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Abstract

Whereas it is fairly accepted that freight transport, measured in ton-km, is closely related to the level of economic activity of a region, there is hardly any study that investigates if this correlation still holds for transport indicators that are independent of the volumes transported.

The aim of this paper is to look at the relationship between the level of road freight transport, expressed both in number of trips and in km driven, and the economic activity in a region. For this purpose, a cross-sectional data sample of regions within the EU-15 is explored.

The sample is analysed for evidence of correlation between the transport indicators and selected measures of the economic activity, namely, GDP per capita, and indicators related to the structure of the economy (share of employment per sector, share of employment in high-tech sectors). Evidence of a correlation is found, but it doesn't hold up when the effects of peripherality are partialled out.

The outcomes should be interpreted carefully, taking into account the limitations of the simple methodology used. Nevertheless, results consistently point to the fact that peripherality is the only variable in the set of indicators considered that can account for differences in number of trips and km driven between the different analysed regions. Rather than shed new light into the question of the correlation between road freight transport and economic activity, this result opens up a whole new set of questions about the nature of this relation.

Keywords

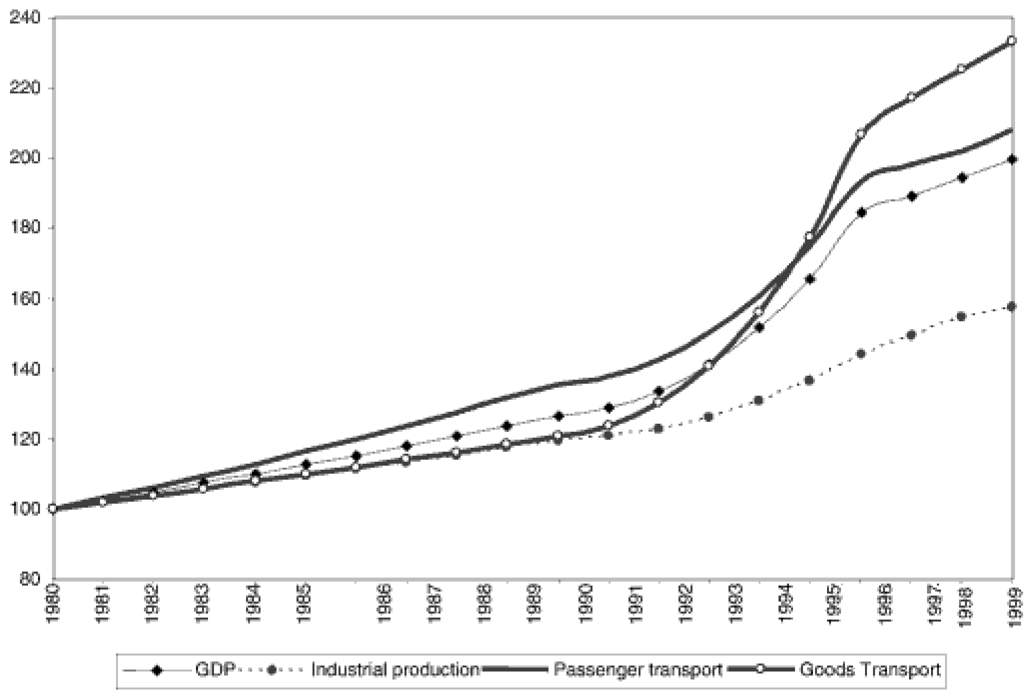
Road Freight Transport – GDP – Correlation Analysis – European Regions – Cross-sectional – number of trips – km driven – Coupling – Decoupling.

1. Introduction

Economic development of a country is, in a broad sense, mainly driven by its level of investment, trade and consumption, and it is a phenomenon that not only diverges on the country level but also on the regional level. As a means of enabling trade, transport is assumed to be a key factor of the economic level achieved by a region.

The relationship between freight transportation and economic activity has been the object of several studies (see, for instance, Bennathan, Fraser et al. 1992; Meersman and Van de Voorde 1999; Hilferink 2003; Meersman and Van de Voorde 2003; Rommerskirchen 2003). It is fairly established that historically, the growth of freight transport has accompanied economic growth.

Figure 1 Evolution of GDP, Industrial Production, Passenger and Freight Transport



Given this close relationship, two main questions arrive. The first relates to the decoupling of freight transport and economic growth. This subject has recently been occupying much of the Transport literature, mainly since the European Commission's 2001 White Paper on Transport (Commission 2001) has referred to decoupling as a main goal for European Transport Policy, due to the negative impact of transport in the environment. Decoupling is defined by Banister (Banister and Berechman 2001) as "a decrease in transport intensity of GDP that will allow the volume of transport to increase at a lower rate than the economy at large".

The second question is of concern especially to Transport planners and researchers, and it pertains to the use of this close relationship for modelling and forecasting of transport intensities. The crucial questions, as put by Meersman and Van de Voorde (2003), are: "to what extent could this spectacular growth in freight transport have been predicted? (…) And which variables are to blame for the fact that predicted evolutions did not materialize?"

However thoroughly the authors have answered these questions, there are still obscure sides to the correlation between transport and the economy. For instance, according to Hilferink (2003), "in a cross-section analysis between different countries, it becomes evident that the correlation between freight transport and GDP is not as close as was shown in the time series at EU-level".

Moreover, whereas the correlation with GDP is established for freight transport indicators measured in ton-km, there is hardly any study that investigates if this correlation still holds for transport indicators that are independent of the volumes transported. While transport indicators measured in ton-km provide useful information in most contexts, some correlation between these indicators and GDP is bound to exist, since the volume or weight of the commodities transported relates directly to trade and thus a correlation with GDP is to be expected.

On the other hand, most studies provide little information on exactly to which variable is due the spectacular growth of freight distance. Has there been an increase of the distances driven, of the number of trips, or of the volumes carried? Which of these three dimensions of the ton-km indicators is coupled with or decoupling from GDP?

It is the purpose of this paper to look at the relationship between the level of road freight transport, expressed both in number of trips and in km driven, and economic activity in a region. For transport indicators expressed in this fashion, it is not straightforward that the aforementioned correlation exists. More specifically, freight transport indicators reflecting trip intensity measured in number of trips per day and corresponding kilometre per day are scrutinized in search for a correlation with GDP and the structure of the regional economy, such as the share of employment in specific sectors of the economy.

Amongst the different freight transport modes, road transport plays an utmost important role and accounts for a considerably high modal share, which furthermore has been growing at high rates (in the period 1990 to 1999, road haulage grew 50% compared to 32% for all modes, according to Meersman and Van de Voorde, 2003). Also, the "decline in the transportation of bulk (e.g. raw materials, semi-finished products), (…) has clearly benefited the road haulage sector" (Meersman and Van de Voorde, 2003). In addition, of all modes, road transport has the most impact on human health and the environment. According to a study undertaken by the OECD, road transport "accounts for over 80% of all transport-related energy consumption, for most of the accidents and the majority of air pollutant emissions, noise and habitat degradation" (OECD, 2006).

Due to the aforementioned reasons, and the purpose of the proposed approach, this paper will deal with road freight transport.

Section 2 reviews existing research studies exploring the relationship between freight flows and economic growth and summarizes the most important literature on the subject.

Section 3 presents the sample of European regions transport and economic data used and describes the methodological approach applied, as well as the assumptions and limitations of this approach. A discussion on indicators is also presented, namely on the use of aggregate and disaggregate indicators, as well as the use of absolute, per capita and per area indicators.

In section 4, the results of the correlation analysis are shown. In a first stage, the sample is analysed for evidence of correlation between the transport indicators and selected measures of the economic activity. In a second stage, these correlations are tested while controlling for the level of peripherality of the region.

The final chapter presents the most important conclusions and recommendations for further research are set out.

2. Previous studies

The relationship between freight transportation and economic activity has been the object of several studies. Most of these studies deal with analyses of time series data of GDP and freight transport, measured in ton-km, in search for a correlation.

In these studies, the question of breaking the link between economic growth and transport growth is often referred to as the decoupling of freight transport and GDP. Decoupling is defined by Banister et al (2000) as "a decrease in transport intensity of GDP that will allow the volume of transport to increase at a lower rate than the economy at large" (Banister & Berechman 2001, p.117).

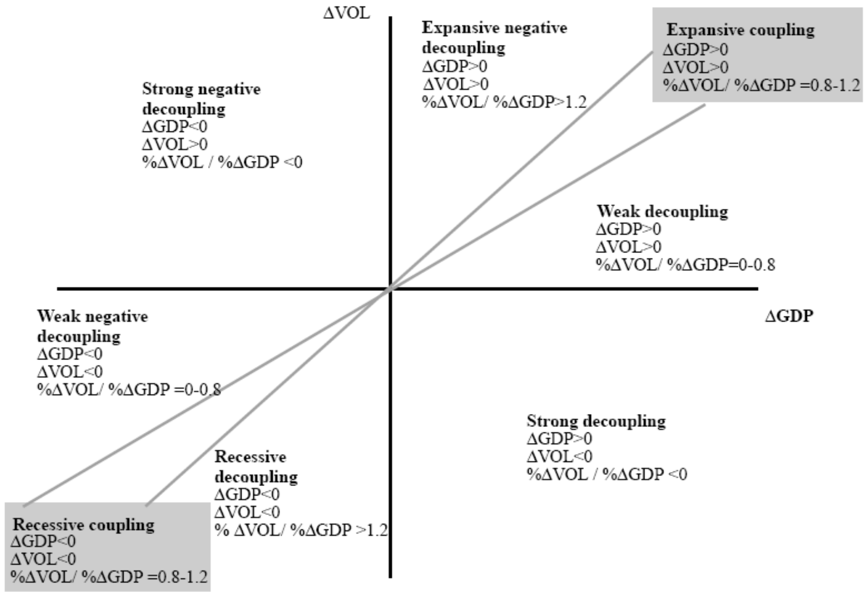
Meersman and Van de Voorde (2003) compare their forecasts for the increase in freight traffic with actual growth for the period 1990-99. The models developed by the authors comprised GDP, Industrial Production, and Imports/Exports as main determinants for freight transport demand. The estimates produced by the model were largely overcome by actual growth, in particular for the road haulage.

Another interesting point made by these authors is that GDP "had a stronger impact in freight transport in the 1990s than it did in the 1980s, while changes in industrial production became far less influential" (Meersman and Van de Voorde 2003). To account for this altered relation between freight transport and economic activity, the authors allude to developments like the emergence of supply chain management, time-based competition (TBC) and the worldwide growth of e-commerce in the 1990s as possible causes for this trend.

McKinnon (2007) also argues that in the UK between 1997 and 2004 a decoupling trend was observed. The study proposes possible reasons for this trend, and points to the growth of foreign road haulage operators, the reduction of road transport in the modal split and the increases in road freight rates as the most significant ones.

Still in the context of time series, but looking more in depth into the type of relationship between GDP and transport, Tapio (2005) distinguishes between three general types of relations: the GDP growth and the growth of transport can be coupled, decoupled or negatively decoupled. The indicators are considered coupled when the elasticity of the values is between 0,8 and 1,2. An overview of the division of the categories is given in Figure 2.

Figure 2 The degrees of coupling of transport volume growth from economic growth



Source: Tapio, 2005

This author also found that in the 1990's there were differences between countries within the EU in the degree of decoupling. While in the UK, Germany, Luxembourg, Austria, Finland, the Netherlands and Sweden a weak decoupling could be observed, countries like Ireland, Denmark, France and Belgium showed expansive coupling (Tapio 2005).

In what concerns studies using cross-section data, Benathan, Fraser and Thompson (1992) investigate the domestic (non-transit) demand for freight transport with correlating ton-kilometres (ton-km) with total GDP and country area for 33 countries. The authors contend that GDP and country area are the long-run determinants of domestic freight transport, measured in ton-km. For the road haulage in particular, the results indicate that the level of transport measured in ton-km is more influenced by GDP than it is country area.

3. Methodology

3.1 Data sample

The sample includes data on 118 regions within 15 European countries. The following indicators are used to describe road freight transport level in each region:

Table 1 Set of transport indicators originally obtained

Data set	Description	Units
trips_intra per capita	Total number of intra-regional HGV[1] trips	HGV trips/day/hab
trips_prod per capita	Total number of HGV trips that leave the region (extra-regional outgoing trips)	HGV trips/day/hab
trips_attr per capita	Total number of HGV trips attracted by the region (extra-regional incoming trips)	HGV trips/day/hab
trips_tran per capita	Total number of HGV transit trips	HGV trips/day/hab
km_intra per area	Total kilometre related to intra-regional HGV trips	km/day/km^2
km_prod per area	Total kilometre related to extra-regional outgoing trips	km/day/km^2
km_attr per area	Total kilometre related to extra-regional incoming trips	km/day/km^2
km_tot per area	Total number of kilometre driven within each region by all trucks, intra-regional trips are not included	km/day/km^2

Transport indicators expressed in number of trips are useful as measures of the intra and extra-regional volume of traffic. In order to harmonize between regions of very different population sizes, indicators based on trips are per capita.

Transport indicators expressed in kilometre encompass two effects: the number of trips and the length of the trip. On the one hand, these provide more information, but on the other hand, they are not as clear-cut as the first, because they are influenced by region size. This effect can be detached from the indicator by dividing it by region area, and obtaining a "trip density" indicator.

[1] Heavy Goods Vehicle

For the purpose of a preliminary exploratory analysis, it is useful to build a set of more aggregate indicators that will allow the approach to the question in a top-down fashion. The following set was built:

Table 2 Set of aggregate transport indicators built

Data set	Description	Units
trips_total per capita	trips_total = trips_prod + trips_attr + trips_intra + trips_transit	HGV trips/day/hab
trips_notransit per capita	trips_notransit = trips_prod + trips_attr + trips_intra	HGV trips/day/hab
km_notransit per area	km_notransit = km_prod + km_attr + km_intra	km/day/km^2

This new set of indicators, together with the km_tot indicator, constitutes the group of aggregate indicators that will be used for a preliminary analysis of the data. The trips_total is the sum of all trips, including both intra and extra-regional trips, both attracted by and leaving the region, as well as transit trips. An equivalent to trips_total for kilometre is the km_tot indicator, but this accounts only for kilometre travelled inside the region's borders.

The rationale behind using two different aggregate indicators for trips, one including transit trips and the other not including transit trips, is that in theory transit trips do not relate to GDP. Firstly, because they do not bring any added value to the region's economy, secondly, because transit trips cross the regions by a mere geographic fact, and not for an economic reason. Thus, if we compare the correlational behaviour of the trips' indicators with or without considering transit trips, we should be able to corroborate or refute this hypothesis.

In addition, indicators expressed in total kilometres driven also take into account the kilometres driven by empty vehicles while the ton-km of an empty vehicle add up to 0. Nevertheless also the empty vehicle has negative effects on the environment.

The economic indicators comprise two of the following sets: regional GDP per capita expressed in Euro per inhabitant; share of employment in agriculture, industry and services, at regional level; and data on employment in technology and knowledge-intensive sectors at the regional level.

Other data used in the present analysis included Population expressed in number of inhabitants referring to the year 2003, Region Area in km^2 (2001) and Mean distance to all other EU-countries (2001) in km. These data sets can be found at the EUROSTAT-REGIO database.

3.2 Methodological assumptions and limitations

Correlation analysis is applied to the data in order to investigate the possible correlation between transport indicators and GDP. When working with correlation analysis, it is advisable to screen the data for evidence of linear correlation beforehand. If there is evidence of linear correlation, the Pearson product-moment correlation coefficient has proven to be an appropriate statistic for measuring the level of association between the variables analysed. Otherwise, non-parametric methods will be more appropriate, and Spearman's rho or Kendall's tau-b are typically the statistics used.

Preliminary analysis of the data consisted of: 1) mapping economic and transport data; and 2) constructing scatter plots of transport indicators versus economic indicators. By building the scatter plots it is intended to identify any visible pattern in the relation between the indicators. A visual pattern can be expected if GDP and Transport level are statistically strongly correlated. Moreover, if the GDP and Transport level are linearly correlated, the data points should revolve around a straight line. The preliminary analysis was inconclusive in respect to providing this evidence.

A limitation of the analysis at hand is that spatial effects are intrinsically present due to the nature of the question being investigated. Transport indicators, whether measured in number of trips or in kilometre, suffer, to some extent, of spatial autocorrelation, meaning that the value for one region in the sample is not independent of the value for the neighbouring regions. Many authors alert to the problems inherent to statistical analysis in the presence of spatial effects:

“In general, this reflects on higher variances for the estimates, lower levels of significance in hypothesis tests and a worse adjustment for the estimated models, compared to data of the same dimension that exhibit independence.” (Câmara, Monteiro et al. 2006)

"Because of these spatial effects, if we blithely carry out an OLS regression using aggregated geographic data… Some large subset of the following undesirable horrors almost certainly awaits us (the curse of Tobler’s 1st Law): our estimated regression coefficients are biased and inconsistent, our estimated regression coefficients are inefficient; our R^2 statistic is exaggerated; we’ve made incorrect inferences; we’ll never get it published – or shouldn’t!" (Voss and Ramsay 2006).

The solution for these problems lies, according to these authors, in Spatial Statistical Analysis. It was chosen not to go into this field, and proceed with correlation analysis notwithstanding these acute warnings. However, bearing in mind the limitations of the present analysis, the resulting empirical outcomes must therefore be interpreted with caution.

4. Results

4.1 Preliminary analysis results

The exploratory analysis also revealed important information regarding the indicators that could yield better results:

- Typically, transport indicators expressed in number of trips seemed to yield better results than transport indicators expressed in kilometre.
- Transport indicators per capita yielded a more expressive correlation with GDP per capita than absolute transport indicators.
- Transport indicators in kilometre yielded a more expressive correlation with GDP per capita when normalized by region area (transformed into trip densities in order to partial out the effect of region size, as discussed in Section 2).
- Disaggregating the transport indicators into intra-regional and extra-regional, attracted, produced and transit trips, did not provide an explanation as to which kind of trips (intra-regional, attracted, produced or transit) contributes for the correlation of total trips with GDP per capita.

4.2 Correlation analysis

The correlation analysis is made using the Pearson's product-momentum correlation coefficient together with its significance level as a measure of the association between the variables. At this point a linear relationship between GDP per capita and transport Indicators is pursued.

Table 3 shows the Pearson's correlation coefficient for chosen correlations of transport indicators and GDP per capita. Pearson coefficients for all the correlations can be found in the annex to this paper.

Table 3 Pearson correlation coefficients for chosen transport indicators and GDP per capita

Transport indicators	GDP per capita
trips_total per cap (HGV/day. 10^3 hab)	0,265**
trips_prod per cap (HGV/day. 10^3 hab)	0,205*
trips_attr per cap (HGV/day. 10^3 hab)	n.s.
trips_intra per cap (HGV/day. 10^3 hab)	n.s.
trips_transit per cap (HGV/day. 10^3 hab)	0,271**
trips_notransit per cap (HGV/day. 10^3 hab)	n.s.
km_intra per area (10^3km/day.km^2)	0,231*
km_prod per area (10^3km/day.km^2)	0,482**
km_attr per area (10^3km/day.km^2)	0,462*
km_notransit per area (10^3km/day.km^2)	0,565**

** Correlation is significant at the 0.01 level (1-tailed)
* Correlation is significant at the 0.05 level (1-tailed)
n.s. not significant

Significant positive correlation coefficients were found for the correlation between trips_total per capita and GDP per capita, between trips_prod per capita and GDP per capita, and between transit trips and GDP per capita. While the two first mentioned results were to be expected, the latter comes to falsify the assumed hypothesis that transit trips do not correlate to GDP per capita.

Also, significant positive correlation coefficients were attained for indicators based on km per region area.

Meersman and Van de Voorde (2003) argue that in the 1980's, it was industrial production rather than GDP that better explained the growth of freight transport (in ton-km). The analogue analysis is carried out here. It was explored the relation between Transport indicators and the structure of the economy, on a very macro level, where the share of total employment that is ascribed to the 3 macro sectors of economy (services, industry and agriculture, where the latter was here replaced by its complementary – the sum of employment industry and services).

Table 4 Pearson coefficients for the correlation between chosen transport indicators and the structure of the regional economy (% employed in industry and services) while controlling for GDP per capita

Transport indicators	Industry	Services	Ind + Serv
Trips_total per cap	n.s.	n.s.	n.s.
Trips_prod per cap	0,224*	n.s.	0,261**
Trips_attr per cap	0,267**	n.s.	0,267**
Trips_intra per cap	n.s.	n.s.	0,212*
Trips_transit per cap	n.s.	n.s.	n.s.
Trips_notransit per cap	0,204*	n.s.	0,278**
Km_intra per area	n.s.	n.s.	n.s.
Km_prod per area	n.s.	n.s.	n.s.
Km_attr per area	n.s.	n.s.	n.s.
Km_notransit per area	n.s.	n.s.	n.s.

** Correlation is significant at the 0.01 level (1-tailed)
* Correlation is significant at the 0.05 level (1-tailed)
n.s. not significant

Another approach to the structure of the economy can be given by characterizing the region in what concerns its position in the so called knowledge economy. Several indicators which are commonly used to describe the structure of the economy in what concerns its dependence on the production of high-technology products were tested for a correlation with transport indicators.

Table 5 Pearson coefficients for the correlation between chosen transport indicators and the structure of the regional economy (high-tech manufacturing and services) while controlling for GDP per capita

Transport indicators	high_tech	ma_high	ma_low
Trips_total per cap	n.s.	n.s.	n.s.
Trips_prod per cap	n.s.	n.s.	n.s.
Trips_attr per cap	n.s.	n.s.	n.s.
Trips_intra per cap	n.s.	n.s.	n.s.
Trips_transit per cap	n.s.	n.s.	n.s.
Trips_notransit per cap	n.s.	n.s.	n.s.
Km_intra per area	0,377**	n.s.	n.s.
Km_prod per area	0,310**	n.s.	n.s.
Km_attr per area	0,310**	n.s.	-0,189*
Km_notransit per area	0,354**	n.s.	n.s.
Km_total per area	0,349**	n.s.	n.s.

high_tech: share of employement in high-tech manufacturing and knowledge-intensive high-technology services
ma_high: share of employment in high-tech manufacturing sector
ma_low: share of employement in medium low technology manufacturing sector
** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level
n.s. not significant

The results report on no clear evidence that higher shares of labour in productive sectors related to high technology products correlate with the number of trips in a region. However, significant correlations appear to exist between the km-driven and the share of high technology employment in a region.

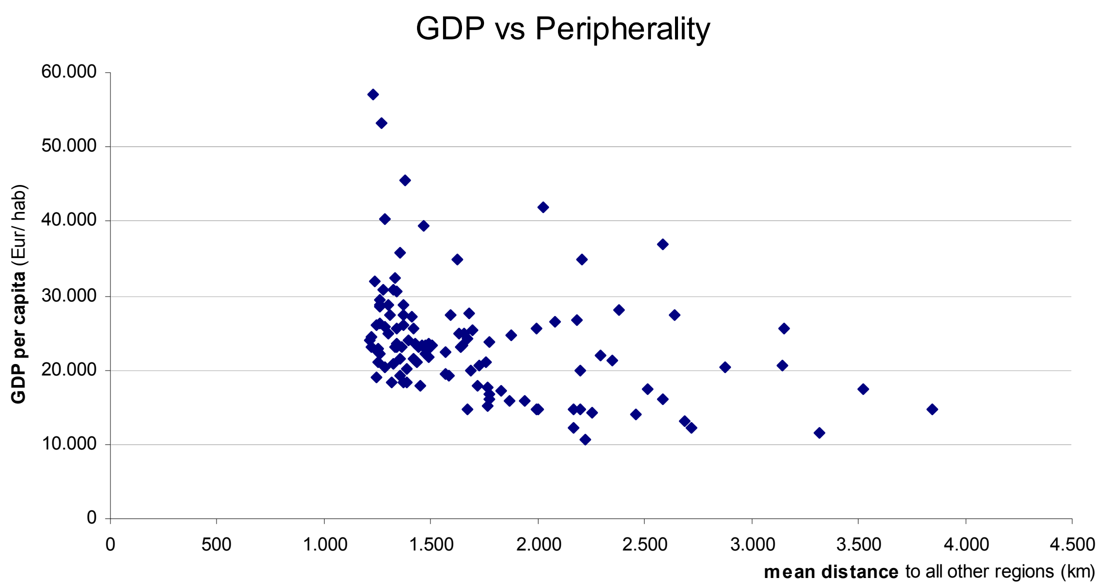
4.3 Controlling for peripherality

The correlation analysis shows significant levels for correlations involving GDP per capita and Transport indicators that include transit trips, than for those that do not include transit trips (see trips_transit per cap and trips_total per cap when compared to trips_notrans per cap). This result comes to falsify the assumed hypothesis that transit trips do not correlate to GDP per capita.

However, it could be the case that the above results do not in fact reveal a correlation between GDP per capita and transit trips. Instead, we could be in the presence of a spurious relation: per definition, transit trips are virtually null for peripheral regions and high for central regions. On the other hand, it is reasonable to assume that in Europe, centrality and high GDP go hand-in-hand.

The hypothesis was tested using the indicator "mean distance to all other EU-regions" as a measure of peripherality. On the one hand, it is true that for the explored sample GDP per capita and peripherality are correlated (Pearson statistic yielded a value of -0,356, significant at the 1% level), although not as strongly as one could initially expect (see Figure 3).

Figure 3 GDP per capita in function of the level of peripherality for European regions



However, none of the above correlations stands, if they are tested while controlling for peripherality. This occurs not only for the variable accounting for transit trips, but for all the indicators used, in all of the correlation analysis described above.

Therefore, the analysis provided no evidence of a correlation between road freight transport indicators expressed in number of trips or km driven and GDP, or with the structure of the economy, that can sustain itself when the variable peripherality is partialled out.

In fact, the level of peripherality seems to be the only variable accounting for variations in the transport indicators.

Table 6 . Pearson correlation coefficients for chosen transport indicators and Peripherality

Transport indicators	Peripherality
Trips_total per cap	-0,452**
Trips_prod per cap	-0,556**
Trips_attr per cap	-0,537**
Trips_intra per cap	n.s.
Trips_transit per cap	-0,365**
Trips_notransit per cap	-0,402**
Km_intra per area	-0,378**
Km_prod per area	-0,205*
Km_attr per area	-0,197*
Km_notransit per area	-0,318**
Km_total per area	-0,514**

** Correlation is significant at the 0.01 level (1-tailed)
* Correlation is significant at the 0.05 level (1-tailed)
n.s. not significant

5. Conclusions

The aim of the work presented was to seek evidence of a correlation between road freight transport and the level of economic activity, when the indicator accounting for transport is not expressed in ton-km. Correlation analysis seemed to confirm the existence of correlation between most of the transport indicators used and GDP, at significant levels. However, the significance of these correlations does not remain significant when the variable peripherality is partialled out.

The results should be interpreted carefully, taking into account the limitations of the simple methodology used. Nevertheless, results consistently point to the fact that peripherality is the only variable in the set analysed that can account for differences in number of trips and km driven between the different regions in the sample. Rather than shed new light into the question of the correlation between road freight transport and economic activity, this result opens up a whole new set of questions about the nature of this relation.

The context of the proposed research question is highly related with the spatial characteristics of the data. In this case, it is advised to complement the traditional statistic methods with spatial statistic methodologies, like the Exploratory Spatial Data Analysis (ESDA), in order to better quantify the significance of the spatial correlation of the indicators.

Several methodological options could be explored in order to confirm the real significance of these trends, such as cluster analysis or quantile regression. One other way to deal with the presented question is to try to skim through the data and see which regions belong to each group, attempting to recognize the common factors between them. A brief overview of the plotted data suggested that the regions that followed the increase of level of freight transport with GDP tendency belonged to the following countries: Portugal, Spain, France and Italy; whereas the regions that followed the opposite tendency (level of freight transport does not increase with GDP) belonged to Luxembourg, Austria, Finland and Sweden.

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