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A research proposal

Roman Rudel, Istituto di Ricerche Economiche

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Roman Rudel
Istituto di Ricerche Economiche
Università della Svizzera Italiana
6900 Lugano

Phone: 091 912 46 67
Fax: 091 912 46 62
eMail: roman.rudel@lu.unisi.ch

Abstract

The transformation of the present haulage industry to a more sustainable system is a major challenge and a high priority in the political agenda. In the terrestrial freight market high hopes rely on the intermodal rail-road transport. However, intermodal transport is used for a rather small market segment of concentrated freight flows over long distances. This intermodal transport is based on the dominant technological and organisation paradigm of long trains and large transshipment facilities. Our main argument is that only radical innovations have the potential to achieve a shift to a more sustainable system. In recent years different ideas for a more flexible technology emerged and the Cargosprinter is likely to become a key element of a new technological paradigm for intermodal services over short and medium distances on the railway. In order to offer more flexible services and to penetrate the large LCL market segment further elements such as a small container and smart organisational solutions are necessary as well. The project aims at understanding the barriers to this kind of innovations and at proposing a framework, within which promising innovation can be tested under real market conditions.

Keywords

Transport Technology, Innovation, Niche Management, Swiss Transport Research Conference – STRC 2001 – Monte Verità

1. Introduction

1.1 Problemsetting

The ongoing economic globalization process and the present lifestyle depend highly on an efficient freight transportation system. The associated and unprecedented growth of freight transported by road is having tremendous environmental impacts. The public debate is regularly focused on various aspects of the problems caused by freight transport. Several studies at the national and international level highlighted the considerable external costs of transportation activities. Until now the policy strategies to internalize external costs regularly failed.

In Switzerland, the shift of freight transport from road to rail has gained high priority and the present transportation policy is based on two major instruments, which should help to reduce the environmental impact of freight transport. The first instrument is the construction of a new transalpine railway infrastructure and the second the heavy truck toll. Both instruments are supposed to shift freight transport from the road to the railway. In particular, the market-based instrument of the heavy truck toll is expected to change the modal split in a most efficient way in favour of railway and especially intermodal freight transport.

In our opinion the ongoing policy debate has neglected technical innovations and their potential to contribute to a transformation of the road dominated haul industry on one hand. On the other, technical innovations have been confined to the sphere of engineering and the emergence and diffusion of technical innovations are considered as a purely technical question. According to the prevailing opinion technologies emerge due to their superior technical characteristics and virtually all models of technical innovation, treat technical change as a process that can be predicted and planned in advance (Gübler, 1990). Engineers ignore the fundamental uncertainty that surrounds any effort to make a significant move in technology (Nelson and Winter 1983).

We therefore argue that a more comprehensive framework to analyse the potential of technical innovations has to be adopted. In the present study we refer essentially to evolutionary economics and the theory of social shaping of technology. Evolutionary economics basically understands technological change as the outcome of a process of selection and variations. Technology and preferences are treated as part of the market process. Dosi (Dosi, 1982) who

considers a given constellation of technological, organisational and institutional elements as a technological paradigm, has developed a similar view. With this concept he tries to describe and explain technological innovations along a path or trajectory (path dependency), which is characterized by continuous changes (incremental) and discontinuities (radical innovations). The theory of social shaping of technologies (Bijker, Hughes and Pinch, 1987) mainly focuses on the social and cultural embeddedness of technical innovations. Technologies are not necessarily evaluated on their intrinsic technological properties but have essentially to fit to social and cultural preferences, expectations and lifestyles. It also underlines the fundamental role of social networks in the development and diffusion of new technologies. Both theories stress the shortcomings of the dominant neo-classical assumption of isolated individuals maximizing their utility when it comes to explain technological innovations.

1.2 Goals

Theoretical level: To contribute to the understanding of innovations in the transport sector. The study aims to build up a comprehensive theoretical framework to analyse and understand technological innovations relating to evolutionary economics and the theory of social shaping of technologies. A major argument is that technological innovations are not necessarily emerging due to their technological superiority with respect of existing technologies but that they depend on a number of surrounding conditions (selection environment). New technologies are also confronted to manifold barriers and difficulties, which are created by the existing and dominant technological paradigm. Dominant technologies are powerful means to eliminate alternatives and promising innovation. Dominant technological paradigms are often challenged by outsider initiatives and their breakthrough depends on social learning processes, which shall constitute the core concept of our framework. This also requires reconsidering of the role of policy in transportation and the strategy to support promising innovations with the potential to substantially transform the freight industry.

Empirical level: The empirical part of the project is focused on the test site where the technological and economic feasibility of a flexible train system with small containers has to be demonstrated. The focus is on the mutual learning process of the actors involved in the transport chain and the opportunities to integrate the technological innovations. A major argument is that the adoption of technical innovations such as small containers on a flexible train requires a series of reorganisations and adaptations in the logistic chain. It has to be observed how the different actors overcome uncertainties and barriers and how the innovation fits into the needs.

2. The dominant intermodal transportation system

Although an innovation such as a flexible train system essentially competes with road transport is a major obstacle is constituted by the dominant paradigm in railway transport. In order to understand the difficulties to overcome the present understanding of freight transport on the railway and the barriers to be overcome we briefly describe the main elements of the dominant production system, which has grown over and successfully been operated during over a century.

2.1 Key elements

In the following chapter we refer to a Bukold (1996), who has analysed the transformation of different systems of freight transport due to technological, organisational and political factors. The core of any transportation system is made up of at least three elements:

- Technological elements: Locomotive, loading units, wagons, railway, transhipment technologies or terminals
- Organisational elements: organisational functions of the different segments of the freight transport (pre- and endhaulage, intermodal transport chain etc.), schedules, slot management, slot attribution, priority attribution.
- Institutional elements: market regulation, financial aspects, standardisation, norms, labour regulations etc.

The dominant regime or paradigm of railway freight transp

ort is a specific combination or constellation of the above elements. The constitutive properties of the present production paradigm are (very) powerful locomotives, long trains, and large shunting areas for traditional and dedicated terminals for intermodal transport. The market targets of this production system are large volumes (low value goods) to be transported over long distances. This production system typically reflects the principles of mass-production in the realm of transportation based on economies of scale. These trains require considerable capacities on the railway network and are generally run on the basis of fixed schedules. The success of this paradigm goes back to the period, when the predominant freight volumes were constituted by heavy and bulky raw materials.

This paradigm includes highly specialized know-how and expertise reaching from the production of locomotives to the design of schedules. This knowledge has proved to be very resistant to innovations and is concentrated in a few (mainly monopolistic) enterprises. Innovation such as the flexible train-systems are counter to the shared understanding embodied in the dominant paradigm. This is a major reason, why radical innovations can hardly be conceived within the railway companies.

2.2 Policy approach

In our view the present paradigm has been supported by the transport policy as well. It would be worthwhile to analyse the narrow relationship between railway companies on one hand and the policy experts (administration) on the other. In the context of this proposal the attention is drawn to the two dominant policy instruments in Switzerland. These instruments clearly reflect the idea and understanding that the railway can only compete in the long distance market segment and that a shift from road to rail can be achieved by means of a change in the relative prices. In fact, the transport policy has focused on the long distance traffic, mainly across the Alps. New railway infrastructures should help to regain competitiveness in this market segment. And finally the policy instruments of the road toll (LSVA) reflects the view that the optimal demand level (volume of road traffic) can be reached by setting a certain price level or price differential between road and railway:

- New transalpine railway infrastructure: A first proposal for a base tunnel dates back to the 1970s and based on a conventional technology approach. According to this approach a new offer of an infrastructural project is basically considered sufficient to guarantee its success. In the meantime the conditions in the transalpine freight market have changed considerably, but the assumptions for realisation were not modified. The initiative for the protection of the Alps gave new arguments to construct this monumental infrastructure and is also in the vein of the dominant technological paradigm. The aim of the initiative, accepted by a popular vote in 1994, was a total banning of the freight traffic transiting Switzerland from border to border across the Alps. However, this initiative caused a conflict between Switzerland and the EU and especially in the neighbouring countries. The common argument was that the measure was discriminatory and favoured the Swiss transport sector. Switzerland accepted this argument and the general ban were transformed in a so-called market-oriented policy instrument.

- The second pillar of the Swiss transport policy is the road toll introduced at the beginning of the year 2001. The road toll is designed to compensate the abolition of the 28-ton limit and to fulfil the requirements of the initiative for the protection of the Alps. The road toll should avoid a "traffic collapse" in the Alps, which had been prospected due to a substantial increase in the heavy freight transport on the road.

> The last official forecasts are confident in achieving these goals and the increase of freight traffic across the Alps is supposed to be small. However, it is possible that until the opening of the first base tunnel across the Lötschberg the freight traffic will increase considerably.

In the context of our research project the New transalpine railway infrastructure and the road toll are both to be considered policy measures triggered to change the modal split in the long distance market segments. In this segment railway should offer a valuable alternative to the road haulage (break-even between the distance of 400-500 km). In particular, high hopes rely on the intermodal freight transport and the rolling highway (piggyback). However, the increase of intemodal freight transport, even over long distances, depends on its capacity to penetrate new market segments, such as the LCL (less than container load) segment. This requires to drastically reduce the time of consolidation and the transport from the logistic platforms to the intermodal terminal. Unless the intermodal transport chain is much slower than the truck, even high road tolls on the Swiss leg are unlikely to substantially modify the present modal split (Rossera and Rudel, 1999).

Therefore, the main argument of this research project is to open up this narrow view, for the simple reason that this type of policy only supports the dominant transport paradigm on the railway as well as on the road. Furthermore it is worthwhile to finally throw light on the black spot regarding the problems of the freight transport in the short and medium distance segment. In particular we want to address the problem of innovations in the railway freight transport and to explore the opportunities linked to a different or alternative development path, which questions the fundamental elements of the dominant paradigm.

3. The evolution of the freight transportation market and the success of road haulage

The trends in transportation in Europe and Switzerland during the last decades can be characterized by a sharp increase in volume of goods carried and a very strong preference for road transport even in the long haul market segment (Thalmann, 2000). The REDEFINE (1999) research project clearly revealed that the growth rate of the volume of transported goods could not be explained by economic growth alone. Instead, logistic factors seem to play a more fundamental role in freight transport. Transport flows are more and more integrated in complex production schemes with very high requirements in the delivery.

Table 1 Evolution of transportation performance in Switzerland

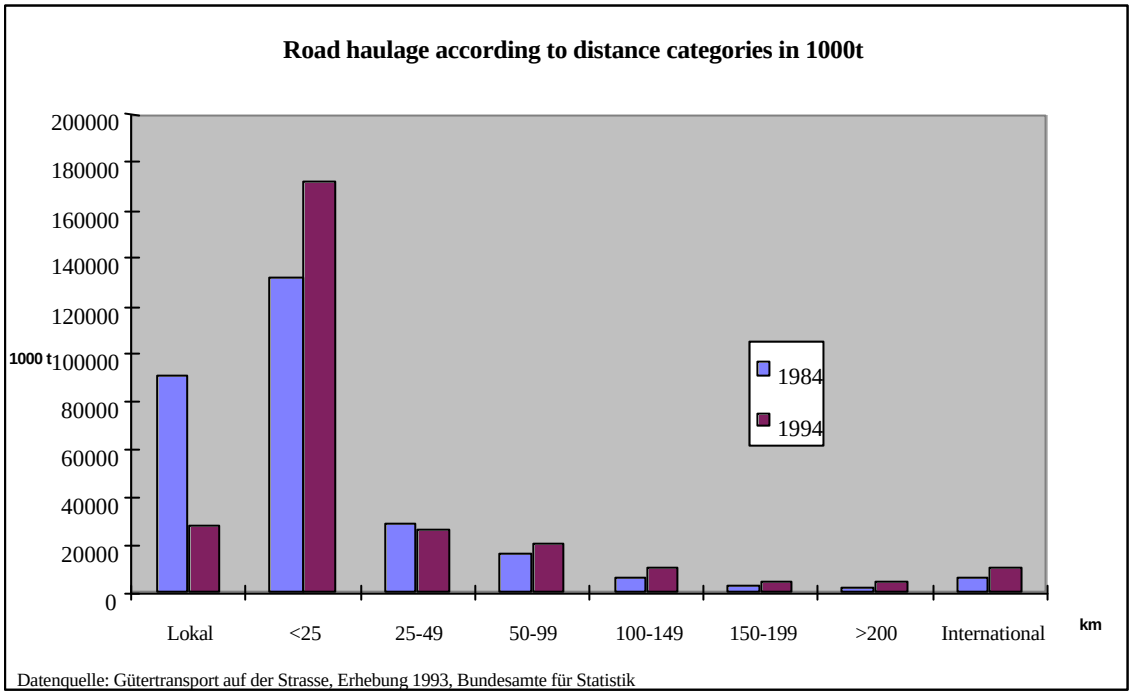
Year	Freight traffic (in mio tonkm)	
	Rail	Road
1960	4315	2152
1970	6983	4846
1980	7799	7287
1990	8862	10464
1993	7883	12456
1994	8648	13009
1995	8686	12868
1996	7907	13451
1997	8688	14236

Source: Swiss Federal Statistical Office, 2000, Neuchâtel.

The pattern of the above table, reflecting the tremendous increase and success in road transport is quite familiar. Different factors led to this result, which can be reassumed by some keywords such as the structural change of the production system, requiring less and less heavy bulk, new organisational principles such as just-in-time or lean organisations. Moreover several weaknesses in the conventional railway and intermodal freight transport - such as failing standards in service quality, lack of intermodal information systems, development of

adapted and standardized load units - have contributed to the success of road transport. The heavy truck offers a flexible door-to-door service has best fitted to the new conditions in the transport market.

Furthermore an additional aspect, we would like to draw the attention to, have favoured the diffusion road haulage. It is best represented in the following figure.



Datenquelle: Gütertransport auf der Strasse, Erhebung 1993, Bundesamte für Statistik

The above figure indicates an increase between 1984 and 1994 in all distance categories but the one of local transport. Despite of the huge freight volume on short and medium distances the present transport policy is almost exclusively focused on the category over 200 km, as has been argued in the precedent paragraph.

The same applies to railway companies and their strategies. In a period of restructuring of the railway sector, railway companies tend to emphasize their "corridor strategy" and the development of long trains and huge terminal or shunting infrastructures. Their aim is to bundle transport flows on a few corridors and large terminals, where they can yield economies of scales. This corresponds to abandonment of a dense network and to dangerously reduce the feeder services. The above illustrated policy approach focuses on the this rather small market segment.

Freight transport in the distance categories under 200 km has, according to the generally shared understanding, no alternative to the road transport. This argument is correct as long as the present and dominant production paradigm is given for granted and no technological, organisational and institutional alternatives are taken into account. In the last few years different ideas and concepts for are more flexible transportation systems on the railway emerged.

4. Radical innovation in the railway transportation industry

4.1 Technical innovations to increase flexibility

The prevailing success of road transport is due to the great flexibility of the truck, which can offer a door-to-door service without any transshipment operations. This limits the handling costs and the danger to damage the goods. However, the truck is heavily limited in its evolution by the overall volume one truck driver can transport. In spite of research projects such as the Prometheus, it is unlikely that road transport can substantially modify is way to produce and to reduce its cost, by the formation of linked trucks, which is the typical advantage of the conventional production scheme of railway transport. Railway freight transport allows yielding economies of scale and networking economies, which are precluded to the road transport. Therefore the major challenge is to combine the advantages of a very flexible and versatile technology such as the heavy truck with the possibilities gain economies of scale, pervasive in the industrial mass production.

As a consequence the ideal technology would be a kind of truck (high flexibility) on the railway (mass production), which can easily be coupled to a long train and uncoupled to single self-propelled railway-trucks. Such an element would build the core of a new and innovative railway system; triggered to enter new market segments (small consignments and shorter distances):

- In the last few years this kind of ideas has been partially realized by different companies with the design and construction of a flexible train-system, best known as the Cargosprinter. The Cargosprinter is a flexible train system with automatic coupling. Its load capacities equal five truck loads and it is propelled by gasoline, electric or hybrid engines.
- Small container boxes recently developed in European projects (Idioma and Cost 339) constitute a further step in the radical change of the existing production paradigm on the railway. It is particularly designed to capture the increasing and very large market segment of LCL.
- Horizontal transhipment technologies build the third technical element of this new paradigm on the railway. Horizontal transhipment technologies are compared to the large vertical transsihpment technologies in use for intermodal freight transport extremely low cost and can easily be implemented, where traffic is generated. There-

fore horizontal transshipment facilities do not require large investments and consequently they are not confined to places where large freight flows can be bundled.

The different technological elements are still in a period of testing and in a pilot stage and different technological solutions are proposed and in a testing phase. It is not the focus of this project to assess the single elements from a technical point of view. On the contrary, it is a conviction underlying this project, that these technologies are essentially in a prototype stage and that the competition between different technological solutions will last in the next years. The outcome of this competition is uncertain and depends on the "selection process" driven by the users. In other words, the emerging technological paradigm can not yet be defined on the basis of its technological properties. The success of a technological solution depends on its integration in logistic chains and its interpretation by the market actors.

4.2 Institutional changes open new opportunities

It is a common argument that the state monopolies in the railway sector have blocked competition and are a major cause of the decline of railway. The ongoing process of opening the market access to new actors is supposed to create the necessary competition to improve the railway service and to give it a new competitive edge. However, there are justified doubts that the barriers to enter the railway transport market remain still very high, unless new operators could enter with the innovative technologies, requiring very modest investments. This could finally lead to a completely different situation, where a high number of actors can offer railway services according to the needs of their clients.

In fact, it has to be considered a major advantage of the above technological innovations that they can be gradually introduced and diffuse together with new acquired market shares. The risk of high initial investments is very much reduced on one hand. On the other additional operators could help to reap network economies and substantially change the present competition between road and railway freight transport. Ultimately these factors could accumulate and contribute to the breakthrough of a new transportation paradigm on the railway sector.

In this perspective the opening of the railway network to free access could not only help to overcome the institutional settings, which have guaranteed the monopoly of a few operators, but also constitute the necessary framework to radically innovate the dominant production paradigm and to create competition by a high number of actors in the market.

4.3 Unexplored organisational possibilities

A further stage in the prospected innovation process can be achieved with completely different organisational principles. In fact, the open access to manifold operators remains an uncompleted change of the old paradigm as long as the access and the organisation of the rail transport is based on the principles of a pre-electronic era. The flexibilization of the railway transport can be achieved by two major innovations on the organisational level.

- Flexible slot management by decentralized decision support systems overcoming the rigid structure of schedules.
- Electronic coupling of trains, which can lead to a much higher use of the existing capacities.

These changes are the most radical step in the innovation process and would completely erode the present production paradigm. In fact, it questions the centralized decision structure, embodied in the schedule and the slot management based on an annual attribution. These organisational principles are key to the dominant single operator production regime. It is totally incompatible with the concept of a flexible use of the railway infrastructure similar to the road, where independent and decentralized decision processes are possible. The European research project Prometheus, fostered by the truck industry to build a kind of trains of trucks on the road by means of electronic coupling, offers interesting arguments and technological solution.

A couple of years ago simulations on the German railway network (Rosebrock, 1992) explored to organisational opportunities offered by these new technologies and clearly proved that there are still large capacities left in the existing railway infrastructures. However, it requires tremendous changes with respect to the present concepts, which are embodied in the know-how of generations of railway engineers. Therefore it would be blind-eyed to think that such radical changes could be achieved overnight and thanks to the insight of a few pioneers.

5. Overcoming barriers to innovation

5.1 The main questions of the research project

The research project addresses the following questions:

- What are the necessary learning processes among the different operators in the intermodal transport chain to introduce innovative technologies and services concepts? The recent literature on innovation management stressed that the first phase of every learning process essentially consists in "unlearning" old mental patterns. The existing understanding of what freight transport is blocks innovations. In particular it has to be unlearned, that railway freight transport can only be long distance haulage with long and heavy trains. According to different experiences in old industries - such as automobile industry - it is almost impossible to initiate radical innovation processes counter to the dominant know-how from inside the the dominant industries.

- What are the major service requirements, which can be satisfied by adopting these innovative technologies? The project is carried out in a test-site experiment under real economic conditions and it is a major focus to understand how the different actors adapt their requirements to the technological and organisational possibilities offered by the innovations. The use of these innovative technologies can not be defined in advanced and therefore it will need a certain try and error process to find the most adequate uses.

- A related question regards the integration of the transport technologies in transport chains? In particular it has to be understood how the transport flows are modified upstream and down-stream in order to fully exploit the possibilities in terms of higher flexibility, higher quality of service, lower or higher cost.

- A fundamental question also regards the key barriers to the introduction of these innovative technological and organisational concepts? In particular it has to be understood, whether to barriers are internal (intrinsic) to the proposed technologies or whether they arise from the surrounding context and whether these barriers are on the technical, organisational and institutional level.

- The last question regards assessing the market potential of these new technologies and on the possible diffusion process. In particular it has to be understood the role of economies of scale and network economies in the diffusion process. The main argument is that is extremely difficult (in not impossible) to understand and assess the preferences for innovative technologies unless the potential users can make its experience and to assess the advantages.

5.2 The methodological approach

The underlying methodology has been developed in the context of *strategic niche management* (Weber, Hoogma, 1998; Weber et al.1999). This conceptual framework offers the instruments to analyse the mutual learning process to overcome the barriers to the introduction and diffusion of innovative technologies and service concepts.

The key elements of this approach to the innovation management are:

- the definition and description of the framework of the test and demonstration site.
- the monitoring and the reporting on the learning process between the involved actors.
- the analysis of the interpretation of the technological possibilities and the definition of the user needs and the shaping/emergence of their preference.
- the shaping of a new understanding of the new intermodal transportation concepts and services.

5.3 The role of policy

The present policy approach is triggered to change the behaviour of the transport operators in terms of the overall modal split within a given technological and organizational context. The main policy goal is to change the relative terms of competition between two existing production patterns, one on the road and the other on the railway. It should be quite obvious, that the policy maker in an innovation-oriented approach has to play a different role (Kemp,1997). Its role is neither to define a certain road toll nor to determine the freight volume to be transported on road and railway. The policy maker has to become a major driving force in the transformation of the dominant production paradigm. The task of the innovation-oriented policy is twofold.

- In a first step, policy has to support the innovations by creating the framework conditions to experiment with the new and promising technologies. This helps to select the most promising technological options. However, it is not the policy maker who will choose the technology.
- In a second step the policy maker has to design instruments or a mix of instruments, which can accelerate the diffusion of the new technologies and promote the transition to a new stage.

6. Conclusion

Elements of this project proposal were developed in a research proposal in the fifth European framework research programme under the key action of sustainable mobility and sustainable growth. It is part of the project "Intermodal door-to-door service concepts utilizing key features of small containers". The overall objective of this research project is to demonstrate in different test-sites in Europe that technological and organisational innovations in the intermodal road-railway industry have the potential to enter the LCL /small consignment market segment even over short and medium distances. It has to be demonstrated that these innovations are solutions to achieve competitive tariffs and service qualities comparable to the road transport.

We also expect to demonstrate that the understanding of technological innovations requires a comprehensive analytical framework overcoming the point of view of the engineer (Stein 1995). There are a number of historical case studies that clearly demonstrate, that the evolution of technologies are locked-in by organisational and institutional factors, creating a major barrier to innovations on one hand. On the other, they stress the importance of social and cultural values and preferences in the process of the selection of technological innovations.

The success of these innovations is highly uncertain and many barriers have to be overcome. It has been argued that these uncertainties can not be assessed in advance. The outcome of the test-site experiments depends on the success of the learning process among the involved operators and the opportunity to fully exploit the technological and organisational possibilities. However, the proposed D2D intermodal services in the short and medium distance segment could substantially contribute to solve the increasing and pressing societal problems linked to the road transport. It explicitly addresses problems of freight transport, which have been largely neglected or ignored in the policy debate (in Switzerland) so far. The innovations presented in this project open new opportunities to reduce the environmental impact of freight traffic and to define a new role for the policy maker.

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