Getting ready for Europe: An Empirical Assessment for the Introduction of Periodical Technical Inspections of Road Vehicles in Turkey

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ABSTRACT

This paper investigates the effects of Periodical Technical Inspections (PTI) on traffic safety due to the convergence of Turkey to the European Union. Because strict and mandatory PTI were introduced in Turkey only in 2008, the effects of such an introduction can be well-studied. Other countries do not offer this possibility because the introduction dates back a long time and circumstances are not comparable. By using triangulation to understand the effects of such an introduction and exclusively using a unique panel data set, we can find that the introduction of PTI has a measurable effect on traffic safety in the country. Further, the monetary effect for the economy is estimated as well. Thus, this study gives insights and encouragement for other countries to introduce such measures as they can be an important step toward more road safety in countries struggling with high accident rates and high costs for the economy.

INTRODUCTION

One main goal of states for their citizens is to improve living conditions in general. To achieve convergence and improvement of living conditions, consumer welfare needs to be increased. This is happening in a variety of fields. Traffic safety is one of those fields, and this research aims to shed further light on this. The country of Turkey and its steps are the focus of this paper.

The official start of the convergence of Turkey to what is now the European Union, can be dated back to September 12, 1963. On that day, Turkey and the European Economic Community (EEC) signed an association agreement, with the goal to establish a customs union, such that Turkey could trade agricultural products and goods with the EEC without any restrictions. This had the goal to accelerate economic progress and reduce the disparity between the Turkish economy and the EEC members, thus improving the living conditions in Turkey (European Economic Community, 1977).

In 1987, Turkey then applied to join the European Economic Community (European Commission, 2018) and in 1993 the EU and Turkey started negotiations for a Customs Union. In 1996, the Customs Union took effect and in 1999, the European Council gave Turkey the status of candidate country for EU membership (Delegation of the European Union to Turkey, 2018). In 2001, the European Council adopted the EU–Turkey Accession Partnership. With this, a road map for Turkey's EU accession process was developed. Subsequently, the Turkish Government adopted the NPAA, the National Program for the Adoption of the Acquis, which signifies adopting EU law.

In 2001, the Commission of the European Communities set out in its White Paper, "European transport policy for 2010: time to decide," that the number of road deaths needs to halve in the period from 2000 until 2010. The harmonization of penalties and the promotion of new technologies to improve road safety were the prime focal areas (Commission Of The European Communities, 2001). To comply with EU law and the strategies set out, it can be expected that Turkey already took steps to perform better in the field of road safety, in preparation for the accession to the European Union.

At around the same time in December 2001, SweRoad, in their Executive Summary for the Road Improvement and Traffic Safety Project pointed out that, "[t]he periodic vehicle inspection is under-staffed and under-equipped, and the inspection is rudimentary" (SweRoad, 2001a, p. 13). In fact, the old inspection system did not offer proper technical inspections for vehicles but merely checked whether taxes were paid along with a quick check of the documents (LifePR, 2008). The government decided to tender this matter to private companies, dividing the country into two parts and thus two tenders, one for the north and one for the south. At the end of 2004, the German TÜV SUD, a private company in the sector of Periodical Technical Inspections (PTI), won the tenders in both the south and the north and on August 15, 2007, TÜVTURK and the Turkish government signed a concession agreement for the periodical revision of cars, trucks, and busses. Subsequently, TÜVTURK started to build nationwide stations for revisions of vehicles.

The consortium, TÜVTURK, was comprised of the two entities, the Tüvturk Kuzey Taşıt Muayene İstasyonları Yapım ve İşletim A.Ş. (for the north) and Tüvturk Güney Taşıt Muayene İstasyonları Yapım ve İşletim A.Ş (for the south). For ease and consistency, it will be called TÜVTURK throughout this study. It consists of the mixed industries companies, Doğuş and Akfen, as well as the German TÜV SUD, which offers periodical revisions in Germany. The total amount invested was 633 million Euros, with 224 million invested in the building of the service centers, as well as the training of the personnel and 409 million paid for the concession (PresseBox, 2008). The share of this cost was roughly 1/3 for each of the partners and the total duration of the concession contract of 20 years (LifePR, 2007). During late 2007, and in the subsequent years until today, the stations were built, depending on need. There are currently 205 fixed stations spread across Turkey, as well as 76 mobile stations (TÜVTÜRK, 2016).

The convergence in this field could be a blueprint for other countries seeking to improve their living conditions and consumer welfare by introducing such a system. The introduction in Turkey is ideal for a study on the effects of PTI, due to the unique setup. Because many other countries either do not have technical revisions comparable in their extent to the ones in Turkey or have had them already for a long time, a comparison of the before and after introduction cases would not prove to be very meaningful as the cars have developed so much over time. Germany, for example, was the first country to introduce technical revisions as early as 1906 (TÜV SÜD AG, 2016). The cars in circulation and the corresponding traffic accident numbers at the time, without roadworthiness inspections, are thus neither comparable to the technical level of current cars or there is simply no data. In Turkey, the introduction of the new system only dates to 2008, and the implementation has been done in a rather short amount of time by private companies, modeled after the system in place in Germany and thus well-proven.

The system in Turkey follows directive 96/96/EC (Directive on the approximation of the laws of the Member States relating to roadworthiness tests for motor vehicles and their trailers), which contains a minimum standard for the testing frequencies of passenger cars and light goods vehicles (Schulz, 2011). The minimum standard states that passenger cars have to be inspected every two years after the first inspection. This first inspection needs to be at four years after the motor vehicle registration. Because it is a minimum regulation, it leads to 13 different national inspection frequencies within the European Union and two-member state groups that can be identified. There are states that have established PTI with over-compliance and those with minimum compliance (Schulz, 2011). Germany, for example, has an over-compliance PTI regime, with the first inspection due after three years and subsequently, every two years (for N1 vehicles). Turkey, because it is modeled after the German PTI rules, uses the same inspection frequency as Germany (TÜVTÜRK, 2017).

THE NEED FOR CHANGE

Consumer welfare and the connected traffic security have been identified as one of the main drivers for convergence. In the following, it should become clear why and to what extent consumer welfare is influenced, if the country is missing an effective roadworthiness test system. Figure 1**Fehler! Verweisquelle konnte nicht gefunden werden.** shows the rapidly increasing vehicle stock in Turkey, growing on average at about 7% a year from 1990 to 2015, more than quadrupling in those 25 years.

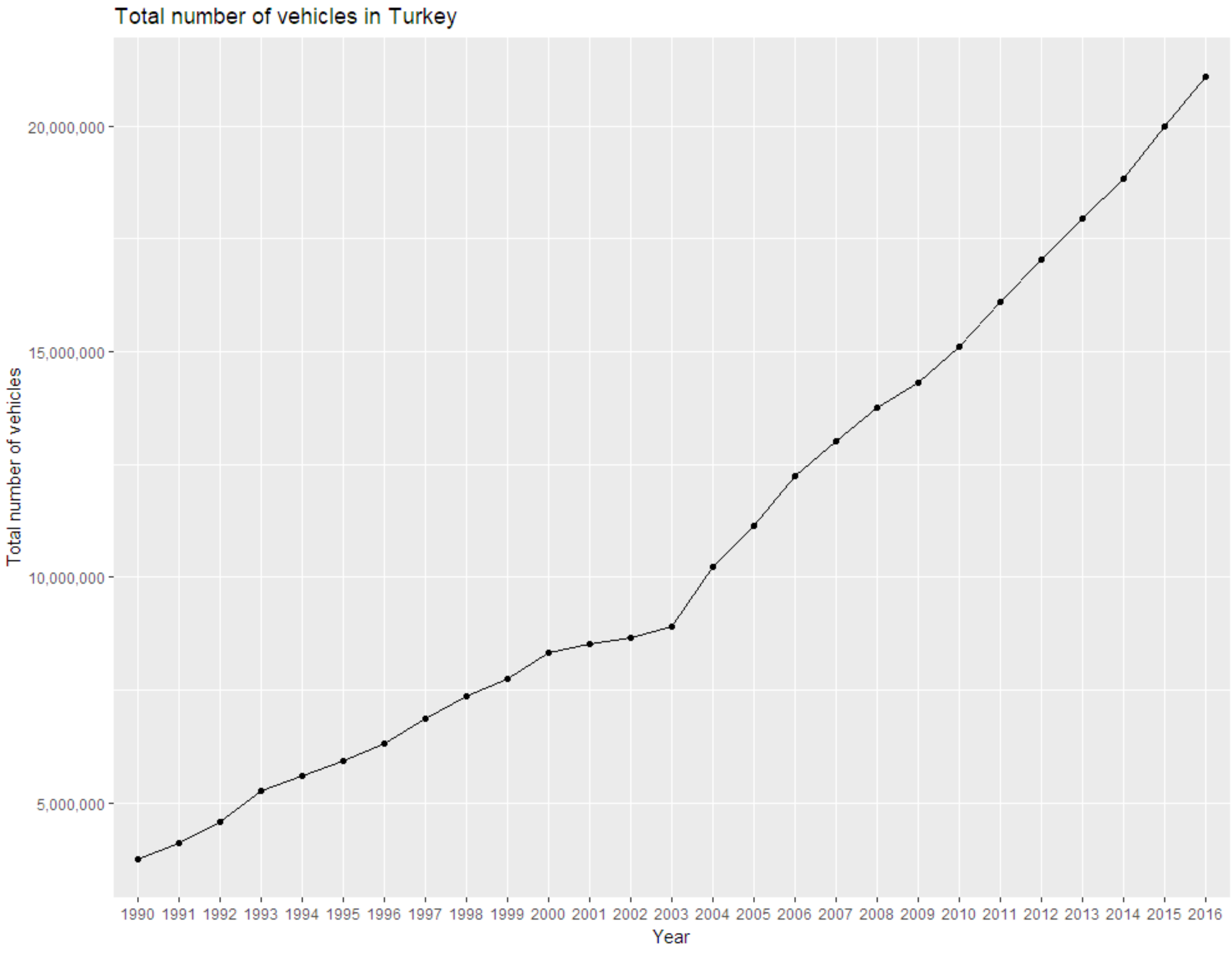

Figure 1 Vehicle stock in Turkey

(own figure; based on data from TÜIK 2016)

Examining the development of the number of injuries by road accidents and comparing it with the average annual increase of vehicles by 7%, the number of injuries increased over-proportionally by 11% on average per year. Contrary to the strong increase in injuries, the number of fatalities has decreased. Over the period from 1990 to 2015, the number of fatalities decreased by 2% per year on average. Taking the average between 1990 and 2007 before the introduction of PTI, the number of fatalities fell by 1% on average; since the introduction of PTI, the numbers have decreased by 3% on average.

During the 1990s, the fatality numbers were very high, ranging between 6000 and 7000 fatalities at the accident site per year (SweRoad, 2001a). The goal was to bring those numbers down and reduce road fatalities. A report from 2001 stated that the projected numbers for 2011 would reach as high as 9000 casualties per year if nothing changed and no safety interventions were carried out (SweRoad, 2001a). Today, the fatality situation in Turkey is getting more comparable with the EU-28.

Counted in 2013, 25,938 fatalities by road accidents occurred in the EU-28 (ERSO, 2016). Assuming 505,700,700 inhabitants for the EU-28, it can be stated that 51 people per 1,000,000 inhabitants were killed in road accidents. In Turkey, in the year 2013, 48 people per 1m inhabitants were killed in road accidents. This means that the number of fatalities since 1990 more than halved from around 111 fatal accidents per 1m inhabitants to 48 per 1m in 2013. However, the number for Turkey only includes the fatalities at the accident site. Since 2015, to harmonize the fatality rates in the statistics with other international statistics, fatalities were also counted that occurred in the hospital within 30 days after the accident. If those numbers are included, then 95 fatalities per 1m inhabitants are counted. Therefore, it can be concluded that Turkey managed to improve quite a lot over the last 30 years, but the numbers are still high compared with EU numbers that were at around 57 fatalities per 1m inhabitants in 2014, which had also almost halved since 2005 when it was 111 in the EU (ERSO, 2016).

WHY PTI?

This study aims to understand the impact of PTI measures on road safety, adding empirical evidence to the existing literature, which in general, acknowledges that there is an empirical relationship between direct and indirect traffic safety effects and the numbers from the inspected variables. This connection has been treated already in the following literature: FMCSA, 2002; AUTOFORE, 2007 and de Brabander, Vereeck, 2007 (AUTOFORE, 2007; De Brabander & Vereeck, 2007; FMCSA (Federal Motor Carrier Safety Administration), 2002.

Roadworthiness enforcement measures make the operation of vehicles safer and more reliable. Thus, the measures contribute to socioeconomic benefits through several impact channels. The impact channels can be distinguished between safety-critical effects and non-safety-critical effects.

Safety-critical effects include the risk of an accident occurring, for example, through extended braking and stopping distances due to poor brakes, or rear-end collisions due to poor vehicle lighting. Non-safety-critical effects include vehicle breakdowns, emissions, and fuel consumption. Vehicle breakdowns due to poor vehicle conditions result in costs to the vehicle owner, (e.g., towing costs, vehicle repair costs, and congestion), which result in lost time, vehicle maintenance costs, and emissions. Badly adjusted engines and exhaust systems result in higher fuel consumption. Increased fuel consumption leads inevitably to rising emission costs and CO_2 costs.

As noted, the numbers for accidents, fatalities, and injuries are not always easy to determine, as countries count them differently. In the EU, there is no uniform system, and thus, the statisticians need to account for the differences in the different countries with different formulas, which are explained in the Glossary of the Annual Accident Report (ERSO, 2016). Furthermore, Elvik points out,

> In the official accident statistics, the proportion of accidents attributed to the technical failure of the vehicles varies between 1.3% and 11.4% (on average, around 4%). According to in-depth studies of accidents, the proportion of accidents attributed to the technical failure of the vehicle varies between 1.5% and 24.4% (on average, around 8.5%)" (Elvik, 2009, p. 743).

This still leaves a considerable 91% to 96% left for human error that could lead to an accident. A PTI is not able to prevent those human errors, but it can attenuate the severity in certain cases by making sure that the technical conditions of the vehicle are correctly operating. Furthermore, it can also lessen some traffic accidents by ensuring that technical errors will be minimized. Elvik states this as well in the Handbook of Road Safety Measures (Elvik, 2009).

ANALYSIS

The data used are from official publicly available statistics, as well as data that was received from TÜVTURK. The data are for all 81 regions in Turkey for the years 2000 to 2015, as seen in Table 1, and derived from the official website Turkstat or TÜVTURK directly, as indicated. The introduction of the mandatory PTI was in 2008, roughly the middle of the observation time span.

Table 1 Variables, time period, and data sources

Variable	Time period	Source
Population	2000–2015	Turkstat (TÜIK)
Total accidents	2000–2015	Turkstat (TÜIK)
Injured	2000–2015	Turkstat (TÜIK)
Length of motorways	2000–2015	Turkstat (TÜIK)
Length of provincial roads	2000–2015	Turkstat (TÜIK)
Number of vehicles	2000–2015	Turkstat (TÜIK)
PTI data for failed inspections	2008–2015	TÜVTURK

Graphic Analysis

To analyze the effects of the convergence, the input variables are examined graphically in a first step.

Figure 1 has shown the development of the vehicle stock in Turkey.

Figure 2 below shows the traffic accident development from 2000 until 2015. A small drop in traffic accidents is visible in 2008, the year in which the PTI was introduced. This is the first hint that such an introduction may have a noticeable impact on traffic safety. To examine this further, the development of injuries from road accidents is examined in Figure 3. What is very noticeable is that the figures look very similar. The reason for this might be an underreporting of accidents without harm to people and the large number of injured in vehicle crashes compared with the absolute numbers for fatalities, resulting in a large share for injured and thus, the resulting curves.

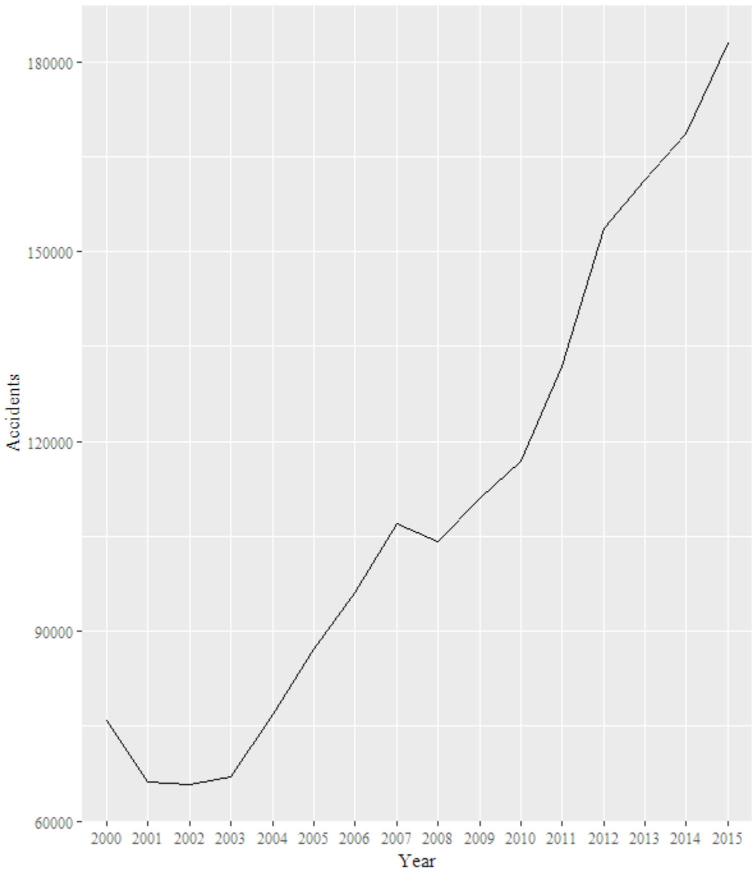

Figure 2 Number of traffic accidents

(based on data from TÜIK, 2016)

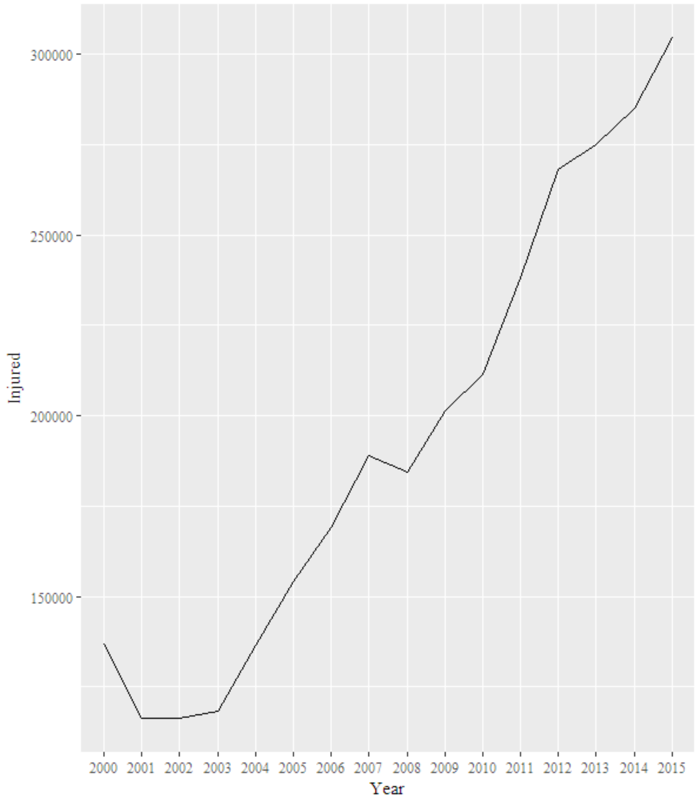

Figure 3 Injuries from traffic accidents

(based on data from TÜIK, 2016)

It is noticeable that in 2008, the year of the introduction, there is a small dip in the numbers. As stated, this could be a hint that the technically worst performing cars were taken out of circulation and that this had a measurable and visible impact on traffic safety.

While the absolute numbers were going up, a further look at the data revealed that the ratio of injuries per accident has fallen, as Figure 4 shows.

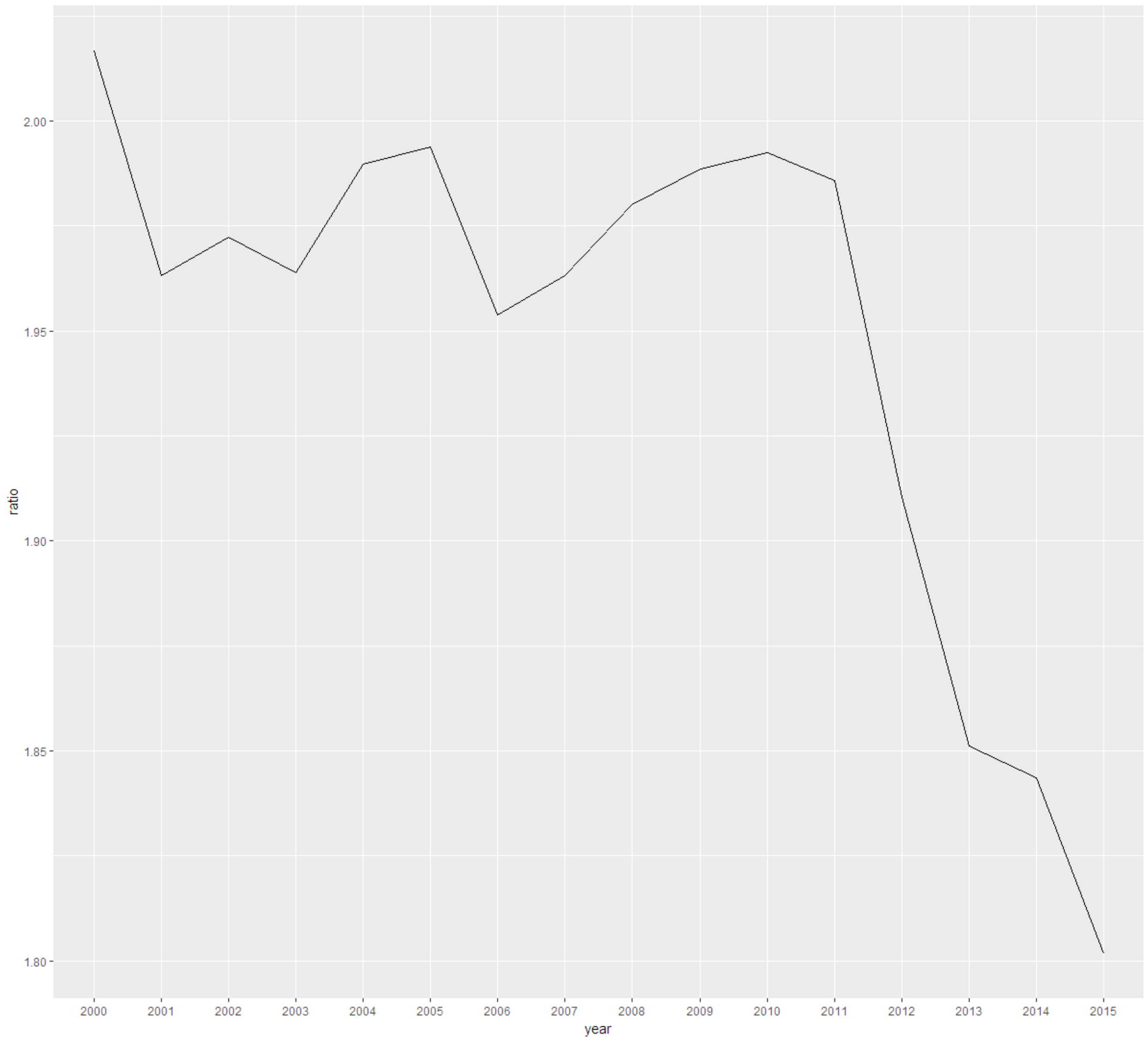

Figure 4 Injuries to accident ratio

(based on data from TÜIK, 2016)

From this figure, we can see that there were roughly 2.01 injuries per accident, and this number fell to 1.8 in 2015, with a sharp decline from 2011 onward. The means that over a 15-year period there were 1.94 injuries per accident. To further investigate the effects of the convergence and introduction of strict PTI enforcement, a further analysis was conducted.

Regression

To assess the effects, the use of triangulation helped to understand the data and the outcome. At first, a simple regression with a dummy variable was used to investigate whether there is a measurable effect after the introduction of PTI. The results of this modeling can be seen in Table 2.

Table 2: Regression results for dummy

(Intercept)	87.70 (3.92)
Dummy	–35.00 (7.06)
R Square	0.51
Adjusted R Square	0.49
Number of Observations	26
Root Mean Square Error (RMSE)	16.62

All values are significant at the 0.01 level. In brackets the Standard Error is denoted.

Here, it becomes visible that through the introduction of PTI, there is a measurable effect. This is another hint that PTI is had an effect on traffic safety and thus, economic benefits for the state and society. To be able to quantify this effect, more data have been collected to better model the influences.

Panel Data Model

Because the first rough analysis has yielded some measurable effects, a further and more detailed analysis was carried out. A panel data model with individual fixed effects over a 15-year time period with all 81 regions was chosen.

Two different scenarios were modelled. The first had accidents as the dependent variable. Independent variables were population, the inverse of the number of vehicles that did not pass inspections because the errors have been removed before they are allowed back on the road, the number of vehicles in the province, as well as the length of provincial roads and the length of motorways. All these variables are available for all 81 regions and for the time span of 15 years.

For the variable that failed PTI, zero were chosen before 2008 as PTI had not been introduced and cars were not checked, thus, no errors had been detected and cars could just drive without inspection. Since 2008, cars are thoroughly checked for failures and are not allowed to operate before repairs are completed. Therefore, absolute numbers were used, which were obtained directly from TÜVTURK.

The results of this modeling showed that the number of failed vehicles has an impact on the accident variable and it is negative. Thus, it could be reasoned that there is an inverse relationship, the more errors in vehicles detected, the fewer accidents there are. The length of the motorways, on the other hand, did have an impact. The more kilometers of motorways in the country, the more accidents are likely to happen, and a similar correlation can be observed with provincial roads.

Population had a slightly negative effect, which signifies that the more people in the country, the fewer accidents will happen. A strong population growth, such as Turkey has experienced can bias the outcome because the population variable includes every age group in the country and not all yet participate in traffic, which might explain this inverse effect. The number of vehicles, on the other hand, is more meaningful and straightforward. The more vehicles there are, the more accidents will happen. All of the variables are significant on a 1% level. The following table summarizes the findings.

Table 3 Model results for accidents

Dependent variable: Accidents	
Population	–0.002 (0.0001)

Failed PTI	–0.007 (0.001)
Number of vehicles	0.008 (0.0002)
Length of provincial roads	0.954 (0.253)
Length of motorways	9.600 (0.750)
Observations	1,296
R^2	0.818
Adjusted R^2	0.805
F Statistic	1,085.044 (df = 5; 1210)

All values are significant at the 0.01 level. In brackets the Standard Error is denoted.

Because there were roughly 2.9m failed vehicles in PTI in 2015, and given that a PTI where failures are detected would lead to an estimated 0.007 fewer accidents, around 20,000 accidents per year could be prevented with a strict enforcement of PTI.

To investigate this relationship further, the effects on injuries in traffic accidents was also examined. The new dependent variable is now injured persons. The independent variables remain the same, as in the scenario above. The outcome proves to be quite similar. The detected failures in vehicles that lead to a failed PTI have an inverse impact on injuries from crashes. The length of motorways, as well as the length of provincial roads, had a direct effect. Population had a slightly negative effect, likely due to the same reason as stated above. The number of vehicles had a positive effect. The results of the modeling are shown in the following table.

Table 4 Model results for injured persons

Dependent variable: Injured persons	
Failed PTI	–0.013 (0.001)
Population	–0.004 (0.0002)
Number of vehicles	0.012 (0.0004)
Length of provincial roads	1.647 (0.406)
Length of motorways	15.745 (1.202)
Observations	1,296
R^2	0.809
Adjusted R^2	0.796
F Statistic	1,027.949 (df = 5; 1210)

All values are significant at the 0.01 level. In brackets the Standard Error is denoted.

The results of this second modeling, in general, confirmed the results of the previous modeling for accidents. It was expected that the effect of PTI would be negative for both the models that used and this effect was confirmed in both. Hence, it can be estimated that roughly 37,700 injured persons can be prevented due to the strict enforcement of PTI.

This result is in line with the previous findings. Considering the injured to accidents ratio that had been previously determined, and considering the mean of the years from 2000 to 2015 of around 1.94 injured per accident and multiplying the result of around 20,000 accidents less due to the strict enforcement of PTI with 1.94 results in 38,800 injured. This is close to the result from the model for injured, thus affirming the findings.

MONETARIZATION

To estimate the effect of the strict enforcement of PTI, the accidents shall be valued in terms of money. The Turkish cost-unit rates will first be considered. Already in 2001, a study by SweRoad stated that there are no studies available that determine the cost-unit rate for an accident or a fatality. They have used the Swedish values and adopted it via the GNP for Turkey, yielding a value of TL 107,000m for a fatality and TL 3,700m for an injury (SweRoad, 2001b). These numbers are around 17 years old and since then, the Turkish currency has changed much in value, hence, the values are hardly comparable to today. A more recent study from Özen, Genç, and Kaya from 2014 concludes that there are no official numbers available and that an assessment is difficult. However, through a series of assumptions and empirical data, they estimated that the cost of traffic accidents in Turkey in 2012 was more than $4 billion (Özen, Genç, & Kaya, 2014). This is also somewhat in line with results from the study, “Crash cost estimates for European countries, deliverable 3.2 of the H2020 project SafetyCube,” which stated that the total cost of crashes is between 0.4% and 4.1% of the GDP for a country (Wijnen et al., 2017). Because Turkey’s GDP was around $768 billion US (1998 prices) in 2012 (Turkish Statistical Institute, 2018a), the estimated $4 billion US would be around 0.52% and thus, in line with the results of the study.

Given that there were 153,552 accidents with fatalities or injuries in 2012 reported on Turkstat (Turkish Statistical Institute, 2018b), one accident equals roughly $26,000. Considering the aforementioned 20,000 accidents which strict enforcement of PTI could help to prevent, this would yield a savings of around $520 million for the Turkish economy.

As stated in the introduction, Turkey has likely introduced these measures to convert to

European policies. Because the cost-unit rates in Turkey are rather on the low end, and because Özen, Genç, and Kaya also expressed that it is rather difficult to determine the values, European cost-unit rates are considered because these will apply once Turkey enters the European Union. The cost-unit rates for the European Union are well-studied and used in a variety of research, being roughly around $1.5 million for a fatal accident, around $200,000 for a serious accident, and $25,000 for a small accident (eIMPACT, 2008; European Commission, 2017; HEATCO, 2005; Schulz, 2011). These costs are directly linked to the vehicle, as well as medical/hospital costs, and resource losses. They do not cover the losses for congestion, for example, that would be caused by accidents on a highway and the costs for increased fuel consumption, higher air pollution, and the lost time of other traffic participants (Schulz, 2011), things that were not examined in this study.

Applying the cost-unit rate for accidents known in Europe, leaving out fatal accidents, but using an average value for serious and small accidents of around $112,000 per accident, this would yield a savings of around $2.2 billion for the economy due to fewer crashes.

LIMITATIONS

Every country has specific aspects that have to be considered when analyzing how a general improvement of traffic safety is possible [compare the study, AUTOFORE (2007), which goes into much more detail for the impairments resulting from traffic accidents]. This study strictly focuses on the part of periodic technical revisions that have not been analyzed this way before.

However, other measures are equally important. The European Commission has identified the main causes for accidents as speeding, driving under the influence of alcohol, and not using a seat belt (European Union, 2004). For example, in Turkey, the issue of not wearing a seat belt has been tackled during a campaign that was not strictly enforced, resulting in a stagnation of seat-belt wearing rates below 5%. Subsequently, this campaign was revised and a decree was issued by the governor, stipulating that nobody will be exempt; as well, law enforcement was made stricter. This, together with further awareness measures, resulted in seat-belt wearing rates of around 49% (World Health Organization, 2013). This increase must also have had an impact on traffic security, as studies like that from Cohen and Einav (2003) have shown, and which illustrate that achieving higher degrees of security is always a combination of different measures. However, this broadness is not in the scope here and has not been examined in this paper. A further example of more broadness that should be included in future studies is the influences of road conditions and public infrastructure on accidents, injuries, and fatalities, and further, for example, the emergency response, which might have a considerable impact on fatalities (World Health Organization, 2013). Further factors not included in this study, but which could influence the number of accidents, might be the education of drivers, the composition of other traffic participants (e.g., more or less pedestrians, motorcycles, scooters, cycles, and in a broader perspective, the laws governing the traffic and their enforcement as in the example of seat belts above). These influences are hard to measure and are hidden in the data of this study. To make this analysis more precise, further studies in Turkey comparable to the work of DEKRA in Germany, which is researching the causes of road accidents, could yield richer, more reliable data that could be included in the panel data model (DEKRA, 2018). Further and much more detailed data could thus close the gap.

Additional data were thought to be integrated into the analysis as various factors may cause or influence accidents and their outcomes, but most of the data are not available for longer time periods and thus were not be used in the analysis. Further research could also examine how a different test cycle (1-year, 2-year, etc.) would influence traffic safety and accident numbers. Studies from Belgium have shown that different cycles of technical inspections are leading to welfare losses (Schulz, Kichniawy, & Weitz, 2014).

IMPLICATIONS AND DISCUSSION

The limitations show the limited area in which this paper is located, yet the aspect of the introduction of PTI, due to the convergence of transport policies, has not yet been examined and the results are yielding revealing new insights into transport policy. The results show a correlation between the number of failed vehicles in PTI and the number of crashes and injuries. In absolute terms, the authors expect the strict enforcement of PTI to prevent around 20,000 accidents and around 38,000 injured per year. PTI can thus be a suitable measure to reduce traffic accident numbers and have positive economic effects. Therefore, the safety effects calculated here, as well as the rough cost–benefit analysis are just a starting point for further welfare gains due to fewer accidents. A full cost–benefit analysis may uncover the full benefit for the economy.

It can be concluded that the convergence of traffic policy can yield substantial welfare gains, which were estimated for Turkey to be between $520 million and $2.2 billion per year. The application of PTI could be done in many other countries across the globe as well. This analysis could help policy makers decide whether an introduction of periodical roadworthiness inspections in countries where it does not exist or is not yet as extensive and strictly enforced and which struggle with high accident rates, could benefit their population and economy. PTI proves to be a suitable measure to improve the consumer welfare and well-being of citizens due to avoided traffic accidents and related trouble with car breakdowns and the resulting impairments.

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