INNOVATION PERFORMANCE OF THE TRANSPORT SECTOR AT REGIONAL LEVEL

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Abstract: Transport is a key enabler of economic and social activity and a major industry in the European economy. However, transport is also a source of environmental concerns and other negative externalities. Improving the efficiency of the transport system, mitigating its negative impacts and increasing the competitiveness of the transport industry are the key challenges of EU policy. Innovation is essential for the European transport strategy to achieve these challenges. Acknowledging the fact that regions are important engines of economic development, regional innovations can be important drivers for growth and improvement of the transport sector in Europe. The innovation process and relative performance of the transport sector at regional level is, however, not extensively studied.

In the framework of the European FP7-funded project METRIC a method has been developed to measure and explain the innovation performance of the transport sector at regional level. This paper outlines this method and presents the results of applying this method to 251 European regions. The method is based on structural equation modelling. This modelling technique enables to get scores for the innovation performance of each region and to derive estimations that express the relative importance of the explanatory factors for innovation performance.

The analysis showed that the high performing regions were predominantly found in Germany and Sweden, while the low performing regions were located in Finland, Poland, Romania, Bulgaria, Hungary, Spain and United Kingdom. However, the scores of regions on innovation performance are rather different when the performance is measured for the transport manufacturing and transport service sector individually. Among the factors that may explain transport innovation performance of regions funding possibilities appear to be highly important, while the relevance of innovation milieu is outmost limited.

Keywords: transport innovation, innovation indicators, regional analysis, structural equation modelling

1. Introduction

Transport is a key enabler of economic and social activity and a major industry in the European economy. The transport industry employs more than ten million people, accounting for 4.5% of total employment in the EU, and representing 4.6% of gross domestic product (GDP). Manufacture of transport equipment provides an additional 1.5% of employment and 1.7% of GDP (European Union, 2013).

The European transport system is one of the world’s best qualified systems, but nevertheless faces major challenges. Growth in passenger and freight transport demand has increased considerably in the last decades and is predicted to rise further. However, overall infrastructure capacity is reaching its limits and (financial) possibilities to expand transport infrastructure significantly are also limited. The challenge is to make more efficient use of existing infrastructure, while meeting higher requirements for safety, security and reliability as well as user convenience (European Union, 2012).

The unabated growth in transport demand also endangers the target of achieving a 60% reduction in greenhouse gas emissions by 2050 from the 1990 level. The increase in total emissions that result from transport growth will likely offset possible reductions of new efficient technologies. Development of more energy-efficient technologies and stimulation of the use of more sustainable transport solutions are therefore needed.

Last but not least, the leadership position of the European transport manufacturing (vehicles and other transport equipment) is challenged. The emerging role of in particular Asian countries endangers the European competitiveness and hence employment.

Innovation is considered essential for the European transport strategy to tackle these challenges. Innovations should lead to more efficient, environmentally sound and more intelligent transport in Europe and to more competitiveness of the European transport industry in developing and selling such new, smart transport solutions.

The conditions for realising innovations and being successful in implementation will vary in Europe, not only at country level but also at regional level. In view of limited budgets of the European Commission to support innovation, the need to spend these budgets effectively, the acknowledgement that regions are important engines of economic development and the fact that regions in general can increasingly apply for EU-finance (e.g. through the smart specialisation strategy program) there is an interest to identify the transport innovation potential of regions. The FP7-funded project METRIC focuses on analysing this transport innovation potential of regions. As part of this METRIC-project this paper describes a method to measure and explain transport innovation performance of regions and presents the results of applying this method to 251 European regions.

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2. Framework for measuring and explaining transport innovation potential

2.1 Conceptual model

Innovation performance in general is measured on a regular base across the European Union. The most extensive measurement tool is the Union Innovation Scoreboard (UIS), which provides an annual benchmark of the innovation performance at the country level of the EU member states and other European countries. Innovation performance is measured using a composite indicator – the Summary Innovation Index – which summarizes the performance of a range of different indicators. IUS distinguishes between 3 main types of indicators – Enablers, Firm activities and Outputs – and 8 innovation dimensions, capturing in total 25 indicators.

The other measurement tool, the Regional Innovation Scoreboard (RIS), accompanies the UIS. The RIS provides a comparative assessment of innovation performance across 190 regions of the European Union, Norway and Switzerland, but it is less frequent and detailed due to lack of innovation data at the regional level. The RIS 2014 uses data for 11 of the 25 indicators in the UIS. Similar as in the IUS where countries are classified into 4 different innovation performance groups, Europe’s regions have also been classified into Regional Innovation leaders (34 regions), Regional Innovation followers (57 regions), Regional Moderate innovators (68 regions) and Regional Modest innovators (31 regions) (Hollander et al., 2014).

In order to measure the transport innovation performance of regions it would have been logic to adopt the approach of UIS and RIS. The limited availability of data at regional level, however, becomes even more problematic when regional data needs to be collected at sectoral level, i.e. the transport sector. For several of the indicators in RIS the data are not available at the level of the transport sector. On the other hand data regarding relevant indicators to measure transport innovation performance are only available at country level. In view of these limitations the RIS measurement framework has been adopted to the framework as presented in figure 1.

![Figure 1. Measurement framework of regional transport innovation performance](image)

Figure 1. Measurement framework of regional transport innovation performance

For the measurement of regional transport innovation performance two dimensions have been distinguished (see also the Regional Innovation Scoreboard 2012, Methodology report: Hollanders et al., 2012):

- **Innovation achievements**: captures the output of innovation activities in the transport sector in the region;
- **Economic performing**: captures the economic effects of innovation activities in the transport sector in the region.

Based on literature review we have defined major aspects that are often quoted in literature as relevant factors to encourage innovation activities and to succeed in the implementation of innovations. These drivers are considered as explanatory factors for the innovation achievements. In addition, it is assumed that the economic performing of the transport sector can be explained by its innovation achievements. Innovation may induce better economic performing, but the level of economic performing of the transport sector will obviously also be determined by other factors. These other effects on the regional economic performing of the transport sector are supposed to be caused by the characteristics of the transport sector in general (see figure 1).

Taking into account the availability of data at regional (NUTS 2) level indicators have been defined to reflect (or actually enable measurement of) innovation achievements and economic performing as well as each of the explanatory factors.
2.2 Indicators: data

The next step was to define indicators to enable the measurement of ‘Innovation achievements’, ‘Economic performing’, ‘Innovation funding’, ‘Innovation milieu’ and ‘Transport sector structure’. The availability of data played a key role in this process. Data was needed at the NUTS2 regional level. To a great extent the data could be obtained from Eurostat statistics. Other sources were the Joint Research Centre of the European Commission and the Cluster observatory. However, not all data were available at the NUTS2 level. In particular data of the Community Innovation Survey (CIS) from Eurostat were only available at country level. Where needed the data have been regionalized according to the regionalization technique proposed in the RIS 2014 ((Hollanders et al., 2014: 37). Furthermore, the number of missing values in the data have been reduced by using different imputation techniques (see Konings and Louw, 2014). Regions with a substantial number of missing values, however, were dropped. Hence 251 (of 284) regions were kept for the analysis. The data for the transport sector covered both the manufacturing sector (i.e. vehicles and other transport equipment) and the transport service sector. The following indicators were used:

Innovation achievements:
- Share of innovative enterprises in transport sector 2010.
- Share of highly innovative enterprises in transport sector 2010.
- Average number of patents per year (2006-2008) per 100,000 employees (2008-2010).
- Share of enterprises that have introduced new or significant improved products that were new to the market as share of total population 2010.
- Share of enterprises that have introduced new or significant improved products that were only new to the firm as share of total population 2010.
- Turnover from innovations 2010.

Economic performing:
- Growth of labour productivity in the transport sector 2008-2011.

Transport sector structure:
- Average firm size 2010.
- Share of manufacturing (or services) in total employment of the transport sector 2008.
- Level of transport specialization 2008.

Innovation funding:
- Product and/or process innovative enterprises that received any public funding as share of the total population 2008.
- Share of public R&D as % of GDP 2008.
- Share of business R&D as % of GDP 2008.

Innovation milieu:
- Specialisation in Transport research as % of total FP7 EC funding 2008.
- Cluster Quality 2008.
- Share of product and/or process innovative enterprises engaged in any type of co-operation as share of total population 2008.
- Share of high educated persons in total transport employment 2008.
- Share of persons employed in science and technology in total of all manufacturing activities and in transport services 2008.
- Share of employment in technology and knowledge-intensive sectors in transport services 2008.
- Educational level total labour force 2008.

2.3 Structural equation modelling (SEM)

SEM is a statistical technique to investigate complex causal relations through combining the technique of regression analysis, path analysis and factor analysis. For the purpose of our analysis SEM is an appropriate tool, because it enables a comprehensive measurement of the innovation performance of regions in the transport sector and it enables to get insights in the relative importance of the explanatory factors for the transport innovation performance.
The influence of the explanatory factors is revealed in the so called structural model of SEM, while scores on the factors, i.e. ‘Innovation achievements’ and etc., are obtained through the so called measurement model of SEM. Usually both models are run simultaneously in SEM, and hence all estimations are obtained in one time. Special software exists (e.g. AMOS in SPSS) to run SEM-models. This approach, however, could not be applied here. The limited number of observations (251 regions) related to the relative large number of parameters to estimate (caused by the number of factors and their relations and indicators) caused difficulties in fitting the model. A possibility to overcome this estimation problem was to construct factors by their indicators before the AMOS analysis was undertaken. Hence a two-step approach was taken in which the scores of factors are input for the SEM-model (i.e. the structural part of the model).

Different methods exist to compute the factor scores, all having some advantages and disadvantages. Based on decision rules and recommendations provided in literature about multivariate data analysis (see e.g. Hair et all., 1998) we have chosen for the method of summat ed scales (= somscores). This means that each indicator gets an identical weight in the construction of the factor. In order to apply the summat ed scales all indicators have been standardized by means of transforming their original values into Z-scores.

3. Results of the SEM analysis

The type of activities in the transport sector of a region can be very diverse. The activities are in particular different between transport manufacturing and service companies, and hence differences are also very likely in their innovation behavior and performance. A region may show a good innovation performance in transport manufacturing, while the transport service companies may have a weak innovation performance. It is important to note that the innovation performance of the total transport sector can be a result of very different performances in the two subsectors. Therefore a SEM analysis is performed for the total transport sector, but also for the transport manufacturing and transport service sector individually.

3.1 Model estimations for the total sector

The estimations for the total sector are shown in figure 2, i.e. the standardized path coefficients, which express the strength of the causal relations and the R squares for ‘Innovation achievements’ and ‘Economic performing’, which express the (local) explanatory strength of the model. The double arrows (expressing correlations between the explanatory factors) have been included to obtain a pure effect estimation of each explanatory factor only. ‘Funding’ is the most important determinant (0.69) for the ‘Innovation achievements’, followed by ‘Sector structure’ (0.30). The role of the ‘Innovation milieu’ should be interpreted as negligible as the path coefficient is close to zero. In view of theoretical notions this is a remarkable result. Specific attention was given to the composition of indicators in this factor. Several variants in the composition of indicators - in which fewer indicators were included – were tested in different model runs. The results, however, were robust. That is to say, they did not lead to relevant changes in the path coefficient that describes the strength of the influence of ‘Innovation milieu’ on ‘Innovation achievements’. Therefore we kept the original composition of indicators for the factor ‘Innovation milieu’.
On the other hand the ‘Economic performing’ of the transport sector can, to a very low extent, be explained by this model. Apparently, there are others factors relevant for the ‘Economic performing’ which are not included in this model.

In figure 3 the relative scores of the regions on ‘Innovation achievements’ are mapped. In this map two categories represent the scores of regions above the European average (‘above average’ and ‘far above average’) and two categories reflect the scores below the European average (‘below average’ and ‘far below average’). The high performing regions are predominantly in Germany, and, remarkably, regions in Portugal and Sweden also score well. On the other hand regions in France, Spain, Norway, Hungary and in particular in Finland, Poland, Romania and Bulgaria are at the lower end of the scores.

![Scores of regions on 'Innovation achievements' in the total transport sector](image)

**Figure 3.**
Scores of regions on 'Innovation achievements' in the total transport sector

### 3.2 Model estimations for the transport manufacturing sector

Figure 4 depicts the result of the analysis for the transport manufacturing sector only. Both ‘Funding’ and ‘Sector structure’ seem to be important for the ‘Innovation achievements’ in this subsector. The role of the Sector structure may point at the relevance of ‘mass’ to achieve strong innovation performances in the manufacturing sector. Namely, the presence of large companies and a high share of transport manufacturing companies go along with high scores on ‘Innovation achievements’ of regions. The importance of ‘Innovation milieu’ for ‘Innovation achievements’ appears also for the manufacturing sector marginal. The variance in ‘Innovation achievements’ which is explained by the model (0.61) is nevertheless substantial.
Figure 4.
Parameter estimations for the transport manufacturing sector

Figure 5.
Scores of regions on ‘Innovation achievements’ in the transport manufacturing sector

The relative scores of regions on ‘Innovation Achievements’ are mapped in figure 5. Many regions that have a high innovation performance are found in Germany, but also a lot of other countries have some regions that perform well, such as France, Italy, Portugal, the Netherlands, Belgium, Austria, Czech Republic, Hungary, United Kingdom Romania and Sweden. The pattern of high performing regions is partly framed by the location pattern of the car manufacturing industry. Several regions that have a weak innovation performance in transport manufacturing are located in France, United Kingdom and Poland. Compared to the map that covers the ‘Innovation achievements’ in the total transport sector, the strong performing regions in the manufacturing sector on one hand and the weak performing regions on the other hand are less geographically clustered.
3.3 Model estimations for the transport service sector

The results for the SEM-analysis for the transport services sector only (see figure 6) are rather different from the manufacturing sector, but resemble the results for the total sector. This can be explained by the fact that there are much more transport service activities (in terms of employment and companies) than transport manufacturing activities. Hence the strengths of relationships found in the services sector put their mark on strengths of relationships observed in the total transport sector.

‘Funding’ appears to be by far the most important determinant for the ‘Innovation achievements’ in the services sector. There is a modest role of ‘Sector structure’ in influencing the ‘Innovation achievements’, but the quality of the ‘Innovation milieu’ here also appears not important. The power of the model to explain ‘Innovation achievements’ is, however, relatively good (comparable to the models for the total and the manufacturing transport sector). Note that the model of the services sector is not able to explain the ‘Economic performing’ of the transport services. There appears to be a weak and even negative relation between ‘Innovation achievements’ and ‘Economic performing’. The influence of the ‘Sector structure’ on the ‘Economic performing’ is also negligible. We cannot explain why these results are different from the models for manufacturing and the total transport sector.

Figure 6. Parameter estimations for the transport services sector

Figure 7 illustrates the regional scores on ‘Innovation achievements’ in the services sector. Regions that are in a similar range of performance are largely clustered geographically. High performing regions are found in Germany, Sweden and Portugal. Italy has for example many moderate performing regions and United Kingdom very modest performing regions. The lowest performing regions are strongly clustered in Spain, Norway, Poland, Slovakia, Hungary, Romania and Bulgaria.

Figure 7. Scores of regions on ‘Innovation achievements’ in the transport services sector
4. Conclusions

In this paper we have measured the innovation performance of the transport sector at regional level. We used an approach that enabled a comprehensive measurement that took into account that there is not one unambiguous indicator to measure performance, but rather a set of indicators since performance actually has several dimensions.

A major observation from our analysis is that the relative innovation performance of regions is strongly determined by the definition of the transport sector. First the innovation performance of regions was measured for the total transport sector, i.e. the transport manufacturing and service activities together. This definition is obviously relevant to map the innovation performance of regions in general. However, because manufacturing and service activities are so different, and most likely, also the innovation behaviour of these subsectors, but also because of large differences between regions in the relative size of the transport manufacturing and service sector it made sense to also look at the innovation performance of these subsectors separately.

As far as the results for the total transport sector are concerned, the high performing regions were predominantly found in Germany and Sweden, while the low performing regions were located in Finland, Poland, Romania, Bulgaria, Hungary, Spain and UK. Since the transport services sector is much greater (in terms of employment and number of companies) than the manufacturing sector, the scores of regions in the services sector resemble the scores for the total transport sector. The map of innovation performances of regions in the manufacturing sector gave a more diversified pattern, i.e. more regional variation within the different countries.

In order to explore explanations for the transport innovation performance of regions and their relative performances a Structural Equation Model (SEM) was used. From general innovation theory relevant factors to explain innovation performance were related to the innovation achievements, i.e. funding, innovation milieu and transport sector structure. Several indicators were used to enable a comprehensive measurement of these factors.

The results of this SEM-analysis indicate a relative great importance of funding possibilities for the innovation achievements. This observation was valid for both the analysis for the total transport sector and for the analyses of the manufacturing and service sectors. However, the role of funding appears to be even more important in the service than manufacturing sector. In general the results suggest that the availability and possibilities for innovation funding are determined at national level rather than regional level, since the scores of regions on funding show hardly variation between regions within countries. The importance of the transport sector structure for innovation achievements is in the manufacturing sector greater than in the service sector. A striking result is that the role of innovation milieu for the innovation achievements appears to be negligible for both the manufacturing and service sector. Since this does not fit to theoretical expectations it gave rise to critical reviews and reformulations in the construction of this factor (i.e. the composition of its indicators), but this did not lead to relevant changes in the outcome.

In this METRIC-project we are faced with the fact that we can only use secondary data, and as the experiences with RIS have shown, there is limited availability of data. In principle we needed comparable data as used in RIS, but even more detailed, because it was needed at sectoral level (i.e. the transport sector). Therefore it took great efforts to obtain regional data for all indicators that were initially proposed to be included in the SEM-model. For several indicators the data appeared too incomplete to keep them in the analysis, while for other indicators, a lot of data imputation (e.g. regionalisation of data) was needed. It is uncertain to what extent this leads to biasedness and has affected our model results. Considering the great emphasis the European Commission places to innovation policy and research it is recommended to extend and improve the data collection to support research in this field.

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References


