwanese firms in the high-tech sector which prevented these firms from developing substantial R&D organisations and capabilities. The importance of SMEs was and is the main feature distinguishing Taiwan's industrial structure in the ICT Industry from those in Japan and Korea where large companies dominate. ITRI's large number of well-qualified engineers[24] would develop internationally competitive prototypes in selected areas that could then be transferred (at a subsidised price) to numbers of Taiwanese SMEs thus allowing the institute to benefit from economies of scale. Close interaction with these 'customers' ensured that ITRI's products were competitiveness-enhancing (although on occasion there were some complaints that ITRI's prototypes tended to be over-designed and engineered, reflecting the institute's research interests).[25]

An important example is in the field of computers. Here ITRI's subsidiary, the Electronics Research and Services Organisation (ERSO), reverse-engineered IBM's BIOS (basic input-output system, the built-in software that determines what a computer can do without accessing programs from a disk) thus allowing Taiwanese IBM-clone manufacturers to enter the market without paying royalties to IBM. This reduced an important entry barrier. Another significant ITRI subsidiary is the Computer and Communication Research Laboratory (CCL). However, a similar subsidiary – the Institute for Information Industries (III) – established with the support of several multinational corporations and aimed at developing software capabilities in Taiwan, has been less successful As we shall see shortly, ITRI also make a huge impact on the Taiwanese semiconductor industry through its fabrication facilities, its prototypes, and most significantly through the spin-off of what would become some of the

[22] Years later a senior executive in one of Japan's best-known ICT companies told me how the company had been 'invited' by the Taiwanese government to establish a new R&D organisation in the country. Asked how the Japanese company had responded the executive replied that since they were heavily involved in the production of electronic products in Taiwan they had little choice but to comply, even though they had no particular desire to do R&D in the country.

[23] For further details about the role of ITRI in the development of CNC machine tools in Taiwan, see Fransman, M (1986) International Competitiveness, International Diffusion of Technology and the State: A Case Study from Taiwan and Japan, *World Development*, 14 (11).

[24] Many of these Taiwanese engineers came from outstanding US R&D laboratories, such as Bell Labs and IBM's laboratories, both of which laid off many researchers in the 1990s.

[25] But why did Taiwanese SMEs not rapidly consolidate and grow in size through merger and acquisition? When I asked this question in Taiwan I was often given by way of reply the Chinese proverb: better the head of a chicken than the tail of a cow, i.e. Taiwanese entrepreneurs tended to want to remain their own bosses. This constrains the growth of large companies.

largest semiconductor companies in the world, TSMC and UMC (two of Taiwan's three largest R&D performers).

Out of this context emerged Taiwan's unique industrial organisational structure consisting of a layered network of Taiwanese firms which itself was inserted into the global production chains that dominate the world of computer producing firms. At the head of these chains are the main computer companies such as Dell, IBM, Hewlett Packard, Apple, NEC, Toshiba, and Fujitsu. Within Taiwan itself there were three layers of firms: the first consisted of a handful of large companies, secondly a larger number of medium-sized firms, and finally many small firms producing relatively simply components.

The strength of this industrial organisational structure lay in the high-powered market incentives that it created, the competencies that it required participating firms to acquire, and the flexibility that the network as a whole thrived on. These three characteristics resulted in high quality together with low price, which in turn guaranteed Taiwan a prominent place in the international division of labour in the computer sector. They also facilitated a formidable process of learning that enabled Taiwanese firms to constantly upgrade their capabilities, moving from original equipment manufacture (OEM) to own-design manufacture.

Flexibility was a particularly important characteristic given the rapid changes that occur in both the design and technology of computer and consumer goods components. The Taiwanese network proved to be particularly adept at adapting rapidly to the required changes. The large number of potential suppliers of any particular component together with market selection by players further up the global production chain created an effective evolutionary process that selected the fittest who were able to produce what was required and gave them the resources they needed. Those that were insufficiently fit dropped out. The proof of this pudding lies in the Taiwanese market shares referred to at the start of this subsection.

Further proof is provided by the relative failure of the large Korean conglomerates to make much headway in the computer industry, until the most successful like Samsung re-entered this market in the early 2000s making use of synergies with their other consumer products. The in-house production of components including semiconductors gave the Korean companies a significant international competitiveness in areas like TVs, memories, displays, microwave ovens, digital cameras, and mobile phones. Further advantage came from their R&D laboratories, from intra-conglomerate financing, and from their global marketing prowess strengthened by the increasing recognition of their brands. They were also able to benefit from economies of scale. But in the area of computers Taiwan was the better performer. Flexibility was one of the major reasons why.

Taiwan's increasing design capabilities in semiconductors were particularly important giving the country an important role in both the design and fabrication of the chips that powered not only computers but also the new mass-produced ICT products such as mobile phones, MP3 players, digital cameras and digital TVs.

As mentioned earlier, Taiwan's two major semiconductor companies are Taiwan Semiconductor Manufacturing Corporation (TSMC) and United Microelectronics Company (UMC). These are also Taiwan's main R&D-performers (see below). UMC was established in 1979 as a spin-off from ITRI's ERSO, created as a commercial semiconductor company to generate profit from ERSO's research. In 1983 UMC began very large-scale integrated circuit (VLSI) production in partnership with the Silicon Valley company, Vitelic, that was established by overseas Chinese. TSMC, now far larger than UMC, was set up in 1985 as another spin-off from ERSO. The Taiwanese government provided almost half of the capital with Philips providing just over a quarter. In 2005 TSMC ranked eighth in the world in terms of revenue, ahead of notable Japanese semiconductor companies such as NEC, Sony, Matsushita and Sharp.[26] UMC was eighteenth. The second ranking company was Samsung which had just over twice TSMC's revenue. First came Intel, by far the largest semiconductor company in the world.

Acer, Taiwan's largest computer company, was founded in 1976 by Stan Shih and four partners. Shih had previously cut his technical teeth in simple electronic consumer products, producing a desktop calculator and watch pen in Taiwan. Graduating from the National Chiao Tung University in Taiwan, Shih had obtained a B.Sc. and M.Sc. in Electrical Engineering.

At first Acer provided consulting services but in 1981, the year the IBM PC was launched, the company sold a PC self-assembly kit. The following year assembly of IBM-compatible PCs began. These used the IBM BIOS that had been reverse-engineered in ERSO. In the 1980s Acer grew rapidly allowing it in the following decade to acquire several US computer companies. Joint ventures were also important such as Acer's venture with Texas Instruments in the area of dynamic random access memories (DRAMs). In 2005 Acer was ranked eighth in the world desktop computer market and fifth in the world portable computer market, ahead of such notables as NEC, Sony and Apple.

Hon Hai Precision is another world-leading player in the ICT Industry and the third-largest R&D performer in Taiwan. Hon Hai is one of the largest contract electronics manufacturers in the world, holding the third spot after leaders Solectron and Flextronics. Its customers include Dell, Cisco, Apple and Sony. The company was founded by Terry Gou in 1974 to make plastic switches for televisions. In 1981 the company began producing the product that would fuel its early growth, connector sockets that allowed memory modules to be added to PCs. With revenue from connectors and assistance from the Taiwanese government in the form of tax incentives and credit subsidies Hon Hai went on to make other components for computers going on to specialise in the manufacture of computers, consumer electronics, and communications products. In 1994 Hon Hai established R&D centres in the US and Japan and during the following two years the company invested heavily in production facilities in Scotland, Ireland and the US. In 2001 Hon Hai became Taiwan's largest manufacturing company. The company was also a substantial manufacturer and exporter in China. Moving up the components value chain Hon Hai has become a significant original design manufacturer and it also offers design engineering and manufacturing services.

China

The Chinese development trajectory in the ICT Industry has been fundamentally different from the three other East Asian countries examined here. Characterising the key difference, one Chinese scholar has labelled the Chinese trajectory a top-down process.[27]

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[26] A key role in the development of TSMC was played by Morris Chang who had been vice-president of Texas Instruments and president of General Instrument. He became director of ITRI and later chairman of TSMC. This example, together with the role played by Taiwanese researchers who had previously worked for distinguished US R&D laboratories such as Bell Labs and IBM's laboratories, highlights the significant contribution that US corporations and institutions have played in the development of Taiwan's ICT industry.

[27] The scholar is the late Qiwen Lu (2003). *China's Leap into the Information Age: Innovation and Organization in the Computer Industry*. Oxford University Press, Oxford. The present section drawn on Lu's work.

What does Qiwen Lu mean by top-down? Lu argues that in both Korea and Taiwan the trajectory of development in the ICTI was bottom-up in the sense that activity began with the low-skill, low-tech activities of assembly of consumer electronic products such as radios and black and white TVs. The next step up the learning ladder involved the local production of simple components (including items such as simple devices, plastic casings, etc). Only much later, after a good deal of learning, technology mastering and technology capability acquisition, were Korean and Taiwanese ICT companies able to design their own products and compete with them in international markets. Own-brand production had to wait even longer.

In China, by contrast, internationally-competitive activity in key parts of ICTI emerged from the relatively sophisticated science and technology institutions that had already been created in China during the pre-reform Communist period, principally under the auspices of the Chinese Academy of Sciences (CAS). In this sense the process was top-down, beginning with science and technology and moving on to design, manufacturing, distribution and marketing.

The key example is computers. Not-surprisingly, after the pioneering progress made in the area of computers in the decade after the Second World War China was quick to identify this field as a national priority. Indeed, China's first long-term development plan for science and technology introduced in 1955 prioritised computers as one of six priority areas. The first home-grown Chinese computer was developed in 1958, modelled on a Soviet computer. Significantly, it was developed by the Institute of Computing Technology, the Chinese Academy of Science's premier computer research institute.

However, by the time China's major post-Mao economic reforms were introduced from 1978 it was already clear that the 'Chinese System' was not working effectively in the field of computers. A major part of the problem was organisational. Specifically, research institutes were organised vertically under the Chinese Academy of Science or different ministries (such as the Ministry of Electronic Industries). They acted as fragmented silos, having little to do with one another.

Even more importantly, they had little interaction with the enterprises charged with manufacturing computers (that themselves were separated from the commercial enterprises that had responsibility for marketing and distribution). Reinforcing this insulation and fragmentation were disincentives that minimised interactions. Researchers had little incentive to find out about the ways in which their knowledge could be put to commercial use by the enterprises which in turn had few incentives to innovate. While this organisational arrangement may have yielded reasonable results in the case of an unchanging product - standard working class housing, where China like the Soviet Union did relatively well in a short period, is an example – it was highly ineffective in the fast-moving area of computers.

Responding to the lack of progress, a major reform of the Chinese science and technology system was introduced in 1985. One immediate effect of this reform was to cut significantly the budgets of research institutes while allowing them to experiment with the establishment of a new breed of enterprises that could generate a replacing income. These were called science and technology enterprises (*keji qiye*).

At one stroke this created the incentives for the marrying of R&D, manufacturing, marketing and distribution functionalities. Although in many cases funding for these enterprises was provided by the research institute (but not by national or local government budgets) which formally owned all or some of the enterprises, the managements of the enterprises were given full autonomy in running the business. This autonomy extended to key decisions in areas such as innovation, diversification, joint ventures, funding and employment.

Like children encouraged to stand on their own feet and find their own way in the world the new science and technology enterprises at first still enjoyed the protection of their erstwhile parents. Accordingly, they were able to get funding from the parent research institute and draw on its scientific and technological expertise (including employing part-time or full-time key experts from the institute). In this way China gave birth to a new kind of enterprise, one that was neither state-owned and controlled nor privately owned and controlled but which, nonetheless, was able to function efficiently, to innovate, and to grow rapidly.

This is how three of China's four main computer companies evolved: Legend (that later became Lenovo, in 2005 acquiring IBM's iconic PC subsidiary), Stone and Founder. The fourth company, China Great Wall, was a more conventional state-owned enterprise under the guidance of the Ministry of Electronic Industries.

The state also attempted to assist the fledgling computer industry in other ways. One of these was through import substituting protection. In the 1980s higher tariffs were imposed on imported computers than were placed on imported knocked-down assembly kits, the aim being to encourage economic activity based on the latter. However, this attempt at creating import-substituting industrialisation in the area of computers was not particularly successful.

One important obstacle was the lack of Chinese language processing facilities in the computers of the day. It was in overcoming this obstacle through sophisticated indigenous innovation that the four companies referred to were able to get their break, in the process setting themselves on the path that would allow them to compete effectively with the world's major computer companies and become major players in their own right. Significantly, the Chinese language processing expertise that was used by the companies came from the scientific research institutes. With these capabilities and the Chinese language applications that they facilitated the four Chinese computer companies were able to grow rapidly.

Lenovo emerged as China's main success story in computers. Its success was underlined when it embarked on a bold strategy of globalisation and in 2005 acquired IBM PC, the company that gave birth to both the era of mass PC-based computing and the Wintel standard that assured Microsoft and Intel a privileged place in this new industry. Lenovo's market share in the global PC market in 2006 is shown in Exhibit 15.b.

Exhibit 15.b. Global PC Market Share, 2006

COMPANY	GLOBAL MARKET SHARE
HP	16.3%
Dell	16.1%
Lenovo	7.5%
Acer	5.9%

Source: Wall Street Journal, November 10-12, 2006.

Conclusion

These brief analyses of the four East Asian countries have focused on the earliest period when the necessary conditions were put in place that would later lead to a sustainable learning-based growth trajectory. The outcome of this trajectory has been considered earlier in this paper in the discussion of the international competitiveness of these countries.

V. THE ROLE OF R&D IN ICTI

In this section the role of R&D in ICTI is examined. Exhibit 16 shows the total amount of R&D by region – that is, the US, Europe (Germany, France and the UK), and Asia (Japan, Korea and Taiwan) - spent by the world's top 300 corporate R&D spenders.

Exhibit 16. Company R&D by Region: From Top 300 R&D Spenders, 2006

COUNTRY **(total R&D spend, $ billion)**	**TOP COMPANIES** **(per company R&D spend, $ billion)**
US ($142.86)	Ford ($8.00) Pfizer (7.44) General Motors (6.70) Microsoft (6.58) Johnson & Johnson (6.31) IBM (5.38) Intel (5.15) Merck (3.85) Motorola (3.68) Hewlett Packard (3.49)
EUROPE	
GERMANY ($ 39.70)	DaimlerChrysler(6.66) Siemens (6.08) Volkswagen (4.81) BMW (3.67) Bosch (3.46) Bayer (2.22) Boehringer Ingelheim (1.60) Infineon (1.47) SAP (1.28) BASF (1.28)
FRANCE ($ 26.08)	Sanofi Aventis (4.77) Renault (2.67) Peugeot (2.54) Alcatel (2.11) Valeo (0.92) France Telecom (0.84) Total (0.80) Michelin (0.67) Schneider (0.64) Thales (0.59)

COUNTRY (total R&D spend, $ billion)	TOP COMPANIES (per company R&D spend, $ billion)
UK ($ 17.76)	 GlaxoSmithKline (5.38) AstraZeneca (3.38) BAE (2.49) BT (1.25) Unilever (1.12) Rolls Royce (0.60) Royal Dutch Shell (0.59) Royal Bank of Scotland (0.56) BP (0.50) HSBC (0.42)
ASIA	
JAPAN ($ 68.38)	 Toyota (6.40) Matsushita Electrical (4.79) Sony (4.51) Honda (3.96) Hitachi (3.43) Nissan (3.37) Toshiba (2.95) NTT (2.69) Canon (2.43) NEC (2.33)
KOREA ($ 11.14)	 Samsung Electronics (5.44) Hyundai Motor (2.34) LG Electronics (1.75) Korea Electric Power (0.39) LG Philips LCD (0.36) Hynix Semiconductor (0.33) Samsung Electro-Mechanics (0.27) SK Telecom (0.25)
TAIWAN ($ 0.99)	 Taiwan Semiconductor Manuf (0.43) United Microelectronics (0.29) Hon Hai Precision Industry (0.27)

Source: DTI R&D Scoreboard, 2006.

Several important points emerge from this exhibit:

i) The extent to which the US dominates total R&D spending by these 300 companies.

ii) Japan's total is approximately half that of the US.

iii) The imbalance between the three European countries with Germany the clear European leader, the UK following a long way behind both Germany and France with less than half the German total.

iv) Both Korea and Taiwan still perform poorly relative to the US, Japan and the European countries. (While in this table the US, Japan and the European countries each have 10 companies included – the top ten from the country concerned – Korea has only 8 and Taiwan 3. This is because the cut-off point was companies spending more than $0.25 billion.)

v) Motor car companies feature prominently in most of the countries.

vi) In the US 5 out of the 10 companies are ICT companies. In Japan the figure is 7, in Germany 3, France 3 and the UK 1. This is roughly in accordance with the relative strength of the ICT Industry in the economy concerned.

vii) In Korea Samsung far outperforms all the other companies with more than twice the R&D spend of the second company, Hyundai Motor.

viii) In Taiwan there are only 3 companies above the cut-off point of $0.25 billion, all of which are in the ICT Industry.

In Exhibit 17, further information is provided on corporate R&D broken down according to layer in ICTI.

Exhibit 17. ICTI Companies: R&D, Sales, Market Cap, 2005

COMPANY	R&D SPENDING £m	R&D/SALES %	SALES £m	MARKET CAP £m
LAYER III				
Internet Firms				
Google, USA	206	12.4	1861	41925
Yahoo!, USA	202	10.8	1862	25385
LAYER II				
Telecoms Services				
NTT, Japan	1818	2.9	54927	68337
Deutsche Tel, Germany	637	1.6	40977	52089
France Tel, France	399	1.2	33385	44088
Telefonica, Spain	326	1.5	21467	48079
BT, UK	257	1.4	18823	18586
Vodafone, UK	219	0.6	34133	94390
SK Telecom, South Korea	137	2.6	5319	8075
AT&T, USA	86	0.5	15906	8298
KDDI, Japan	67	0.5	14487	12116
KT, South Korea	51	0.6	8508	5856
Chunghwa Tel, Taiwan	40	1.3	3043	9370

COMPANY	R&D SPENDING £m	R&D/SALES %	SALES £m	MARKET CAP £m
<u>LAYER I</u>				
Electronics & Electrical				
Siemens, Germany	3584	6.7	53216	41860
Matsushita, Japan	3129	7.1	44292	22132
Sony, Japan	2552	7.5	33940	17682
Samsung, Korea	2467	6.0	41240	48580
Philips, Netherlands	1794	8.4	21465	20051
Canon, Japan	1399	7.9	17627	23100
LG Electronics, Korea	776	3.6	21761	5029
Sharp, Japan	705	6.1	11474	8865
Sanyo, Japan	636	5.0	12748	2465
IT Hardware				
Nokia, Finland	2714	13.1	20720	41183
Intel, USA	2489	14.0	17818	83499
Hitachi, Japan	1976	4.3	45885	11064
Hewlett-Packard, USA	1826	4.4	41619	36126
Ericsson, Sweden	1743	16.7	10344	30679
Toshiba, Japan	1712	6.0	28361	6687
Cisco, USA	1663	14.5	11482	59217
Motorola, USA	1594	9.8	16315	27385
NEC, Japan	1400	5.7	24679	5455
Fujitsu, Japan	1275	5.3	24230	6348
Alcatel, France	1102	12.7	8683	9097
Texas Instruments, USA	1030	15.7	6552	26875
Nortel, Canada	1020	23.9	4272	7434
Lucent, USA	662	14.0	4711	6830
Mitsubishi Electric, Japan	637	3.8	16823	5798
S'ware & Computer Services				
Microsoft, USA	3221	15.5	20724	152227
IBM, USA	2950	5.9	50155	68318
Oracle, USA	777	12.6	6146	35627
SAP, Germany	722	13.6	5320	32180
Computer Associates, USA	396	21.5	1839	8223
Electronic Arts, USA	330	20.2	1630	9467

Source: DTI R&D Scoreboard

A number of significant observations emerge from Exhibit 17.

First, **Layer III** is dominated by the US Internet companies, Google and Yahoo! Both these companies have relatively high R&D intensities, significantly higher than the Telecoms Services companies in Layer II, higher than the electronics and electrical companies in Layer I, though not as high as the IT Hardware companies and the Software and Computer Services companies in Layer 1. Furthermore, they have very high market cap to sales ratios, reflecting their high price-earnings ratios.

Significantly, Google and Yahoo! are far more R&D intensive than many of the leading telecoms operators. This is important since they are relatively new companies with sales that are far lower than these operators. In absolute terms Google and Yahoo! spend about the same on R&D. The sum they spend is only a little lower than Vodafone, the second largest mobile company in the world after China Mobile, and is significantly higher than that spent by AT&T. In terms of R&D intensity (R&D as a proportion of sales), as already noted, Google and Yahoo! are significantly higher than the telecoms operators.

Second, NTT is the clear leader amongst the **Telecoms Services** companies in Layer II. This is the case both in terms of its absolute spending on R&D (which is about three times as high as the second company, Deutsche Telekom) and in terms of its R&D intensity (which is almost twice as high as Deutsche Telekom's). Significantly, the only telecoms operator that comes close to NTT in terms of R&D intensity is the Korean mobile company, SK Telecom. Clearly, these two Asian companies have made a significant commitment to R&D. However, the same cannot be said of the other Asian operators. KDDI from Japan and KT from Korea spend 0.5 and 0.6% of their sales on R&D, a figure that is approximately the same for both AT&T and Vodafone. The other European operators fall between these two extremes.

Third, the Telecoms Services companies in Layer II are significantly less R&D intensive than the companies from all the other segments in Layers I and III. In my book, *Telecoms in the Internet Age* (Oxford University Press, 2002) I have analysed in detail this important characteristic, examining how over time the telecoms operators have relinquished more and more of the R&D-intensive aspects of the telecoms business (mainly equipment) to specialist equipment suppliers. The R&D expenditure of the telecoms operators, however, should not be confused with their expenditures on innovation which include many activities that are not measured in the R&D statistics.

In the fourth point we turn to the three categories in Layer I. In **Electronics and Electrical** it is highly significant that of the 9 companies included 7 come from East Asia. The remaining 2 are the European companies Siemens (that came first) and Philips (that was fifth). Five of the companies were from Japan and two from Korea. As these figures make clear, East Asia is dominant in this area.

In **IT Hardware** there were 15 companies. Of these 6 were from the US, 5 from Japan, and 3 from Europe (two the mobile equipment companies, Nokia and Ericsson, and the third the telecoms equipment firm, Alcatel). Although the US had a larger number of firms the strength of Japan is notable.

In **Software and Computer Services**, however, the US is overwhelmingly dominant with 5 of the 6 firms. Europe had 1 (SAP of Germany) and Japan and East Asia had none. **This highlights a significant weakness in the ICT Industries in Japan and East Asia, namely weakness in packaged software and computer services**. However, in a few software areas (notably embedded software in microcontrollers used in consumer electronic products) the Asian countries have significant strengths.

Conclusion

Companies from Japan and East Asia are particularly strong in Layer I. Conversely, they are relatively weak in Layer III. Layer II differs from the other layers in that telecoms services, provided by telecoms network operators, is primarily a national industry provided by national operators. Globalisation has made little impact on Layer II. However, in terms of R&D expenditures Japanese and East Asian companies do relatively well in Layer II.

The European companies that feature strongly in Layer I include Siemens, Philips, Nokia, Ericsson, and Alcatel and SAP in software. In Layer II the main telecoms operators from the largest European countries are, unsurprisingly, amongst the largest R&D performers. They include Deutsche Telekom, France Telecom, Telefonica and BT. Their R&D expenditures are dwarfed by those of NTT, by far the leader in this layer.

However, it is in Layer III that US companies are clearly in the lead with little competition from their Asian or European counterparts. This requires an explanation which is provided in the following section.

VI THE UPPER LAYERS IN ICTI: USING THE INTERNET AS PLATFORM

Layer III is concerned with the production of content, applications and services (as discussed in detail in connection with the Fransman Layer Model). One of the key features of Layer III is dominance by US companies.

A. The Dominance of US Internet Companies in Layer III

In the case of the Internet companies (i.e. those companies in Layer III that use the Internet as a platform for their content, applications and services) we all intuitively know that it is US companies that are dominant. Almost all of us who use the Internet have had direct experience with at least one of the main US companies that dominate this field, companies like Google, Yahoo!, eBay and Amazon.

But is it possible to provide a more rigorous quantification of the dominance of US companies in Layer III? In order to provide such a quantification the present author has constructed a list of the top global ICT companies taken from the Financial Times Top 500 for 2006 (which includes all industries). The companies are ranked by market capitalisation. These ICT companies are from the US, Japan, Europe and East Asia (Korea, Taiwan and China). The full list of ICT companies is shown in the Appendix. Exhibit 18 provides a breakdown by layer (in the Fransman Layer Model) of the companies from the US, Japan, Europe and East Asia.

Exhibit 18. ICT Companies in the FT Top 500 from the US, Japan, Europe and East Asia (Korea, Taiwan and China), 2006

LAYER	TOTAL NUMBER OF COMPANIES	NUMBER OF COMPANIES BY REGION
III	9	US 6 Japan 2 Europe 1
II	18	US 5 Japan 3 Europe 8 East Asia 2
I	29	US 12 Japan 9 Europe 6 East Asia 2

Source: M. Fransman (copyright), calculated from FT Top 500, 2006.

Significantly, in Layer III 6 of the 9 companies are from the US. This is 67% of the companies. In Layer II 5 out of 18 companies are American, or 28%. In Layer I, 12 of the 29 are US companies, or 41%. **It could be argued that these percentages provide a rough indicator of country international competitiveness in the three layers. To the extent that**

this is correct, the US is overwhelmingly competitive in Layer III and highly competitive in Layer I. (As noted earlier, Layer II is a special case since telecoms services are largely not internationally traded with the result that most users get their services from nationally-based providers, even if on occasion these providers are foreign owned. For example in almost all countries the main telecoms service provider is the national incumbent.)

B. The Relative Absence of European and East Asian Companies

Europe, however, performs poorly in Layer III with only 1 of the 9 companies listed in the FT Top 500, or 11%. (The company concerned is Vivendi Universal from France, a media company, which was ranked 167th in the FT Top 500.)

Japan had two companies in Layer III (Yahoo! Japan, a joint venture between Yahoo! and Japan's Softbank that has become the number three player in the telecoms market after NTT and KDDI, and Nintendo, the games company.) There were no East Asian companies in Layer III.

In Layer I, 9 of the 29 companies were Japanese, or 32%. Six were from Europe, or 21%. If Japan is added to East Asia then 38% of the companies came from this region. The 2 East Asian companies were Samsung (ranked 35 in the overall FT Top 500 and 6th in our list of top ICT companies) and TSMC from Taiwan (which was136 in the former and 36th in the latter ranking).

C. Explaining US Dominance in Layer III

We have, therefore, provided further evidence that the US is overwhelmingly dominant in Layer III, particularly in that part of the layer that uses the Internet as a platform for its content, applications, and services. But why is this the case? How is US dominance in this layer to be explained?

In answering these questions it is useful to begin with an illustrative case study that points to some of the key determinants.

The Case of Jajah[28]

Jajah is a VoIP (voice over the Internet) company founded in 2005 by two young Austrians, Daniel Mattes and Roman Scharf. Both had previous business experience prior to establishing Jajah. Mattes had been involved in a media business and e-government solutions business, while Scharf had been running a German software company.

Introduced by a mutual friend, the two men shared a fascination with the possibilities of VoIP. Their interest had been stimulated by a survey showing that while only 2 to 3% of Internet users were using VoIP almost all were comfortable typing queries into search engines such as Google. This suggested that existing VoIP services are too complicated.

The Jajah founders then set about combining the two elements by developing a VoIP system that would require nothing more from the user than a keyword or number typed into a search box. In other words they set out to simplify and demystify the VoIP proposition. The system that they then developed eliminated the need for off-putting requirements such as a broadband

[28] The case of Jajah was discussed in the Financial Times, September 27, 2006.

connection, software downloads and microphone and headset. In fact even sitting at a computer was made unnecessary since calls are completed using the regular phone network.

The name of the new venture was said to be taken from F. Jajah Watamba, supposedly an eccentric Australian aborigine who had posted a manifesto calling for free global communications at Watamba.com. But it was not to Australia but rather to the U.S that the new company would quickly be drawn.

Just when it looked as though the new company would be funded by European venture capitalists, Michael Moritz of Sequoia Capital (an early investor in Yahoo!, Google and YouTube) made an approach, offering to invest in the company. However, a necessary condition was that the company and its founders relocate to California. The founders accepted the offer without hesitation and in May 2006 they moved the company HQ to Mountain View (next to Google). This raises the important question of why the U.S. dominates the creation and development of new Internet companies.

Why the US dominates the New Internet Companies

This case would suggest that one of the main factors that make the U.S a more fertile environment for young Internet companies is the positive role played by that country's venture capital professionals. In the European context the venture capital firms are said to follow a banking business model, only releasing portions of money when specific targets and conditions have been met. This can force entrepreneurs in new start-ups to become more focussed on meeting the venture capitalist's conditions than developing their actual business idea.

Certainly this is the view taken by Jajah's Roman Scharf. He contrasts this cautious and restrictive approach in Europe with the much freer and more open-ended attitude in the U.S. In the US, he suggests, the venture capitalist companies assess what level of finance the new business will need over the following two years and write out a cheque for that amount. This allows the entrepreneur to spend time getting the business right rather than constantly keeping the financiers convinced that the business proposition is still viable. Scharf's business partner, Daniel Mattes, agrees:

> "Enough money makes your mind free. When your mind is not free, you're not focused anymore and you lose traction"

Moreover the U.S venture capitalists enjoy the benefits that come from a long association with establishing high-tech enterprises in an around Silicon Valley. In the case of Sequoia, their experience stretches back 25 years. This means that they have deep roots in the ICT business community which can greatly assist a new arrival such as Jajah. Getting an Internet-based business started and keeping it viable requires many interactions with other complementary companies. Hiring and keeping the right staff also requires appropriate contacts.

Forms of assistance such as these to a new start-up go far beyond the mere provision of financing. 'Venture capital' is as much about contacts and connections as it is about capital. With their close involvements in the Internet cluster in US locations such as Silicon Valley venture capitalists like Sequoia are in an unparalleled position to give a boost to new Internet companies such as Jajah.

The benefits provided by location in a cluster such as Silicon Valley are far greater than the provision of funding and the liberal conditions under which the funds may be used. Indeed, the benefits are systemic. It is the entire ‘system’ in Silicon Valley that bestows these benefits, rather than a single part of it such as the venture capitalists. For example, in Silicon Valley Internet-based innovations and discussions are ‘in the atmosphere’ (to use the words of the nineteenth century economist, Alfred Marshall). Accordingly, even if European venture capitalists were to mimic the financial conditions provided by Sequoia and other US capital providers Europe would still find it difficult to provide the same kinds of advantages as were provided by Jajah.

The Jajah case study, therefore, although just one small example, provides a good illustration of why specific locations in the US have spawned most of the successful Internet companies. It also suggests the magnitude of the task facing companies and government policy makers in Europe and Asia who would like to mount a challenge to the US dominance of Internet companies in Layer III.

Some Exceptions?

But if this conclusion is correct, how have Internet companies such as Skype (a major pioneer of VoIP that was started in Europe) and Baidu (the Chinese equivalent of Google that outperforms Google in the Chinese market) managed to grow up outside the favoured US locations? Clearly, these cases merit closer attention.

The Case of Skype

Skype was established by Niklas Zennström and Janus Friis in 2003. Skype is a VoIP (voice over the Internet) company. Its software (that can be easily and freely downloaded from a web site) allows Skype subscribers to speak for free to other subscribers over the Internet (provided they have a microphone and headset or speakers). Skype’s revenue comes from calls to phones or to non-subscribers for which low charges are levied.

Skype (and other VoIP services) have radical implications for telecoms service providers (both fixed and mobile). Most of the revenue of these companies has come from their telephony services. Free VoIP is now rapidly eating into these revenues, making VoIP a disruptive technology.

Telecoms service providers have high fixed costs (largely the costs of their networks). They also have high administration and advertising costs (intended to keep customers and therefore reduce churn rates, get new customers, and increase average revenue per user (ARPU) and significant billing costs.

However, Skype’s business model constitutes a fundamental threat to this way of operating. True, Skype had the initial fixed costs of developing its software (reduced by the fact that its software developers were from Estonia). But once this software is up and running on the Internet the marginal cost of providing it to an additional subscriber is zero. Furthermore, Skype does not advertise, relying on so-called viral distribution (i.e. word of mouth aided by media publicity). There are very low billing costs – simply a credit card payment for charged services. This allows Skype to offer free voice to subscribers, with additional charged services generating Skype’s revenue. From these details it is easy to see how disruptive Skype has proved to be.

Significantly, Skype was not the pioneer-innovator in VoIP. The first VoIP commercial service was started in 1995 by an Israeli company called Vocaltec. I used Vocaltec's software in 1995. It was possible to find others available at the time on the Internet, email them the software, and then speak to them over the Internet. The main problem was that with slow-speed Internet dial-up access the speaker could not be heard in real-time and there were delays and gaps in the conversation (as some packets were delayed or lost). Nevertheless, a reasonable communication was possible (though not of high quality) and I remember my amazement that all this was for free and my shock at realising the implications that this would inevitably have for the incumbent telecoms operators and other telecoms companies dependent on voice services for revenue.

However, it would take almost a decade before this disruptive technology began to make a major impact on the telecoms services market. But once the disruption began it moved like wild-fire. Skype, as noted, was established in 2003. Within the space of two years Skype had itself added over 50million new VoIP users. As of 2005 the VoIP market was said by Ovum to be worth around $ 2.3bn. By the end of 2008 it was forecast to rise to $15.4bn.[29]

By 2005 the founders of Skype decided that if they were to survive in the tough environment of the Internet it was necessary to tie up with one of the major Internet companies. They eventually got round to talking with eBay's CEO Margaret C. Whitman in May 2005. Whitman was impressed enough for a complete takeover. In the end eBay agreed to buy Skype for $1.3bn in cash and $ 1.3bn in shares (with a further $ 1.5bn payable after four years if certain targets for users and revenues were met).[30]

Why did VoIP take so long to begin rapidly diffusing? The answer is that VoIP was initially constrained by the speed of the Internet. Once broadband began to be widely adopted – from the early-2000s – and at flat-rates, which meant that users could remain on the Internet for as long as they liked without incurring additional charges, so the infrastructure was put in place that would make VoIP commercially viable. Broadband speeds quickly improved the quality of VoIP, increasing the substitutability between it and regular fixed and mobile calls.

To what extent was Skype a 'European affair', conceived and nurtured by Europeans and European institutions? Certainly, Niklas Zennström, a Swede, and Janus Friis, a Dane, were thoroughly European. Zennström studied at Uppsala University in Sweden (just north of Stockholm) in the same town where he grew up with his teacher parents. Here he did a dual degree with business supplementing his MSc in Engineering Physics and Computer Science.[31] However, as a student he also got some exposure to American university life, becoming in the final year of his studies an exchange student at the University of Michigan in Ann Arbor.[32]

In 1991 Zennström was recruited by Tele2, a new Swedish telecoms operator that eventually came to challenge the incumbent, Telia (although at this stage it only employed 23 people). It was in Tele2 that Zennström was to get his first experiences with the Internet, being charged with developing a new European Internet Service Provider business called get2net.

It was in 1997 that Zennström met Janus Friis when, as part of his Tele2 Internet development role, Zennström was sent to Denmark to build an ISP business. In order to recruit a new team

29 The Guardian (London) - Final Edition, September 13, 2005
30 The Guardian (London) - Final Edition, September 13, 2005
31 http://www.skype.com/company/founders.html: Accessed March 6, 2006
32 http://www.skype.com/company/founders.html: Accessed March 6, 2006

he had advertised in the Copenhagen papers. Friis was one of the successful applicants.[33] Ten years younger than Zennström, the Dane had left school at 16.[34] Reportedly, he then spent some time on the Hippy Trail in India.[35] Prior to joining Tele2 he had worked at the help desk of CyberCity, one of Denmark's first ISPs.[36]

It was in Tele2 at this time that Zennström and Friis first experimented with VoIP. As Zennström later recalled:

> "When I was at Tele2 in 1997, we did trials with the first generation of VoIP and concluded the net wasn't good enough. We hoped that as broadband penetration improved and phone lines would be converted to DSL, it would allow us to use VoIP on a broader scale."[37]

However, Zennström and Friis decided that rather than working for someone else they wanted to be able to take their own initiative. They accordingly chose to leave Tele2.

Moving to Amsterdam the two ended up living in the same house, with Zennström turning the kitchen of his flat that he shared with his wife into an office and Friis taking up residence in the guest room.[38] In this makeshift centre of operations they tried to fine tune their strategy for exploiting the potential of the Internet. Various ideas, including a product review site, were considered and discounted.[39]

Finally a product was decided upon which derived from the experience they had had with Tele2's ISP business. Reportedly, Zennström had often been frustrated at the bandwidth limitations that made multimedia transferrals across the Atlantic problematic.[40] He realised that if the same content were stored locally (or even on customers' own networked computers) then things should run more smoothly. In other words he was visualising a product that would exploit the benefits of a peer-to-peer (P2P) network.

The idea was hardly original, with the concept of distributed computing having been around since the start of the Internet. Moreover, with Napster (the free music website) already exploiting the same Internet dynamics Zennström and Friis were not even the first to market. What the pair did have, though, was a tremendous drive to put a product in the market place quickly. Commenting upon this speed of the implementation of the basic idea, Zennström again draws upon his telecoms experience. In his words:

> "What I learned when working with Tele2 is that sometimes when you come in with a business plan, it's like, 'Why are you wasting your time writing that? Just go out and do it,' "[41]

In developing the actual P2P software Zennström once more made use of the Tele2 connection. In creating the Tele2 portal he had contacted a group of Estonian programmers

[33] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46
[34] Sunday Times (London), November 27, 2005
[35] Sunday Times (London), November 27, 2005
[36] http://www.skype.com/company/founders.html: Accessed March 6, 2006
[37] The Guardian (London) - Final Edition, July 14, 2005
[38] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46
[39] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46
[40] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46
[41] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46

who worked together under the name Bluemoon.[42] These programmers now worked in collaboration with Friis to come up with software than would transcend that used by Napster. The result was FastTrack, an innovative system which allowed the networked computers to negotiate among themselves to discover which were the most efficient. The so-called "supernodes" that were identified allowed the whole system to be supported by its users rather than external servers.[43]

This distinguished the system from Napster which had to add new servers as it expanded. Moreover, in the case of Napster these servers maintained a record of the files that were contained by its members' computers. The FastTrack system, on the other hand, kept no such record, allowing the operators to distance themselves from any illegal activities taking place on the network.

This issue of potentially dangerous records became all the more important in December 1999 when the Recording Industry Association of America (RIAA) filed a law suit against Napster.[44] This ultimately led to a court decision in July 2001, which effectively spelt the end of the line for Napster.[45] This same year Zennström and Friis launched their new product.

Suddenly the superior (and from the owner's view-point, less risky) FastTrack software had the file transfer market virtually to itself. As Fortune magazine put it "Their timing was impeccable".[46]

By this stage the means by which customers accessed the software was going under the name Kazaa (also written KaZaA and named by Zennström and Friis after the Sawaddee Ka restaurant in Amsterdam[47]). With Kazaa potentially charging a licence fee, the partners had the beginnings of a business model for exploiting the system.

Quickly the software was to establish itself as the most popular for file transfers (both legal and illegal) on the Internet. Indeed it was to distinguish itself as the world's most downloaded Internet software to date with more than 370 million downloads.[48]

In 2003 "Kazaa" was the top search term entered on Yahoo.[49] As of 2005 (by which time the company had been sold – see below) experts were stating that four out of every five online file-swaps were still being achieved using Kazaa.[50]

However, Kazaa soon ran into the same legal and proprietary problems that Napster had encountered, prompting Zennström and Friis to gradually distance themselves from its activities. Rather than give up they rapidly moved on to their next venture.

The application which allowed the partners to bounce back so quickly was the same VoIP idea that Zennström had ruled out as too premature a few years before. While the Internet bubble had well and truly burst by 2002, this had not stopped the rapid uptake of broadband

[42] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46
[43] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46
[44] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46
[45] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46
[46] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46
[47] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46
[48] http://www.skype.com/company/founders.html: Accessed March 6, 2006
[49] Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46
[50] The Guardian (London) - Final Edition, September 13, 2005

connections. By this point the necessary infrastructure was just about in place. This fundamental change in the nature of the Internet underpinned the counter-intuitive logic of launching a new business at “the nadir of the dotcom crash”.[51]

By this stage VoIP was beginning to take off, with a huge growth in the number of IP minutes between 1998 and 2002. This was the growing market that the business partners wanted to exploit. Expanding upon the reasons for now focussing on telecoms, Zennström later stated that:

> “It became apparent to us that telephony would be the killer application for P2P technology. When we started Kazaa the vision was P2P as a disruptive technology that enables new businesses. We realised voice would be a very, very good application because the internet had become, for many people, broadband. The capacity is good on the internet, that's not going to go away. Within a few years' time you will have wireless broadband.”[52]

By attacking the telephone business (including possibly the mobile sector) this could clearly prove to be a business with huge potential. Importantly, it was also one that would not repeat the copyright issues thrown up by Kazaa. Everyone, after all, can claim the copyright to their own voice and conversations.

In establishing Skype Zennström made use of the same Estonian programmers who had collaborated with Kazaa. This explains the existence of the Skype offices in Tallinn, Estonia. There were also reports of a private company called Skyper, based in Stockholm, that was responsible for distributing the product.[53]

While the Skype company itself was incorporated in Luxembourg, it set up its main base in London.[54] The London office was established in December 2003, with an initial staff of less than 12. Within weeks this number had grown to around 25.[55]

Crucially, on this occasion, Zennström was able to convince various **financial backers** of the logic behind the new business. **Key among these was Tim Draper, the US technology investor, best known for his original backing of Hot Mail.[56] His venture capital company <u>Draper Fisher Jurvetson</u> gave the new venture some much needed credibility (not least on the U.S. business scene). It also contributed around $10m to the new venture over the next couple of years**.[57]

Unlike some of his compatriots Tim Draper did not seemed phased by Zennström’s previous run in with the music industry. Indeed he seemed to see the experience as a strength. Speaking of the investment he stated that:

> “I think Niklas is an extraordinary guy. He has been through so much with his first deal and taken on an extraordinarily powerful industry, and he's going to do it again. This (is) going to be the next great company.”[58]

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51 The Daily Telegraph (London), January 08, 2005.
52 The Independent (London), September 3, 2005.
53 Business Week Online; January 6, 2004.
54 Business Week Online; September 19, 2005.
55 Business Week Online; January 6, 2004.
56 The Daily Telegraph (London), January 08, 2005.
57 Economist; September 17, 2005, Vol. 376 Issue 8444, p69-71.
58 Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46: brackets added.

Other venture capital groups to take an interest included European companies Index Ventures (started in 1992 and based in Geneva) and Mangrove Capital Partners (based in Luxembourg) as well as the long-established US venture capital firm, Bessemer Venture Partners.[59] Between them these contributed a further $10m to Skype's early funding needs.[60] Another early investor in Skype was Morten Lund, a maverick investor and CEO of antivirus company Bullguard.com[61] (a company which Janus Friis was involved in setting up[62]).

The official launch of Skype took place in late August 2003. By mid-November 2003 the software had been downloaded more than 1.5m times.[63] Thereafter the growth was exponential as word spread that good quality international calls could be accessed for free. In six months its software had been downloaded 8.9m times. This was a faster take-up rate than even Hotmail, the internet e-mail service, at its peak.[64] In September 2005, after only two years or so in existence, it was claimed that Skype had an "eye-popping" 54 million users.[65]

The Case of Baidu

Once again China offers a remarkable example, the case of Baidu, the Chinese-language search engine. As shown in Exhibit 21, Baidu beats Google by a long margin in the Chinese search market. This is no mean feat. With an estimated 111 million Chinese Internet users China is set to overtake the US as the world's largest Internet market in 2007.

Exhibit 21. Baidu's Share of the Chinese Search Market

COMPANY	CHINESE MARKET SHARE (%)
Baidu	56.6
Google	32.8
Yahoo	4.5

Source: Financial Times, June 24, 2006.

But do Baidu and China contradict the arguments we have just examined purporting to explain the dominance of US new Internet firms in Layer III? The answer to this important question, in fact, is no. The examples of Baidu and China confirm these arguments.

Why is this? The reason is that Baidu itself owes much of its existence to the same American institutions that have facilitated the dominance of US new Internet firms such as Google, Yahoo!, eBay and Amazon.

Consider the following. The two founders of Baidu are Robin Li and Eric Xu Yong (although Xu Yong has since left Baidu). Both did their first degrees at China's elite Peking University (sometimes called the Harvard of China). Li did a bachelors degree there in information management while Xu Yong did his in biology. Both went on to do post-graduate work in the US. Li received an MSc degree in computer science from the State University of New York in Buffalo. Xu Yong did a doctorate at Texas A&M University (funded by the Rockefeller

59 http://www.skype.com/company/founders.html: Accessed March 6, 2006.
60 The Daily Telegraph(London), January 08, 2005.
61 Fortune (Europe); February 9, 2004, Vol. 149 Issue 2, p38-46.
62 http://www.skype.com/company/founders.html: Accessed March 6, 2006.
63 Financial Times; Nov 19, 2003.
64 Financial Times; Mar 17, 2004.
65 Business Week Online; September 19, 2005.

Foundation) and went on to do post-doctoral work at the University of California, Berkeley. Both worked with American firms before going back to China.

Baidu (the name inspired by Song Dynasty poetry but literally meaning hundreds of times) was founded in 2000 and its search engine launched in September 2001. It was clearly modelled on Google with its revenue model based on advertising click-throughs, very similar to Google's. In this sense Baidu was very much Google-inspired.

But Baidu also depended on another key American institution, financial firms. In 2002 Baidu raised around $10 million from **Draper Fisher Jurvetson**, a California-based specialist private equity group. In 2004, seeking further funding, Baidu sold about 10% of its equity to a group of eight investors, led by Google. Google's investment amounted to $5 million.

In 2005 Baidu had its IPO on Nasdaq. This was underwritten by Goldman Sachs, LLC, and Credit Suisse First Boston. The IPO raised $109 million. Robin Li with his 25.8% share in the company ended IPO day with a paper value of almost $1 billion. **After the IPO the company's largest shareholder was its first venture capital provider, Draper Fisher Jurvetson, which held 28% of the equity**. In mid-2006 Google sold its 2.3% stake in Baidu after it launched its own search engine in China in competition with Baidu. This raised $33 million for Google, a good rate of return on its initial investment of $5 million.

As this story clearly shows, American institutions played a crucial role in the emergence of Baidu. While these institutions have usually created new Internet companies based in the US, Baidu's establishment in China was obviously the result of the rapidly-growing base of Chinese Internet users.

But what still needs to be explained is why Baidu has managed to compete so successfully against Google in China. Part of the answer has to do with the complexities of the Chinese language and its characters. These took longer for foreign companies like Google to master. At the same time it gave Baidu a head-start (as it gave to Chinese PC companies like Lenovo that made their initial entry into the Chinese PC market on the basis of their Chinese Academy of Science-developed expertise in Chinese language computer processing).

But the support of the Chinese authorities also seems to have played a role in Baidu's success. In 2002 they briefly blocked Google's activities in China, giving Baidu and other Chinese companies important visibility. Many believe that Baidu's greater willingness to conform to Chinese government Internet controls has also won the company official (and unofficial) support.

D. Conclusions

The aim of this section has been to give a flavour of the forces at work that have produced a US dominance particularly of the Internet-based content and applications layer. The outcome is all too evident in the global prominence of companies such as Google, Yahoo!, eBay and Amazon as well as the latest generation of so-called Web 2.0 companies (which include YouTube and MySpace, both of which were purchased in 2006 for substantial sums).

The significance of the Skype example – which has been discussed at some length here particularly because of its European origins – is that it does provide evidence of the possibility of globally successful Internet content and application providers emerging in

Europe. However, despite the encouragement that this example undoubtedly offers Europeans (and perhaps Asians), the paucity of such examples – and the significance of counter-examples such as the case of Jajah also examined here – does point to the superiority of the American System in this area. Two institutional aspects of this system have been highlighted here, namely financial institutions and universities. The important role played by American venture capital in Skype's early development was also emphasised. These two factors are an essential component of the 'cluster phenomenon' that has been amply analysed in the literature.

A more detailed analysis of all the factors that have influenced the success of US Internet-based content and applications companies such as these, as well as studies of the precise shortcomings that are negatively affecting the emergence of similar firms in Europe, await further research. In the meantime, however, it is possible to suggest policies that should be pursued within the European context in order to improve European performance in this important area. This is done in the following section.

VII POLICY IMPLICATIONS FOR EUROPE

What are the three main policy implications for Europe that follow from the present study of the global ICT Industry? This question is deal with in this section.

Policy Implication 1:

Europe needs to have a far more public debate about how to deal with the challenges from the US and Asia in ICTI

1. This study has highlighted some of the competitive challenges that face Europe in ICTI.

2. To put part of the challenge in a nutshell, in many parts of ICTI European companies are caught in a scissor-squeeze, pressurised by better-performing global leaders from above and by lower-cost but innovative Asian firms (increasingly Chinese) from below. The challenge to Europe is very much the same as that facing Korea. Although Korea has had some outstanding successes in attempting to meet this challenge – Samsung is the sung champion that emerges from the Korean story, as emphasised in the present study – its way forward between the US and Japan on the one hand and China on the other remains unclear. The Korean government and large Korean conglomerates are putting their faith in expanding their innovative capabilities (including longer term and basic research). But it is not entirely clear how this will provide a solution in the future.

3. Europe needs to be more self-reflective and more self-critical in generating honest appraisals of both the strengths and weaknesses in its status quo in ICTI and in debating the viable options that we have in dealing with these advantages and disadvantages. There are obvious difficulties that confront the European Commission and European governments were they to attempt to play this role. It is understandable that those who make policy often find it difficult to stand back and criticise it.

4. But in dealing with these difficulties it is possible to be inspired by the post-US election period from the end of 2006 regarding the situation in Iraq and Afghanistan. True, it is misleading to compare the fortunes of Europe in global ICTI markets with those of Western involvement in these two troublesome countries, and no attempt to do so will be made here. However, what may be emulated in a positive and constructive way is the newfound willingness in the US to stand back from the current situation, to ask difficult questions, and to seek strategies that may lead to improvements. It is suggested that a similar willingness in Europe to re-examine its position in the global ICT Industry may yield fruitful results.

Policy Implication 2:

Far more needs to be done by the European Commission, national governments, and independent analysts (including academics) to benchmark European activities and performance in ICTI (including both private and public activities) against global best-practice wherever it is to be found.

1. All too often European countries and companies are benchmarked against each other, ignoring best-practice that may exist in other parts of the global ICTI, usually in the US or

Asia (particularly Japan, Korea and Taiwan, although one suspects, increasingly in the future China which is rapidly catching up). This benchmarking is crucial so that Europeans are forced to confront, in the first instance, relative weaknesses and then, secondly, the difficult decisions that may have to be taken if European performance is to be improved.

2. Although this is a crude generalisation, and although there are many important exceptions, it is true to say that in large parts of Layer I European companies have been increasingly displaced by US and Asian competitors. This is particularly true in some areas of consumer electronics, computer hardware and packaged software, and semiconductors. Although European champions such as Siemens and Philips continue to find significant global markets in ICT products, and although their activities remain extremely important for Europe, it must be acknowledged that global competitiveness in many of their areas of activity has shifted to Asia and the US. It is important that we understand the forces that have enabled this to happen as well as the options that remain for European companies, policy-makers and institutions. Far better than attempting to 'rally the troops behind the European flag' we should be willing to face uncomfortable evidence of European shortcomings and to formulate viable strategies to create and build on European strengths.

3. It is worth noting the comparative global strengths that exist in Europe in the telecoms area. In the field of telecoms equipment this strength is highlighted by the examples of the acquisition of Lucent by Alcatel, and the relative global standing in mobile communications of leading firms like Nokia and Ericsson. There are also considerable strengths in Europe in the area of telecoms services (contained in Layer II). Some of these strengths have been facilitated by the fact that globalisation has had little impact on this sector. Although during the Telecoms Boom (1996-2000) some predicted that the global telecoms services market would be shared by a small handful of global operators this vision has failed to materialise. In almost all countries the bulk of telecoms services are still provided by the main national incumbents. Foreign players (including those who are incumbents in their own national markets) have been relegated to relatively minor positions (although there are some indications that in some smaller and developing countries this situation may be slowly changing). The fact remains that amongst Europe's telecoms network operators are those that are world class.

Policy Implication 3:

The European Commission, with the support of relevant stakeholders, should select three or four sites in the European Union to be designated as 'Internet Platform Innovation Sites'

1. As we have seen from this study, the US is overwhelmingly dominant in Layer III, particularly regarding 'New Internet Firms' that use the Internet as the main platform for their activities. The leaders in this area are companies like Google, Yahoo!, eBay, Amazon and more recent-comers such as MySpace (acquired by News Corp) and YouTube (acquired by Google).

2. The study of Skype undertaken in this paper, however, suggests that under the right conditions it is possible for New Internet Firms to be created in Europe (although the Skype case does raise questions about the longer term future of such companies in Europe, given that Skype was acquired by eBay).

3. The case of Jajah, also studied in this paper, suggests that financing institutions are crucial if Europe is to make significant headway with New Internet Firms. It is not only the conditions under which funding is made available that are important but also the networking capabilities that are provided by these funding institutions. These capabilities include contacts and connections and also access to the other resources (particularly ‘people resources’) that are important in establishing new businesses. From the Skype study we saw that Europe-based financing institutions played an important role (as did US institutions). It is necessary to ensure that such institutions play these roles effectively in Europe for Europe-based New Internet Firms (even though the institutions themselves do not necessarily have to be themselves European owned and controlled).

4. The examples of companies such as Google and Yahoo! suggest that universities are another key institution in the generation of New Internet Firms. Not only may they act as seedbeds for the entrepreneurs who may go on to found such firms, they also provide many of the subsequent employees of these firms. However, the ability of universities to encourage (at least not constrain) the kind of Internet-related research that may result in New Internet Firms should not be assumed. To begin with the university environment needs to accept as legitimate research the kind of work that can conceivably become an Internet-based innovation. There is a chance that this kind of research may conflict with the university’s RAE (research assessment exercise, as it is called in the UK) objectives. Other conditions also need to be conducive (for example, dissertation supervisors need to be flexible in the supervision rules they employ so as to give potential entrepreneurs the leeway they will need).

5. Although the details would have to be negotiated, at this stage I would suggest that an appropriate part of the European Commission invite bids from stakeholders to become one of three or four designated European Internet Platform Innovation Sites. A detailed design for these sites would have to be created. For example, specific kinds of stakeholders would need to be required (including the two referred to here, namely financial institutions and universities). Decisions would have to be taken regarding the criteria that would be used in judging the applications and the rules that will be used in allocating resources to the chosen sites (for example, will each be given resources or should they compete for resources from a common pool). Furthermore, it will be crucial that the design provide for an effective incentivisation of all concerned and that bureaucratic constraints are kept to an absolute minimum. It must be recognised from the outset that it is all too easy for such an initiative to become a white elephant.

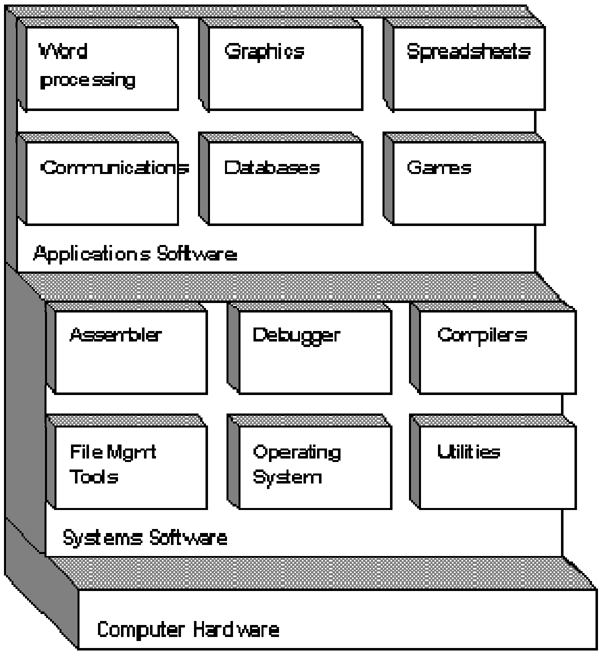
6. To conclude, the point here is simply to raise the need and idea for an initiative of this kind in Europe if significant headway is to be made in creating New Internet Firms in Europe. If there is sufficient support in principle the details will have to be thrashed out later.

APPENDIX 1: APPLICATIONS AND SERVICES

Applications and services may be defined in the following ways.

An *application* is a program or group of programs designed for end users. Software can be divided into two general classes: *systems software* and *applications software*. Systems software consists of low-level programs that interact with the computer at a very basic level. This includes operating systems, compilers, and utilities for managing computer resources.

In contrast, applications software (also called *end-user programs*) includes database programs, word processors, and spreadsheets. Figuratively speaking, applications software sits on top of systems software because it is unable to run without the operating system and system utilities.



Source: http://www.webopedia.com/TERM/A/application.html

A *service* is a provider/client interaction that creates and captures value.

For instance, most everyone is familiar with a typical doctor/patient interaction, in which both sides benefit from the transaction - referred to as "capturing value" in services parlance. The doctor receives a fee; the patient gets a health assessment and (it is hoped) recovers from the illness. This basic principle also underlies the work between a services provider and a corporation.

The provider and client coordinate their work (co-production) and in the process, both create and capture value (transformation). Services typically require assessment, during which provider and client come to understand one another's capabilities and goals. In the case of the doctor/patient interaction, the patient checks to see if the doctor is licensed and/or accredited and if he or she has the right specialty for the given illness. The doctor also conducts an assessment to determine the patient's medical history, gather information on the current ailment, and verify insurance or payment details. All of these steps factor into both sides capturing value from the services engagement. Obviously, for IT and business services, these assessments can be far more complex, but the processes and measurements are similar.

In business services, if the client does not install the new IT systems and train the necessary people in the reengineered process, the client firm will not receive the benefit of the service. Thus, the provider in many cases must monitor and assess the way the client is performing its responsibilities. And, of course, the client needs to determine that the provider is likewise applying satisfactory effort and quality controls in the performance of its tasks. These issues become of paramount importance in outsourcing deals, where a client may outsource a component of its business to a provider that is in a different country with different government regulations and national cultures.

Because services depend critically on the co-production relationship, it is very important that the service contract spell out mutual responsibilities and expectations. A significant percentage of service engagements (estimates range from 10-50%) do not meet the client's or provider's expectations, resulting in poor performance and low satisfaction, and, therefore, in less value created and captured than anticipated. This gap is an opportunity for services innovation that will improve returns, performance and satisfaction.

Here are some additional ways of thinking about services:

- A change in condition or state of an economic entity (or thing) caused by another (Hill, 1977)
- Intangible and perishable… created and used simultaneously (Sasser et al, 1978)
- Deed, act, or performance (Berry, 1980)
- Characterized by its nature (type of action and recipient), relationship with customer (type of delivery and relationship), decisions (customization and judgment), economics (demand and capacity), mode of delivery (customer location and nature of physical or virtual space) (Lovelock, 1983)
- All economic activity whose output is not physical product or construction (Brian et al, 1987)
- Deeds, processes, performances (Zeithaml & Bitner, 1996)
- An activity or series of activities… provided as solution to customer problems (Gronroos, 2000)
- A time-perishable, intangible experience performed for a customer acting in the role of co-producer (Fitzsimmons, 2001)

Source: http://www.research.ibm.com/ssme/services.shtml

APPENDIX 2: TOP ICT COMPANIES, 2006

Selected ICT Companies from the FT Top 500, 2006

Global rank 2006	Global rank 2005	Company	Country	Market value $m	Sector	Layer	Turnover $m	PER
3	3	Microsoft	US	281,170.80	S/ware & comp services	I	39,788.00	24.1
24	27	Cisco Systems	US	133,282.60	Tech H/ware & equip	I	24,801.00	24.6
26	13	IBM	US	129,256.20	S/ware & comp services	I	91,134.00	16.6
29	12	Vodafone	UK	125,672.50	Mobile telecoms	II	59,558.70	
33	15	Intel Corporation	US	114,483.10	Tech H/ware & equip	I	38,826.00	13.7
35	52	Samsung Electronics	South Korea	107,197.10	Tech H/ware & equip	I	58,435.90	12.8
37	45	AT&T	US	104,908.60	Fixed line telecoms	II	43,862.00	19
38	64	China Mobile Hong Kong	Hong Kong	104,203.30	Mobile telecoms	II	30,257.00	15.6
41	33	Verizon Communications	US	99,687.40	Fixed line telecoms	II	75,112.00	12.8
45	68	Hewlett-Packard	US	93,055.00	Tech H/ware & equip	I	86,696.00	39.6
46	54	Nokia	Finland	91,648.90	Tech H/ware & equip	I	41,470.80	20.5
57	75	Qualcomm	US	83,824.60	Tech H/ware & equip	I	5,673.00	38.6
58	56	Siemens	Germany	83,078.90	Electronic & elec. Equip.	I	91,508.40	22.4
60	279	Google	US	80,767.40	S/ware & comp services	III	6,138.60	73.4
64	38	Telefonica	Spain	77,124.10	Fixed line telecoms	II	45,947.80	14.2
69	50	NTT	Japan	75,504.00	Fixed line telecoms	II	92,030.30	11
73	44	Time Warner	US	74,179.00	Media	III	43,652.00	27.1
74	169	Sprint Nextel	US	73,639.90	Mobile telecoms	II	34,680.00	29.4
75	40	Deutsche Telekom	Germany	71,777.20	Fixed line telecoms	II	72,294.60	10.6
77	66	Oracle Corporation	US	70,668.10	S/ware & comp services	I	11,799.00	24.4
80	42	NTT DoCoMo	Japan	69,030.70	Mobile telecoms	II	41,260.10	11
81	36	Dell	US	68,656.10	Tech H/ware & equip	I	55,908.00	20
97	105	BellSouth	US	62,294.30	Fixed line telecoms	II	20,547.00	21.7
99	114	Ericsson	Sweden	61,252.80	Tech H/ware & equip	I	19,578.80	19.3
102	106	Canon	Japan	58,677.50	Tech H/ware & equip	I	31,973.30	17.9
104	49	France Telecom	France	58,419.50	Fixed line telecoms	II	59,479.00	8.1
108	148	Motorola	US	57,266.10	Tech H/ware & equip	I	36,843.00	12.4
110	48	Comcast	US	57,172.80	Media	II	22,255.00	62.3
114	74	Telecom Italia	Italy	55,011.10	Fixed line telecoms	II	36,289.20	14.1
115	100	eBay	US	54,862.00	General retailers	III	4,552.40	49.4

118	152	Matsushita	Japan	54,366.70	Leisure goods	I	74,211.40	
120	63	News Corporation	US	54,122.10	Media	III	23,859.00	24.1
121	79	Walt Disney	US	53,711.50	Media	III	31,944.00	22.3
124	159	Apple Computer	US	53,224.90	Tech H/ware & equip	I	13,931.00	38
127	123	Texas Instruments	US	51,963.00	Tech H/ware & equip	I	13,392.00	22.9
136	139	Taiwan Semiconductor Man	Taiwan	48,925.50	Tech H/ware & equip	I	8,234.40	17
143	145	Sony	Japan	46,265.70	Leisure goods	I	55,912.20	30.8
144	108	Yahoo!	US	45,739.90	S/ware & comp services	III	5,257.70	23.9
148	150	Philips Electronics	Netherlands	44,420.50	Leisure goods	I	36,866.60	12.2
167	163	Vivendi Universal	France	39,560.70	Media	III	23,632.40	10.6
181	154	Yahoo Japan	Japan	36,786.60	S/ware & comp services	III	1,003.10	30
215	161	BT Group	UK	32,150.70	Fixed line telecoms	II	32,495.30	10.3
302	275	KPN	Netherlands	24,213.20	Fixed line telecoms	II	14,172.90	14.1
308	274	Hitachi	Japan	23,778.70	Electronic & elec. Equip.	I	76,880.60	53.4
311	272	KDDI	Japan	23,600.10	Mobile telecoms	II	24,869.10	13.1
332	385	Alcatel	France	22,070.80	Tech H/ware & equip	I	15,931.60	18.5
355	399	Nintendo	Japan	20,964.00	Leisure goods	III	4,388.60	26.2
391	355	Sharp	Japan	19,627.10	Leisure goods	I	21,631.20	29.6
406	470	Toshiba	Japan	18,661.00	General industrials	I	49,704.60	47.6
414	476	Infosys Technologies	India	18,362.30	S/ware & comp services	I	1,598.00	43.4
415	390	Telenor Group	Norway	18,332.50	Mobile telecoms	II	10,496.20	17.4
420		Mitsubishi Electric	Japan	18,180.00	Industrial engineering	I	29,047.80	30
436	462	Sun Microsystems	US	17,754.90	Tech H/ware & equip	I	11,070.00	
449		Fujitsu	Japan	17,421.20	Tech H/ware & equip	I	40,563.00	64.1
460	461	Kyocera	Japan	16,895.00	Electronic & elec. Equip.	I	10,055.30	42.3
465	409	STMicroelectronics	France	16,767.80	Tech H/ware & equip	I	8,876.00	61.6
476	450	SK Telecom	South Korea	16,300.40	Mobile telecoms	II	10,334.10	7.7

Source: Calculated by author from *Financial Times* Top 500 Global Companies, 2006.

European Commission

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Title: The Evolving ICT Industry in Asia and the Implications for Europe
Author: Martin Fransman
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Technical Note

Abstract

The Information Society Unit at IPTS (European Commission) has been investigating the Information and Communication Technologies (ICT) sector and ICT R&D in Asia for several years. This research exercise led to a series of reports, written by experts from Europe from countries such as China, India and Taiwan.

This report covers several countries in Asia: namely, Japan, Korea, Taiwan and China. It describes their ICT sectors, within the framework of a Layer Model (FLM) developed by the author. It examines the industrial dynamics in the region and the role played by Asian countries in the global ICT industry. It then attempts to explain why these East Asian countries have come by the international competitiveness they currently enjoy. Finally, the report analyses the emergence of companies in the upper layer of the model and particularly in those parts that use the Internet as a platform, namely the new Internet companies which include such firms as Google, Yahoo!, eBay, Amazon and also Baidu, Jajah or Skype.