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1995

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citation for published version (APA)

Freudensprung, P., & Nijkamp, P. (1995). *Bottlenecks in Trans-Alpine freight transport: a multicriteria analysis on future Brenner corridor alternatives*. (Research Memorandum; No. 1995-8). Faculty of Economics and Business Administration, Vrije Universiteit Amsterdam.

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**BOTTLENECKS IN TRANS ALPINE FREIGHT
TRANSPORT**

**A Multicriteria Analysis
on Future Brenner Corridor Alternatives**

Paul Freudensprung
Peter Nijkamp
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1: Introduction

Isolation refers to limited accessibility of certain areas. Physical or other bottlenecks may act as barriers in the communication and transport systems connecting such areas. The Alpine region is a clear example of this phenomenon. Because of its natural conditions the Alpine region offers only limited options and limited capacity to the transport sector. The geographic location of the mountain range in the middle of Europe separating important economic regions leads to the necessity of commodity flows through only a few corridors in this area. With the rapid increase of freight traffic during the last two decades, it has been difficult to find a satisfactory solution for both overcoming this bottleneck in the European transport network and guaranteeing the Alpine population an acceptable quality of life. Therefore, the problems of this part of the European transport network seem to be one of the most challenging ones to be solved.

Two major transit corridors for freight transport in a North-South direction can be identified on the Austrian territory:

- The "Brenner-route", a corridor from Kufstein to Brenner, passing through the Inntal.
- The so-called "Balkan-route" via Salzburg and then splitting into two corridors, the Phyrn and the Schober.

This paper will concentrate on the Brenner which by far is the most important transport corridor in Austria. In 1987, 62 million tons of freight were shipped through the Alpine region from the North of Europe to Italy. 20.75 million tons (16.45 million of tons truck traffic) crossed the Alps via the Brenner. These simple figures illustrate that congestion and environmental pollution are severe problems due to the high concentration of transport activity on this route.

The prognoses for the transport volume on the Brenner corridor vary, but all expect an annual growth rate between 2.0 and 3.5%, that is a commodity flow ranging from 53 to 70 million tons per year in 2015. Consequently, an acceptable compromise between the goal of the Austrian (Tyrolean) government to strictly reduce the negative effects of transit traffic and the benefits for the EU-regions from an extended infrastructure capacity has to be found.

Although the region of the Alps offers only little available space to use, the maximum physical capacity seems not yet to be reached. The implementation of additional transport infrastructure (tracks, roads) is still feasible. But more important than the physical capacity is the ecological capacity, which has a far lower threshold level.

The environmental damage and the rising opposition of

citizens lead to the conclusion that the ecological capacity limit has been exceeded under the euphoria of growth during the past two decades (Meadows 1972,1992). If this is the case, there are only two basic possibilities to solve the problem in a satisfactory way: either to reduce transport to a level below the ecological limit, or - since the physical capacity limit is also a logistic function - to push this limit towards a higher level by means of environmental friendly technological change. The best effects will be gained if the two ways are used jointly together.

In the next section we will discuss in detail the so-called Pentagon model, which is a systematic approach to identify the critical success factors for an efficient and effective policy implementation and operation of transport systems. This approach will be used as the main frame of reference in this paper leading into the use of a multi-criteria analysis for evaluating different transport system alternatives for the Brenner corridor.

2: The Pentagon Model of Critical Success Factors

The Pentagon of critical success factors (Nijkamp and Vleugel, 1993) was introduced to identify the necessary conditions for advanced new infrastructure networks (see Figure 1). In the sequel the five dimensions of the model will be used as a basis to identify the specific impediments to the Alpine freight transport on the Brenner route and to offer systematically possible interesting solutions. We will first outline the five essential elements of the Pentagon approach.

Figure 1. The Pentagon model.

2.1 Hardware

Hardware refers to the physical technological aspects of transport, for both road transport and railways.

a) Road transport

The congestion caused by the limited capacity of the four lane Brenner motorway can of course be alleviated by adding an additional lane. This may be realized by either constructing a new lane in both directions or by using the existing emergency lanes.

Furthermore, the use of trucks with a higher load may be seen as a way to reduce the number of vehicles. However, in contrast to current practice in many countries where trucks have a maximum gross vehicle weight of 50 tons, the weight limit for Austria is 38 tons. On the other hand, large vehicles cause higher damage to the motorway and hence cause higher maintenance costs.

b) Railways

The renewal of the Austrian railway tracks (with a designed speed up to 160 km/h) will be completed in 1997. Additionally, a tunnel for freight trains to by-pass Innsbruck is due to be opened in order to reduce the travel time through the corridor of the Unter Inntal. The capacity added by this project will be 70 trains per day. The planned Brennerbasistunnel and the adjustment of the tracks for a high speed railway system (with a designed speed of 200 km/h) will double the daily capacity of transit trains. Not only the tracks, but also the rolling stock have to be adjusted in order to meet the needs of modern transport systems. The necessity to cooperate with the road sector in terms of intermodality and the increasing demand for individual containers of relatively small shipments (the trend of dematerialization) needs the use of both flexible and standardized wagons.

To favour a shift from road to rail on the Brenner corridor, first the "Rollende Landstraße" was introduced, where the truck tractor plus semitrailor are loaded on the train (cf. Backhausen, 1992). Due to the uneconomical high percentage of dead weight, this operation is not likely to survive in the long run. Containers, swap bodies and the road railer have become more promising projects to invest in.

2.2 Software

Software refers to information and use of measures that serve to increase the efficiency of transport operations. Traffic management measures taken in the past dealt mainly with time and access restrictions for the Brenner corridor.

Though there is also the possibility to restrict passenger cars (e.g., to guarantee a constant speed for trucks), only trucks have been affected by restrictions so far, mainly because of ecological reasons. All Austrian roads are subject to a night-time ban (22.00-6.00 hrs.) and a ban on sundays and holidays for trucks.

American studies have demonstrated that the cost effectiveness of road investment increases if an additional lane is exclusively reserved for trucks. There is no operational experience with truck-only lanes yet, but this might be a step to improve the performance of the Brenner motorway. The main obstacle for rail transport is caused by the relatively long operating times of transshipment. Therefore, investment in intermodal terminal infrastructure is necessary to guarantee an intermodal competitive edge for freight transport by rail. The introduction of advanced information systems will be another decisive method to improve both rail and road transport, with a major focus on combined transport. Such information systems may concern:

- road conditions and traffic situations
- free capacities on both rail and road
- type and volume of commodities to be shipped.

It is important to have information systems for both the users and the operators in a transportation network. While the first alternative may also be included in traffic guidance systems (e.g. LISB, Prometheus) and is of main interest to forwarders to avoid congestion on the road, the latter is more concerned with the economic efficiency of shipping. Better information about where and when to find freight(capacity) will accelerate transport operations and increase the efficiency of the network.

2.3 Finware

Finware is concerned with economic and financing aspects of transport. In the 1980s the total investment in transport infrastructure has been decreasing, although the volume of traffic was rapidly growing. So the capacity constraints arising nowadays are a logical consequence of this past policy. In order to finance expansion of infrastructure networks, user charges are often advocated. This means that all relevant costs of operating and managing infrastructure have to be directly borne by the user of the transport facilities. This is important, as transport prices do not include all costs caused by the various transport modes. For example, road infrastructure is available to freight transport without a proper compensation for the higher construction costs of motorways that have to be suitable for vehicles of larger dimensions and weight than passenger cars. This holds also for the high maintenance costs,

which are to some 90% caused by trucks. This biased price system offers thus road transport an important advantage in competition with respect to rail transport. The motorway from Innsbruck to Brenner is at present a toll road; and most likely this toll road system will be extended in the near future.

This brings us to the issue of financing the infrastructure. Infrastructure investments bear a relatively high risk-benefit ratio. The combination of high political risk, a long pay-back period (mostly > 20 years) and relatively low revenues appear to discourage private investors. Traditionally, investments in infrastructure belonged to the public domain, because the goal was to guarantee a public service also to peripheral regions by using the revenues from profitable parts of the networks. In any case, private financing is gaining importance (see for instance Nijkamp and Rienstra, 1995). Thus, there may be a fair chance to finance the new infrastructure of the Brenner corridor from private sources, in particular in light of the growing public deficit in Austria.

A more practicable method which is gaining importance in many European railway companies might be to divide the infrastructure and the operational sector of the railways, as it is also done for roads. The right to use a specific corridor at a specific time may then be sold to operators by way of a concession. This slot-exchange is already used in air traffic and may also be practicable for trains. Moreover, the price mechanism implied in this system might then be used to regulate the congestion in a high traffic area like the Brenner.

2.4 Ecoware

Ecoware refers to the environmental conditions to be fulfilled by transport. In Austria nowadays, the environmental impact of traffic in general and transit traffic in particular is a hot item. In fact, there are two kinds of problems in relation to the Alps. First, there is the 'natural-environmental' problem because of the environmental vulnerability of the Alps. This means, for instance, that the mountain forests are relatively quickly affected, while it takes a long time to recover. The mountain-forests are very important to protect the mountain against erosion, but also to protect the people against avalanches.

Secondly, there is, because of the Alps, very little space to build more roads or railways. In fact, there are only a few places where one can pass the Alps by car. This means that the traffic passing the Alps is heavily condensed on a few roads (for example, the Brenner-pass). An alternative may be to build a tunnel, but this is often expensive.

2.5 Orgware

Orgware deals with the control and organization of infrastructure. In trying to control and influencing the actual and future traffic flows, the Austrian government is changing the organization of infrastructure. The old situation is comparable to that of many European countries. The use of infrastructure is indirectly subsidized, because the drivers do not pay the full price for the infrastructure used. Secondly, about 20% of the trucks is empty because of cabotage agreements and the network is not functioning optimal because of a separate development of infrastructure.

In order to solve these problems the Austrian government recognizes that it has to follow the way that most European countries have followed. First, in the next years new measures are to be expected that will make the railway system more competitive, for instance, more market orientation.

Secondly, the Austrian government will gradually introduce a toll system to let transit trucks pay for the infrastructure used.

Thirdly, there is a great interest in reducing the amount of empty trucks, because that will reduce the total amount of traffic as well.

Having now briefly discussed the five components of the Pentagon model, we will in the next section assess and evaluate different Brenner corridor options.

3: Evaluation of Brenner Corridor Alternatives by Means of Multicriteria Analysis

A multicriteria analysis aims to identify the most plausible realistic option out of a set of discrete alternatives, by investigating in a systematic manner all relevant impacts of each alternative on the basis of a set of evaluation criteria. This means that the construction of a systematic impact table is an important step (see Nijkamp and Blaas, 1994).

3.1 Alternatives

At present, the infrastructure of the Brenner corridor is composed of a motorway with 4 lanes (2 in each direction) from Kiefersfeld to the Brenner, with 3.700 trucks (1991) passing each day. The construction of a third lane has partly been realized, as it was mainly built as a 'creep lane' to guarantee smooth traffic on steep parts. The completion of the third lane over the full length of the motorway may be realized in the medium-term future, alt-

though resistance from the local population may be expected. The alternatives given for improving the railway network on this route are backed by both the population and the government. Budget restrictions will have a major influence on the level of improvement that will be realized and in which time span. This means that various alternatives may be envisaged. The following alternatives are possible depending on a number of factors, in particular the political pressure on the Austrian government from both the environmentalists and the industry. Their lobbying within the EU will be of decisive importance.

- Alternative I : Renewal and doubling of the tracks in the Unter Inntal and construction of a third lane on the motorway.
- Alternative II : Renewal and doubling of the tracks in the Unter Inntal but no capacity increase of the road infrastructure.
- Alternative III: Brenner-Basistunnel and construction of a third lane on the motorway.
- Alternative IV : Brenner-Basistunnel but no capacity increase of the road infrastructure.

These four alternatives will be evaluated by means of relevant assessment criteria which will now successively be discussed.

3.2 Criteria

The basic idea here is to operationalize different criteria according to the dimensions of the Pentagon model in combination with other important factors. Next, the design of scenario's (by changing the political weight factors of the assessment criteria) may then highlight the potential of the various alternatives under varying preconditions. Due to lack of data, we will mainly use here a qualitative multicriteria analysis. The criteria taken into consideration will first successively be discussed (see for more details Simons and Freudensprung, 1994)

(1) Land use

This is an important factor, as human activities require more and more space. Space is a scarce good in an Alpine valley and has to be used with caution. Therefore, land use as a result of new infrastructures is an important policy criterion.

(2) Energy consumption

The factor used to measure the energy consumption of the

two transport modes, viz. road and rail, refers here to the transportation operation only. Of course, it would be better to calculate also the energy used during the construction of infrastructure and the rolling stock in order to have a complete eco-budget, but this is problematic because of data reasons.

(3) Pollution/emmission

Transport causes several emissions. Here we will only look at freight transport. The table of Kürer (ECMT, 1992) is used here, as this contains the most important emission of traffic, viz. CO₂. As we want to use the different emissions in one criterion, the total sum of emitted g/tkm will be calculated over all the relevant substances.

(4) Project costs

Of course the costs of investments for each alternative are a decisive factor in any evaluation. The budget situation of the Austrian government is subject to many constraints, as there are more and more fields competing for public funding. In our calculation only the construction costs are taken into account, as no data were available on the operational costs per ton for each of the four alternatives.

(5) Noise

Noise is an often underestimated factor of environmental damage. Some 54% of the people feel directly affected by this type of pollution. The quantitative measurement of the disturbance caused by noise is very difficult, because it does not only depend on the volume (dB(A)), but on numerous other factors that can hardly be taken into account.

(6) Integration effects

The economic effects of a higher accessibility for a region is a useful factor in order to judge the economic potential of infrastructure investments. In our case it was not possible to quantify the effects of the European integration for the area of interest because of lack of data, so that we had to resort to a qualitative assessment.

(7) Free railway capacity

According to a study of the Austrian Traffic Ministry, the total volume of transit traffic in 2000 will be about 75% higher, compared to 1990. The motorway transport will grow with approx. 100%. The problem in our case study is to estimate the volume of traffic that will pass via the Brenner. This will of course depend on the various alternatives chosen. Our aim is to estimate the extent to which

the measures of the Austrian government may create flexibility with respect to future transport developments. Thus we have to look at the free capacity, because in this way it is possible to influence the traffic flow in a more economic way. If, for instance, in the future the government wants to have more goods transported by trains, then it is necessary to have sufficient capacity left in the railway system. In this way we may define 'free capacity of the railway' as the free capacity that is not yet used.

(8) Safety

Although a declining accident rate on the Brenner Corridor is noticed, there is still a big problem concerning traffic safety. Another problem is how to estimate safety. We can of course only count the fatal accidents, but that leaves out the 'normal' accidents which have often many consequences for the functioning of the transport network. To find an expression for fatality chances, we have to look into the differences between road and rail. Transit traffic on the road has on average a 60% higher risk of being involved in an accident. Furthermore, trucks on transit routes are relatively more involved in accidents than private cars. Finally, we know that road transport is about 10 times more risky than railway transport. Then we can use these global figures - in combination with traffic volumes - to assess the fatality risks in terms of ordinal ranking.

(9) Speed

Of course, the criterion speed is very important. With speed we do not only mean the actual speed that can be achieved, but it is also an approximation of congestion. It is, for instance, plausible that the congestion on the Brenner will get worse, if the capacity of the network does not grow. On the other hand, according to the Austrian government, there will be less congestion in the railway system, because of the many great improvements to take place in the future. Thus, the average speed in any of the four options has to be assessed.

(10) Reliability

Reliability refers to the robustness of estimated travel time with regard to external shocks, such as weather conditions. This can only be approximated in a qualitative sense.

(11) Landscape segmentation

This is an environmental criterion. The area of the Brenner

pass is a touristic, agricultural and yet densely populated area. It is therefore important to see in what way the landscape will be segmented by new infrastructure projects. In this case we will also use an ordinal approximation for our assessment.

Having discussed now eleven evaluation criteria for the four Brenner Corridor alternatives, we may construct a comprehensive impact matrix which comprises in a numerical form (quantitatively or qualitatively) the various outcomes. This information is contained in a concise form in Table 1.

crite- rion	ALTERNATIVES				units of mea- sure- ment
	I	II	III	IV	
1	12	9.1	12.02	9.12	km ²
2	43.14	34.47	47.69	39.02	n/MJ
3	4130.6	3287.3	4506.8	3663.5	g/tkm
4	9	7	58	56	billion AS
5	1	3	2	4	ordinal
6	3	1	4	2	ordinal
7	16	-157	216	45	free train capaci- ty
8	3	4	2	1	ordinal
9	125	110	145	130	average speed
10	2	1	4	3	ordinal
11	1	2	3	4	ordinal

Table 1. The comprehensive impact matrix for the Brenner Corridor alternatives.

4: Scenario's for the Brenner Corridor

Now we turn to the specification of different policy scenario's which can be formulated by varying political weight or priorities attached to each of the successive criteria. Each scenario represents thus a specific political position or angle reflected in the fact that the criteria are weighted differently. We distinguish here the following six scenario's:

- (a): **Indifference**; all criteria are given the same weight.
- (b): **Ecology 1**; all eco-factors are assumed to be more important than the other criteria.
- (c): **Ecology 11**; here the eco-factors are split up into two groups; the first group consists of the components directly infringing on people, while the indirect eco-effects are assumed to be less important.
- (d): **Ecology-tost mix**; the same as (c), but the construction costs are here more important than the indirect eco-criteria.
- (e): **Democracy**; the weight factors are ranked according to the hottest current political issues for the Austrian population.
- (f): **Network efficiency**; the most important criterion is the construction costs, followed by the criteria characterizing the network potential.

In Table 2 the ranking of the criteria for these six scenario's is presented, based on background information gathered by Freudensprung and Simons (1994).

SCENARIO'S

crite- rion	a	b	c	d	e	f
1	1	2	2	2	2	1
2	1	2	2	2	2	1
3	1	2	3	4	3	1
4	1	1	1	3	3	3
5	1	2	3	4	3	1
6	1	1	1	1	1	2
7	1	1	1	1	1	2
8	1	1	2	2	3	1
9	1	1	1	1	1	2
10	1	1	1	1	1	2
11	1	1	3	4	2	1

Table 2. Brenner Corridor scenario's based on ranking of criteria.

The Tables 1 and 2 can now be further treated by applying a multicriteria analysis for discrete choice alternatives. Given the qualitative nature of these tables, the Regime method is particularly useful (see for full details Nijkamp et al, 1991)

In Table 3 the results of the multi-criteria programme Regime are presented.

SCENARIO

ranking	(a)	(b)	(c)	(d)	(e)	(f)
first	IV	II	IV	II	II	IV
second	II	IV	II	IV	IV	II
third	I	I	I	I	I	I
fourth	III	III	III	III	III	III

Table 3. Results of the Regime method

The results from Table 3 show that alternative II and IV are most favoured. This suggests that there should be no increase of road capacity, as suggested in the scenario's I and III. This is important to notice because the Austrian government is planning more road capacity in order to solve the traffic problems on the Brenner in the medium term, while in the long run a Brenner-basis tunnel is planned. The plans of the Austrian government are in a way comparable to scenario III, which is, according to our analyses, an inferior alternative.

Secondly, for both alternatives II and IV the frequency they score the first place is equal and they change positions with each other. An explanation for this phenomenon is found in Table 1. First, alternative IV seems to be some sort of compromise-alternative; there is no exceptionally low or high score for any criterion. Alternative II is to a large part comparable to alternative IV, where the low construction costs compensate for the strong network-performance. There seems to be a trade-off between scenario II and IV. Scenario II is stronger in eco-factors and has a lower score in network-performance, while scenario IV has a strong network-performance and a lower score in eco factors. Alternative I and III seem to be more radical with poor scores on the eco-factors and only modest scores on the network-criteria.

References

- Backhausen J. and H.J. Ewers, Marketingstrategien für den Schienengebundenen Güterverkehr, 1992.
- BMÖWV, The Vienna Paper, 1994.
- BMÖWV, Das österreichische Gesamtverkehrskonzept, 1991.
- ECMT, Transport growth in question - 12th Symposium, Lisboa, 1992.
- Freudensprung P. and R. Simons, A multicriteria analysis on Brenner alternatives, Vienna, 1994
- Maggi R., Masser I. and P. Nijkamp, Missing Networks: The case of European Freight Transport, European Planning Studies, vol. 1, No. 3, page 351-366, 1993.
- Meadows D., Die Grenzen des Wachstums, 1992.
- Nijkamp P., From Missing Networks to Interoperable Networks: The Need for European Cooperation in the Railway Sector, Transport Policy (forthcoming), 1994.
- Nijkamp P. and S. Rienstra, Private Sector involvement in Financing Transport Infrastructure, Annals of Regional Science, no. 1, 1995. (forthcoming)
- Nijkamp P., P. Rietveld and H. Voogd, Multicriteria Analysis in Physical Planning, Elsevier, Amsterdam, 1991
- Nijkamp P. and J. Vleugel, Success Factors for High Speed Rail Networks in Europe, Research Memorandum, Economics Faculty Free University, Amsterdam, 1993.
- OECD, Road transport research - cargo routes: truck roads and networks, Paris, 1992.
- öIR, Alpenquerender Transitverkehr, Vienna, 1989.
- Rietveld and Nijkamp, Transport and Regional Development, Research Memorandum, Economics Faculty Free University, Amsterdam, 1992.