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How far to A Europe of the Regions ? Evidence from Gravity-Model Analysis of European Road Freight Traffic

Markus Mende und Simone Scharfe, Dresden

Abstract
It is the aim of the article to investigate two hypotheses concerning integration of the European Union: firstly, national boundaries are still relevant and secondly the measurable effect of these boundaries decreases in time. Applying a testing scheme based on the gravity model to EU road freight traffic for 1987 and 1991 we provide a measure of where the EU currently stands relative to the Common Market project of a "boundaryless" region. It is shown that depending on the particular gravity model specification used distance reduces spatial interaction between 5 and 6,5 times more on the intra-EU than on the intra-national level. Evidence on a decrease in the impedance parameter, i.e. on integration, is also consistent. We conclude that the European region is still a supra-national rather than multi-regional entity and that robust evidence on integration tendencies requires an analysis of more recent data.

Contents

1. INTRODUCTION

With the launch of the Common Market project as the result of the Intergovernmental Conference in 1986 the EU Commission committed itself to a Europe without boundaries where goods as well as physical and human capital flow freely. At the same time the Commission proposed the principle of subsidiarity as a framework for decision-making. Combining the Common Market aim with the tool of subsidiarity gives rise to a crucial role of regions in the process of European integration. The importance of the regional factor is reflected in the reporting of the statistical office of the EU Commission. EUROSTAT publishes economic, political, social and geographic statistics on four levels of disaggregation. The so-called NUTS 0 level consists of the now 15 national regions and all higher levels, i.e. NUTS 1 to NUTS 3, are regions at the sub-national level with increasing disaggregation.

With the process of European integration still in a flux the eventual shape of Europe's regional structure is unclear. Given the many uncertainties surrounding, for example, monetary union, the eastern enlargement etc., it is difficult to predict where Europe will settle on a scale that reaches from loose free-trading area on one end of the spectrum to a single state for most purposes of international relations on the other extreme. Tied to this is the fate of sub-national regions in a future Europe: will they define themselves principally in reference to EU member states, in relation to a central administration in Brussels or as a second layer of decision-making power in a federal Europe? Given these uncertainties about the future we use the current structure of regional interaction as a benchmark against which to measure the current intra-European interaction. Thus we ask how far is the EU from reaching a state of integration that characterises regions in the individual member states.

The basic assumption of the investigation is that national borders or frontiers represent separating lines between regions, thus border-barriers with penalising and discriminating impact. This traditional and „negative“ interpretation of the border concept contrast with a positive understanding of border as a contact area (Ratti, 1993). Within the traditional definition Rietveld (1993) argues that distance similarly to borders reduces spatial interaction between locations. However, while distance does so gradually and continuously, borders introduce discontinuities. In an empirical analysis, borders should thus be discernible as a positive deviation from the „normal“ distance effect (Blum and Leibbrand, 1994). For the purposes of this investigation the „normal“ of reference point for the effect of distance on interaction is provided by the current structure of interaction in member states. Following the above argument, national borders are still relevant if intra-European interaction reacts significantly more stronly to distance than intra-national interaction (hypothesis I). Moreover, if this difference in the negative impact of distance is shrinking then the measurable relevance of national borders decreases (hypothesis II).

2. MEASURING THE EFFECT OF BORDERS USING GRAVITY MODELS

For modelling spatial interaction the gravity model is a tested tool. Erlander and Stewart (1990) provide a comprehensive overview of its derivation and application. The model can be derived from Newton's law of gravity that sets the attraction, a_{ij}, between two masses, m_i and m_j, proportional to the magnitude of these masses and inversely proportional to the square of the distance, d_{ij}, between them, i.e.:

$$(1) \quad a_{ij} = \gamma\left(\frac{m_i m_j}{d_{ij}^2}\right)$$

, where γ is a factor of proportionality. Log-linearisation yields a multivariate regression model in canonical form:

$$(2) \quad t_{ij} = \gamma + \beta_1 d_{ij} + \beta_2 m_i + \beta_3 m_j$$

, where t_{ij} now stands for number/volume of interactions between locations i and j and where for the law of gravity to hold we require that $\beta_1 = 2$ and $\beta_2 = \beta_3 = 1$. For the purpose of the investigation we use the annual volume of road freight traffic in thousands of tons for the years 1987 and 1991 as the dependent variable t_{ij}. The explanatory variables are distance as measured in kilometres between the capitals of the regions of origin, i, and destination, j. Gross domestic product in constant ECUs of 1991, y, population, *pop*, and GDP per head, *ypop*, of the regions of origin, i, and destination, j, function as alternative proxies for the masses. The data was taken from the *EUROSTAT REGIO* databank. The data space is thus:

$$(3) \quad \Omega_{1987/1991} = \left[t_{ij}, d_{ij}, y_i, y_j, pop_i, pop_j, ypop_i, ypop_j\right]$$

The two hypotheses to be tested on this data space are:

$$\beta_1(\textit{intra-EU, 1987/1991}) > \beta_1(\textit{intra-national, 1987/1991})$$

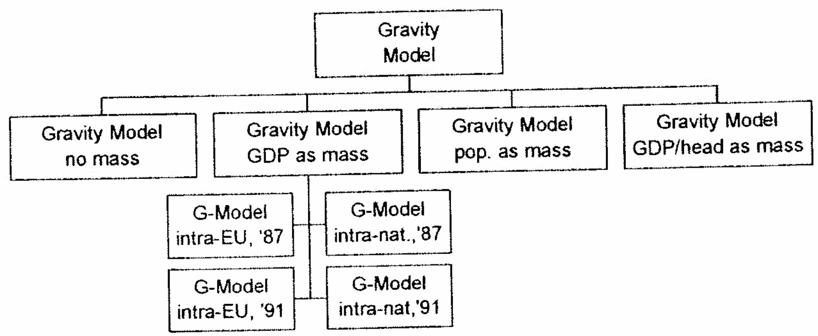
(4)

$$\beta_1(\textit{intra-EU, 1987}) > \beta_1(\textit{intra-EU, 1991})$$

i.e. firstly, that the elasticity of road freight traffic volume with respect to distance is significantly higher for intra-EU traffic than for intra-national flows and that secondly the former elasticity is higher for 1987 than for 1991.

Following Leamer (1994) we use alternative proxies for the masses in the gravity model to mimic a sensitivity analysis. This gives rise to a series of models. Only if evidence as to the two hypotheses is insensitive relative to different mass-specifications could the conclusions be considered robust. The testing scheme is summarised in diagram 1 containing three levels.

Diagram 1. Testing Scheme of Gravity Models



On the first level we have the prior for the empirical investigation, i.e. the assumption that European road freight traffic flows can be modelled adequately through gravity models. This prior determines the outcome of all estimates since it limits the data space *a priori* to information on spatial interaction, distance and economic mass. On a second level we find the gravity model prior operationalised through alternative proxies for the masses. The first model is restricted in the sense of having distance as the sole explanatory variable. This specification was included to have some measure of how well distance alone is able to explain interaction in the European Union. Finally, the third level lists for each mass-specifiaction the models that were actually estimated: one model for intra-EU flows and ten models for intra-national flows for the years 1987 and 1991 respectively.

For Denmark, Ireland and Portugal there was only national data on road freight flows, while for Luxembourg the data was incomplete even at that level of aggregation. Consequently we were unable to estimate national gravity models for these countries. For Germany we estimated four models to see how reunification with East Germany influences the results. For Belgium and the Netherlands we estimated a joint model because of considerations of degrees of freedoms. Together with intra-national models for Spain[1], France, the United Kingdom, Greece and Italy[2] this yielded a total of ten estimable models.

[1] between 1987 and 1991 the level of disaggregation at which intra-national flows for Spain are reported was increased; the 1991 was summarized to the 1987 level of aggregation to obtain compatible samples

[2] at the time the gravity models were estimated in 1995, there was no data on intra-national road traffic flows for Italy in 1987

3. EMPIRICAL RESULTS FROM THE GRAVITY MODEL ANALYSIS

For convenience diagrams 2 to 5 below only show the estimation results for the distance coefficient β_1. Detailed regression results including the coefficient estimates for the masses plus the R^2 and the F-statistic are set out in the appendix.

The constrained gravity model with the distance variable only performs surprisingly well in terms of the R^2 goodness-of-fit measure. For the intra-EU model distance alone explains between 19 percent (1987) and 14 percent (1991) of the variation in road freight flows, while for the intra-national models the lowest fit is 23 percent (Italy, 1991) and the highest is 90 percent (Greece, 1991).

Diagram 2.: Estimates for Distance Parameter with no Masses

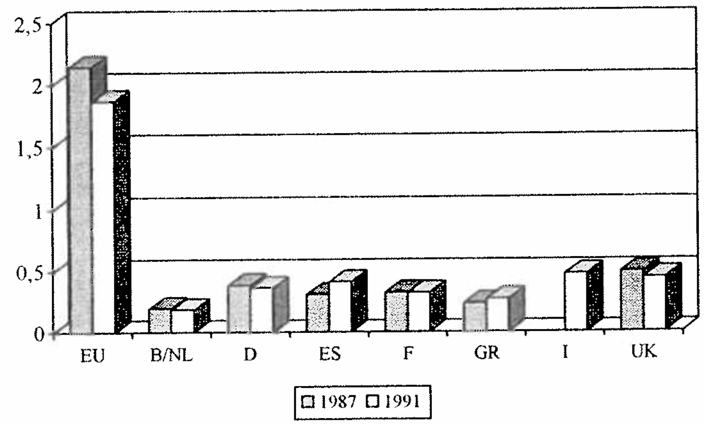
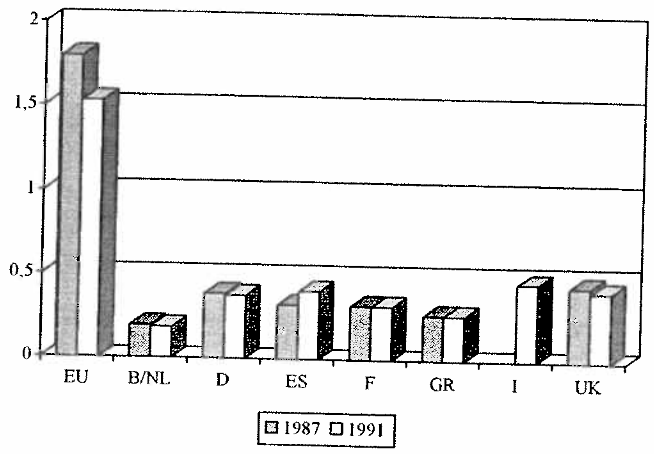


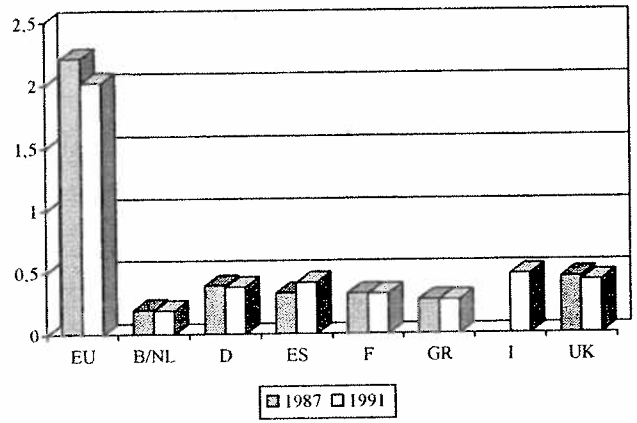
Diagram 3.: Estimates for Distance Parameter with GDP as Masses



When unconstraining the model to a traditional gravity model with GDP as masses, the goodness-of-fit rises for the intra-EU model to 55 percent and 69 percent for 1987 and 1991 respectively.

The fit also increases for most country models, except for Greece, for the year 1991 where the R^2 statistic remains unchanged at 90 percent. Also, while the distance parameter for intra-EU flows increases significantly from 1,75 and 1,5 to 2,25 and 2,0, the distance parameters for the intra-national models all remain below 0,5.

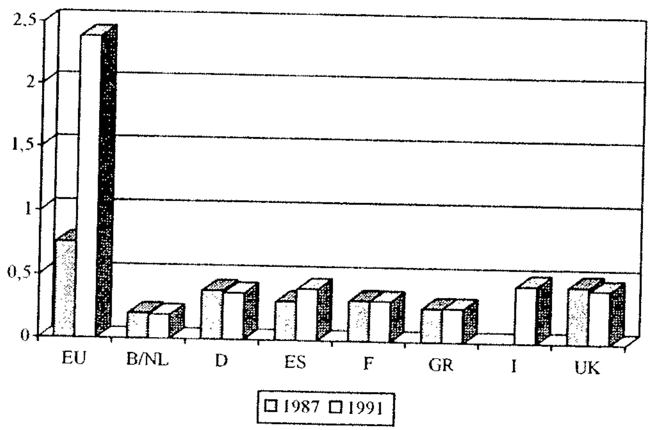
Diagram 4.: Estimates for Distance Parameter with Population as Masses



Using, on the other hand, population as masses changes little with respect to the gravity model with GDP as masses. The fit is higher than for the constrained case for all models except for Greece and the 1991 sample. The distribution of magnitudes of the distance coefficients is also very similar to the GDP model: for the intra-EU sample they are 2,25 and 2 respectively and for all intra-national models below 0,5. Also while Belgium/The Netherlands have the lowest elasticity of flows with respect to distance, Italy and the UK have the highest. This result is consistent for all model specifications and can be interpreted as deriving from the particular, lengthy shape of the two latter countries. As a result, transport infrastructure is significantly better along the vertical axis than the horizontal axis raising the average transport cost per distance unit.

Finally, employing GDP per head as a proxy for the gravity masses leaves the overall pattern of regression results unchanged. The exception is the distance coefficient for the intra-EU sample of 1987 that falls sharply to 0,75. We are unable to provide an intuitive explanation for this result and characterise it as an „outlier" in an otherwise consistent picture.

Diagram 5.: Estimates for Distance Parameter with GDP per Head as Masses



4. CONCLUSIONS

In relation to the two hypotheses we conclude that on the basis of the data set chosen we are unable to reject either. The result is robust to alternative mass specifications and implies the following. Firstly, Europe was in 1987 and 1991 a supra-national entity differing from a nation with regions in the current definition by a factor of 5 to 6,4 on average[3]. This factor, however, was shrinking between the years 1987 and 1991 as the EU has been moving towards a „Europe of the Regions". The conclusions are compatible with Blum et al. (1996) that apply the gravity model to similar European data augmented by US/Canadian data. They conclude that there remain significant

[3] the factors were calculated as the ratio of the intra-EU distance coefficient to the unweighted average of inztra-national distance coefficcints for the years 1987/1991 and the four mass-specifications respectively

integration deficits in road traffic flows crossing national boundaries relative to intra-national flows.

The power of the conclusions is limited by the sample years chosen. A more comprehensive analysis covering in particular observations after the start of the Common Market in 1993 could yield information of the speed at which the EU is becoming „boundaryless". Such research, however, must be undertaken by future projects as past transport data for the 1980s is patchy and new data is available with delays of up to four years.

APPENDIX

EQUATION: FLOW(o/d) = f(DIST)

		coefficient		
		DIST	R-squared	F-statistic
INTRA-EU	1987	**-2,143**	0,194	28,61
		-5,349		
	1991	**-1,864**	0,140	21,18
		-4,602		
BELG./NETHERL.	1987	**-0,194**	0,590	33,13
		-5,756		
	1991	**-0,183**	0,511	24,01
		-4,899		
GERMANY (west)	1987	**-0,387**	0,478	109,09
		-10,445		
GERMANY (west)	1991	**-0,405**	0,510	124,92
		-11,177		
GERMANY (east)	1991	**-0,129**	0,275	8,35
		-2,889		
GERMANY (all)	1991	**-0,364**	0,301	109,42
		-10,461		
SPAIN	1987	**-0,309**	0,839	181,82
		-13,484		
	1991	**-0,411**	0,231	14,11
		-3,757		
FRANCE	1987	**-0,325**	0,729	166,67
		-12,910		
	1991	**-0,321**	0,727	165,37
		-12,860		
UNITED KINGDOM	1987	**-0,492**	0,385	74,40
		-8,625		
	1991	**-0,444**	0,472	106,47
		-10,318		
GREECE	1987	**-0,273**	0,778	49,09
		-7,006		
	1991	**-0,269**	0,900	126,03
		-11,227		
ITALY	1991	**-0,474**	0,227	34,96
		-5,913		

EQUATION: FLOW(o/d) = f(DIST, GDP(o), GDP(d))

		coefficient				
		DIST	GDP(o)	GDP(d)	R-squared	F-statistic
INTRA - EU	1987	**-1,800**	**0,850**	**1,432**	0,550	47,69
		-5,744	3,948	9,043		
	1991	**-1,530**	**1,234**	**1,462**	0,687	85,500
		-6,074	7,496	11,757		
BELG./NETHERL.	1987	**-0,196**	**0,838**	**0,887**	0,844	37,82
		-9,018	4,000	4,234		
	1991	**-0,185**	**0,963**	**0,903**	0,805	28,86
		-7,508	4,095	3,840		
GERMANY (west)	1987	**-0,388**	**0,887**	**0,885**	0,800	156,43
		-16,793	9,727	9,709		
GERMANY (west)	1991	**-0,406**	**0,853**	**0,879**	0,810	167,44
		-17,847	9,578	9,930		
GERMANY (east)	1991	**-0,132**	**1,310**	**1,359**	0,562	8,54
		-3,606	2,527	2,614		
GERMANY (all)	1991	**-0,379**	**1,000**	**0,801**	0,767	276,76
		-18,797	17,517	14,059		
SPAIN	1987	**-0,327**	**0,704**	**0,442**	0,886	85,74
		-16,024	2,752	1,726		
	1991	**-0,408**	**3,189**	**2,286**	0,547	18,13
		-4,759	4,558	3,267		
FRANCE	1987	**-0,324**	**0,810**	**0,606**	0,799	79,62
		-14,732	3,674	2,745		
	1991	**-0,320**	**0,574**	**0,754**	0,795	77,38
		-14,549	2,685	3,529		
UNITED KINGDOM	1987	**-0,450**	**1,493**	**1,344**	0,610	60,95
		-9,765	6,126	5,511		
	1991	**-0,419**	**0,892**	**1,062**	0,633	67,21
		-11,541	4,611	5,489		
GREECE	1987	**-0,272**	**0,514**	**0,471**	0,827	19,08
		-7,330	1,353	1,238		
	1991	**-0,269**	**0,047**	**0,101**	0,904	37,53
		-10,583	0,286	-0,611		
ITALY	1991	**-0,464**	**2,536**	**1,733**	0,495	38,19
		-7,097	6,500	4,443		

EQUATION: FLOW(o/d) = f(DIST, POP(o), POP(d))

		coefficient			R-squared	F-statistic
		DIST	POP(o)	POP(d)		
INTRA-EU	1987	**-2,210**	**0,770**	**1,358**	0,497	38,530
		-6,803	3,027	7,966		
	1991	**-2,014**	**1,448**	**1,435**	0,687	93,796
		-8,174	11,010	11,108		
BELG./NETHERL.	1987	**-0,199**	**0,818**	**0,884**	0,908	68,86
		-11,910	5,700	6,161		
	1991	**-0,189**	**0,967**	**0,883**	0,889	56,21
		-10,176	6,165	5,634		
GERMANY (west)	1987	**-0,389**	**0,834**	**0,831**	0,788	145,21
		-14,408	10,180	9,927		
GERMANY (west)	1991	**-0,408**	**0,775**	**0,844**	0,793	150,71
		-17,204	8,658	9,340		
GERMANY (east)	1991	**-0,141**	**1,205**	**1,339**	0,503	6,76
		-3,589	2,042	2,239		
GERMANY (all)	1991	**-0,375**	**0,987**	**0,963**	0,612	132,57
		-19,717	12,713	12,494		
SPAIN	1987	**-0,328**	**0,766**	**0,355**	0,882	82,02
		-16,024	2,752	1,726		
	1991	**-0,409**	**3,629**	**2,587**	0,595	22,08
		-5,040	5,186	3,697		
FRANCE	1987	**-0,325**	**1,358**	**1,133**	0,832	99,00
		-16,123	4,658	3,886		
	1991	**-0,321**	**1,067**	**1,296**	0,827	95,32
		-15,852	3,724	4,525		
UNITED KINGDOM	1987	**-0,452**	**1,668**	**1,518**	0,602	58,98
		-9,719	5,927	5,394		
	1991	**-0,421**	**0,963**	**1,161**	0,624	64,82
		-11,454	4,402	5,310		
GREECE	1987	**-0,273**	**0,530**	**0,480**	0,822	18,46
		-7,234	1,273	1,153		
	1991	**-0,269**	**0,045**	**-0,120**	0,904	37,88
		-10,626	0,262	-0,702		
ITALY	1991	**-0,474**	**2,584**	**2,034**	0,435	29,99
		-6,860	5,151	4,056		

EQUATION: FLOW(o/d) = f(DIST, GDP(o)/POP(o), GDP(d)/POP(d))

		coefficient			R-squared	F-statistic
		ZDIST	ZYO	ZYD		
INTRA - EU	1987	**-1,800**	**0,850**	**1,432**	0,550	47,69
		-5,744	3,948	9,043		
	1991	**-1,530**	**1,234**	**1,462**	0,687	85,500
		-6,074	7,496	11,757		
BELG./NETHERL.	1987	**-0,196**	**0,838**	**0,887**	0,844	37,82
		-9,018	4,000	4,234		
	1991	**-0,185**	**0,963**	**0,903**	0,805	28,86
		-7,508	4,095	3,840		
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		-16,793	9,727	9,709		
GERMANY (west)	1991	**-0,406**	**0,853**	**0,879**	0,810	167,44
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		-3,606	2,527	2,614		
GERMANY (all)	1991	**-0,379**	**1,000**	**0,801**	0,767	276,76
		-18,797	17,517	14,059		
SPAIN	1987	**-0,327**	**0,704**	**0,442**	0,886	85,74
		-16,024	2,752	1,726		
	1991	**-0,408**	**3,189**	**2,286**	0,547	18,13
		-4,759	4,558	3,267		
FRANCE	1987	**-0,324**	**0,810**	**0,606**	0,799	79,62
		-14,732	3,674	2,745		
	1991	**-0,320**	**0,574**	**0,754**	0,795	77,38
		-14,549	2,685	3,529		
UNITED KINGDOM	1987	**-0,450**	**1,493**	**1,344**	0,610	60,95
		-9,765	6,126	5,511		
	1991	**-0,419**	**0,892**	**1,062**	0,633	67,21
		-11,541	4,611	5,489		
GREECE	1987	**-0,272**	**0,514**	**0,471**	0,827	19,08
		-7,330	1,353	1,238		
	1991	**-0,269**	**0,047**	**0,101**	0,904	37,53
		-10,583	0,286	-0,611		
ITALY	1991	**-0,464**	**2,536**	**1,733**	0,495	38,19
		-7,097	6,500	4,443		

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