# FULL STEAM AHEAD OR DOWN? AN EVALUATION OF EUROPEAN RAILWAYS AFTER THE "YEAR OF RAIL"

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***Abstract***

*The year 2021 was a critical juncture for European Railways. Not just the deadline for full implementation of the Fourth Railway Package, but the EU also advertised the whole year as "the year of Rail" to accelerate mobility on rail and aid member states to speed up their compliance with the norms of highly anticipated "Single European Railways". Nevertheless, both goals seemed pretty ambitious to achieve when member states were still coping with the pernicious effects of the pandemic and the war. This research evaluates EU nations' current performance towards the EU's railway regulations. Through a machine-learning model, the analysis suggests three classes of states. It assumes a significant differentiation in member state performance, which causes the EU to fall behind the assumed schedule immensely.*

***Keywords:*** *European Union, Rail transport, Mobility, Differentiation, Integration.*

# TAM GAZ İLERİ Mİ YOKSA GERİ Mİ? "DEMİRYOLU YILI" SONRASI AVRUPA DEMİRYOLLARININ DEĞERLENDİRİLMESİ

***Öz***

*2021 yılı Avrupa Birliği demiryolları politikaları için oldukça önem arz eden bir yıl olmuştur. Avrupa Birliği bahsedilen yılı sadece Dördüncü Demiryolu Paketi'nin tamamlanma dönemi olarak ele almamış, aynı zamanda*

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*"Demiryolları Yılı" olarak ilan etmiş ve "Tek Avrupa Demiryolu" projesi ışığında trenyolu ile ulaşımı ve entegrasyonu arttırıcı tedbirler almıştır. Fakat, üye ülkelerin pandemi ve savaşın etkilerinden tam olarak sıyrılamadığı bu dönemde, konulan hedefler birçok açıdan iddialı ve fazla iyimser olarak değerlendirilmiştir. Bu araştırma, AB ülkelerinin istenilen demiryolu düzenlemelerine yönelik mevcut performansını değerlendirmektedir. Makalenin analizi makine öğrenmesi modeli temelinde üç grup ülke oluşumu üzerinden yapılmıştır. Araştırma, AB'nin üye ülke performans ve uygulamalarındaki farklılaşmalar sebebiyle öne sürülen hedeflerin gerisinde kaldığını iddia etmektedir.*

***Anahtar Kelimeler:*** *Avrupa Birliği, Demiryolları, Hareketlilik, Farklılaşma, Entegrasyon.*

## Introduction

European integration has been at crossroads. While the most pernicious effects of the war are yet to come, it has already caused certain fluctuations in the process. This decade may face more nuclear options, opt-outs, opt-ins, and variations between member states. Differentiations have steadily increased (Schimmelfennig and Winzen, 2020), and the EU is prone to see more soon. Amid this new era, emerging problems in transport policy have been raising alarm bells. Since the Treaty of Rome, transport has played a central role in the integration process. Combined with the newly announced Green Deal, the EU has widened the scope of the policy to build an efficient and environmentally friendly deep integration (European Commission, 2022a).

Nevertheless, from impaired mobility to the impacts on aviation, the entire sector is now on the edge of setbacks. Strangely enough, despite the headlines dominated mainly by survival strategies, progressive ambitions have never disappeared. An example can be the declaration of 2021 as the "European Year of Rail", an advertisement campaign designed to attract more citizens to use railways. However, 2021 was not only the year of cherishing railways; it was also a critical juncture for European transport. After four implementation packages, 2021 became the final straw for the much-anticipated Single European Railway Area and full market liberalization (European Council, 2022). The latest fourth railway package, implemented in 2016, ensured the last framework for complete standardization between member states (European Commission, 2022b). Considering all this, it is uncertain whether this "European Year of Rail" campaign was a victory lap signifying European success or a cry for help to nudge member states for one last push.

The looming puzzle starts here. Albeit the EU has been persisting about the complete execution and establishment of the “Single European Railway Area” in 2021, the initial observation from raw data and reports claimed that it is simply not conceivable. Enduring disparities amid member states, non-implementation, and various transposition setbacks have been observed. Accompanying the preliminary findings, the EU itself had admitted the pandemic's severe detrimental effects on the European railway sector (Eurostat, 2021), and the latest market monitoring report of the European Commission (2022c) signaled no sign of a modal shift to the rail, which was the fundamental purpose of uniform integration in the railways. To understand what the EU has achieved so far on its railway targets, this article was introduced to make a comprehensive evaluation concerning the transposition of EU regulations. Therefore, this article asks, "To what extent has the EU been prepared to establish a uniform railway area?" and analyzes the member states' performance in railways' infrastructure, market, and technology through a K-Means method. After such an important year, this article aims to contribute to the literature by making a contemporary analysis of the railway sector and possibly introducing railway policy as another example of differentiated integration. The initial findings suggest that the EU still has a mountain to climb for deep integration on railways, and differentiation in this area is mainly multi-speed, with a threat of durable differentiation soon.

**Conceptual Framework**

Let alone railways, the place of transport research in European studies has not yet reached its potential. Its procedural nature attracts engineering sciences, but its socio-political aspect is still there to explore. There were several early attempts to break this chain and bring transport into the realm of integration studies. J. Michael Thomson (1978) is one of those initiators to make a comprehensive expert analysis of the European transport network in its planning stages. Along with Thomson (1978), Goedhuis (1957) and Ross (1994) brought aviation and high-speed rail sectors to the fore as a potent catalyst for integration.

In tandem with the changes in the level and scope of integration, transport studies also started to shift focus on the variations between the member state implementation. Kaeding's (2008) research, in this sense, is an archetype by proving severe transposition deficits in member states by using 95-2004 datasets. Kaeding (2008: 133) identified integration in transport as “clustered” due to national dynamics and characteristics of different directives. Kaeding's (2008) analysis has significantly inspired the present article, which aims to show this cluster's persistence with a more extensive and up-to-date dataset on railways.

European literature on railways gained momentum in the new millennium by introducing four transposition packages and the EU's perseverance to put railways at the center of its sustainability goals. Knill and Lehmkuhl (2002) were the first to examine changing railway regulations and their impact on member states. Like Kaeding's (2008) case analysis, the duo underlined the existence of divergent implementation in the members (Knill and Lehmkuhl, 2002). However, the growing market and aggressive liberalization changed the direction of scholarly works in the last decade. Market-related concerns became the point of focus for most of the literature, including how the EU liberalization changed market efficiency (Navarro, Nombela and Tranchez, 2019), the effects of the market reforms on rail modal shares (Tomes, 2017), the relationship between competition governance and rail market performance (Finger, 2014) and the importance of regulatory agencies (De Francesco and Castro, 2018).

Although they give great insights into the different parts of integration, none provide a complete picture of the railways in today's Europe. Differentiation between member states is evident almost in all papers. Still, one cannot simply attribute this to the entire policy area without considering all relevant variables, including performance on rail infrastructure, market, and technology. After such an important year where Europe had anticipated a uniform integration, a lack of comprehensive academic analysis on railways could be assumed as a gap in the literature. Therefore, the humble contributions of this article to fill this gap are as follows:

Picking up where Kaeding (2008) and Knill and Lehmkuhl (2002) left off, this research would like to enrich differentiated integration literature by demonstrating the differences among a group of member states at the anticipated last stage of railway integration. In this way, the overall expectancy is that the outcomes of this article would further validate the assumptions of these past studies with more up-to-date data. Literature is either too market-oriented[1] or limited in scope[2]. This research offers a broad, up-to-date quantitative classification table collaborating the most indispensable aspects that the European Union has presented in the latest fourth railway integration package and the EU Green Deal.

[1] Boston Consulting Group published a "European Railway Performance Index" in 2012, 2015, and 2017. The scope of these indexes is primarily limited to market concerns such as the relationship between public funding models and railway performance, the intensity of use, and quality of services. On the same footing, the McKinsey & Company report of 2019 made an informed impact analysis of the EU rail liberalization but again did not include more than the passenger aspect.

[2] For example, Fraszczyk et al. (2016) evaluate rail performance in Europe but limit their focus on passenger rail. Likewise, recently, Esposito and Cicatiello (2020) also restricted their case to the correlation between liberalization and rail freight market.

Conceptually, multi-speed Europe could explain the emerging differentiation in railways transposition. This differentiated integration typology emerged in the 70s after member exclusions from emerging policy areas such as EMU and Schengen and selective integration of non-members had started (Holzinger and Schimmelfennig, 2012). Since the 70s, the conceptualization of this developing variance in the level and scope of integration has continued. The "multi-speed Europe" thesis gained responsiveness, especially after the EU had included new members. There are two key variables, time and space, to determine the direction of differentiation. Stubb's categorization in 1996 explains time as the difference between groups of member states, where a core group of states – both capable and willing – leads others in pursuit of common objectives. If the crucial cause of differentiation is a state's short-term inability to provide necessary measures of convergence (Warleigh-Lack, 2002), this type of variance is known as "temporal" (Stubb, 1996), and there are no essential break-ups from the way of uniformity since latecomers can catch up when they are ready and capable (Warleigh-Lack, 2002; Holzinger and Schimmelfennig, 2012).

Differentiation over time occurs for various reasons. In their "vertical differentiation" analysis, Schimmelfennig, Leuffen and Rittberger (2015) assert the variation in the interdependence between European and national aims as the main factor. Centralization happens at different speeds and reaches varying levels (Schimmelfennig, Leuffen and Rittberger, 2015), and the nature of the policy area can shape the intensity of interdependence (Lindberg and Scheingold, 1970). As a result, homogenous integration rarely happens due to the increasing number of heterogeneous states trying to cooperate in one set of policies (Andersen and Sitter, 2006). Operationalization of mutual ideas (Andersen and Sitter, 2006), ideological preferences (Holzinger and Schimmelfennig, 2012), domestic constraints (Holzinger and Schimmelfennig, 2012 ), ideational factors (Holzinger and Schimmelfennig, 2012), bargaining power of a member state to get exemptions or delays (Schimmelfennig and Sedelmeier, 2004), the willingness of actors and the character of the policy area (Kölliker, 2001) may all determine the direction of the differentiated integration.

Nevertheless, factors of differentiation are subject to change for each policy case. For example, while geography is decisive for transport, it is not merely a driver of monetary policy. Thus, each policy area should be investigated through its *sui generis* characteristics.

If typology comprises other variables such as space (Stubb, 1996) or political choice (Warleigh- Lack, 2015), this might call for a more enduring, long-term, and stable differentiation. A variation would become much more territorial and clustered (Stubb, 1996) if states were divided into separate

leagues depending on the set of regional measures and state choices about their long-term goals (Warleigh-Lack, 2015). Contrary to a multi-speed category, these differing tiers have been called "concentric circles" and are defined as permanent and irreversible separation amid regions (Stubb, 1996). So far, both categories have been applied to different policy areas such as the EMU (Kölliker, 2001; Schimmelfennig, Leuffen and Rittberger, 2015), energy policy (Perez, Scholten and Stegen, 2019), Schengen Agreement (Schimmelfennig and Winzen, 2020; Jensen and Slapin, 2012). The results of this article can assume more of a temporal multi-speed differentiation since all member states have already agreed on the measures of centralization, yet, national/policy area-oriented factors could still claim variations. The anticipated results could contribute most to the recent findings of Schimmelfennig and Winzen (2020) and Leruth, Ganzle, and Trondal (2019), who defined *temporary forms* of differentiation as the most dominant model. Yet, this article has found no evidence to support existing long-term opt-outs[3] and durable separation. However, as Map 1 shows in the next chapter, the emerging clusters and groups do not rule out the possibility of future concentric circles.

**Method and Data**

Since this article and data comprise up-to-date content, this research has ensured that the method used is topical. In this instance, this research is computer-supported social science research. A machine-learning (ML) model was created and operated specifically for the EU's railway policy data. Software such as Python 3 and JupiterLab 3 sci-kit-learn packages was collaborated to build and use such a model. In this respect, this comprises three stages. In the upcoming paragraphs, readers can see the problems that emerged while elaborating on the data and solutions. Here, the expectancy is that the explanations in this chapter can help clarify the research and encapsulate problem-solving examples for future studies of this kind.

*Collecting and constructing the data*

To collect necessary data and locate the datasets for this research, the EU's emerging legislation in the 4th railway package, the EU Green Deal goals, and general norms of compliance on railways, especially those that had become prominent in the 2021 Year of Rail, were evaluated. This data collection allowed the research to observe the variables for the evaluation, and those variables were categorized into three groups. In this sense, the analysis is based on the latest EU rules for the full integration of railways and outlined datasets. The categorization includes three clusters: infrastructure, market, and

[3] Cyprus and Malta opted out due to geographical factors, not because of any other internal issue or opt-out through bargaining.

technology. The compilation of data was drawn from Eurostat and EU's Rail Market Monitoring Reports[4] and located fifty independent variables.

Nevertheless, the observed first problem was the shortage of panel data regarding member states, which could have defected a Machine Learning model. Even if a certain amount of lost data could have been collected from member states' datasets[5], it would still be scientifically necessary to narrow the observance timeline to 2014-18 from 2010-19[6]. In the end, other missing pieces have been completed by taking the mean of member state data in given years. After this editing stage, the final dataset comprised the data of 49 independent variables from 25 member states[7] and the EU average in years between 2014-18.

*Evaluating and understanding datasets*

The second phase of the methodology was concerning the evaluation of the collected dataset to construct a machine-learning model and select relevant variables. The dataset's central tendency, range, and correlation between variables were inspected at this stage. In this context, the initial observation had shown that the standard deviation of the dataset (constructed yearly and at the country level) was high before the dataset failed to ensure the assumption of normality concerning the Shapiro-Wilk test. Under the circumstances, the determination was to correlate the coefficients using Kendall's Tau method. After thoroughly investigating the coefficient table, the total number of variables has decreased from 49 to 31. Inside the relationship of 47 continuous variables (variables with detected correlation coefficients), only one issued a high negative correlation, and 14 of them remarkably signaled low negative correlation quality. As a result, it could be assessed whether the 47 continuous variables in the dataset can positively or not affect one another.

*Shaping and operating a machine-learning model*

The third and last phase of the method building included the formation and operation of the machine-learning model. Compared to the first two phases, the previous step had proceeded with more obstacles, so more extensive and complicated research emerged. These obstacles mainly stem from the content

[4] The other statistical datasets and websites used in this article are: INFRABEL, ERTMS.net statistics, European Environment Agency Noise data, European Commission Transport Scoreboard, and European Railway Agency- ERADIS Database.

[5] This was certainly a problem for Belgium. Lost data for Belgium was collected from INFRABEL dataset.

[6] Sufficient data for the year 2020 is more or less missing in all datasets used in this article, mainly due to operational reasons regarding the pandemic.

[7] Excluding Cyprus and Malta. These states are not voluntary but natural opt-outs because of their impossible geography for railway infrastructure.

and scope of the research. Methodologically, the differentiation of member states in capacity and political interests, shaped by internal and external factors, has created an outlier problem. Here, this article can put forward two arguments: (I) Against outliers, the position of machine learning models in international relations does not help generalize the methodology. However, it does not make it impossible either. (II) The differences in the resources, trends, and actions of 25 member states seemingly support the main argument of differentiation in the level and scope of EU integration processes.

Another problem encountered in the third phase was the method used in the machine-learning model. Since a dependent variable was not clearly identified to specify as the "score," the decision was to operate a K-Means method, an unsupervised learning algorithm, instead of a regression model. On the other hand, the Elbow method to was also initiated to determine the number of clusters for the EU members included in the dataset. Although the initial observation had presumed a cluster of five, the observation later clarified that the Elbow value advised a score of 4. To make a determined verdict, the authors considered their field knowledge and combined Germany/France and Italy/Spain in the same cluster (they were in separate groups during the first tests). As a result, the clusterization of the final three has been sanctioned. During the visualization stage of the article, a Principal Component Analysis (PCA) was authorized. The representation of the results was visualized in a scatter-plot graph by dividing the entire dataset into two and three variables.

*Selection and categorization of variables*

This section aims to justify the selection of independent variables that were used to measure member states' performance in designed categories. These variables were categorized to clarify the differentiation between member states and visualize the dataset better, especially regarding measuring. For 25 years, the EU has strived to create a uniform integration in railways by building a Single European Railway Area- aspiring to strengthen railways' position as the most environmentally friendly transport mode and establish a robust internal market with increasing competition (European Council, 2022). Intending to solidify this purpose, the EU has three main goals for its entire railway policy: (I) opening the market to competition, (II) strengthening the safety and interoperability of the national railways, (III) ameliorating and modernizing the railway network of Europe with new technologies (European Council, 2022). Inspired by the level and scope of these extensive goals, the categorization follows the same logic to measure the current structure of railways; evaluation of member states in infrastructure, market, and technology categories. The *infrastructure* category included mainly prerequisite variables, which are indispensable for any rail network. While the *market* category deals with the necessary elements for full market liberalization, *technology* monitors the

member state compliance rates on integrating new technologies and ensuring safety.

To select variables for measurement, this article first tried to understand what compliance measures are most vital for the EU in 2021- a critical juncture for establishing a Single European Railway Area. As mentioned in the introduction part, 2021 is:

-The European Year of Rail for boosting travel with this mode against all detrimental effects of the pandemic,

-The end of the railway packages designed to assure full implementation of European norms and values,

-The year to turn back to ambitious climate targets of the EU Green Deal after a yearlong blockade of the pandemic.

As a result, the fourth and most elaborate railway package became the center of attention in the selection process. The fourth railway package has been the last hurdle of the ongoing Single European Railway Area implementation. With this package, the EU aspires to establish a single market by initiating two pillars for compliance (European Commission, 2022b). The technical pillar demands that member states implement directives regulating safety and interoperability. In contrast, the market pillar completes market integration through regulations on public service obligations (PSO) contracts and the final opening of the national railway markets (European Commission, 2022b). In addition, various cornerstone variables from first, second, and third railway packages and general EU goals, which are still accountable to present dynamics and where member state performance is still worth measuring as an indicator, were compiled.

Moreover, even though rail transport is one of the most environment-protecting transport modes[8], railways have been a significant cause of excessive noise. Since the EU Green Deal vows to create a quiet transport area by 2050 (European Commission, 2022a), the member state level of noise emission on railways has also been evaluated. Finally, related to the Green Deal's initiation and completion of railway packages, the 2021 European Year of Rail initiatives were also found worthwhile in variable selection. See Table 1 below for further definitions.

[8] Railways cause the least amount of emissions according to the EU Green Deal report of the European Commission (2022a).

**Table 1:** Definition of variables

| Code of variable | Definition of variable |
|---|---|
| **Infrastructure** | |
| **Flines** | Total rail lines for freight. Decision (EU) 2020/2228 of the European Parliament and of the Council for modal shift on freight. |
| **Plines** | Total rail lines for commercial trains. |
| **Fnumber** | Total number of freight by rail. |
| **Pnumber** | Total number of passengers by rail. |
| **Fmod** | Modal share of railways (freight) |
| **Pmod** | Modal share of railways (passenger) |
| **Prights** | Implementation rate of Regulation (EC) No 1371/2007 of the EU regarding safeguarding passenger rights. |
| **Ppropensity** | EU wide propensity to travel by rail |
| **Pservices** | Number of services for rail passengers |
| **Accidents** | Number of accidents in both passenger and freight rail. |
| **Market** | |
| **Renterprises** | Number of railway enterprises |
| **Rbodies** | Number of regulatory bodies in member state |
| **FCMS** | Competitive market share of freight by rail |
| **PCMS** | Competitive market share of passenger by rail |
| **PSOCT**[9] | Number of competitively tendered Public Service Obligations (PSO) contracts |
| **PSODA**[10] | Number of directly awarded Public Service Obligations (PSO) |
| **Tfunds** | Total funds awarded to railways |
| **Texpenditure** | Total expenditure of the railway sector |
| **Frevenue** | Total revenue in freight by railways |
| **Prevenue** | Total revenue from passenger rail lines |
| **PSOCrevenue** | Total revenue from PSO contracts |
| **Temployee** | Total number of employees working in the rail sector |
| **Technology/Technic** | |
| **Vehicles** | Number of vehicles used in railway sector |
| **Lnew** | Number of new train licenses |
| **Lsafety** | Number of valid safety certificates |
| **Ldrivers** | Number of operating train drivers in the EU. |
| **Ndirective**[11] | Implementation rate of the EU noise directive |

[9] As a part of the "market pillar" of 4th railway package, Regulation 2016/2338 (European Commission, 2016a) envisages compulsory tendering in public service obligations contracts (PSO).

[10] Regulation 2016/2338 (European Commission, 2016a) demands member states to not direct PSO awards only to in-house operator.

| | |
|---|---|
| **ERTMSgoal**[12] | Expected implementation rates of member states on ERTMS technology |
| **ERTMSachived**[13] | Actual implementation rates of member states on ERTMS technology |
| **Lsinglesafety**[14] | Number of recently introduced EU single safety certificates |
| **Leulicence**[15] | Number of introduced EU driver licenses |

**Source:** Authors' own elaboration.

**Results and Findings**

The EU published its latest assessment report shortly after the "European Year of Rail." Inside this seventh monitoring report on the rail market, European Commission (2022c) stated its main findings and trends for 2015-18 as a period of progress with caution. Even though the report had found increasing traffic in both passenger and freight markets before, it also marked difficulties in interoperability (European Commission, 2022c). EU's assessment relies on and strategically upon limited variables, including market share, traffic, and length of tracks. Although these are important, they neither provide the policy area's entire picture nor measure all railway packages' fundamental goals. This research validates these claims and enlarges its scope to show that the EU member states still have a mountain to climb to meet the expectations settled in the above documents. Concerning that, the findings are listed in the Table 2 and Map 1.

[11] Directive 2002/49/EC (European Commission, 2002) and Regulation 2015/429 (European Commission, 2015) require member states to decrease noise pollution by effective charging, retrofitting and limiting.

[12] European Rail Traffic Management System (ERTMS) aims to standardize single European signalling and speed control system. Each member state have different goals and length/km of track to deploy due to geographical area and length of total train lines.

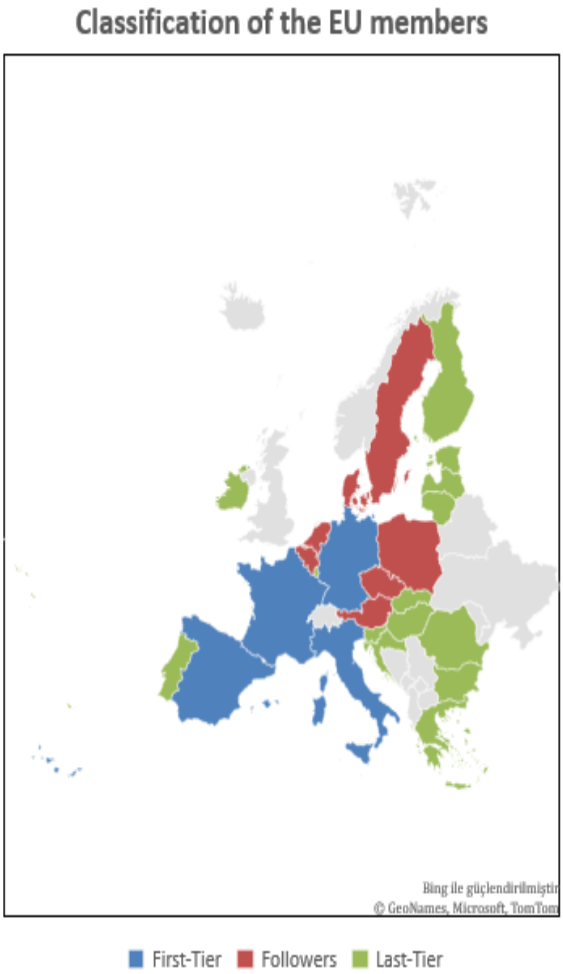
[13] As a part of the "technical pillar" of the 4th railway package, Directive 2016/797 Recast Interoperability Directive regulates the implementation of ERTMS in the Union until 2023 and claims implementation plans and dates from member states (European Commission, 2016b).

[14] Regulation 2018/763 (European Commission, 2018) gives the right issue safety certification to the EU level. This centralization is aimed to harmonise safety certification operations in Europe. The new regime has been started in 16 June 2019. Lsafety variable indicates the numbers of national certificates before new regime.

[15] Directive 2007/59/EC gives European Railway Agency (ERA) to issue minimum requirements for drivers to reach certification and European train driver license. All drivers need a European license from 2018 to operate on European railways (European Commission, 2007a).

**Table 2 and Map 1:** Classification of the EU members

| Member Cluster | EU Member |
|---|---|
| First-Tier | Germany<br>France<br>Italy<br>Spain |
| Followers | Belgium<br>Sweden<br>Poland<br>Czechia<br>Austria<br>Denmark<br>Netherlands<br>EU-Average |
| Last-Tier | Portugal<br>Slovakia<br>Latvia<br>Hungary<br>Estonia<br>Slovenia<br>Finland<br>Bulgaria<br>Lithuania<br>Greece<br>Ireland<br>Romania<br>Croatia<br>Luxembourg |




**Source:** Authors' own elaboration.

Table 2 and Map 1 show the complete classification of the EU member states according to the K-Means method designed for this research. Differentiation is observable with a wide emerging gap between the frontrunners Germany, France, Italy, Spain, and tailenders at the bottom of the table. If one would require a categorization with the EU average, three categories as *First-Tier* (Germany, France, Italy, Spain), *Followers* (Belgium, Poland, Netherlands, Austria, Sweden, Denmark, Czechia), and *Last-Tier* (Hungary, Portugal, Finland, Romania, Slovakia, Ireland, Latvia, Bulgaria,

Luxembourg, Croatia, Slovenia, Greece, Lithuania, and Estonia) could be identified. *First-Tier* states are the ones that have well exceeded the EU average and are on track with the alignment of measures stated above. *Average* are countries with relatively sound compliance performance but have also been falling behind on some variables simultaneously. *Last-Tier* states estimate a minor performance and give minimal hope for uniform integration soon. The sheer size of the last group and the fact that only four countries are in the first tier indicates the impossibility of completing the Single European Railway Area anytime soon. Table 3 shows the numerical difference between the clusters.

**Table 3:** Transformed Dataset after the PCA, n = 3

| EU Members | Infrastructure | Market | Technology |
|---|---|---|---|
| Spain | 0.174190048 | -0.185377437 | -0.430537772 |
| Italy | 0.262133939 | -0.081145142 | -0.464122389 |
| France | 0.367472566 | -0.270661063 | 0.354042467 |
| Germany | 0.83942048 | 0.013713359 | 0.107810812 |
| Belgium | 0.09643169 | 0.080415969 | -0.173864907 |
| Sweden | 0.068705286 | 0.147924319 | -0.005676758 |
| Poland | 0.090641659 | 0.737839229 | -0.219391086 |
| Czechia | 0.056631687 | 0.274222671 | 0.08673224 |
| Austria | 0.088495112 | 0.246411204 | 0.205767126 |
| Denmark | 0.062463963 | -0.070466534 | -0.138733721 |
| Netherlands | 0.095783281 | -0.002429294 | -0.17106241 |
| EU | 0.096427046 | 0.080369342 | 0.002244815 |
| Portugal | 0.040941551 | -0.028511383 | -0.060551928 |
| Slovakia | 0.021137347 | 0.150571981 | 0.214609279 |
| Latvia | 0.006814536 | 0.182455219 | -0.034695342 |
| Hungary | 0.045008798 | 0.120436289 | 0.148522238 |
| Estonia | 0.002922111 | 0.105784323 | -0.024444287 |
| Slovenia | 0.004644332 | 0.066394518 | -0.005905378 |
| Finland | 0.02490422 | 0.100341219 | -0.033447961 |
| Bulgaria | 0.007052253 | 0.044297382 | -0.013325734 |
| Lithuania | 0.002733589 | 0.189722059 | -0.036313577 |
| Greece | 0.004634194 | -0.002243695 | 0.290816205 |
| Ireland | 0.012795546 | -0.019301242 | -0.018916257 |

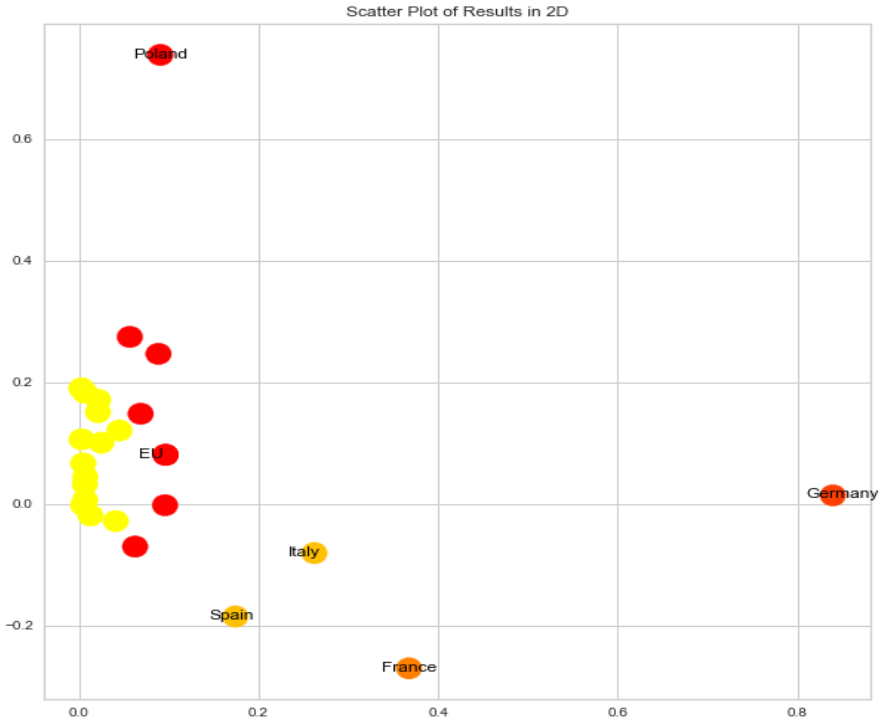
| | | | |
|---|---|---|---|
| Romania | 0.021326789 | 0.170795641 | 0.210151353 |
| Croatia | 0.006544974 | 0.031813478 | -0.013853583 |
| Luxembourg | 0.006846396 | 0.006232556 | 0.282783618 |

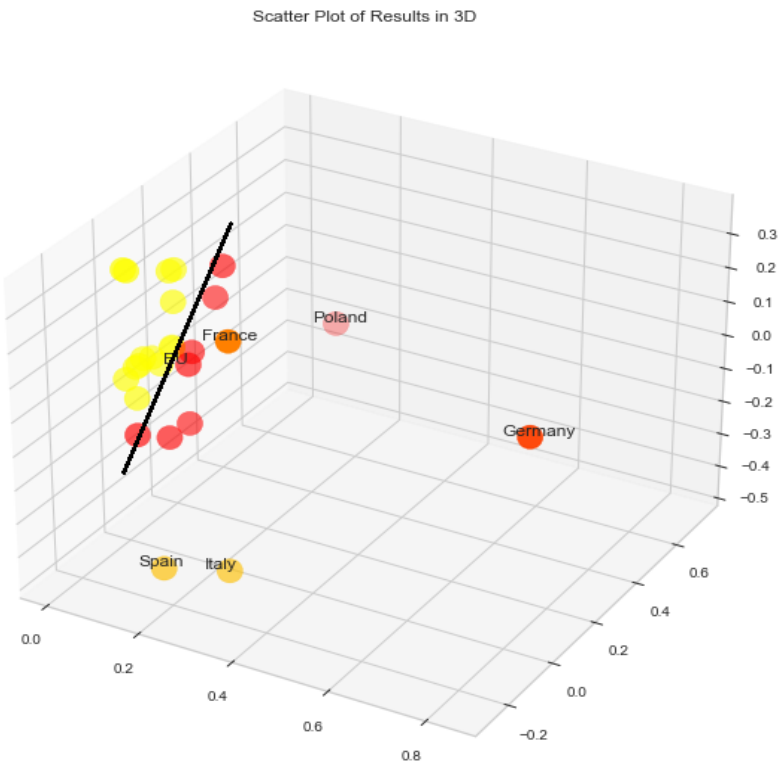
**Source:** Authors' own elaboration.

Table 3 and Figures 1-2 provide the score in a three-level analysis bound to the categorization of variables. Table 3 identifies that differentiation in transport compliance is not only on a cross-national basis but also categorical. While first-tier countries generally exceed expectations in one or two categories- Germany on infrastructure and France on technology- follower countries hold a more even distribution in each category. Last-tier states are yet to clinch any categorical success. Germany, France, Italy, and Spain have lifted the EU average in the infrastructure category. This is not a surprise since many of these countries are the founding nations of the EU, started integration earlier- had a time advantage over others- and have the most significant GDP[16] in numbers, which also gives them a competitive advantage for creating funds to support infrastructure. However, this structure changes in the market and technology categories. Poland surprisingly leads the market category along with Germany. The reasons for that have been identified in the following paragraphs. The overall performance of the EU member states on technology- especially for the ERTMS- is perilous. Expect Germany, France, and Austria, the implementation rates are beyond unsatisfactory, and this area needs careful attention from the EU.

[16] The biggest GDP's in the EU-area are as follows: Germany, France, Italy and Spain (World Bank Data, 2020).

**Figures 1 and 2:** Visualization of Clusters and Classification in Scatter Plot






**Source:** Authors' own elaboration.

Although differentiation is clear-cut to connect these findings with the conceptual framework, there is no evidence to claim that this difference is neither territorial nor perennial. Suffice it to say that none of these countries have willingly opted out of transport integration. Furthermore, the distribution of countries in Table 2 does not indicate any established or enduring geographical cluster- where Bulgaria, Luxembourg, and Ireland share close rates. This research has also found no robust evidence to support any potential claim on good performance due to membership dates. Even though last-tier member states generally comprise the latest 2004, 2007, and 2013 enlargement cycles, Poland and Austria's relatively high integration rates falsify this and leave us with explanatory variables such as time and political choice to change and shape the performances of member states and create differentiation. The last part will elaborate more on the determinants of this fraction.

Overall, state classifications and correlated data signify significant results for future policymaking in this area. First of all, as an expected outcome, investing in railways with more funds, expenditure, new vehicles, and entering new enterprises would have an energetic effect on the increase of freight and passenger market share. Aligning with the European Commission's (2020) call to increase the rail's claim during the "European Year of Rail" and seventh monitoring report outcomes, this article has validated railways' critical aspect: countries need to spend more to get more. A similar correlation was detected on the passenger side: passenger numbers, revenues, and the propensity to travel with railways increases when funds and expenditure rise.

Nevertheless, even though the EU knows this cure, effective investment takes time, and this is the point where non-implementation would clog the drain. Here, these findings can be correlated with the latest Esposito, Cicatiello, and Ercolano (2020) analysis on market reforms; liberalization and competition increased market share, but this impact remained modest and are nowhere near expectations. Accessibility and underperformance are two key remaining challenges (Fraszczyk, Lamb and Marinov, 2016), and the EU should take a more quality-oriented approach to speed up implementation (Islam, Ricci and Nelldal, 2016).

Secondly, the results also show that more investments are not always the answer to all problems. In other words, situations when regulation does not affect implementation. A key example here is the passenger rights directive. As an alarming issue for the EU, the results show that increasing investment, competition, and modal share do not reflect a positive impact in implementing the EU directive on passenger rights. A potential solution here, which can be driven by this research, is the establishment of independent regulatory bodies. When the number of regulatory bodies increases in a state, this could also raise a state's compliance rates on passenger rights. The same results can also be observed in De Francesco and Castro's (2018) or Benedetto, Smith and Nash’s (2017) studies, revealing a positive relationship between monitoring the effectiveness of regulatory bodies and compliance.

Thirdly, ERTMS needs stable investment and funds as an expensive and complicated system. However, the increasing number of vehicles has not pushed any meaningful deployment pressures on the side of ERTMS equipment, and it shows that even though a competitive, liberal market is energizing the sector, the ERTMS deployment process has been going slower than anticipated.

An individual focus on member states could also reveal exciting facts. As a stand-out case in all Central and Eastern Europe regions, Poland is located before some important Western European counterparts such as Netherlands and

Denmark. Of course, there are reasons why Poland has been making progress while other CEECs are staging non-implementation. Studies have shown that Poland is one of the earliest pioneers of the liberalization of the railway market, dating back to 1991 (Taczanowski, 2015) and the frontrunner of the 4th railway package's full market access measures (Krol, Taczanowski and Kolos, 2018). The World Bank Data- collected in 2017- can also support this relatively higher position of Poland through successful facts of organizational restructuring, recovered revenues, and increasing competition.

Furthermore, growth in intermodal services is also detected (Marcysiak, 2020). On the other hand, Denmark can be considered an underperforming member based on its location and potential. Denmark's shortcomings could be directly associated with its productivity in the technology component. A European Commission (2022d) evaluation states that even though Denmark has an implementation plan to deploy ERTMS, it has ensured long delays for compliance until 2023-24. A recent difficulty with the installation once more pushed the already delayed implementation to 2030 (International Railway Journal, 2017). Strangely enough, Denmark was one of the countries that ambitiously started its migration to ERTMS in the 2010s (Laroche and Guihery, 2013).

Thanks to a successful rail reform process, Germany maintains the leadership position with an integrated market model called “holding structure”, where there is no direct separation between infrastructure managers and railway operators (Nikitinas and Dailydka, 2016: 81). Although the EU demands an explicit vertical separation between the two (Lodge, 2003), the German system does not allow companies belonging to the same group to have an advantage over one another (Nikitinas and Dailydka, 2016: 81). This structure has let Germany increase rail traffic, shrinking emissions, rising productivity, customer satisfaction, and intermodality (Deutsche Bahn, 2014). Italy's similar vertical separation practices have also increased competition (Desmaris, 2016) and raised passenger levels (Cascetta and Coppola, 2015). Contrary to the EU acquis, France has never realized a liberalized market. According to Deville and Verduyn's (2012) article, the incumbent operates in all commercial passenger services. Potentially detrimental to the EU's understanding, this did not change the fact that France – in a non-liberalized structure – made the most passenger revenues between 2015-18 (European Commission, 2022c). Around these highly differentiated models taken by member states, the market opening remains a tough nut to crack for Greece, Finland, Ireland, Lithuania, and Luxembourg (European Commission, 2022c).

*Determinants of differentiation*

Several factors cause differentiation in this policy realm. Thus, this section looks at the determinants such as the nature of the policy, time-delays and exemptions, COVID-19, etc. that determine differentiation.

***Nature of the policy***

Each policy area under European integration has unique features. Transport governance in the EU has always been an aggressively neo-liberal exercise with marketization, privatization, and liberalization to cater to any industry's mobility needs (Aspinwall, 1999; Dobbin, 2001). Market opening necessitates sufficient infrastructure and organizational preparedness, and these requirements foresee a financial instrument. Thus, it is no wonder that member states with the highest GDPs have been clustered at the top of the classification. The very nature of the policy area- which dramatically relies on the funding capacity of the states- automatically establishes a border between the rich and poor and creates a significant funding gap between the first and last tiers. To understand this gap, further analysis is a requirement on the allocation and effectiveness of the EU Cohesion Funds.

***Time- Delays and Exemptions***

Although none of the member states has initiated an opt-out from the integration until now, their speed on compliance has been immensely unsteady. One of the reasons for the interchangeable rate is time, more specifically, delays and exemptions given to member states. One particular example can be Regulation No 1371/2007, which entered into force in 2009 to improve quality by safeguarding rail passengers' rights (European Commission, 2007b). After ten years of its entrance, only five member states had been on track to implement the rules thoroughly, so the Commission (2017) decided to update to fix the problem of unawareness among citizens regarding the regulation. However, another wave of varying exemptions significantly deprived the initiation plans (European Commission, 2017). Another stage of negotiations in 2020 aimed to provide a recast to the regulation (European Parliament, 2022).

Nevertheless, the European Consumer Organization (2020) considered it another lost opportunity since two-thirds of rail services are still exempted from regulation. The recast allowed member states to renew their exemptions until 2024. The same kind of exemption is reasonably commonplace in the ERTMS deployment, where the law calls for uniform implementation in 2023 at the latest. So far, member states have grouped regarding their delay intentions. While Germany and Netherlands had opted for long delays exceeding the target date, Italy and France provided no detailed plans and claimed severe exceptions

(European Commission, 2022d). Other cases, such as Romania, indicated no specific dates for implementation (European Commission, 2022d ).

***ERTMS***

The system calls for a good network alignment and depends on a continuality concept, and any actor's slow-moving can cause severe disruption and discontinuity (Laroche and Guilhery, 2013). Lack of knowledge of specifications, the unprecedented nature of the system, problems in transition, and driving practices were coupled to impose more complexities on the EU's anticipated growth from conventional signaling systems to ERTMS (Smith, Majumbar and Ochieng, 2012). The EU has also admitted that it is a complex and costly system regarding renovation, retrofitting, and other infrastructural aspects (European Commission, 2022d). Differentiation between states mainly arises from distinct perspectives on implementation and varying funding stability (European Commission, 2022d). So far, the ERTMS package has faced delays due to procedural problems, expert shortages, and financial problems (European Commission, 2022d). On the other hand, to reach the ambitious 2023 targets in ERTMS deployment, the EU has to set a rigorous timeline for investment (Laroche and Guilhery, 2013).

***Structural problems and Political Choice***

As evident in all other determinants, national choices are a matter of great significance. In infrastructure, costs can easily prevent a middle-income EU member from exhibiting the same level of progress as others. In the case of ERTMS deployment, the lack of sufficient infrastructure coverage has been directly related to unstable funding schemes (European Commission, 2022d). The cost of implementation (Smith, Majumbar and Ochieng, 2012) has dragged member states to make drastic political choices, such as irregular changes in deployment strategies and the disappearance of long-term perspectives (European Commission, 2022d). For the market opening, each national choice tells a discrete story. While France was able to receive a boost in the market category without fully opening the market, Finland has failed to succeed in a somewhat monopolistic model.

Lastly, ambiguities among ERTMS regulation and national requirements created unorthodox ERTMS clusters in different member states with national flavors (European Commission, 2022d). To grasp how national choices determine the direction of compliance, individual national studies are a must. Finally, the EU goals are also contradictory in some measures. As the findings suggest, the whole market opening with more enterprises, vehicles, rail lines, and modal share could be the predicted cause of increasing noise.

### *COVID-19*

The pandemic has already cost railways to consider 2020 as the lost year. Even for this research, it was nearly impossible to locate any dataset belonging to 2019-20 due to the halt in all operations. So far, the pandemic has brought a very high price to the rail sector, with drops in passenger numbers (DW, 2021). The rail sector also lost 26 billion euros in 2020 (Euractiv, 2021). COVID-19 is not a determinant for this research. Still, it has the power to affect the costs and national political decisions, which might help decision-makers to put new exemptions, delays, and procedural problems in the future. In other words, if it continues in the following years, the pandemic has the power to widen the gap between the first and last tiers. It is more likely to form many durable differentiations.

## Conclusion

2021 was the year of "a critical juncture for the European railways. First, the EU aimed to successfully conclude the 4th railway package and establish a "Single European Railway" with a uniform integration. Secondly, 2021 became the "year of rail" to boost the integration process, modal shift to rail, and market shares. This paper aims to provide an extensive analysis for evaluating the preparedness of member states in such a crisis-laden but challenging year to see the coherence of ambitious targets. Ensuring such a dataset was not an easy task. The analysis started with locating the independent variables by considering various European targets, such as the EU Green Deal, the Single European Rail network framework, and the 4th railway package. In the second part, these variables were categorized into three groups – *infrastructure, market, and technology*. The measurement process of member states was experimented with through a K-Means method, and the results have displayed tremendous differences between the member states in compliance with regulations. In three groups- *first tier, followers, and last tier*, this article has found that most member states are well below the European average in most indicators. Since this continuing differentiation can be considered a barricade against full integration, the EU has fallen far behind its targets for the end of 2021. However, this research also affirms that the evident transport differences are temporal rather than territorial because of time, lack of knowledge, financial instruments, and ever-changing national policies. Each can be settled in a much more comprehensive agenda before turning into durable differentiations. Unfortunately, the timing of the pandemic is undoubtedly not playing into railways' hands and is prone to create more complications in the next decade.

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