MAPPING THE EVOLVING TELECOMS INDUSTRY: THE USES AND SHORTCOMINGS OF THE LAYER MODEL

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Acknowledgements: The author would like to acknowledge helpful comments from Cristiano Antonelli, Jackie Krafft, and Klaus Rathe, none of whom bears responsibility for the contents of this paper.

This paper is to be published in *Telecoms Policy*.

INTRODUCTION

The aim of this paper is to examine both the uses and the shortcomings of what is referred to here as the layer model in attempting to analyse the changing Telecommunications Industry. It is shown that while the layer model has some significant drawbacks, and its use can obscure some crucial issues, it has a potentially important role to play in facilitating an understanding of this industry.

MAPS AND PURPOSES

A map is a tool. As with a tool, a map must have a purpose. But - still following the tool analogy - it is not necessarily the case that a map will be perfectly adapted to achieving its purpose. In order to judge the adequacy of the map-tool, it is necessary to clarify the purpose that it is intended to achieve.

The general purpose of the present exercise I take to be the development of a cognitive framework that will facilitate an understanding of 'the evolution of the structure of the Telecommunications (Telecoms) Industry'.[1] The attainment of this general purpose involves coming to grips with 'structure' and 'Telecoms Industry' and the processes through which they evolve over time.

The mapping track that will be followed in this paper involves the use of a layer model. Layer models have long been used by telecoms engineers and software developers as a cognitive framework for organising their work and knowledge interdependencies.[2] The aim in this paper will be to examine some of the uses and shortcomings of layer models when they are used as a tool to understand the evolving structure of the Telecoms Industry.

A LAYER MODEL

It is worth beginning with a concrete example of a layer model as applied to the Telecoms Industry in order to go on and examine the uses and shortcomings of this model. It is also worth noting that there is a fairly large degree of discretion regarding how many layers should be distinguished and precisely what should be included in each of these layers. Accordingly, the example presented here should not be thought of as *the* representative layer model of the Telecoms Industry. Generally, however, such layer models follow roughly a tripartite division, roughly summarised in Exhibit 1.

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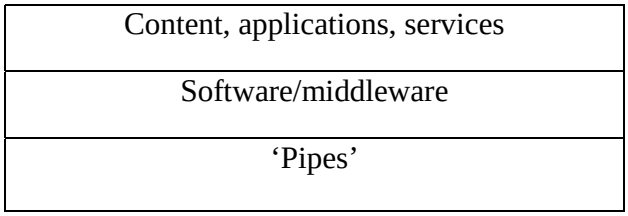
[1] This is a rough summary of the overall purpose outlined by the guest editor of *Telecommunications Policy* in his invitation to contributors (Vol. 25, Nos 8/9, September/October 2001, p. 647-649). More specific purposes, following from this general purpose, are also referred to in this outline.

[2] Janet Abbate (1999) in *Inventing the Internet*, for example, discusses the role of layer models in the development of computer software and the Internet (see, pp. 51-54, 214-216).

Exhibit 1. The General Layer Model



In Exhibit 2 an elaborated layer model is shown, distinguishing several more layers and adding some of the major companies that specialise in the various layers. In addition, this model also adds a consumer/consuming layer (for reasons that will be elaborated upon later).

Exhibit 2. A Layer Model of the Infocommunications Industry

LAYER	ACTIVITY	EXAMPLE COMPANIES
VI	*Customers/Consuming*	-
V	*Applications Layer, including contents packaging* (e.g. Web design, on-line information services, broadcasting services, e-commerce etc)	Bloombergs, Reuters, AOL-Time Warner, MSN, Newscorp, etc
IV	*Navigation & Middleware Layer* (e.g. browsers, portals, search engines, directory assistance, security, electronic payment, etc)	Yahoo, Netscape, Vizzavi, Genie, etc
III	*Connectivity Layer* (e.g. Internet access, Web hosting)	IAPs and ISPs
TCP/IP INTERFACE		
II	*Network Layer* (e.g. optical fiber network, mobile network, DSL local network, radio access network, Ethernet, frame relay, ISDN, ATM, etc)	AT&T, BT, NTT, WorldCom, Qwest, Colt, Energis, Vodafone, NTT DoCoMo etc
I	*Equipment & Software Layer* (e.g. switches, transmission equipment, base stations, routers, servers, CPE, billing software etc)	Nortel, Lucent, Cisco, Ericsson, Nokia, etc

Source: M. Fransman, http://www.TelecomVisions.com

Since Exhibit 2 is rather intuitively obvious (given the information that is provided in the exhibit) and since it seems fair to assume that the readership of this journal is reasonably familiar with the layer model in telecoms, no further description will be provided here.[3] Instead, attention will be focused on how useful a layer model is in understanding the evolving structure of the Telecoms Industry. See also J.Krafft, 'Vertical Structure of Industry and Competition: An analysis of the evolution of the info-communications industry', *Telecoms Policy*, forthcoming.

[3] The reader, however, may be referred to http://www.TelecomVisions.com where an elaboration of this layer model is provided. See in particular the Mapping Zone. The reader is also referred to M. Fransman, *Evolution of the Telecommunications Industry in the Internet Age*, downloadable in pdf format from the Articles Zone.

A LAYER MODEL ILLUMINATES

How useful is a layer model for this purpose? In this section it will be suggested that a layer model may be particularly useful in illuminating at least six issues that are important in developing an understanding of the evolving structure of the Telecoms Industry. These six issues are:

- Industry boundaries/subsectors
- Modularisation and hierarchy
- Industrial Organisation (including issues of vertical and horizontal specialisation and integration)
- The location of R&D
- Entry barriers
- The role of consumers/consuming

Industry boundaries/subsectors

In order to analyse the 'Telecoms Industry' the analyst's first problem is to delimit the area under investigation. To put it simply, how is the boundary to be drawn between what is to be included and what excluded? In short, how is 'the system' to be defined? More concretely, how does the 'Telecoms Industry' relate to the computer, software, and semiconductor industries; how does it relate to the Internet; etc?

One advantage of using a layer model such as that in Exhibit 2 is that it provides a way of developing at least a first approximation in answer to these questions. Depending on the purpose in hand (which is always necessary to keep firmly in mind), further elaborations may be developed.

Traditionally (that is roughly until the advent of data communications and the Internet), the 'Telecoms Industry' was thought of as encompassing Layers 1 and 2 in the layer model presented in Exhibit 2. However, the evolution of the Internet changed this decisively. The TCP/IP interface shown in Exhibit 2 not only provides an effective way of transferring data across disparate networks (much the same way that containerisation allows goods to pass more easily and at lower cost across different transport networks). In addition, the TCP/IP interface provides a platform on which several higher layers can be built in order to offer final consumers a range of services, content and applications (as shown in Exhibit 2).[4]

This new architecture, therefore, opened up new possibilities. A number of vigorous new entrants rapidly took advantage of these new opportunities, including well-known

[4] For a more detailed elaboration of the evolutionary processes that brought this new architecture about see M. Fransman, *Evolution of the Telecommunications Industry in the Internet Age*, downloadable in pdf format from the Articles Zone of http://www.TelecomVisions.com

examples such as Yahoo! and Netscape. However, telecoms companies – including both traditional incumbents like AT&T, BT and NTT as well as new entrant network operators in Layer 2 – also took advantage of the new openings in order to extend their activities, directly or by acquisition, into Layers 3, 4 and 5. At the same time they entered into new relationships, both competitive as well as cooperative, with companies that previously were considered to be involved in separate domains of activity. It is for this reason that many have felt increasingly uncomfortable with the term 'Telecoms Industry' to capture accurately the changed domain in which telecoms companies and others now operate. This is reflected in the use of the alternative term 'Infocommunications Industry' in Exhibit 2.

Modularisation

A layer model also draws attention to the modularised structure of the Infocommunications Industry. As we are now increasingly coming to appreciate, a modularised structure has properties that are particularly conducive to the division of knowledge and labour and the generation of innovation.[5] Within a modularised system, specialists in any module need have knowledge only of the rules for connecting their module to complementary others with little knowledge necessary of what goes on within the other modules. As Baldwin and Clark (2000) have shown, this has facilitated rapid innovation in the computer itself (as a modularised system) as well as in the Computer Industry (a modularised system of modularised systems). In the Infocommunications Industry modularisation has facilitated the entry of companies into all the layers by allowing them simply to focus on their own activities while ignoring the complementary activities that are a necessary condition for their entry. One example is the rapid entry of large numbers of ISPs (Internet service providers) into Layer 3 that in turn facilitated the rapid diffusion of the Internet.

Industrial Organisation

A layer model also facilitates the addressing of questions relating to industrial organisation: put simply, which company do what and why, and how are their activities co-ordinated? These questions include questions about vertical (between layers) and horizontal (within layers) specialisation and integration.

A layer model also invites comparison and contrast between industries. For example, Andy Grove (1996) of Intel has argued that the process of vertical specialisation has been particularly important in shaping the Computer Industry. He contrasts the vertical integration of the mainframe era, when companies such as IBM and DEC dominated, with the vertical specialisation that replaced it with different specialised firms involved in semiconductors, operating systems, peripherals, assembly, and sales.

[5] Recent elaborations on the importance of modularisation include Baldwin and Clark (2000) and Langlois and Robertson (1995).

Is the same process of vertical specialisation occurring in the Infocommunications Industry, or will vertical integration continue to be more durable in this industry? Which segments are being specialised in or integrated? Are there inter-country differences, for example is the US more vertically specialised than Europe and Japan?

From the perspective of the layer model, there appears to be a strong tendency towards both vertical and horizontal integration. For example, incumbents such as AT&T, BT, Deutsche Telekom, France Telecom, Telecom Italia, and NTT have attempted to extend their activities from Layer 2 into Layers 3, 4 and 5. In addition, they have also moved horizontally into mobile and data networks. In the mobile segment, especially in Europe, they have been making particularly strenuous efforts to capture the portal and browser space that in the US in the fixed Internet has been occupied by specialised new entrants such as Yahoo, Lycos, Excite, and Netscape.[6]

Location of R&D

The area of the Infocommunications Industry where vertical specialisation has been most pronounced is between Layer 1 (the equipment layer) and Layer 2 (the network layer). Telecoms equipment companies such as Lucent, Nortel, Ericsson, NEC and Fujitsu have not become network operators (even though there are significant instances where network construction and even in a few cases network operation have been outsourced to them by the network operators). Furthermore, although in the pre-liberalisation period the incumbents frequently played an important role in the research, development and design of telecoms equipment, by the 1990s they had almost completely exited from these activities, leaving them to the specialised equipment suppliers. (The notable case was AT&T that from the beginning vertically integrated telecoms equipment and network operation, but in the 1990s spun-off Lucent, its equipment business.)

I have been particularly interested in the re-location of R&D between Layers 1 and 2 that has accompanied this process of vertical specialisation, and the consequences that have followed. The re-location has been significant, as is shown in Exhibit 3.

[6] These activities are closely examined in M. Fransman, *Telecoms in the Internet Age* (forthcoming book).

Exhibit 3. Telecoms R&D, 1999

TELECOMS OPERATORS	1999 R&D SPEND ($'000)	SALES ($m)	R&D % SALES	R&D PER EMPLOYEE ($'000)
AT&T	550,000	62,391	0.9	2.3
BT	556,037	30,163	1.8	2.6
Deutsche Telecom	701,611	35,552	2.0	2.2
France Telecom	594,572	27,297	2.2	2.1
NTT	3,729,910	95,061	3.9	10.3
SPECIALIST TELECOMS SUPPLIERS				
Cisco	1,594,000	12,154	13.1	47.1
Ericsson	3,877,196	25,214	15.4	22.9
Fujitsu	3,859,723	51,224	7.5	12.7
Lucent	4,510,000	38,303	11.8	18.3
NEC	3,382,483	46,495	7.3	13.3
Nokia	2,030,662	19,817	10.2	22.8
Nortel	2,908,000	22,217	13.1	23.5
SECTORS				
Telecoms Operators			2.6	
Automobiles			4.2	
Beverages			2.2	
IT Hardware			7.9	
Media & Photography			4.2	
Personal Care			3.3	
Pharmaceuticals			12.8	
Software & IT Services			12.4	

Source**:** *Financial Times R&D Scoreboard*, FT Director, Sept. 19, 2000

Bearing in mind that in the pre-liberalisation era up to the mid-1980s the engine of innovative change in the Telecoms Industry was largely located in the famous central research laboratories of the monopolist incumbents – such as AT&T's Bell Labs, BT's Martlesham Laboratories, France Telecom's CNET, and NTT's Electrical Communications Laboratories – the re-location of R&D has been remarkable. By 1999,

as shown in Exhibit 3, the five top incumbents – AT&T, BT, Deutsche Telekom, France Telecom and NTT – on average allocated 2.6 percent of their sales to R&D. Particularly noteworthy is AT&T whose R&D-intensity was only 0.9 percent. At the other extreme, NTT was the only incumbent that protected its R&D, although here too R&D-intensity decreased. This left NTT with a significantly higher R&D per employee than the other incumbents.

One of the important points to emerge from Exhibit 3 is that the incumbent telecoms operators (AT&T, BT, Deutsche Telekom, France Telecom and NTT) – often regarded as part of the 'high-tech sector' – are on average less R&D-intensive (the usual definition of 'high-tech') than sectors not normally considered to be high-tech, such as personal care and automobiles. These telecoms operators were only slightly more R&D-intensive than the beverages industry!

In notable contrast, the telecoms equipment companies from Layer 1 are some four times more R&D-intensive (R&D as a proportion of sales) than the incumbent telecoms operators and in terms of R&D per employee the multiple rises to six or seven times. Furthermore, Exhibit 3 omits the new entrant telecoms operators – such as WorldCom, Qwest, Level 3, Global Crossing, Colt and Energis. These companies have elected to outsource practically all of their R&D to the few specialist equipment suppliers they have selected, making the contrast in this R&D respect between Layers 1 and 2 even starker.

Of course, it is necessary to be reminded that innovation is not to be equated with R&D and therefore that the distribution of innovation amongst the layers is not the same as the distribution of R&D. However, the re-location of R&D has had significant consequences for the evolving structure of the Infocommunications Industry, particularly for Layer 2.[7]

Entry Barriers

The existence of vertically specialised telecoms equipment suppliers in Layer 1 is a significant determinant of the barriers to entering Layer 2 (as well as the other layers, to the extent that entry into them depends on specialist equipment including software). The reason is that the equipment suppliers are willing to sell their equipment to whoever can pay (and sometimes, even when they cannot pay, the equipment vendors are willing to provide credit). As a result, new entrant network operators have been able to 'modularise' their equipment and network requirements, needing knowledge of how to *use* this equipment without requiring to know how to produce it. The result is that technological barriers to entry have fallen dramatically. The best indicator of lowered technological barriers to entry is the large number of new entrants into the different layers of the Infocommunications Industry (although significant entry has also depended on other barriers also being relatively low).

[7] The consequences of the re-location of R&D for the Telecoms Boom and Bust, 1996-2002 is analysed in detail in M. Fransman, *Telecoms in the Internet Age* (forthcoming book).

Rapid and substantial new entry, in turn, changes the structure of each of the layers, intensifying competition and therefore stimulating innovation. In Layer 2, for example, this has resulted in a significant fall in long-distance and international voice and data tariffs. From around 2000 this led to significant pressure on incumbent and new entrant telecoms operators alike and was an important contributor to the Telecoms Bust that emerged from March 2000.[8]

Consumers/Consuming

The layer model shown in Exhibit 2 parts company with conventional layer models particularly in its inclusion of a top layer that deals with consumers and consuming.[9] The main reason for this inclusion is to emphasise the importance of consumers and the processes of consuming as a relatively autonomous, but co-evolving, 'module'.[10]

However, the 'consumption module' is a module of a special kind. From a demand-pull perspective it is a module that drives the other modules. The interfaces between the consumption module and the other modules are different from the other modular interfaces that essentially facilitate interoperability. Furthermore, many of the companies involved in the other five layers (though not necessarily all of them) need to have in-depth knowledge of what does on inside the consumption module since it is here that questions such as what the consumer wants and how much the consumer is willing to pay are determined. The difficulties associated with developing a knowledge of the consumption module emerged in a stark way, for example, when mobile network operators and their financial backers had to construct the demand curve for future third-generation mobile services in order to calculate their maximum bids for auctioned 3G licenses. The sharp revision of their constructed demand curves over the period 2000-2001 provides an illustration of the co-evolution of this and the other modules.

A LAYER MODEL OBSCURES

It is important to be aware that although a layer model can provide illumination regarding the evolving structure of the Telecoms Industry, for example along the lines suggested in the last section, such a model can also obscure important issues. These include:

- Dynamics of change
- Modes of co-ordination
- Intra-layer diversity
- Interacting institutions
- The cognitive dimension

[8] For further details, see M. Fransman, *Telecoms in the Internet Age* (forthcoming book).

[9] Layer 6 refers specifically to final demand while intermediate demand occurs between and within the other layers.

[10] For an excellent set of articles on consumption and consuming see the special issue of the *Journal of Evolutionary Economics*, 11:1, 2001, Economic Growth – What Happens on the Demand Side?, edited by Ulrich Witt.

Dynamics of change

The layer model is essentially static in that it does not include processes of change and their causes (an all-too-common failing in many models). The layer model does suggest 'structure' (and how structure differs in the various layers). And this can be a useful starting point for an analysis of processes of change. However, an additional analytical framework is needed in order to tackle these processes of change. What this 'additional analytical framework' should consist of in order to understand the main processes of change in the Infocommunications Industry is itself a key question, but a highly complex one that requires further elaboration (that will, however, not be provided here).[11]

Modes of co-ordination

A further issue, of great importance in industrial organisation, that remains unclarified in the layer model relates to the modes of coordination that are used in the Infocommunications Industry.[12] These ways of coordinating activities are the 'cement' that holds the entire layered system together, giving it coherence as a system. Yet in the layer model it is implicitly assumed that appropriate modes of coordination are in place and work effectively without examining how they came to be and how they work.

While the market provides one of the most important and best understood modes of coordination, also significant are the many forms of non-market-mediated cooperation that exist in the different parts of the industry. Such forms of cooperation that have interested me exist in the relationship between network operators and specialist equipment suppliers, both before the liberalisation era that began in the mid-1980s and afterwards.[13] These forms of cooperation have played an important role in coordinating the activities undertaken in Layers 1 and 2 without which the process of vertical specialisation in these two layers could not have occurred. Related issues of coordination arise in the relationship between software developers and the users of their software.

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[11] In some of my own work I have suggested, following Schumpeter, the usefulness of trying to identify the "prime movers" of the Infocommunications Industry. However, far more work is needed in order to develop an appropriate analytical framework. See M. Fransman, (2001).

[12] An early insightful attempt to spell out some of the key issues is to be found in G.B. Richardson (1972).

[13] Some of this work involved comparing the different modes of coordination used by AT&T, BT and NTT and their suppliers of equipment up to the early 1990s (see Fransman, 1994a and b and 1999). More recently the same issues of coordination have emerged in the new relationships being forged between new entrants such as WorldCom, Qwest, Level 3, Colt and Energis and their specialist equipment suppliers. These relationships are analysed in M. Fransman, *Telecoms in the Internet Age* (forthcoming book).

Intra-layer diversity

Another possible shortcoming in the use of layer models arises from the fact that while they emphasise the differences between the various layers, they tend to neglect differences within layers. For example, in Layer 2, the network layer, there are fundamentally different forces at work in local access networks on the one hand and the rest of the core network on the other. These differences are evident in the difficulty that has been confronted in all countries in attempting to open local access markets to vigorous competition. There are also fundamental differences, for instance, between fixed networks and mobile networks that have to be grasped if the network layer is to be understood[14].

Interacting institutions

An important shortcoming in using layer models is that interacting institutions are left out of the picture and therefore have to be somehow added. Again this has important implications for the overall analytical framework that is to be used.

A particularly important set of institutions are involved in the regulation/legal/political processes that shape both the structure of the Infocommunications Industry and how it works. It is worth noting that these significant institutions are also often omitted from analyses of modularisation. However, although it is necessary that these institutional processes be incorporated in the overall analytical framework, the unavoidable tradeoff is the increasing complexity that results.

Another class of institutions that also have to be included are financial institutions. Even a cursory look at the Telecoms Boom and Bust, 1996-2002, provides sufficient evidence supporting the necessity to include financial institutions. But again, the cost, though unavoidable, is a significant increase in complexity.

Finally, the institutions involved in the innovation process must also be incorporated. These include, for example, standards setting bodies (that amongst other things help to settle the interconnection rules without which modularisation would not be possible) and universities (that have been particularly important in the development of the upper layers of the Infocommunications Industry).

The cognitive dimension

Also usually omitted from layer models (and modularisation models) is the cognitive dimension. It is often implicitly assumed in these models that 'what needs to be done' is obvious and follows automatically from the existing structure. But again, not much reflection is needed in order to dispel this assumption. Examples from the recent history

[14] For example, in view of the limitations in spectrum, and despite ways of making more intensive use of existing spectrum, competition may be inherently more limited in mobile than in fixed networks

of the Infocommunications Industry that suggest otherwise include the debacle over third generation mobile license auctioning, the collapse of the so-called dot-coms, and the speculative telecoms bubble that blew up and burst between 1997 and 2001. These examples suggest that the answer to the question 'what needs to be done' is anything but obvious, requiring that more analytical attention be devoted to the cognitive frameworks that guide human action and to their construction and change.[15]

CONCLUSION

This paper has been concerned with the uses and shortcomings of layer models as a tool for understanding the evolution of the structure of the Telecoms Industry. It has been suggested that layer models provide a potentially useful tool for addressing many of the relevant key issues that are necessary for such an understanding. However, the layer model tool also obscures other issues that are also essential and need to be brought into a more general analysis of the evolving structure of the Telecoms Industry. More specifically, the layer model is inherently static while the dynamic processes of change are of the essence. Nevertheless, it has been shown in this paper that the layer model can help to focus attention on a number of important issues. In short, while the layer model has a justifiable place in the toolkit of the analyst of the Telecoms Industry, it will have to be complemented with other analytical tools if the ultimate purpose is to be achieved.

[15] See, for example, Loasby (2000) and Witt (2000).

REFERENCES

Abbate, J. (1999) *Inventing the Internet*. Cambridge, Mass: MIT Press.

Baldwin, C.Y., and Clark, K.B. (2000) *Design Rules. Volume 1. The Power of Modularity*. Cambridge, Mass: MIT Press.

Fransman, M. (forthcoming) *Telecoms in the Internet Age*.

Fransman, M. (forthcoming) 'Evolution of the Telecoms Industry in the Internet Age', in *The International Handbook on the Economics of Telecommunications*. Edward Elgar.

Fransman, M. (2001) 'Analysing the Evolution of Industry: the Relevance of the Telecommunications Industry', *Economics of Innovation and New Technology*, 10:2-3, 109-140.

Fransman, M. (1999) *Visions of Innovation*. Oxford: Oxford University Press.

Fransman, M. (1995) *Japan's Computer and Communications Industry*. Oxford: Oxford University Press.

Fransman, M. (1994a) 'AT&T, BT and NTT: a comparison of vision, strategy, and competence', *Telecommunications Policy*, 18:2, 137-153.

Fransman, M. (1994b) 'AT&T, BT and NTT: The role of R&D', *Telecommunications Policy*, 18:4, 295-305.

Grove, A.S. (1996) *Only The Paranoid Survive*. New York: Doubleday.

Klepper, S., and Simons, K.L., 1997, 'Technological Extinctions Of Industrial Firms: An Inquiry Into Their Nature And Causes', *Industrial and Corporate Change*, 6:2, 379-460.

Klepper, S., 1997, 'Industry Life Cycles', *Industrial and Corporate Change*, 6:1, 145-183.

Krafft, J., forthcoming, 'Vertical Structure of Industry and Competition – An analysis of the evolution of the info-communications industry', *Telecommunications Policy*.

Langlois, N., and Robertson, P.L. (1995) *Firms, Markets And Economic Change*. Routledge: London.

Loasby, B.J. (2001) 'Cognition, imagination and institutions in demand creation', *Journal of Evolutionary Economics*, 11:1, 7-22.

Loasby, B.J. (2000) 'Decision Premises, Decision Cycles and Decomposition', *Industrial and Corporate Change*, 9:4, 709-732.

Metcalfe, J.S. (2001) 'Consumption, preferences, and the evolutionary agenda', *Journal of Evolutionary Economics*, 11:1, 37-58.

Richardson, G. B. (1972) 'The Organisation of Industry', *The Economic Journal*, 82:327, 883-896.

Schumpeter, J. A. (1966) *Capitalism, Socialism and Democracy*, London: Unwin.

TelecomVisions.com http://www.TelecomVisions.com

Witt, U. (2001) Economic Growth – What Happens on the Demand Side?, special issue of the *Journal of Evolutionary Economics*, 11:1.

Witt, U. (2000) 'Changing Cognitive Frames – Changing Organizational Forms: An Entrepreneurial Theory of Organizational Development', *Industrial and Corporate Change*, 9:4, 733-756.