INTERNATIONAL TRANSPORTATION AND COMMUNICATION NETWORKS IN EUROPE, THE ROLE OF BARRIER EFFECTS

Piet RIETVELD
Department of Economics
Vrije Universiteit
Amsterdam
The Netherlands

INTRODUCTION

National borders have a discouraging effect on spatial interactions. Passing a border gives rise to monetary or non-monetary costs. Little is known about the nature and size of these border effects, however. This is a pity since the meaning of national borders is changing drastically in Europe. National borders separate areas where different governments exert authority. In addition, a national border can coincide with the transition between culture and language areas. National borders imply barriers to trade, but the extent to which these are effective depends on the institutional setting. Between EC countries the barriers are much smaller than between other countries in Europe.

One may conclude therefore, that borders have a clearly multidimensional character. A change in the meaning of borders, as takes place in the process of European integration concerns mainly one aspect of borders. We know little about the question to which extent this integration process will reduce the barrier effects of borders in relationship to the other factors mentioned here.

The purpose of the present paper is to give an analysis of barrier effects of borders. Section 1 is devoted to a typology of barriers. The following sections contain empirical results on barrier effects of borders in

- physical networks: rail, road (section 2)
- the airline network (section 3)
- the telecommunication network (section 4)

Section 5 concludes.

1. TYPOLOGY OF BORDER RELATED BARRIERS

Barrier effects of borders are multidimensional. In this section we discuss a number of those dimensions.

Borders sometimes coincide with physical barriers such as rivers on mountains. These barriers are usually symmetric: communication is discouraged in both directions to the same extent. There are also physical barriers which have been created by man after the border started to exist. Examples are the Chinese wall and the iron curtain. Protection-oriented barriers of this type often have an a-symmetric influence: discouragement of communication is not equal in both directions.

Visa costs are an example of fiscal barriers related to borders. In the field of trade, fiscal barriers such as import duties or import restrictions are used to protect domestic producers. These barriers provide a discouragement to trade and communication which is usually not symmetric. Although import levies have been abolished within the EC, this does not mean that fiscal barriers no longer exist in the EC. Differences in excise duties are still existent in the EC. These differences sometimes lead to a strong stimulus for cross-border shopping (or tanking petrol) in one direction, and a similar disincentive for cross-border traffic in the other direction.

Even if excise duties were to be equalized, fiscal barriers may continue to exist in the EC. Some European Community countries demand value added taxes at the time of import, which is discriminatory in favour of domestic producers. Subsidies are another form of fiscal barrier which may continue to exist in the EC.

Institutional barriers relate to costs involved in crossing a border between different jurisdictions. This entails differences in currencies, laws and regulations. Crossing a border gives rise to delays which may be quite substantial, especially when goods are transported. For the road-haulage sector, this gives rise to both driver costs and opportunity costs of vehicle utilization. Avoidance of border delays is vital for firms working according to just-in-time principles. Even when delays are short, crossing borders is still an important cost component because of the paper work needed for it.

Another cost component relates to differences in currencies. For example, firms involved in international trade may be confronted with high hedging costs.

Differences in company law may discourage firms from becoming transnational. For example, differences in accounting practices among countries lead to higher costs for central management control. A related problem is 'fiscal suspicion' against transnational corporations (Cost of Non-Europe, 1988, p. 202). This may lead to rigid controls against transnational corporations to prevent tax evasion.

A well-known example of technical barriers to communication is incompatibility in railway systems of various countries, giving rise to delays or inconveniences when crossing borders. Technical barriers also occur in other forms, i.e., when producers must alter their products to comply with industrial standards or legal regulations in other countries. Such barriers to trade are quite significant for various products such as foodstuffs, automobiles, building materials, and in telecommunications.

Another form of technical trade barrier occurs when producers must have their product tested and certified by the importing country. This may give rise to long delays and high costs before new goods can be introduced in a country. The pharmaceutical industry is a well-known example of an industry frequently facing this barrier.

Market regulation is another source of barriers to communication and trade. In Europe, tariffs for international air traffic are quite high due to regulatory policies. Similarly, in the road haulage sector cabotage and quota systems lead to high tariffs in international transport.

In a wider sense, market regulations leading to discrimination against foreign firms is clearly present in government procurement. This is clearly visible in sectors such as the arms industry, business services and ship-building where domestic firms get preferential treatment above foreign firms.

A difference in time zones is also a barrier to communication. The overlap in official working times in London and New York is relatively small, but between London and Tokyo the overlap is almost non-existent. This is clearly a disincentive for using the telephone for business purposes. Other modes of communication such as telefax and electronic mail are not subject to this type of barrier, however.

Cultural, language and information barriers are other forms of barriers hampering communication. These barriers do not always coincide with national borders (cf. the linguistic frontiers in Belgium and Switzerland). Education aiming at making people multilingual helps to reduce the impact of language differences, but differences in the mother tongue will continue to reduce communication across linguistic frontiers (cf. Klaassen et al., 1972). It should be noted that language barriers also refer to machine and protocol differences, which often prohibit or complicate information flows.

2. BARRIER EFFECTS OF BORDERS IN THE RAILROAD HIGHWAY NETWORK

Despite the relatively small size of most European countries and the emphasis on economic integration, planning and operation of infrastructure is predominantly done by individual countries using a narrow national perspective. Only rather recently the international dimension has grown in importance, as can be seen from initiatives such as the Channel-tunnel, a bridge between Sweden and Denmark and a highspeed railway connection between France, Belgium, Germany and the Netherlands. The existing networks display a clearly nation oriented culture.

One way to investigate the role of borders in infrastructure networks is to use a density indicator. Highway density is measured as the length of the highway network (measured in km) divided by the area of the country (measured in square km). In a densely populated country such as the Netherlands highway density is as high as 0.05 km per km^2. This means that the average length of the highways in an arbitrary area of 100 km^2 is equal to 5 km. In border areas this density is usually lower than the national average which is partly a consequence of low population densities which may occur in border areas, and partly a consequence of the fact that borders exert a barrier effect. One way to analyse barrier effects of borders is by investigating highway densities on borders. The concept of density cannot be immediately applied in this case since the area of a border is equal to zero. By introducing a small border zone as depicted in Figure 1, we can compute the highway density in that zone.

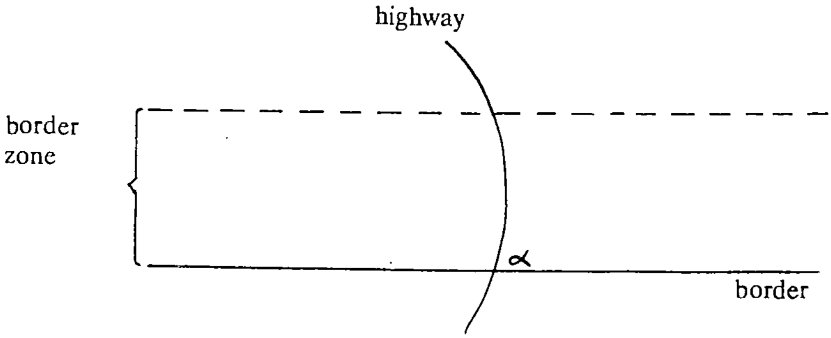

Figure 1. Highway density in a border zone

Let B denote the length of the border and x the width of the border zone. Then the area of the border zone is Bx. The length of the highway in the border zone is L(x). We assume that the length of the highway is a polynomial function of x: $L(x) = ax + bx^2 + cx^3 + \ldots$. Then the density in the border zone is L(x)/Bx. The density on the border line is defined as:

$$\lim_{x \to 0} L(x)/Bx = a/B$$

If the highway crosses the border in a perpendicular way, $\alpha = 90^\circ$ (see Figure 1), and a = 1. In the case of a non-perpendicular crossing, a is larger than 1. For example if $\alpha = 75^\circ$ or 60°, a is equal to 1.04 or 1.15. Thus we conclude that in the case of perpendicular crossings, the highway density on a border line is equal to the number of crossings divided by the length of the border. In the case of non-perpendicular crossings, the highway density is somewhat higher. For the Netherlands, the highway density on borderlines is about 1.3 per 100 km, which is considerably below the national average of about 5.0 per 100 km.

In Table 1, densities of railways and highways are presented for a number of borderlines in Europe. The figures are computed relative to the density in the border region. For example, the figure of .25 for the German - Belgium border means that the railway density on this border is only 25 percent of the density in the German and Belgian border regions. The table shows very clearly that substantial barrier effects exist for national borders. In all cases border crossing densities are much lower than average densities in border areas. The average

border between countries	network density on borderline relative to border area	
	rail	highway
Belgium - Netherlands	.10	.21
Belgium - France	.20	.29
Germany - Netherlands	.12	.31
Germany - Belgium	.25	.36
Germany - France	.18	.22
Switzerland - Austria	.20	0
Switzerland - France	.23	.31
Italy - France	.12	.16
Italy - Switzerland	.16	.11

Table 1. Network densities for rail and road on borderline (1989)

reduction factor is .18 for rail and .22 for highways. The balance between the two varies per country. For example, in the Netherlands, Belgium and Germany, the border effect is most clearly visible for rail, whereas for Switzerland it is the highway system which tends to be most clearly effected by borders. For a more detailed account of empirical results, refer to Bruinsma and Rietveld (1992).

The barrier effects of borders give rise to relatively large detours when one wants to cross a border. The detour factors will be largest for short distance trips across the border. For trips originating and ending in non-border regions these detour factors will be smaller. Thus it will be border regions themselves which are most strongly effected by the lack of border crossing network infrastructure.

3. BARRIER EFFECTS OF BORDERS IN THE AIRLINE NETWORK

Consider two airports at a certain distance from each other. Then frequencies of flights between these airports tend to be higher when they are located in the same country compared with the situation that the two airports are in different countries. There are two main reasons why this is true. The first one relates to the demand side. Demand for international air traffic along a certain distance is smaller than demand for domestic air traffic along the same distance. This is a consequence of the various barrier components of borders discussed in section 2. The second reason related to the supply side. Regulation in the airline system tends to reduce the number of flights in international linkages.

In this section we give a numerical estimate of the extent to which these effects occur. The method to be used is the quasi experimental approach. In this approach (cf. Isserman, 1989), one compares a pair of airports (A,B) with another pair (A,C). The airports B and C have been chosen in such a way that they are identical in all relevant economic characteristics. In addition, the distance between A and B is equal to that between A and C. The only difference is that A and B are located in the same country, which is not the case with A and C.

By comparing the frequency of flights between A and B with that between A and C one can isolate the impact of borders. One of the factors which has to be controlled in the approach is the availability of all alternative transport modes. For example, the number of flights between Brussels and London is much larger than between Brussels and Paris. The reason is that no rail or road connection exists between Brussels and London so that the share of air traffic on this link is very high. Thus, a barrier in a certain mode (road) appears to function as an incentive to use another mode (air). Another factor which might interfere is the different position of airports in hub and spoke networks.

The advantage of the quasi experimental approach is that one does not need to formulate and estimate a model to isolate the border effect. An obvious disadvantage of this approach is that one will never find airports which are entirely identical according to all relevant features. One is forced therefore to use airports which are only approximately identical which produces noise in the outcomes.

In Table 2 we present results on flight frequencies for a number of approximately identical pairs of airports in Europe. The reduction factor for international flights is in all cases smaller than 1: international flights are consistently less frequent than domestic flights. The average value of the reduction factor is about .30. This means that against ten flights a day on a certain domestic connection there are only about three international flights to a similar destination at a similar distance.

4. BARRIER EFFECTS OF BORDERS IN TELECOMMUNICATION

In about all countries international calls can be carried out as smoothly as domestic calls. From this viewpoint would not expect a barrier effect to exist ion telecommunication. Tariffs are another factor to be considered. The tariffs for international calls are usually considerably higher than for equidistant local calls, although some notable exceptions exist (cf. Rietveld et al., 1991). Given the low price elasticity of telecommunication's demand, one would not expect that the volume of international calls would be seriously effected. Nevertheless, the share of international calls in the total number of calls is below 2 per cent for the large majority of countries. This figure suggests that borders do exert an influence on telecommunication, but that the mechanism is not in the first place determined by inconveniences with international calls or by tariffs.

airport pair		country pair	frequency per day	reduction factor
Frankfurt	- Dresden	G-G	4	
	- Rotterdam	G-N	0	.0
Frankfurt	- Bremen	G-G	7	
	- Basle	G-S	2	.29
Frankfurt	- Munich	G-G	16	
	- Brussels	G-B	6	.38
Madrid	- Bilbao	S-S	8	
	- Porto	S-P	1	.13
Madrid	- Malaga	S-S	11	
	- Porto	S-P	1	.09
Milan	- Roma	I-I	29	
	- Munich	I-G	5	.17
Paris	- Strassbourg	F-F	12	
	- Basle	F-S	3	.25
Paris	- Marseille	F-F	22	
	- Stuttgart	F-G	5	.23
Paris	- Mullhouse	F-F	7	
	- Eindhoven	F-N	3	.43
Stuttgart	- Hamburg	G-G	7	
	- Vienna	G-A	3	.57
Stuttgart	- Bremen	G-G	3	
	- Torino	G-I	2	.67
Zurich	- Geneve	S-S	16	
	- Munich	S-G	5	.31

Table 2. Flight frequencies between alternate pairs of airports (1991)

Estimates of the reduction factors can be found in Table 3 for Greece (Giaoutzi and Stratigea, 1991) and the Netherlands (Rietveld and Janssen, 1990).

The main reason why border related barrier effects exist in telecommunication seems to be that telecommunication is complementary to other types of spatial interaction such as trade, tourism, etc. This is confirmed by statistical analyses of relationships between these variables (cf. Rietveld and Janssen, 1990).

In this section we study the extent to which borders lead to a reduction of telecommunication flows. We will use a gravity type model for this purpose. The telecommunication flow between regions r and s X_{rs}, depends on a number of factors including the distance d_{rs}. This dependence is reflected by a distance decay function exp (-a d_{rs}) or d_{rs}. A border effect can be introduced by adding an extra reduction factor δ_{ij} where i and j denote the countries in which the regions r and s are located. When r and s are located in the same country δ_{ij} is set equal to 1, so that a reduction effect does not occur. On the other hand, when r and s are not in the same country, the decay factor becomes equal to exp (-a c_{rs}) δ_{ij} where δ_{ij} is smaller than 1.

The barrier factor found for EC and EFTA countries is about .30 to .40 for both countries. This means that crossing a border from these countries leads to a reduction in telecommunication flows which makes them only 30 to 40 percent of the volume one would expect when no borders exist. It is interesting to note that the difference between the barrier factors for EC and EFTA is negligible which implies that no impact of trade areas on telecommunication can be observed in Europe (both Greece and the Netherlands are EC members). The relatively high outcome for the Dutch Belgian border suggests that language is an important factor. This is also suggested by the high outcome for communication between Greece and Cyprus (although it is difficult to believe that in this case the barrier effect is so much higher than 1).

Telecommunication interactions with Eastern Europe are very low for both countries. Also with developing countries telecommunication is low for the Netherlands and Greece. An exception is telecommunication between Indonesia and the Netherlands which suggests that former colonial relationships play an important role.

The Netherlands		Greece	
Belgium	.40*	EC	.31*
Germany	.36*		
Rest of EC	.31*		
Scandinavia	.31*	EFTA	.28*
Central Europe	.36*		
Eastern Europe	.05*	Eastern Europe	.04*
US, Canada, Japan	.34*	US, Canada, Japan	.22*
Developing countries	.08*	Africa	.13*
Indonesia	.88	South America	.06*
		China, India, Hongkong	.05*
		Middle East	.30*
		Turkey, Yugoslavia	.22*
		Australia/New Zealand	1 .95
		Cyprus	9 .84
R^2 = .812		R^2 = .613	

*: significantly different from 1 at 5% level

Table 3. Barrier effects of national borders for the Netherlands (1983) and Greece (1988)

5. CONCLUDING REMARKS

The empirical results in this paper indicate that national borders exert a strong influence on the shape of railway and highway networks, airline service levels, and telecommunication flows. In Western Europe the border related reduction factor found usually varies between .20 and .40. Further international cooperation in the field of trade and network infrastructure will have a dampening influence on the border effects, but one may not expect that other dimensions of borders related to culture and language will soon disappear as limiting factors to international communication.

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