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The trend towards convergence in road accident fatality rates in Europe: The contributions of non-economic variables

José I. Castillo-Manzano [a,*], Mercedes Castro-Nuño [a], Diego J. Pedregal [b]

[a] University of Seville, Spain
[b] University of Castilla-La Mancha, Spain

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ABSTRACT

This article examines the trends in road traffic fatality rates in a sample of European States over the 1970–2010 period. Taking into account that previous research seems to find that the *Europeanization* process has had a favorable impact on national road safety performance, our main contribution is to test whether the same mechanism might lead to the convergence of Member States as a whole as a possible outcome. Based on typical convergence methodology for Economic Growth Theory, our findings reveal evidence of the full convergence of road fatality rates across a sample of EU countries during said time period. Compared to the uncertain results obtained by the literature on macroeconomic convergence, we do not find support for the convergence of sub-groups of countries, but a one-speed-convergence for all EU countries. This fact shows that convergence is achievable in certain EU areas even beyond economic convergence through successful efforts made jointly at national and community levels.

1. Introduction

The World Health Organization highlights road traffic accidents (RTA) as one of the most relevant public health problems in the European Region (WHO, 2009). More than 28,000 people are killed and about 250,000 people seriously injured in road accidents in the European Union (EU) every year (European Commission, 2013). However, as Table A1 shows, before this public awareness of the problem the Euro zone had gone a long way towards building a true European Road Safety Policy (ERSP), as the main initial priority of the Treaty of Rome of 1957 was, basically, the creation of a customs union and a single market in which the free movement of goods, services and factors were guaranteed. Notwithstanding, relevant improvements have been made since said date (European Commission CARE database, 2012) and today road transport and road safety have become a fundamental part of EU common policy, as reflected by the three White Papers published and the four European Road Safety Action Programmes (ERSAPs) implemented during the last two decades (Racioppi et al., 2004).

Prior research (see Castillo-Manzano et al., 2014) analyzes how the concept of *Europeanization* (in the sense described by scholars, such as Radaelli, 2002; Knill and Lehmkuhl, 2002 and Richardson, 2012) might help to describe the impact of the EU on national road traffic policies. This paper aims to confirm the hypothesis regarding how EU membership has particularly benefited countries with traditional high road fatality rates (the so-called South-East-Central, or *SEC belt*) that are geographically, politically, socially and economically distant from other leading European countries on road safety (the so-called *SUNflowers*: Sweden, the Netherlands and the UK). Following the Club Theory, benefits would exceed accession costs for new members, and 'the club' would continue to expand (Sandler and Tschirhart, 1997). In this regard, national efforts made by new members, such as, e.g., Latvia, Spain and Lithuania, with road death reductions of 68%, 63% and 58%, respectively, from 2001 to 2011 (European Transport Safety Council ETSC, 2012a, have benefited from the successful road safety policies previously developed by older European States, such as Sweden, the Netherlands, Germany and the United Kingdom, true international leaders in road safety (Gitelman et al., 2010).

Nevertheless, despite the possible favorable impact of the Europeanization mechanism on traffic fatalities, both Castillo-Manzano et al. (2014) and Wegman et al. (2008) agree that improvements on a microscopic level might be achieved at different speeds in countries that are tackling singular initial problems, with diverging economic, political, social and cultural elements and different accession dates to the EU. Recent studies indicate differences in the level of safety performance from one EU member to another (WHO, 2009), mainly due to the influence of

* Correspondence to: Facultad de Ciencias Económicas y Empresariales University of Seville, Avda. Ramón y Cajal, 1, 41018 Seville, Spain.
Tel.: +34 954 556727; fax: +34 954 557629.
E-mail addresses: jignacio@us.es (J.I. Castillo-Manzano), mercas@us.es (M. Castro-Nuño), diego.pedregal@uclm.es (D.J. Pedregal).

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social, cultural, economic and governance factors on the quality of infrastructure, enforcement and driver behavior (Castillo-Manzano et al., 2011; Gaygisiz, 2010; Gitelman et al., 2010).

Furthermore, as Mikulik (2004) states, EU road safety policy is non-compulsory for the accession process, all of which determines a heterogeneous integration process in the construction of the ERSP that still has a long way to go (Avenoso and Beckmann, 2005; Bax, 2011).

In this regard, even considering the successful implementation of the ERSP as Bax (2011) and Castillo-Manzano et al. (2014) state, this does not necessarily imply the convergence of traffic accident rates of countries with very different income levels, which naturally affects road quality and maintenance, the vehicle fleet or post accident medical care (see e.g., Anwaar et al., 2012, and Bishai et al., 2006 on how the correlation between the level of economic development and road fatality rates is conditioned by specific components of economic progress; and Castillo-Manzano et al. (2013) on the influence of health care system in EU). In short, as Héritier (2001) argues, in certain fields, the implementation of a European policy by Member States does not mean the convergence of domestic structures towards a single European model. In other words, as Nicolaides (2010) and Radaelli (2002) explain, the EU encourages Member States to change, but it is possible that, despite "punishment" for non-compliance, the Europeanization process may not lead to full convergence, perhaps because the domestic political benefits of non-convergence are greater than EU sanctions or due to delays in the transposition and implementation of EU actions (Dimitrova and Steunenberg, 2000).

Therefore, *Europeanization* is not *Convergence*; they are not the same concept and, as Radaelli (2002) states, Europeanization can even lead to divergence. Following Knill (2005), Europeanization is a *process of policy change* (related to policy transfer, in the sense studied by Marsden and Stead, 2011; and policy diffusion) while convergence is the *process effect* (the result of the process of policy changes during a timeframe). Börzel and Risse (2000) explain how these findings would refute the convergence school's expectations of increasing similarities leading to strong structural convergence. In the opinion of these authors, irrespective of the pressures of change and adaptation, every member has a domestic set of institutions and interest groups that may both facilitate or inhibit full convergence, leading to the *partial* or *clustered convergence* of a club of countries that has been recently studied by Bartkowska and Riedl (2012). There may even be some political motives (such as transaction costs) that influence the adaptation of policy enforcement at the national level (see e.g., Sutter and Poitras, 2002 for the case of the political economy of automobile safety inspections). For example, Héritier and Knill (2000) and Lehmkuhl (2002) have demonstrated how the Europeanization of transport policy has resulted in striking national differences between domestic actors, mainly due to the reluctance of governments and pressure from lobby groups.

In this area, the contribution of our paper is not only conceptual, as we apply traditional convergence methodology for economic growth to evaluate the results of a specific EU policy (the ERSP) without any other preceding research. Despite the doubts that the literature raises about whether European economic policy developments are important drivers for increasing convergence on macro-economic indicators, our goal consists of evaluating the existence of the effective convergence on road accident fatality rates of all the countries that were in the EU-27 during the 1970–2010 period.

This goal is, in fact, very difficult to define *a priori* as, although, as was previously stated, the EU seems to have had a positive effect (Castillo-Manzano et al., 2014) the truth is that there are reasons that raise doubt. First, it should not be forgotten that some of the countries under consideration, basically those in the East, joined the EU during the last part of the period under analysis, and showed that they had difficulty adapting to European Transport Policy (Mikulik, 2004; Tilling, 2006).

Second, it is arguable from the economic point-of-view whether there is full convergence between the incomes of these countries during said time period (e.g., Crespo-Cuaresma et al., 2008 suggest an asymmetric and irregular convergence-stimulating impact of EU membership on long-term growth), and convergence is, rather, at different speeds and by club or cluster (Bartkowska and Riedl, 2012). This could also prevent convergence on road safety, bearing in mind the correlation between the level of economic development and road fatality rates found by authors, such as Anwaar et al. (2012) and Bishai et al. (2006). Nevertheless, part of the effect that the great discrepancy in income has on road safety has been mitigated by the major improvements achieved in health conditions and road infrastructure in South and Eastern Europe, as a result of investment by EU structural funds and cohesion policy (Demetropoulou, 2002; Mackenbach et al., 2013; Tilling, 2006).

Third, the substantial differences that exist in countries' educational systems highlighted by the main international rankings, such as the OECD PISA report on secondary education, and the *Shanghai Jiao Tong University* ARWU ranking for undergraduate and graduate levels (Theodoropoulou, 2010) could also have a negative impact the training of roadusers and, therefore, also on the main road safety indicators (see Hatakka et al., 2002 for a review of the effects of driving education on road safety).

Fourth, the findings obtained by recent research for the OECD countries (Nghiem et al., 2013), does not enable convergence on traffic crash fatality rates as a whole to be spoken of, although there seems to be evidence of the convergence of sub-groups of countries.

Finally, we should not forget, either, the undoubtable influence of weather conditions on the various road accidents rates (Eksler et al., 2008) since the extremely large geographical area results in major meteorological differences being recorded between countries in the north of Europe and Mediterranean countries.

In short, we start from the idea that the process for integrating road safety policy in the EU-27 reflects the differences that exist between Member States' respective initial situations (Dimitrova and Steunenberg, 2000), which were especially alarming in countries like Portugal and Spain, where road accident rates were traditionally very high (Orsi et al., 2012). Following the above considerations, we empirically analyze whether there has been convergence in European Road Safety Policy for the 1970–2010 period using the concepts of sigma and beta-convergence applied to fatality rates as others do for Gross Domestic Product (GDP) series or many other variables (e.g., Bernard and Durlauf, 1996; Hitiris, 1997; Sala-i-Martin, 1996).

Nevertheless, the possible Euro convergence in road fatality rates might be the result both of convergence of national strategies and policies (through a Europeanization process) but also of the convergence of underlying elements in the road-safety policies and programs of the countries (exposure risk and motorization levels, economic activity, education level, health care systems, etc.). Be that as it may, the purpose of our research is not to determine the factors that have influenced the convergence of road mortality rates, but rather to find out if this convergence has actually occurred or not.

For this, in addition to this introduction, the paper is structured as follows: a brief overview of EU convergence literature is considered in Section 2 together with a consideration of the context underlying the ERSP; a description of data, variables and the convergence methodology used are included in Sections 3 and 4 lays out the discussion of the results obtained from the estimated models, and Section 5 gives the conclusions.

2. State of the art of convergence of European policies: The road safety policy

The concept of *convergence* has been widely used in academic studies and political debates on European integration (O'Connor, 2011). Heichel et al. (2005) portray the findings and conceptualization of selected empirical studies on EU policy convergence in areas such as social policy, environmental policy, migration policy and education policy. Other papers have appeared addressing convergence on other topics, such as health economics in the EU (Hitiris, 1997). However, most studies refer to economic aspects (trade, competition, regional policy, tax policies and fiscal pressure, the labor market, industrial relations, the agriculture sector, banking regulations…) and above all, convergence on economic growth theory. There are important contributions in this field in the economics literature; see, for example, Cappelen et al. (2003), Galor (1996), Luginbuhl and Koopman (2004), Próchniak and Witkowski (2013), Quah (1996), Vickerman et al. (1999) or Williamson (1996).

Most convergence research concentrates on income convergence measures between countries or regions, due basically to the fact that this was the natural initial issue and that seminal works on convergence were related to neoclassical growth models (e.g., Baumol, 1986; Barro and Sala-i-Martin, 1991, 1992; Sala-i-Martin, 1996). An explosion of literature followed, mainly restricted to income level convergence from different points of view.

EU convergence analyses in the transport sector, such as, e.g., Crescenzi and Rodríguez-Pose (2012) for the case of infrastructure endowment, are also predominantly related to its influence on economic growth. Even convergence of road safety in the whole of the OECD is studied by Nghiem et al. (2013) by *log t test* as a Kuznets' function depending on the economic development status of the countries.

Widespread points of view divide the methods into cross-section tests (the so called β-*convergence* and σ-*convergence* tests, see references in the previous paragraph) and time series tests that rely heavily on unit root and co-integration tests (e.g., Bernard and Durlauf, 1996). Though cross-section and time series tests are usually shown as alternatives, in fact they rely on different assumptions, since economies are assumed to be in transition towards a steady state in cross-section tests, while in time series tests economies are assumed to be close to a steady state (Bernard and Durlauf, 1996).

The choice of a simple definition of convergence to use in our paper is a very difficult topic, because although there is a certain consensus on the description (Knill, 2005) from an empirical and theoretical point of view, as O'Connor (2011) argues, every author contributes to the literature with a specific notion of the concept. Considering the broad scientific papers that examine the different meanings distinctly from other similar terms, like *Harmonization* or *Europeanization* (Radaelli, 2002), and causal factors and mechanisms, such as *Imposition*, *Lesson-Drawing*, *Emulation* or *Penetration* (see e.g., Bennett, 1991; Drezner, 2005; Holzinger and Knill, 2005), our concern in this paper is convergence as defined by Knill (2005), p. 768 as "any increase in the similarity between one or more characteristics (time series of traffic fatalities in our study) of a certain policy (road safety in our case) across a given set of political jurisdictions (EU-27 Members in our case) over a given period of time" (1970–2010 is our timeframe).

The scope of convergence on ERSP is specifically mentioned by the main official EU institutional documents analyzed in Table A1, but we take a further step and test *the degree and the direction of this convergence* as an *outcome* derived from the *Europeanization process* considered by Castillo-Manzano et al. (2014), in the sense provided by Holzinger and Knill (2005).

The ERSP did not appear as a real goal before the nineteen-nineties, as it was subordinated to other actions that benefited free competition and the removal of trade barriers between States (Commission of the European Communities, 1993, 1997), including: the standardization of the technical aspects of vehicles and working conditions for professional drivers or the unification of the single driving license for removing barriers at internal frontier crossing. Nevertheless, Table A1 shows other facts that highlighted the need for community action in the field of road safety, such as the Council Resolution of 1984, 1986 being declared European Year of Road Safety and legislative initiatives since 1989, such as the mandatory wearing of seat belts and child restraint use.

As can be seen in Table A1, according to Avenoso and Townsend (2010) and Bosetti et al. (2010), two crucial points can be observed in the history of the ERSP: 1992 and 2001. The first is the Treaty of Maastricht, which gave explicit recognition to road safety by establishing a legal framework under the so-called *principle of subsidiarity*. The second, 2001, was the result of the publication of the White Paper entitled "Time to Decide" (European Commission, 2001) in which for the first time the EU proposed to all Member States the quantitative objective of halving traffic fatalities by 2010, establishing a long-term *zero-accident* approach by 2050 (see Rosencrantz et al., 2007 on vision zero implications).

According to the European Commission CARE database (2012), improvements have been reached throughout this time, not only by reason of the national efforts made by Member States (Orsi et al., 2012) but, as Bax (2011) states, also all the support given by the EU to improve road safety outcomes.

From a legal point of view, the EU uses the usual set of processes to formulate and enact its policies (see Alesina et al., 2005 for a general description and Bax, 2011 and SWOV Institute for Road Safety Research, 2013 for a specific treatment of road safety policy) that includes a mixture of policy-making instruments, such as: legal acquis (regulations and directives referring e.g., to vehicles–road-worthiness inspection, blind spot mirrors, weight and dimensions, daytime running lights-, to infrastructure-safety requirements for tunnels in the Trans-European Road Network-, or to driving license and cross-border enforcement); recommendations on specific areas of behavior (speeding, alcohol and drugs while driving); the so-called "soft law" based on non-binding stipulations for the States (action programs ERSAPs, policy targets and White Papers on topics not directly covered by the EU on account of the subsidiarity principle); economic tools (grants and investments through the Cohesion Fund and the European Regional Development Fund, not only for infrastructure and police activities, but also for research funding, which is also considered a priority); a network of benchmarking and sharing of best practices and a bilateral feedback relationship with Non-Governmental Organizations (NGOs) (WHO, OECD) and research institutions.

Following Bax (2011) and Castillo-Manzano et al. (2014), the ERSP decision-making process is mainly dealt with by two institutions: the European Commission's Road Safety Unit (from the Directorate General for Mobility and Transport), which proposes directives and soft law; and the High Level Group on Road Safety (made up of national road safety directors), which discusses and approves these proposals with the Council of Ministers of Transport. The role that the European Parliament usually plays is to give encouragement to interest groups, such as manufacturers, NGOs and research institutes.

Ultimately, the EU's procedures and decisions influence a large part of national road safety policies, although there is no loss of national sovereignty for Member States due to the application of the *principle of subsidiarity,* which may impose several constraints to road safety issues as certain authors state (Bax, 2011; SWOV Institute for Road Safety Research, 2013). In accordance with this

principle: "…actions and policies should be implemented at the most appropriate level and through the most appropriate means; so that, in areas which do not fall within its exclusive competence, the EU shall act only if and in so far as the proposed objectives cannot be sufficiently achieved by the Member States, either at central level or at regional and local level…" (art. 5.3 of the Treaty on European Union).

Therefore, the principle of subsidiarity is applied to binding regulations and directives for all Member States, but not for "soft law", where States may be reluctant and free to accept or reject it. However, although regional and local authorities clearly play a key role in promoting road safety, relevant measures are taken at EU level because road safety is a crucial aspect of the Common Transport Policy and for the internal market: "…many legislative actions could be undertaken at EU level…, but implementation and enforcement of such legislation varies strongly from one Member State to another (e.g., the wearing of seat belts) which may reflect in great variances in accident and injury risks" (Commission of the European Communities, 1997, p. 10).

Thereby, from a governance point of view, the *principles of subsidiarity and proportionality* are covered by the approach of *shared responsibility*, where there is no legislative action at Community level, but the EU gives a stimulus to governments, regional/local institutions, researchers, policy makers and civil society, each in their areas of responsibility. As the European Commission states, the "European Road Safety Charter" (see Table A1), may be a good example of how the EU encourages States to contribute, through their national road safety strategy, to achieve a common objective, "taking into account their specific starting points, needs and circumstances" (European Commission, 2010, p. 4).

Taking into account all the above considerations, this paper examines the effective results of these efforts. We shall indirectly test whether a "two-speed EU" or even a "multi-speed EU" can be spoken of (see, e.g., Alesina and Grilli, 1993; or Stubb, 1996, for the concept of "multi-speed" EU economic integration) for traffic safety issues. Or, if not, whether the existence of convergence in terms of road safety policy, enables us to conclude that a true European Road Safety Area exists, i.e., whether there has been noticeable structural change that goes beyond the theoretical-legal acquis established by the European institutions.

3. Empirical framework: Data, variables and methodology

In our sample it is not possible to assume that the economies considered in this study are close to the steady state for safety rates typical of time series tests that rely on co-integration tests, since more countries have continued to join the EU over the time span. Most of these countries are structurally very different to the countries that already belonged to the EU, including Greece in 1981, Spain and Portugal in 1986, and, most strikingly, the group of countries from Eastern Europe in 2004 and 2007.

There are at least two main years that should be highlighted with respect to dates when European countries joined, as they are dates on which several countries joined at once, thus having a significant overall impact on the EU, either in terms of economic growth, welfare or a higher standard of living. Various authors, such as Breuss (2002), state that EU enlargement did not only foster economic trade and financial integration, but also increased competition, promoted structural reforms and led to higher productivity and potential growth. The first date was 1986, when Spain and Portugal joined, whereas the second was 2004, when a large number of Eastern countries joined. Both of these years may be useful for segmenting the time period under study, as the first refers to Western Europe, whilst the latter performs the same function for Eastern Europe. Several data spans are therefore considered relevant and will be taken into account throughout the paper: 1970 to 1985 ($t=1$ in later equations), 1986 to 2003 ($t=2$) and 2004 to 2010 ($t=3$).

The two measures of σ-convergence used below are: standard deviation (σ) and *the coefficient of variation* (CV_t) given in Eq. (1), where $y_{t,i}$ is the fatality rate (number of road accident fatalities per million inhabitants) in year t in country i, $\bar{y}_t$ is the mean value across countries and n is the number of countries in the sample.

$$\sigma=\left(\frac{1}{n}\left[\sum_{i=1}^{n}(y_{t,i}-\bar{y}_t)^2\right]\right)^{1/2} \qquad CV_t=\frac{\sigma}{\bar{y}_t} \tag{1}$$

The complementary *β-convergence* term refers to the correlation between initial levels of road traffic fatalities per million of population and the mean rate of growth between two fixed dates. Therefore, a negative significant correlation implies that countries with higher fatality rates decline at a higher (negative) speed, meaning that all countries tend to draw together. Moreover, as Sala-i-Martin (1996) and Quah (1996) argue, calculating σ-convergence on its own is not enough, as it does not ensure β-convergence. This is due to the fact that economies may converge towards one another but either shock keeps them apart or they converge to different steady states (*conditional β-convergence*).

The usual model to verify β-convergence is in the form of Eq. (2), where $y_{1970,i}$ and $y_{2010,i}$ stand for the fatality rate in years 1970 and 2010 for country i, respectively; Other_i are other control variables included in the model specific for each country (see below); u_i is the error term; and the endogenous variable is the annual average rate of change of the fatality rate during these 40 years.

$$\ln\left(\frac{y_{2010,i}/y_{1970,i}}{40}\right)=\alpha+\beta\ln(y_{1970,i})+\gamma\text{Other}_i+u_i \tag{2}$$

The preceding analysis may be enriched by adding the time dimension, consisting of dividing the whole period into three subperiods ($t=1,2,3$ according to the above). Eq. (2) is then extended to Eq. (3), in which a time index is added to all variables; l_t is the length of each period in years; and the 0 sub-index applies to different time origins for each time sub-period (the initial years are 1970, 1986 and 2004, respectively)..

$$\ln\left(\frac{y_{Tt,i}/y_{0t,i}}{l_t}\right)=\alpha+\beta\ln(y_{0t,i})+\gamma\text{Other}_{t,i}+u_{t,i} \tag{3}$$

The specification of Eq. (3) allows the inclusion of time effects in a context of panel data that was impossible in Eq. (2). Several specifications of Eqs. (2) and (3) are investigated in Section 4, with different assumptions on the residuals u_i and $u_{t,i}$. One advantage of model (3) is that the degrees of freedom are multiplied by approximately 3.

The data for this study's main variable (rates of traffic fatalities per million inhabitants within 30 days of the accident, in accordance with the Vienna Convention) were collected from OECD statistics online (stats.oecd.org) for the 1970–2010 period.

The intention was for the study to be of the whole EU-27 dataset, but several countries had to be omitted due to irregularities in the statistics or simply because they were missing, which is understandable given the extensive time period under study, from 1970 to 2010. To be precise regarding statistics on fatalities, Cyprus is not directly reported in the OECD database; data for Malta is only available from 1999, and showed just 15 fatalities in 2010; the Czech Republic and the Slovak Republic do not have separate statistics until 1993, meaning that the Czech Republic data included both; finally Romania had a rather suspicious profile, with a very sharp steady decline from 105.2 road fatalities per million in 1977 to 47.85 in 1989, and a sudden jump up to 162.9 in 1990 that subsequently once again fell sharply. This may be explained by the major institutional changes that the country

underwent due to the transition from the communist period to the democratic period. The final sample therefore comprised 23 countries.

The candidate variables in the $Other_{t,i}$ vector are all those which are considered relevant, mainly those related to the implementation of the ERSP, and other variables that may have influenced the evolution of traffic fatality rates, such as the natural evolution of road safety rates linked to social and economic development, variations in exposure linked to the economic cycles, the effects of national policies independent of EU initiatives, etc. Two points have to be taken into account. First, regarding the implementation of the ERSP, belonging to the EU may be a good proxy variable as Castillo-Manzano et al. (2014) found strong econometric evidence of how "…being in the EU, with all that this entails with respect to participating in large numbers of institutions, funds, binding regulations, non-binding actions and programmes, has a positive effect on road traffic accident numbers in Members, and the longer a country has been a member of the EU, the greater this effect should be" (p. 3).

Therefore a variable called EU in later tables captures the proportion of years that country *i* has belonged to the EU during said 40 years (as we tried to capture the effect that the EU itself has had on this European convergence process).

Second, other obvious traffic fatality-related variables are very difficult to find for such a long time span and such a wide range of countries. The only variable available to our knowledge is a traffic volume proxy (for traffic risk exposure, in fact) clearly related to the economic cycle, (see e.g., the bi-directional correlation found by authors such as McMullen and Eckstein, 2012, among others), namely the number of kilometers per inhabitant and year (variable Traffic Volume in tables below).

The descriptive statistics presented in Table 1 for the traffic fatality rates variable indicate higher overall mean levels in Eastern countries albeit with smaller dispersion. The countries with the lowest mean values are Sweden and the United Kingdom, although those with the smallest dispersion are Bulgaria and the Czech and Slovak Republics. The highest values of mean fatality rates are seen in Latvia and Slovenia, while the highest dispersion is seen in Slovenia and Luxembourg.

4. Results

Following the methodology proposed in the previous section, Fig. 1 shows the σ-convergence properties of the road traffic fatality rates variable in the EU country sample, dividing the sample into Western and Eastern countries (that joined the EU from 2004). It is clear that there is an overall reduction in dispersion, with the exception of years 1986 to 1991, mostly, but not totally, due to the Eastern countries (Greece joined in 1981 and Spain and Portugal in 1986). The effect of the fall of the Berlin wall is clearly seen in the figure, together with a remarkable reduction in dispersion in the East from 2004, the year that most of these countries joined. The bottom panel of Fig. 1 shows the coefficient of variation, which shows dispersion with respect to the mean level and gives a somewhat different picture, since the convergence of Western countries is less obvious. These initial results have to be tested thoroughly in the rest of the paper taking into account the year that each of the countries joined the EU.

Another raw initial indication of convergence is shown in Fig. 2, where a scatter plot between the log of road fatalities in the initial year of 1970 and the mean rate of annual growth indicates a negative slope, implying that the higher the starting point in 1970, the more negative is the rate of growth, therefore indicating that countries have become closer over the years. Fig. 2 also shows that there may be some specific country effects in three standard groups already considered in Castillo-Manzano et al. (2014), namely:

- SEC belt: Southern, Eastern and Central European countries with higher fatality risk rates and safety indicators below the EU-15 mean. The countries in this group are Estonia, Latvia, Lithuania, the Czech and Slovak Republics, Hungary, Slovenia, Belgium, France, Italy, Portugal and Spain.

Table 1
Descriptive statistics of road accident fatality rates (number of road fatalities per million inhabitants), 1970–2010 in EU countries.
Source: Prepared by authors.

Sample of EU countries	Mean	Median	Standard deviation	Coefficient of variation	Maximum	Minimum
Austria	183.91	179.62	76.17	0.41	349.91	65.91
Belgium	185.84	187.64	67.10	0.36	322.83	74.91
Denmark	123.85	121.39	49.40	0.40	246.18	46.07
Finland	119.10	115.48	52.58	0.44	249.90	50.83
France	191.47	192.43	80.67	0.42	350.34	63.40
Germany	149.68	130.31	76.42	0.51	313.64	44.60
Greece	151.55	150.42	28.70	0.19	202.09	105.51
Ireland	131.79	126.39	41.24	0.31	212.42	47.45
Italy	136.97	129.46	36.36	0.27	220.78	67.78
Luxembourg	200.02	187.19	81.12	0.41	389.96	63.74
Netherlands	110.76	92.40	58.73	0.53	245.68	36.20
Portugal	214.63	225.21	67.64	0.32	343.61	79.04
Spain	131.05	134.37	28.28	0.22	185.46	53.88
Sweden	89.21	90.54	35.34	0.40	163.29	28.48
United Kingdom	87.52	91.98	31.80	0.36	145.24	30.71
Overall west	147.16	133.69	68.62	0.47	389.96	28.48
Bulgaria	127.33	124.06	16.08	0.13	178.73	99.00
Czech & Slovak Republics	123.50	125.82	22.95	0.19	158.41	76.33
Estonia	174.52	177.90	47.75	0.27	313.19	58.20
Hungary	151.76	150.92	32.41	0.21	234.41	73.89
Latvia	237.26	251.75	50.31	0.21	347.23	96.96
Lithuania	212.90	217.11	38.19	0.18	295.25	89.82
Poland	154.00	153.48	24.12	0.16	206.92	102.37
Slovenia	240.79	253.84	93.51	0.39	398.39	67.42
Overall east	177.76	164.06	63.83	0.36	398.39	58.20

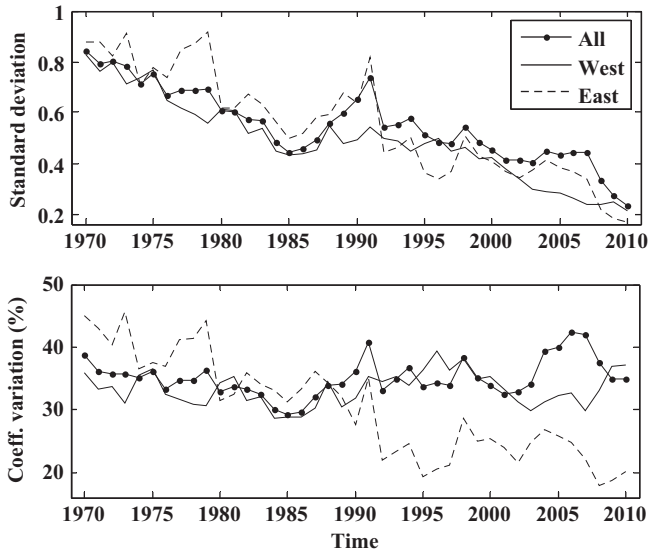

Fig. 1. σ-Convergence of road traffic fatality rates (number of road fatalities per million inhabitants) in the EU country sample, 1970–2010.
Source: Prepared by authors

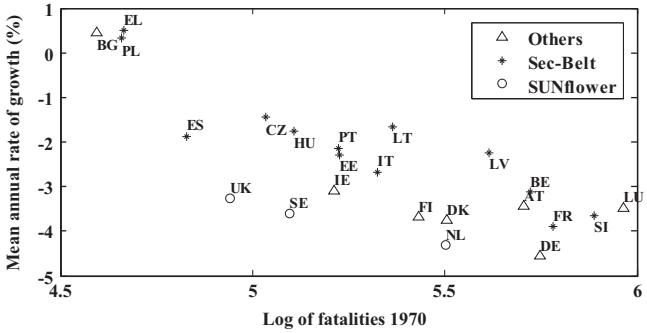

Fig. 2. Log of road fatality rates of change vs. mean annual rate of growth between 1970 and 2010.
Source: Prepared by authors.

- SUNflower: three northern countries that have developed solid road safety policies with significant improvements and have the highest performance in road safety. These countries are the Netherlands, Sweden and the United Kingdom.
- Others: A heterogeneous group formed by old and new EU members with varying levels of road safety development. The countries in this group are Austria, Denmark, Finland, Germany (where specific conditions affect the road accident trend as a result of the impact of reunification, see Wissmann, 1994), Ireland and Luxembourg.

This paper considers a slightly different set of groups based on the evidence in Fig. 2. It seems quite clear that Poland (PL), Bulgaria (BG) and Greece (EL) form a group by themselves and may bias the subsequent analysis as they are, in fact, influential observations. This new group will henceforth be referred to as FOURTH.

These results are supported by data analysis by models in Eqs. (2) and (3) in the previous section. Table 2 reports the estimated results under different specifications of the residual term, namely:

- Model 1 (Eq. (2)): the error term is assumed iid Gaussian.
- Model 2 (Eq. (2)): the error includes fixed country effects, i.e., $u_k = \theta_k + \varepsilon_k$, for $k = 1, 2, 3, 4$, where countries are grouped in four groups as mentioned above, namely SEC belt, SUNflower, Other and FOURTH.
- Model 3 (Eq. (3)): the error term includes fixed time effects, i.e., $u_{t,i} = \mu_t + \varepsilon_{t,i}$, with $t=1$ for the period 1970 to 1985; $t=2$ for 1986 to 2003; and $t=3$ for 2004 to 2010. To avoid perfect collinearity with the constant term α in (2), only two dummy variables are included, corresponding to the two last time effects in the model. Thus, the first time effect is α, the second is $\alpha+$ the time effect coefficient for $t=2$ in Table 1, and the third time effect is $\alpha+$ the time effect coefficient for $t=3$.
- Model 4 (Eq. (3)): model with fixed country effects, i.e., $u_{t,i} = \theta_k + \varepsilon_{t,i}$, for $k = 1, 2, 3, 4$, corresponding to each group of countries. Each observation i (i.e., each country) is assigned to one of the country groups according to sub-index k. This model includes 3 dummy variables to account for the country group effects.
- Model 5 (Eq. (3)): model with fixed time and country effects, i.e., $u_{t,i} = \theta_k + \mu_t + \varepsilon_{t,i}$, for $k = 1, 2, 3, 4$ corresponding to each group of countries, and $t = 1, 2, 3$ for each time period. This model includes 2 dummy variables to account for the time effects and 3 for the country group effects.

Model 2 is estimated by Generalized Least Squares. Following Bertrand et al. (2004), standard errors of estimates in Models 3 to 5 are robust to heteroskedasticity and serial correlation.

The main results in Table 2 include especially:

First, the β parameter governing convergence is negative and statistically significant in all models with the only exception of Model 4, which is negative, but not significant. According to the models specification given in Eqs. (2) and (3), this implies that the countries with the worst (higher) level of fatality rates at the beginning of the sample in all models, or at the beginning of each period, experience a more negative average rate of change, implying that the final levels of fatality rates are closer to each other or, in other words, that convergence of this sample of EU-27 countries is a fact. However, from these models we cannot conclude that convergence is due to the enforcement of the ERSP.

- Second, the EU variable (the percentage of years that each country has belonged to the EU) is significant and consistently negative, i.e., the longer a country has belonged to the EU (and, according to Castillo-Manzano et al., 2014, the more committed to the EU road safety policy it is), the more negative the fatality index's rate of change. In addition, the Traffic Volume variable

Table 2
Estimated results of β-convergence in the EU country sample with time and country effects. Part I.
Source: Prepared by authors.

	Eq. (2)		Eq. (3)		
	Model 1 iid	**Model 2 Country effect**	**Model 3 Time effect**	**Model 4 Country effect**	**Model 5 Time and country-group**
α	0.123	0.108	0.126	0.007	0.181
	(0.026)***	(0.018)***	(0.042)***	(0.036)	(0.034)***
β	−0.029	−0.026	−0.027	−0.005	−0.039
	(0.005)***	(0.003)***	(0.008)***	(0.007)	(0.006)***
EU	−0.008	−0.002	−0.017	−0.038	−0.006
	(0.005)**	(0.001)*	(0.006)***	(0.008)***	(0.004)*
Traffic Volume	0.196	0.071	0.143	0.361	0.069
	(0.092)**	(0.050)*	(0.121)	(0.131)***	(0.113)
Time effects					
t = 2. (1986 − 2003)			0.001		−0.007
			(0.006)		(0.004)*
t = 3. (2004 − 2010)			−0.054		−0.071
			(0.011)***		(0.009)***
Country effects					
SEC belt		0.006		−0.004	0.007
		(0.002)**		(0.008)	(0.004)**
SUNflower		−0.012		−0.002	−0.018
		(0.003)***		(0.008)	(0.005)***
FOURTH		0.013		0.023	0.029
		(0.003)***		(0.007)***	(0.006)***
R^2 adjusted (%)	67.50	91.59	70.93	40.98	81.03

Note: 23 observations for models 1 and 2, 69 observations for the remainder. One, two or three asterisks indicate coefficient significance at the 10%, 5%, and 1% levels, respectively. R^2 adjusted stands for R^2 adjusted for degrees of freedom.

is consistently positive, though not always significant, implying that higher rates of change of fatalities follow from higher rates of change of traffic volumes. As expected, more traffic on the roads implies higher fatality rates, confirming the findings of earlier studies such as e.g., Albalate and Bel (2011).

- Third, regarding models 3 to 5, R^2 is substantially higher in models with time effects, i.e., time is a crucial variable for explaining the rate of change of fatality rates. In fact, the final time effect (for $t=3$) is the most significant of all time effects and coincides with most Eastern countries (Baltic States) joining the EU, i.e., there is a secular acceleration in convergence in ALL countries produced at the same time that the Baltic-Eastern countries join. A country with a mean fatality rate of 90 road deaths per million would have a mean rate of increase of 0.45% during the 1970 to 2004 period, but a reduction of (−4.95%) after 2004.
- This finding, which is clearly visible in Fig. 3, might be explained by the fact that Latvia, Lithuania and Estonia are precisely the countries that head road accident reduction rates during the implementation of the 3rd ERSAP and two of these countries (Latvia and Estonia) also form part of the select group of Member States that met the EU 2010 target between 2001 and 2009 (i.e., within the prescribed period), along with Spain and Portugal (European Transport Safety Council (ETSC), 2010). The positive effect of the strategies applied in the Baltic countries has intensified as a result of the sharp decrease in the population during 2004–2010, especially in the case of Latvia (−6.8%) and Lithuania (−7.5%), according to Eurostat.
- Finally, there are specific country effects (models 2 and 5). The most relevant points here are that the SUNflower group has a significantly smaller negative mean rate of change; the FOURTH group has the highest overall mean level, while the SEC belt remains within the mean value.

Thus far Table 2 demonstrates that there is evidence of β-convergence with the addition of time and country effects. In purely modeling terms, model in Eq. (3) with significant time and country group effects, as is the case of model 5 in Table 2, implies that for each group of countries and for different time periods there is evidence of different α coefficients. At least regarding time periods, this fact is clearly visible in Fig. 3, since the intercept term of each imaginary regression line fitted to each separate scatter plot (crosses, circles and stars) are different, especially for the latter period. Moving one step further along this line of reasoning,

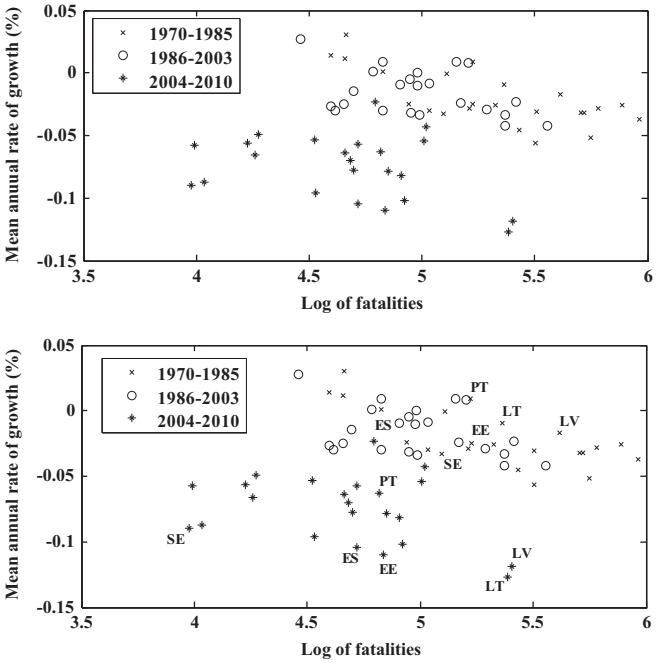

Fig. 3. Log of road fatality rates of change vs. mean annual rate of growth during three different time periods: 1970–1985, 1986–2003, 2004–2010.
Source: Prepared by authors.

Table 3
Estimated results of β-convergence in the EU country sample with time and country effects. Part II.
Source: Prepared by authors.

	Model 2 with β changing by group	Model 5 with β changing by group		Model 5 with β changing in time
α	0.058	0.194	α	0.101
	(0.058)	(0.039)***		(0.033)***
β **Others**	−0.017	−0.042	β ($t=1$)	−0.025
	(0.009)**	(0.007)***		(0.006)***
β **SEC belt**	−0.027	−0.041	β ($t=2$)	−0.043
	(0.004)***	(0.009)***		(0.008)***
β **SUNflower**	−0.015	−0.031	β ($t=3$)	−0.047
	(0.003)***	(0.009)***		(0.013)***
β **FOURTH**	−0.039	−0.038		
	(0.002)***	(0.015)***		
EU	−0.002	−0.007	**EU**	−0.007
	(0.001)*	(0.004)**		(0.004)***
Traffic volume	0.092	0.072	**Traffic volume**	0.155
	(0.047)**	(0.113)		(0.113)
Time effects:			**Time effects**	
$t=2$. (1986−2003)		−0.007	$t=2$	0.181
		(0.005)*		(0.058)***
		−0.071	$t=3$	0.047
$t=3$.(2004−2010)		(0.009)***		(0.068)
Country effects			**Country effects**	
SEC belt	0.054	0.004	**SEC belt**	0.001
	(0.040)	(0.046)		(0.004)***
SUNflower	−0.022	−0.069	**SUNflower**	−0.019
	(0.058)	(0.042)*		(0.005)***
FOURTH	0.121	0.009	**FOURTH**	0.034
	(0.058)**	(0.088)		(0.006)***
R^2 **adj. (%)**	91.51	80.12		82.23

Note: 23 observations for models 1 and 2, 69 observations for the remainder. One, two or three asterisks indicate coefficient significance at the 10%, 5%, and 1% levels, respectively. R^2 adjusted stands for R^2 ad.

the analysis may be still extended further by allowing the convergence speed (i.e., the β parameter) to change, depending either on the group of countries or on time. This change consists of adding a subscript for country groups or time period (one at a time) to the β's in Eq. (3). Table 3 shows the extended versions of models 2 and 5 with country-group and time specific βs (bear in mind that Model 2 does not allow for estimation of βs changing in time).

The new version of Model 2 in Table 3 shows that only the α and β in the FOURTH group differ from the others, as was also demonstrated by formal statistical tests. There are no differences in any of the other groups. When Model 2 is extended with the time effects shown in the new version of Model 5, all the differences between countries disappear entirely, implying that there are no significant changes in the rate of convergence (β) within groups. All this evidence supports the idea that there are no different speeds within groups of countries regarding fatality rates and that there are no clubs.

Table 3 shows yet further evidence in the last column, as the rates of convergence are found to be changing in time, in fact, speeding up in time. The mean rate of the convergence of all countries in the initial period was statistically significantly smaller than in any other period.

5. Conclusions

Today, road transport and road safety have become a fundamental part of the European Union's (EU) common policy. Geerlings and Stead (2003) discuss the importance of policy integration for European research programmes and projects in the field of transport. Prior to the nineteen-nineties it was subordinated to other actions that benefited free competition and the removal of trade barriers between States. Broad improvements have been achieved since then, not only by reason of the efforts made by Member States, but also thanks to support given by the EU through the provision of better road infrastructure, instruments and processes to formulate and enact its policies, including regulation and directives, recommendations on specific areas of behavior, so-called soft law based on non-binding stipulations, economic funding, the sharing of best practices and wide-ranging contact with Non-Governmental Organizations and research institutions.

Previous research (Castillo-Manzano et al., 2014) analyzed how the concept of *Europeanization* might help to describe the favorable impact of the EU on national road safety. Nevertheless, this does not necessarily imply the convergence of countries' traffic fatality rates. In fact, the possible Euro convergence in road fatality rates, if it exists, might be the result of both the convergence of national strategies and policies (through a Europeanization process imposed by the European Commission and/or emulation, transposition or imitation between Member States) but also of the convergence of underlying elements in the road-safety policies and programs of the countries (exposure risk and motorization levels, economic activity, education level, health care systems, etc.).

The literature has demonstrated that there is a lack of convergence in terms of factors that have a decisive influence on national road safety performance (arguable convergence recorded in terms of income; those that are political in type, such as the different rates at which the South-Central-Eastern countries joined the EU; and other more specific factors, such as inequalities in education systems, infrastructure quantity/quality or disparities in weather conditions), which posed initial questions as to whether

the Europeanization of road safety would lead to convergence as a whole.

Therefore, the main contribution of this paper in this respect is to test the hypothesis of the existence of the effective convergence of EU Member States on road safety during the 1970–2010 period. Our purpose is to analyze empirically if this convergence has actually occurred or not as an effect of Europeanization.

The convergence of EU traffic fatality rates is evaluated by applying typical convergence methodology for economic growth, which allows two complementary convergence approaches to be obtained: so-called *σ-convergence* and *β-convergence tests*. Our findings point to the convergence of EU countries as a whole on road safety being a clear empirical fact, as the countries with traditionally higher fatality rates at the beginning of each period have experienced a more negative average rate of change (although the SUNflower countries show different dynamics with a significantly smaller mean rate of change than the SEC belt group). In other words, unlike the doubts raised about convergence in other fundamental areas, such as economics, Euro-convergence has been a success in road safety or, to put it another way, convergence on road safety is possible even without economic convergence.

This finding is all the more striking if we take into account that, first, unlike the economic variables, no minimum standards are demanded for road safety as conditions for joining the EU. Second, the transfer of sovereignty to the EU of issues relating to economic policies, especially in the European Monetary Union (EMU), is incomparably higher than that of road safety policy.

Our findings show that the Europeanization process seems to lead not only to improvements in individual road accident rates for each Member State (in the sense that the longer the State has been a member of the EU, the more negative the fatality rates of change are), but a greater acceleration in the convergence of all EU countries at the time that the Baltic countries joined in 2004. Despite the fact that they joined at a later stage, the major efforts that were made even before they joined, both on an individual basis (e.g., by drawing up National Road Safety Plans, as was the case in Latvia, with goals for reductions in the death rate that were even more ambitious than the 3rd ERSAP itself), and coordinated by the EU (through e.g., the BALTRIS Programme 2007–2013with transnational cooperation with the safety leader Sweden; Baltris, 2011), are a true example of European convergence on road safety. These countries are a case in point of how the road safety policy advanced by the EU has managed to bring down political, economic and geographic barriers.

Our findings also enable us to conclude that there is evidence of the joint convergence of the Member States, i.e., without the pattern being produced that is traditionally found in economic convergence, consisting of the convergence of clubs, or at different speeds. This idea is particularly relevant taking into account the lack of significant evidence of the overall convergence of OECD country road traffic fatality rates found in the recent study conducted by Nghiem et al. (2013).

Finally, now that convergence between European countries has been tested for, one line of research that remains for the future is a detailed analysis of the factors that might have had a bearing on said convergence, but within the constraints that working with such a broad database imposes.

In conclusion, all the foregoing considerations seem to indicate that there are more than just strictly economic facets to the benefits for the EU. However, this European success does not mean that there are no aspects left to be developed in European Road Safety Policy. For example, the legal homogenization of risk factors, such as the maximum allowed BAC (blood alcohol content) limit and speed limits, has still not been achieved after decades. The same is also true for other key factors, such as penalties and fines (although Directive 2011/82/EU facilitates the cross-border exchange of information on traffic offences) and issues related to the vehicle insurance sector (European Transport Safety Council (ETSC), 2012b).

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Annex

See Table A1.

Table A1
Building a European road safety policy:Major steps.
Source: Prepared by authors from official European Commission (EC) and European Council documents on Transport Policy, road safety and White Papers (http://europa.eu/documentation/official-docs).

Key years	Member States	Facts	Main milestones
1957	European Economic Community (EEC)-6: Belgium, France, German Federal Republic, Italy, Luxembourg, the Netherlands	Treaty of Rome (came into force in 1958)	• Creation of a common market which includes the adoption of a common transport policy (CTP) (articles 74-84)
1962	EEC-6	Action program for the implementation of a Common Transport Policy (CTP)	• Harmonization of several measures on safety conditions, but subordinated to fair competition and a free market. • 1980: 1st driving license Directive (80/1263/EEC)
1984	European Community (EC)-10: (since 1973) EEC-6+United Kingdom, Ireland, Denmark+(since 1981) Greece	Resolution of the European Council (OJ C 341)	• Recommendation to the European Commission to propose appropriate research and actions on road safety

Table A1 (*continued*)

Key years	Member States	Facts	Main milestones
1985	EC-10	White Paper: "Completing the internal market"	• Removal of technical barriers between Member States (harmonization of safety controls of vehicles and standard conditions for safety reasons)
1986	EC-12: EC-10+(since 1986) Spain, Portugal	European Year of Road Safety	• Reference point for the establishment of a program of measures to improve road safety in the EC. The Commission considered this objective to be a major task of paramount importance to be assumed in the public interest. ("Seefeld Report", June 1987)
1989	EC-12	Commission communication: "Road Safety: a priority for the Community" (COM 88-704)	• The Commission announced the presentation to the Council of a package of legislative measures on road safety
1991	European Union (EU)-12: EC-12+(since 1990) German Democratic Republic	"The Gerondeau report" by a high-level group of experts	• Fields with clear recommendations for action on road safety: the influence of alcohol/medicines and drugs, young drivers, country roads. • 2nd driving license Directive (91/439/EEC) • Turning point: legislation on mandatory seat belt and child restraint use (Directive 91/671/EEC)
1992	EU-12	**Treaty of Maastricht (came into force in 1993)** **White Paper: "The future of the CTP, a global approach to the construction of a community framework for sustainable mobility" (DELORS White Book)**	• Boost to the CRSP: For the first time, measures to improve safety receive explicit recognition. • The CTP must consist of actions which cannot be accomplished individually by the Member States and the better application of the "principles of subsidiarity and proportionality" (article 3.B)
1993	EU-12	1st European Road Safety Action Programme (ERSAP) (1993–1996)	• Creation of the Trans-European Road Network (TERN) to improve road infrastructure, adopted by Council Decision 93/629/EEC (within the Trans-European Transport Networks TEN-T) • Creation of CARE: a Community database on road traffic accidents (Council Decision 93/704/EC) • Integrated approach of the CRSP with other modes of transport, although with independent qualitative targets and specific priorities for road safety
1995	EU-15: EU-12+(since 1995) Austria, Finland, Sweden	Green Paper: "Towards fair and efficient pricing in transport"	• Using the "willingness-to-pay" approach, the direct costs of road accidents across the Community - medical treatment, police time, vehicle repairs and so forth - are estimated at 15 billion ECU/ year. The estimated value of losses to the economy is another 30 billion ECU
1997	EU-15	Treaty of Amsterdam (came into force in 1999) 2nd ERSAP (1997–2001)	• Article 71 of the Treaty: the subsidiarity principle is reformulated with the statement that "action is the sole competence of the Community" • Quantitative targets for the first time: Reduction in the annual number of road deaths by at least 18,000 by 2010
2001	EU-15	**White Paper: "European Transport Policy for** 2010**: time to decide"**	• Quantitative target of halving the number of 2001 road deaths by 2010
2003	EU-25: EU-15+(since 2004) Czech Republic, Cyprus, Estonia, Hungary, Lithuania, Latvia, Malta, Poland, Slovakia, Slovenia	3rd ERSAP (2003–2010)	• Creation of European Road Safety Observatory (ERSO) developed in a pilot phase within the SafetyNet project in 2004–2008 • European Road Safety Charter since 2004 (the largest platform of good practices in road safety which "can help to save 25,000 lives in Europe") • Important legislative acts: 3rd driving license Directive (2006/126/EC), compulsory use of seat belts, safety management of roads and tunnels...
2006	EU-25	Mid-term review of White Paper (2001): "Keep Europe moving—sustainable mobility for our continent"	• Analysis of the evolution and progress of Member States as of 1st January 2006 and new recommendations
2007	EU-27: EU-25+(since 2007) Romania, Bulgaria	Treaty of Lisbon (came into force in 2009)	• EU policy-making on road safety (as laid down in the Maastricht treaty) is reconfirmed

Table A1 (*continued*)

Key years	Member States	Facts	Main milestones
2011	EU-27	White Paper: "Policy orientations on road safety"	• Creation of a "common European road safety area" with an integrated approach with other public policies • From the "principle of subsidiarity" to "shared responsibility" (private and public agents)
2011	EU-27	4th ERSAP (2011–2020)	• 50% reduction in the number of road deaths by 2020 compared to the number in 2010, with a long-term objective ("Zero-Vision"): "zero fatalities" by 2050 • After reaching a common definition of "severe injuries", a "road injuries reduction target" can be a key priority action
2013	EU-28: EU-27+(since 2013) Croatia	**Towards a Strategy on Serious Road Traffic Injuries**	• Common definition of serious road traffic injury • Way forward for Member States to improve data collection on serious road accidents • Principle of adopting an EU-level target for the reduction of serious road traffic injuries

Note: International UNECE (United Nations Economic Commission for Europe) Transport Agreements and Conventions are not included.

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