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MANAGEMENT OF INFRASTRUCTURES – WHAT CAN THE INTERNET DEVELOPERS LEARN FROM THE HISTORY OF RAILWAYS?

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Abstract

Purpose The aim of this paper is to compare the railway and Internet revolutions. What do they have in common and what is different between them, considering the 150 years time difference in their occurrence. As time has passed, can the Internet developers learn something from the railway industry?

Fingings

The two industries have a lot of common. Both railways and the Internet represent national infrastructures that can not be managed just based on business management principles. As both have to do with traffic, either that of physical goods or of messages, the two industries seem to have a lot of common things in technical terms too, when one takes an abstract enough point of view. The main message is that on the long term, the railway revolution vanished and the industry turned to a low profit/interest field. The Internet might follow the same path.

Research limitations/implications

The paper at current form is based on literature review only. Its quality could be improved with a detailed empirical study. Other similar infrastructure-type industries could too be involved.

Practical implications

There are several things that could be improved in the management of Internet, but they are large-scale issues needing co-operation between many stakeholders of the Internet. Examples are those of avoiding digital divide and catering for the critical last mile connections, as well as managing the diversity of different standards.

Originality/Value

As far as the author knows this is the first paper in its kind comparing these two industries. The message is to perform more cross-industrial studies. Too little discussed is too the message of the paper that the Internet might turn into a low-interest business on the long run.

Keywords: Internet, Railways, History
Paper type: Conceptual paper

Introduction

Comparing the Railway and Internet industries might sound a little odd at first. They are symbols of totally different eras: railways symbolize the industrial revolution, whereas the Internet is at the heart of the information revolution. However, to delve a little deeper; both are concerned with communication and the transfer of items. Both involve conquering distance: railways in physical transportation, and Internet in the transportation of data (Cairncross 1997). The industries are substitutes for one another.

As we can not say that there is an established research area of comparing railways with the Internet and telecommunications in general, this article is polemical and hypothesis-formulating in nature, rather than presenting ready research results. It is purely conceptual in nature, but benefits from the author's keen interest in railways and their history over the last 3 decades. The research questions are: "Do the railway and Internet revolutions have something in common?" and "Can the Internet community learn anything from more than 150 years of Railway history?"

Work has been conducted in this field already. A great motivation for this article has been the work of (Coult 2001) on museums as corporate memories; this article contains an insightful introduction on railways as a record of social history. Concrete work on this history is documented in (Booth and Hopkin 1994), whose reason for conducting the study is also relevant here: "the (railway) collection covers a very wide range of social, economic and technical subjects and is of interest to a number of academic disciplines". In his seminal work on economics, Oliver E. Williamsson introduces the reader to the importance of railways as an economic agent that lower transaction costs (Williamson 1985).

Railways and the Internet both offer a network example for economists. The topic of network externalities has been identified as relevant for both industries (Koski 1999; Shapiro and Varian 1999; Kauffman, McAndrews et al. 2000; Schoder 2000). Network externalities are produced both at the supply and demand side (Schoder 2000). For example, current traditional knowledge in railway planning suggests that a part of the network is always unprofitable, but is needed in order to provide the main lines with traffic (Hooghiemstra, Knoon et al. 1999). Discussions like this have seldom occurred in the telecommunications industry.

Railways have been developed in line with societal needs. For example, in the USA, the boom days of railway building coincided with the great Gold Rush. In Europe, railways emerged in a period when iron foundry was required: coal and iron ore had to be transported to one single place for iron production. In the modern Internet economy similar metaphors can be observed (Frank 1996; Rosen and Howard 2000). Exploitation of natural resources, conquest of distant territories, and war or other tactical reasons have been major reasons to build railways. It is well known that the Internet has its roots in the military technology of ARPANET dating from 1969 (Lawton 1995).

Railways have been the midwife of many telecommunications innovations. Take the very key concept of synchronization. Before railways, time was not so important and countries did not have synchronized clocks. In the United States the railways led directly to the establishment of synchronized and ordered time zones. Telegraphs were first built alongside railways and were primarily used for the needs of the railway traffic; thus resulting in the birth of electric communication. Even punch cards have their origins in the railway industry. In the early days, trains were slow, crowded and stopped often. People had a tendency to try to and share the same tickets around. The railway industry decided to punch the tickets according to the characteristics of

the travellers: man/woman/, white/coloured, old/young etc., therefore the punch card was born long before Herman Hollerith.

Nowadays, railways form a backbone for many logistics applications and are an object of many logistics studies (Hooghiemstra, Knoon et al. 1999; Felici, Sujan et al. 2000). The problems encountered in the industry are huge, and major failures have been reported (Mitev 1996; Mitev 1996).

Technical similarities

Railways and the Internet are both world-wide networks, and whilst the units transferred through the networks are different, we can see analogies in the technical terminology and options. For example: bandwidth = gauge, packet size = train weight, used cabling = track weight, digitalization = electrification, mode of transportation: slow or fast traffic, routing problems, the list goes on. Here we point out some shared concepts, referring to similar issues in both industries. The list is far from exhaustive.

In the history of railways we can see a continuum from circuit-switched to packet-switched technology. In the early days, one track had to be reserved totally for one train. Waiting times grew as the available capacity became inadequate. However, multiplexing stepped in shortly afterwards, which allowed several trains to be run on the same track with the help of sophisticated signalling systems. The real revolution in efficiency came as a result of a radical change in approach: instead of managing trains, the industry began to manage individual wagons in the 1970s. The whole industry became logistically very complex, but at the same time very flexible and effective. Similarly we have seen telecommunications move from circuit-switched to packet-switched, with the TCP/IP protocol as the locomotive for the change. The right conception of a "packet" is a constant design parameter in telecommunications.

Or consider the crucial resource of "bandwidth" in modern telecommunications. Bandwidth problems are also common in railways, and get a very concrete form there. The number of tracks is limited, and because of shortcomings in traffic protocols, trains have to keep a certain distance from each other. Railways could also solve a part of the bandwidth problem with software solutions. However, hardware gives its limitations too. As in telecommunications cabling twisted pair is not coaxial cable is not optical cable, in the railway industry different rail weights give varying technical limitations to the used transfer speeds, in addition to switching technologies.

In telecommunications, packet switching is made more difficult because of varying packet size requirements and the fact that different modes of communication have to use the same channel (voice, data, TV-stream, etc). These can be compared directly with the rail industry, where heavy freight-rains, little local rains and fast large Inter-city trains have to use the same tracks and other parts of the infrastructure. Furthermore, speed and packet size requirements vary a lot, putting a heavy stress on traffic management software.

Both industries experience problems with standardization. This is exacerbated by the fact that railway infrastructure investments have a lifetime of maybe hundreds of years, whereas telecommunication infrastructure is notably shorter in life cycle. Perhaps the most severe problems are associated with gauges, electricity and coupling arrangements. Europe alone has three broad gauge standards and there are a multitude of narrow gauge railways. Similarly, trains use three

main electricity voltages in Europe. On top of these difficulties, different coupling arrangements hinder the universal application of rolling stock.

Finally, both industries have experienced internal revolutions in their form of transportation. Telecommunications has already won the battle of turning the industry from analogue to digital. Railways started very much earlier with electrification, but the process is still far from being completed.

Table 1 Technical concepts in the Internet and in railways – a comparison

- **Changing the mode of operation from circuit-switched to packet-switched**
- **Bandwidth – rail weight, switching technologies and traffic protocol arrangements**
- **Many modes of transportation, many speed and packet size requirements**
- **Standardization issues: gauge, electricity, coupling**
- **Internal revolution: digitalisation vs. electrification**

Societal issues in common

Governance structures were a major discussion topic in the railway revolution. Railway companies first grew to be huge giants with multiple tasks, both in the service and regulation domains. The same was true in the classical world of national PTT's. Only in the 1990s did more detailed roles begin to emerge: the regulator and service company roles were separated in both industries. Ownership, running and hiring capacity of basic infrastructure (track, cables, stations and switching equipment) all became the responsibility of separate organisations. We can also learn from the British experience, where separating the responsibility for railway traffic into too many entities created a number of problems (European Commission 2001).

In the railway industry train operators and governments sometimes have conflicting interests, as (Hooghiemstra, Knoon et al. 1999) have documented. Similar discussions are evident in the telecommunications industry. Both industries are considered to be environmentally-friendly technologies that deserve government support, particularly rail where the alternative of private cars is particularly polluting. Intertwined with the environmental issue is that of providing a universal service. Railways have a strong regional and social importance, and their infrastructure should be extended to distant places. However, this is very expensive, and traffic loads are not always enough to make the investments worthwhile. Needless to say, the same topic is discussed frequently in telecommunications literature (Mueller and Schement 1996; Bar and Riis 2000; Gillett 2000; Goggin and Newell 2000; Lievrouw 2000; Preston and Flynn 2000; Sawhney 2000; Schechter 2000; Schement and Forbes 2000; Scogerbøø and Storsul 2000).

The business feasibility of railways has fluctuated. In the beginning, railway stock was in great demand. Pioneering companies were successful to varying degrees, but now in the third millennium the traditional knowledge is that full-scale national railway systems are hardly profitable: they only survive through public support. Even at the heart of capitalism, the USA, the government has taken over the running of the railways. Governments have to find intelligent and complicated solutions and partnerships with private industry in order to finance the necessary investment (Roll and Verbeke 1998). On the other hand, it is accepted that they are a key cornerstone of modern society, which cannot be assessed solely on business logic. On the Internet

side we are experienced a period of inflated business expectations. The lesson here might be that the Internet will be reduced to an unattractive business infrastructure in the future.

The work and professional structures of railways and the Internet have many similarities. Both revolutions produced groups of elite professionals at first, who earned well, developed their own professional language and traditions, and owned professional practices (Wilner 1998). Several lessons can be drawn from this: with railways the professional structure become too complicated and rigid and contributed in part to the decline of the industry. Professional interests came first and customer needs lagged too far behind. This is not far from the situation of Internet designers at the moment.

Last but not least, we should consider the regional effects of networks. It is well known that railways opened up new territories for habitation, but contributed to centralization and the birth of even bigger cities over the longer term. Some communities became deserted as they could not get the benefits of railways. In a similar way, the Internet is going to make structural changes to regions: in principle it should allow for the distribution of activities, but it seems in the long run to be one more device that will foster further urbanization. Whereas economic activities concentrate at big railway junctions and stations, the telecommunications industry has the similar concept of 'teleport', i.e. a strong communication centre (Ruzic 1989).

Both railways and the Internet are dependent on complementary goods and services (Ruzic 1989), another example of indirect network effects (Schoder 2000). For the Internet, critical issues are for example an establishment of payment structures at the macro and micro level, and security services, for example through trusted third party arrangements (Zucker 1986; Salnoske 1998). A current development in railways is that major stations will have to become centres for shopping and other leisure activities, providing a multitude of service offerings. This concept is not far away from that of "portals" in the Internet economy.

For the railways, security when travelling has always been important. This has anyway not always been the case. In the early days, a speed of some 35 km/h was considered to be harmful to health. In some countries, men with red flag had to run in front of trains to clear the tracks ahead. A major problem was exploding boilers; this might still be the case if strict security standards had not been implemented. Today, Internet security is a common topic of discussion, and security standards are being developed. Nevertheless, according to some research findings some 85% of Americans are still reluctant to engage in electronic commerce for security reasons. Hardly anyone is scared of trains today, suggesting that people will overcome their fear of the Internet

Railways require frequent maintenance work and this can be very expensive. Marginal gains from railway traffic are so low in many countries that the necessary capital for track, other infrastructure and rolling stock maintenance is hard to find. In particular, electrification increased pressure on maintenance activities. The telecommunications industry also suffers from high maintenance costs. In many traffic areas income is too low to maintain the networks. For example, in the whole Europe, the network of public phones has been stripped down and Automatic Teller Machines are facing the same fate. In telecommunications, digitalisation is putting pressure on the maintenance, in the same way was as electrification did for the railways. Neither industry has been able to tap into all of the benefits of new technology.

The Digital Divide is also present in both railways and the Internet. The UK alone has more track than the whole continent of Africa. In New York there are more Internet connections than in the whole of Africa. The lesson here is that the Digital Divide might not be eliminated even after 150

years. Further, we have seen that just building the network is not enough – maintenance, usage skills and social acceptance are even more important. Railway facilities are not used and operated unless they are supported and accepted socially and economically by their users, and the same is true for telecommunications (Strover 2000). Developing counties are full of examples of deserted Railway lines that the white man once built.

The issue of the critical last mile is more than lively in Telecommunications (Strover 2000; Organization for Economic Cooperation and Development 2001). Failure to deliver high-speed, easy to use interfaces to the Internet is a threat for the whole Telecommunications industry (Farrell and Saloner 1992). The same was painfully seen in the Railway industry. Failure to build tracks to small communities and to individual production plants etc. caused Railway to lose market share to trucks. Simply, cheap and uncomplicated enough technologies were not found, and maybe price politics had a stake too. In Telecommunications, we can now see how a new generation of wireless network access technologies (Varshney and Vetter 2000) is going to take over the place of cable.

What do we have to learn?

By now we hope the reader is aware that the history of railways can provide plenty of valuable lessons to the Internet generation.

Principle amongst these is that they cannot live as a separated technical entity without being integrated into the rest of society. Where this integration has taken place railways still bloom today. The same must be true for Internet: it must become a part of society's normal day-to-day activities: it cannot survive as some kind of separate technology and on the basis of hype. Nowadays, railways are part of a total traffic infrastructure scheme, where multiple modes of transportation all support each other (European Commission 2001). In telecommunications, interoperability and network gateways are approaching a crucial juncture regarding digital television services and the Internet.

Keeping up service levels is of crucial importance for both industries. If railways are not able to meet the speed, punctuality and convenience requirements of passengers, they will turn to other modes of transport. Structural changes towards railways can also be identified: in many middle-distance routes, new fast trains are eroding the market share of airlines. Within telecommunications, outdated and limited technologies are constantly giving way to better solutions: take for example the demise of telex or EDI and their replacement with Web-based solutions.

Standardization seems to be a key building block for any network. The railway industry has suffered a lot from the lack of compatible standards, the result of industry and national politics, rather than technical superiority reason. Unfortunately, the telecommunications industry has not learn anything in this respect.

Some global mistakes are about to be repeated in the telecommunication industry. Railways could have been a key tool for industrializing and helping poorer countries, but unfortunately the new technology never reached them. Telecommunications is about to make the same mistake. In both industries the concept of network is crucial: delivering a single phone, computer or locomotive is not enough. The crucial issue is to organize and maintain a working network, which requires a lot of education and training. The social aspect of innovations (Arnbak 1988; Introna, Cushman et al. 2000) must be taken into a closer discussion.

Conclusions

Our paper has shown that railways and telecommunications (currently the Internet) have many things in common. Railways led to many knock-on innovations in information technology. Currently, both industries are benefiting from the established and emerging concepts of network economics. Both are intense areas of logistics and operational research studies.

Railways have had their ups and downs, but they have survived. Telecommunications too will have ups and downs, but it will survive. The need for transportation and communication is always there. However, it would be foolish to think that some technologies, say WWW or GSM, will be around forever. The railway community has seen technologies come and go: take semaphores, steam engines or the famous German "Zeppelin". The same will happen in telecommunications.

Both railways and telecommunications have similar technological problems and solutions, if we allow for a little bit of abstraction and interpretation. Mutual learning could be intensified in these areas.

Finally, both railways and telecommunications form a key infrastructure and have social, economic and environmental implications. Their governance structures are of key importance: history has shown that total privatisation of the railways does not lead to success and good service, although the telecommunications industry has not yet considered this form of ownership. As economics assert, no industry can on the long run keep up profits above the average. The railway industry has already seen this and telecommunications may have to face it in the future.

The railways have been a popular topic of studies for industrial history. Telecommunications has already been the subject of a number of insightful documents that have tried to establish a historical perspective (Saunders, Warford et al. 1994; Holzmann and Pehrson 1995; Cairncross 1997). Unfortunately, in both areas the discussion has often limited itself just to technical details, or to current business hype as in the case of Internet and especially electronic commerce. What we seem to be lacking are works of multiple angles of study, and especially works that compare these two actually very similar industries. We hope this paper has been a modest addition to this work.

Implications for future research and practice

Industry history is not an untapped area. Both railways and the Internet have been studied in detail, along with many other industries. However, all too seldom do we see cross-industrial studies, comparing one or more industries. Yet they could be very instructive. For example, the author of this is currently working on that the topic of electronic prescriptions: they seem to be hard to implement in any country. Yet it appears to be easy to keep track of personal finances in electronic form in the banking industry. It therefore seems strange that it is almost impossible to keep track of our medicines in electronic form in the medicine and pharmacy industry.

This article is based on descriptive conceptual work from a historical long-term perspective, rather than detailed empirical study. However, it would be of interest to perform empirical studies on the subject. One subject could be railway companies. In addition to the core railway business, many of them run additional Internet-based services for their customers, and often use the track beds for

delivering telecommunications channelling services. Such companies should have a deep understanding of all of these business environments and their differences.

One issue we did not take up in this article is that railways and the Internet are also competitors. They both lower transaction costs in their own way, and support each other. For example, electronic commerce would not be possible without efficient physical distribution, and physical transportation would not function without efficient communications. Working and communicating in virtual environments can be a substitute for personal meetings and the travelling associated with them, and in many cases electronic distribution can substitute physical distribution. Any analysis of the relationship between the industries should and could be extended with this joint competition and cooperation perspective.

If we talk about national infrastructures, railways are just one example. They are a real business with profit-making possibilities. Still more profound lessons could be learnt from infrastructure industries such as water or other utilities, where the starting point seems to be that the services must be provided to society, even when there is no business case for doing so, just an endless burden of maintaining unprofitable infrastructure. The energy industry, especially electricity and its distribution, would be an interesting case for comparison.

For practitioners, the message of this article is to look beyond the boundaries of your own industry. Experiences from other industries, which might be ahead in the industry life cycle, might turn out to be invaluable. This article also calls for taking a long-term perspective when taking business decisions, something that is too often forgotten or neglected in the current economy of producing quarterly results. This is especially true in industries that provide basic infrastructures that should be operating for many decades to come, such as telecommunication networks or railways.

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