ESTIMATE OF THE DISTANCE TRAVELLED ANNUALLY BY THE VEHICLE POPULATION FOR 2024

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Contents

1. Introduction

As part of the 2030 Road Safety Strategy, the Directorate-General for Traffic (DGT) requires accurate and up-to-date estimates of the kilometres travelled annually by the Spanish vehicle population. This indicator is essential for assessing exposure to road risk and informing decision-making in the field of road safety.

Since 2013, the DGT has systematically collected the odometer readings recorded at each roadworthiness test (ITV) for all vehicles in the national vehicle population. However, the direct use of these data has its limitations: newly registered vehicles do not yet have odometer records, and the frequency of roadworthiness tests varies depending on the type of vehicle. For example, cars do not undergo annual tests, while other vehicles, such as buses, may undergo several tests in the same year. These circumstances make it difficult to obtain complete and up-to-date information on the kilometres travelled.

Scientific literature has approached the estimation of distances travelled from different perspectives. Some studies, such as that by Hossain & Gargett (2011), use fuel sales data to estimate the kilometres travelled in different regions, while others, such as that by Sungwoon et al. (2017), use traffic volume and vehicle registration data. In Spain, recent research (Narváez-Villa et al., 2021) has applied machine learning models to odometer readings from roadworthiness tests to estimate the annual number of kilometres travelled by cars.

This report presents the results for the vehicle population on the road in 2024, applying a different methodology to that used in the publication concerning the vehicle population on the road in 2023. On this occasion, only data from roadworthiness tests conducted in 2024 have been used, unlike previous studies that included information from earlier years.

The methodology incorporates additional data filtering techniques and new variables into the models. These changes have led to differences in some values compared to the previous report. They have also improved accuracy in estimating the annualised number of kilometres travelled by vehicles.

2. Construction of the ITV database

In order to build the database used in this study, the odometer readings recorded at each roadworthiness test (ITV) conducted in 2024 were collected. The data cleansing and filtering process was carried out according to strict criteria in order to ensure the quality and representativeness of the sample. The main exclusion criteria applied were:

- **Type of test and result:** All roadworthiness tests that are not periodic or whose result is not favourable are excluded, thus eliminating type approval tests, failed tests, etc., in accordance with Royal Decree 920/2017 of 23 October.
- **Sequence of readings:** Vehicles whose odometer reading sequence is not ascending are excluded, thereby removing any records with errors or manipulations, as well as any vehicles whose odometer has been reset.
- **Vehicle type:** Trailers (category O, according to Royal Decree 2822/1998 of 23 December), agricultural vehicles, special purpose vehicles, temporary transport vehicles, and vehicles with tourist or private registration plates are excluded. As a result, the database consists exclusively of motor vehicles used for ordinary transport.

For each vehicle, the difference in days and kilometres between each passed test and the previous one is calculated. These values enable us to calculate the indicator of annualised number of kilometres for each vehicle and test, defined as:

- **DIF_KM**: the difference in kilometres between two consecutive passed inspections.
- **DIF_DAYS**: the difference in days between two consecutive passed inspections.

Therefore, the annualised number of kilometres (**KM_ITV**) for each vehicle between two consecutive roadworthiness tests is calculated as follows:

$$KM\_ITV = \frac{DIF\_KM}{DIF\_DIAS} \cdot 365{,}25$$

The vehicles are then grouped into 8 mutually exclusive categories (see Annex I). To ensure data quality, any tests where the interval between checks (DIF_DAYS) falls outside the ranges established for each category are excluded. These intervals are set out in **Table 1**.

Table 1. Inclusion intervals (in days) for each vehicle category.

Vehicle Category	Minimum interval (days)	Maximum interval (days)
Mopeds	60	1,095 (3 years)
Motorcycles	60	1,460 (4 years)
Cars	60	1,460 (4 years)
Vans	60	730 (2 years)
Lorries (up to 3,500 kg MAM)	60	730 (2 years)
Lorries (over 3,500 kg MAM)	60	365 (1 year)
Buses	60	365 (1 year)
Industrial Tractors	60	730 (2 years)

The maximum intervals established for each vehicle category correspond to the legally permitted periods between roadworthiness tests. For example, in the case of cars, the maximum of 1,460 days is equivalent to the first four years in which the vehicle is exempt from passing the roadworthiness test. Meanwhile, the minimum interval of 60 days represents the maximum legal deadline for rectifying defects detected in a failed test. If the period between two tests is less than this minimum, it is interpreted that the previous test was not passed and, therefore, that record is excluded from the analysis.

To ensure data quality and remove outliers, a minimum and maximum number of kilometres travelled between tests has been established for each vehicle category, as shown in **Table 2**. These intervals have been set so that they are broad enough to include all relevant vehicles, but at the same time allow erroneous or unrepresentative records to be excluded.

Table 2. Inclusion intervals (in kilometres) for each vehicle category.

Vehicle Category	Minimum (KM)	Maximum (KM)
Mopeds	50	30,000
Motorcycles	50	70,000
Cars	1,000	200,000
Vans	1,000	300,000
Lorries (up to 3500 kg MAM)	1,000	300,000
Lorries (over 3500 kg MAM)	1,000	300,000
Buses	1,000	300,000
Industrial Tractors	1,000	300,000

In addition to the fixed filtering described above, which was also used in the previous 2023 study, a new filtering process has been introduced for each numerical variable used to train the model, as well as for the target variable of annual kilometres. The aim of this additional filtering is to remove cases of extreme or erroneous data that could negatively affect the model by confusing it with unrealistic data.

Extreme-value filtering removes all entries in which any numerical variable, including annual kilometres, exceeds the 99.5th percentile of its own distribution. In other words, entries whose values are above 99.5% of the values for that variable are excluded.

Once the above criteria have been applied, a clean sample is obtained that allows us to analyse the distribution of the annualised number of kilometres by vehicle category. **Table 3** summarises the main statistics for the 2024 roadworthiness tests. It is important to note that the new extreme-value filtering has led to notably different values in some sections of the table (such as maximum values) compared to the 2023 report, in which this filtering was not applied.

Table 3. Annualised number of kilometres by vehicle category for 2024 roadworthiness tests (clean data).

	Mopeds	Motorcycles	Cars	Vans	Lorries ≤ 3500 kg	Lorries > 3500 kg	Buses	Industrial Tractors
N	82,661	740,730	12,876,500	1,157,862	1,180,654	161,136	42,151	166,646
Mean	2,165	2,655	10,870	13,098	12,190	25,461	52,552	92,352
SD	2,437	2,680	7,817	12,344	10,269	27,597	38,948	53,344
CV	1.13	1.01	0.72	0.94	0.84	1.08	0.74	0.58
Minimum	50	50	1,000	1,000	1,000	1,000	1,005	1,000
P1	63	76	1,238	1,161	1,184	1,178	2,495	2,123
P5	122	184	2,064	1,791	1,908	1,938	8,270	7,952
P10	211	324	2,952	2,561	2,760	3,011	13,597	17,399
Q1	556	799	5,321	4,897	5,163	6,989	26,073	48,621
Median	1,365	1,836	9,246	9,505	9,496	16,875	45,076	95,366
Q3	2,886	3,582	14,428	17,063	16,019	34,402	68,071	131,393
P90	5,087	6,005	20,356	27,690	24,551	57,165	97,939	156,632
P95	6,814	7,989	24,825	36,453	31,503	76,437	122,777	174,529
P99	12,037	12,939	37,898	61,063	50,323	132,828	204,600	223,948
Maximum	20,173	20,336	73,315	109,931	100,133	299,996	299,474	299,974

These results reflect the variability and range of annual vehicle usage in each segment, after removing outliers and unrepresentative records.

Finally, analysing the density of the annualised number of kilometres for each type of vehicle allows us to visualise the distribution and concentration of values within each category, thereby facilitating the identification of mobility patterns and possible differences between segments, as shown in the following figures.
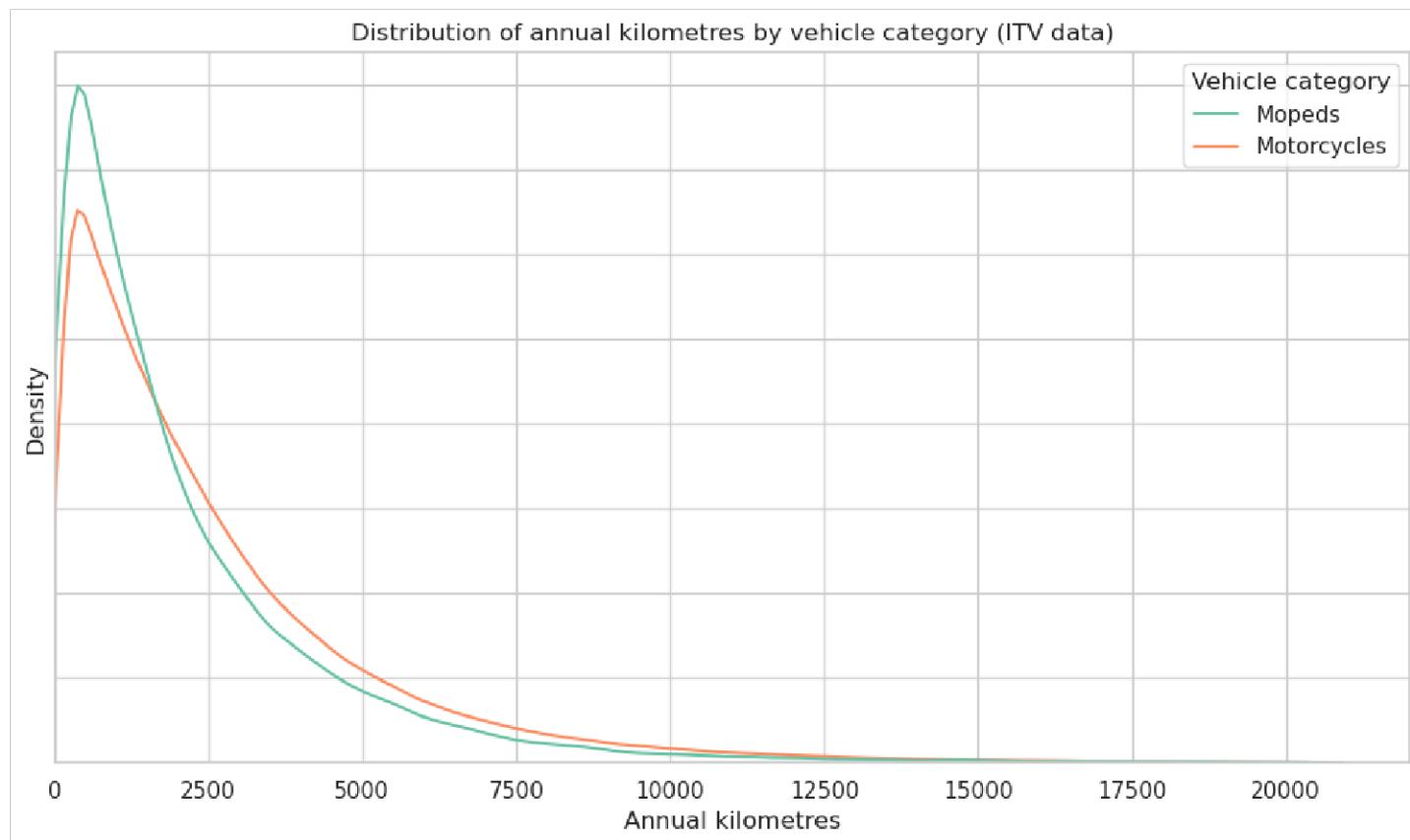
Figure 1. Kernel density estimate of the annualised number of kilometres travelled by mopeds and motorcycles.
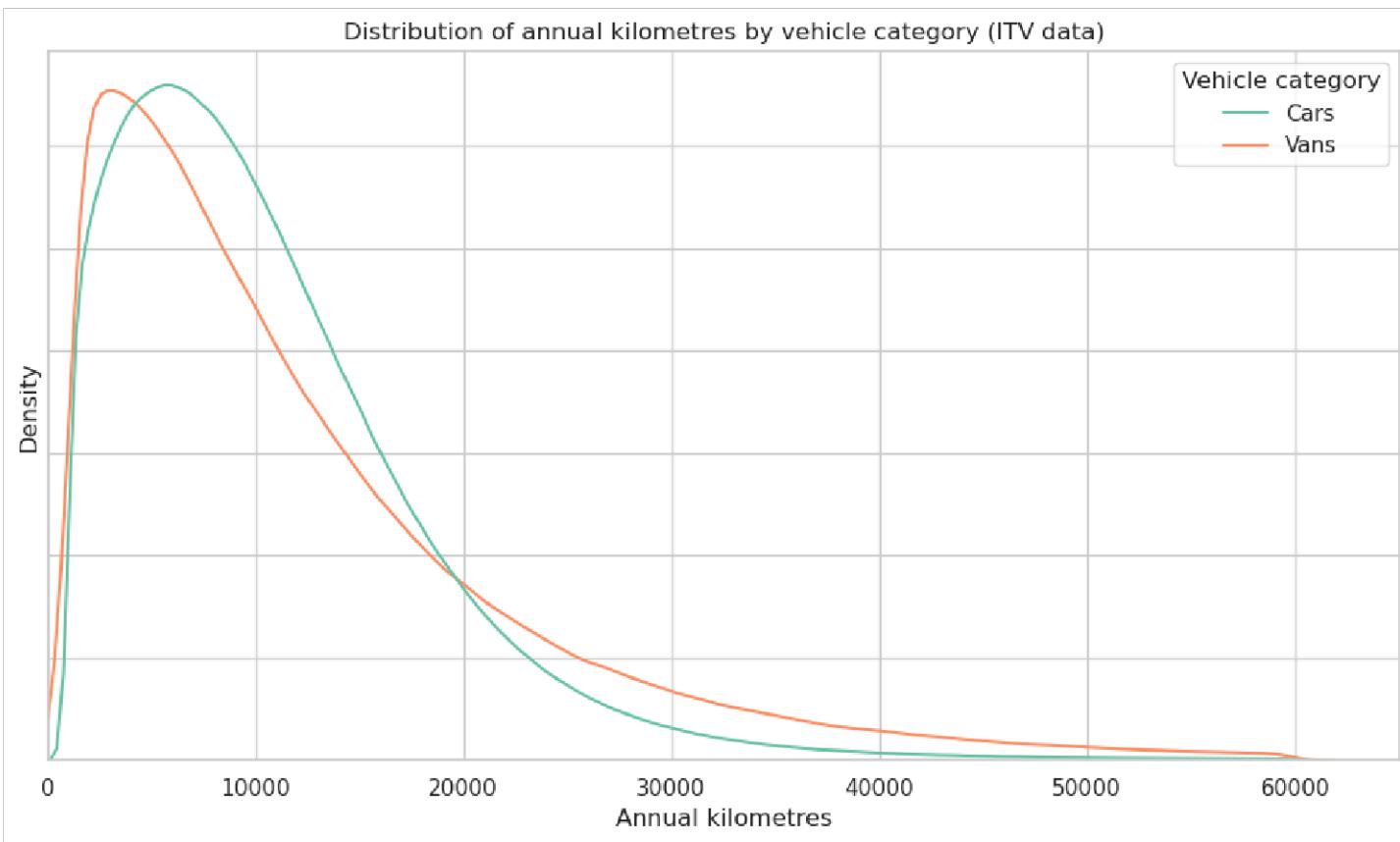
Figure 2. Kernel density estimate of the annualised number of kilometres travelled by cars and vans.
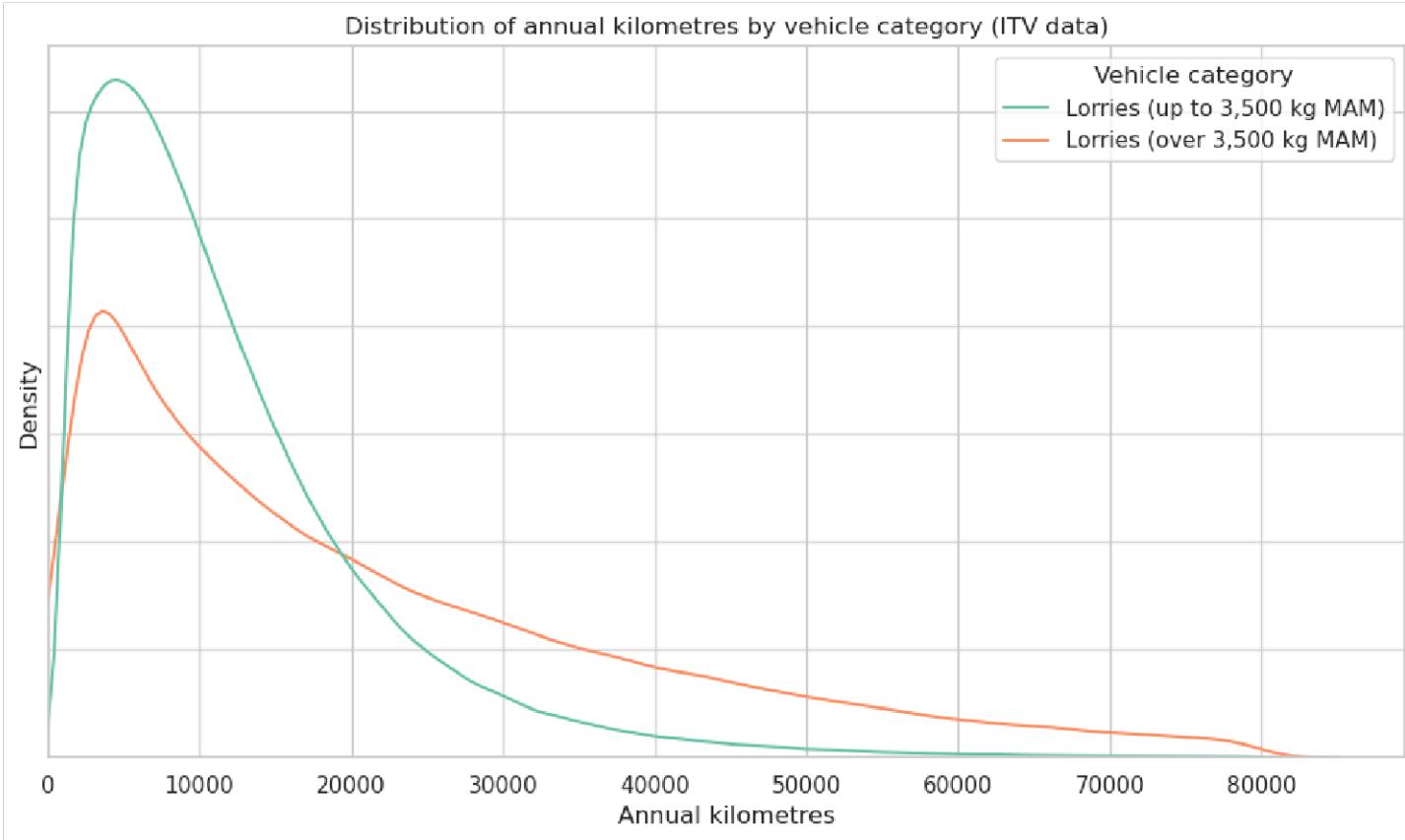
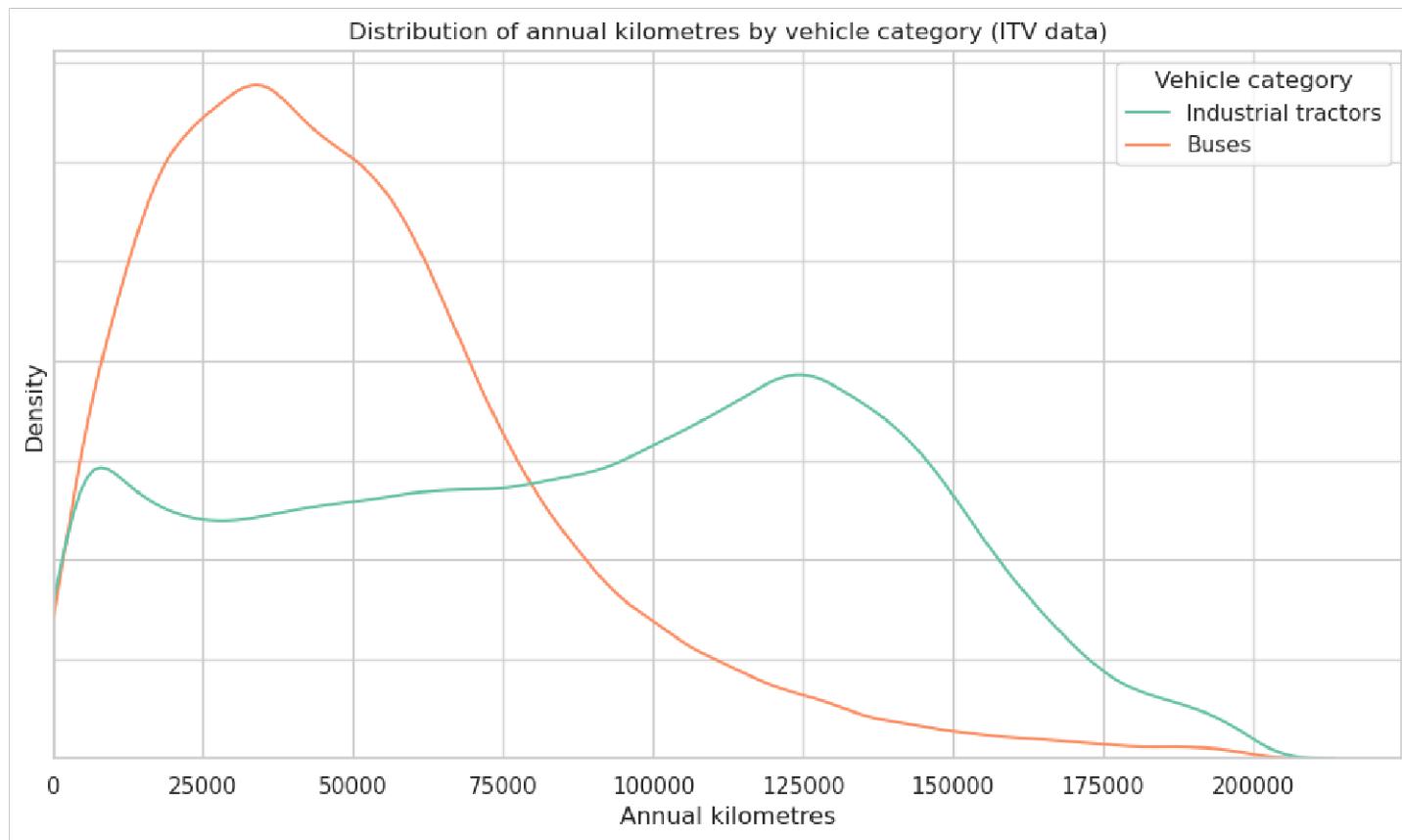**Figure 3. Kernel density estimate of the annualised number of kilometres travelled by lorries.**

Figure 4. Kernel density estimate of the annualised number of kilometres travelled by buses and industrial tractors.

3. Kilometre imputation model

3.1. Model adjustment

In order to estimate the annual kilometres travelled by the vehicle population, Gradient Boosting Decision Tree (GBDT) models (Friedman, 2001) were fitted using the ITV database. This methodology allows us to extrapolate the results to the entire vehicle population.

The final selection of variables incorporates both technical characteristics of the vehicle and sociodemographic and geographic attributes of the owner, with the aim of capturing the multidimensional complexity of usage patterns. The variables used are grouped into the following blocks:

- **Technical variables of the vehicle**:
  - Age: Age of the vehicle in years.
  - Tare weight: Tare weight of the vehicle, in kilograms.
  - Power: Fiscal horsepower of the vehicle.
  - Cylinder capacity: in cubic centimetres (only for combustion vehicles).
  - Environmental label.
  - Propulsion: Type of vehicle propulsion (petrol, diesel, electric, LPG, CNG, hydrogen, etc.).
- **Owner variables**:
  - No. of owners: Number of owners the vehicle has had up to the time of the test, including the current owner.
  - Gender of owner: Indicates the gender of the owner of the vehicle, distinguishing between whether the owner is a natural person (male or female) or legal person.
  - Age of the owner: Indicates the age (in years) of the owner of the vehicle when the owner is a natural person. If the owner is a legal person, this information is not provided.
- **Geographical context variables**:
  - Provincial area: Area of the province in square kilometres.
  - Provincial population: Number of inhabitants in the province.
  - Population density: Number of inhabitants per square kilometre of the province.
- **Usage variable**:
  - Service: Type of service performed by the vehicle (private, public, taxi, school bus, etc.).

To prevent the largest categories (such as cars) from dominating the learning process and skewing the overall results, the "vehicle category" variable is used to segment the training into eight independent models, one for each vehicle type. This strategy allows each model to specialise in the characteristics and usage patterns specific to its segment. It also facilitates the analysis of the relative importance of the variables in each category and the possibility of adapting the set of variables according to the needs of each segment. In this study, we have chosen to use the same set of variables for all the specialised models.

Table 4 shows the main validation metrics obtained on the validation dataset for each specific model developed by vehicle category. The Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE) reflect the average error in estimating the annual kilometres travelled per vehicle, with the MAE being less sensitive to extreme errors than the RMSE.

Table 4. Validation and accuracy metrics of predictive models by vehicle category for the 2024 vehicle population.

Metric	Mopeds	Motorcycles	Cars	Vans	Lorries ≤ 3500 kg	Lorries > 3500 kg	Buses	Industrial Tractors
RMSE	2,209.47	2,410.90	6,739.21	9,948.65	9,116.89	22,396.15	28,061.27	36,177.39
MAE	1,426.54	1,660.67	4,902.67	6,553.95	6,339.36	14,376.31	18,788.37	27,325.67
R²	0.1827	0.2038	0.2558	0.3410	0.2083	0.3286	0.4827	0.5432

The graphs below depict the relative importance of each variable used in the predictive models for the categories of cars and mopeds, as shown in **Figure 5** and **Figure 6**, respectively. These graphs allow us to identify the factors that most influence the estimation of the kilometres travelled annually by each type of vehicle.

For the other vehicle categories, variable importance graphs are available in the attached documents.
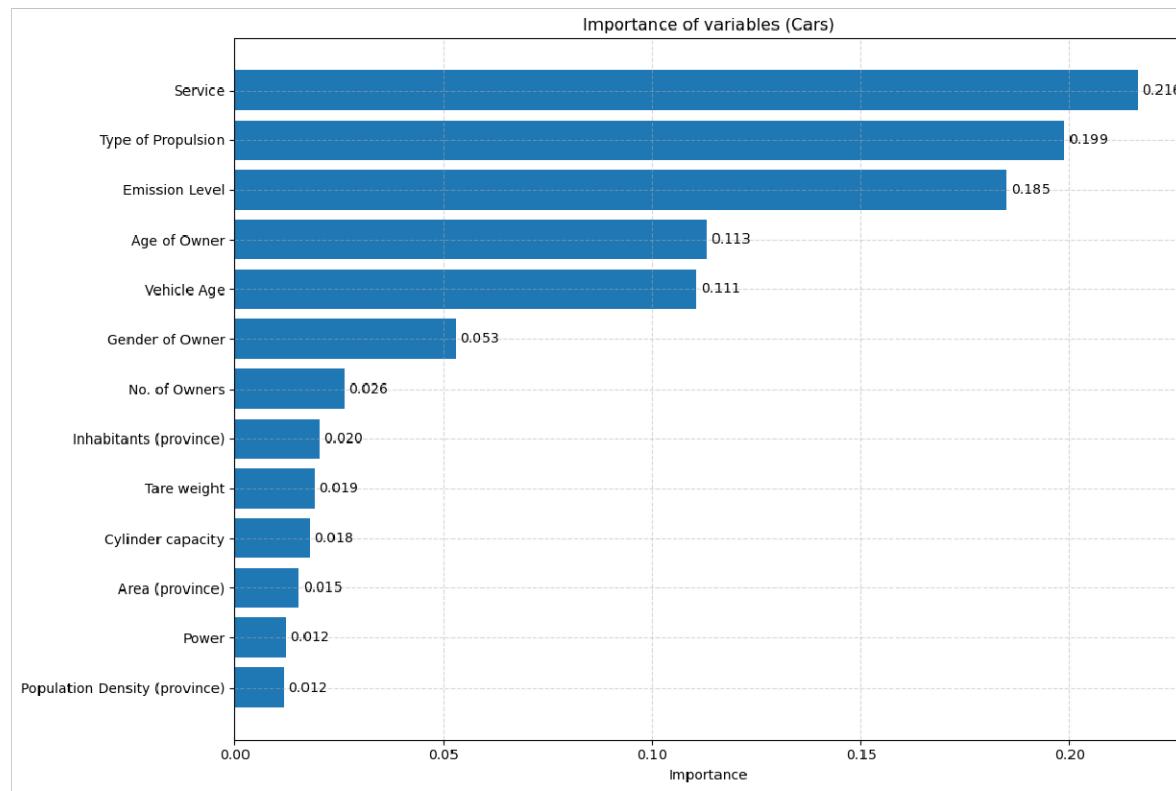
Figure 5. Importance of the variables used for the car model.
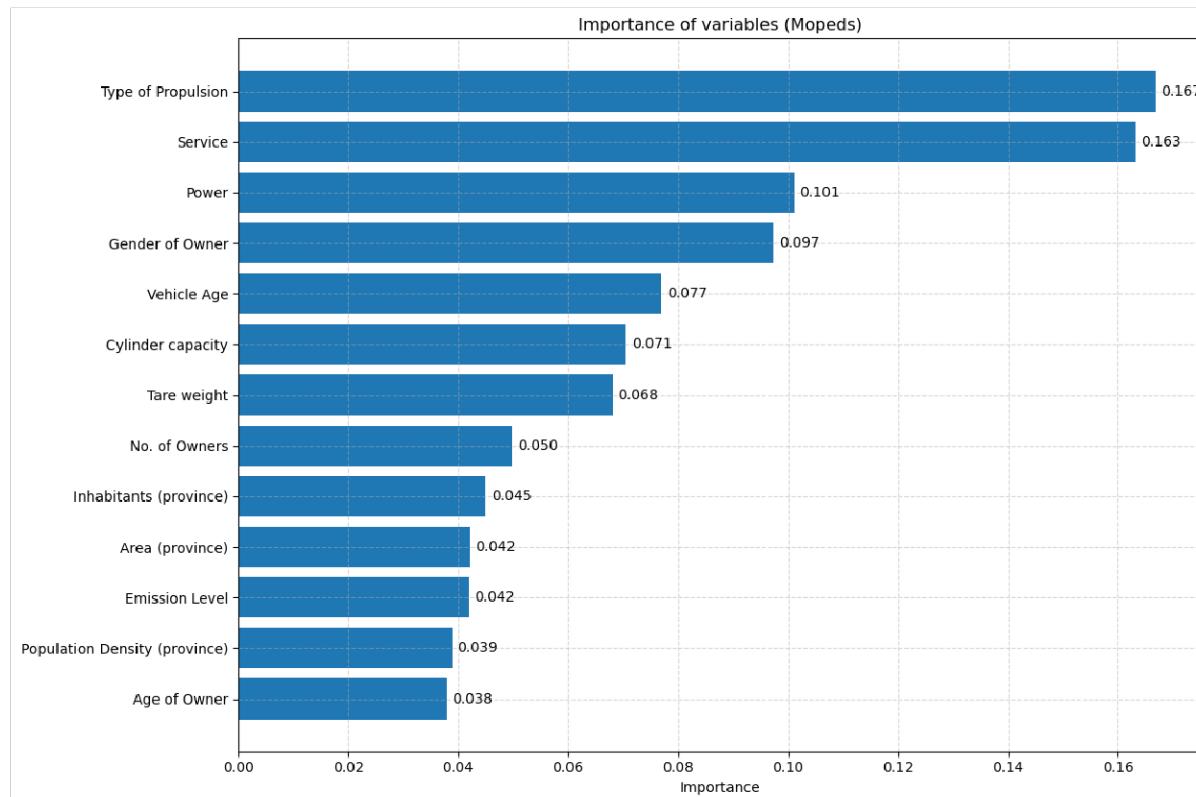
Figure 6. Importance of the variables used for the moped model.

3.2. Key findings

This section presents the key findings obtained from the predictions made by the models developed. The results are presented at different levels of aggregation, which allows us to analyse both overall behaviour and specific characteristics according to the type of vehicle and its technical specifications. For additional disaggregations and further analysis, please refer to the accompanying documentation.

For 2024, the values for kilometres travelled are obtained from a combination of actual data and estimates. In the first instance, the annual kilometres recorded during the roadworthiness test are used, provided that these records are available and have met the quality criteria established. In cases where there is no valid record, either due to a lack of data or exclusion during the cleansing process, the estimate generated by the specific predictive model for the corresponding vehicle category is used.

Table 5 shows the estimated kilometres travelled by the vehicle population on the road for 2022, 2023 and 2024.

Table 5. Kilometres travelled by the vehicle population on the road (2022–2024). Values are given per 10 million.

Year	Mopeds	Motorcycles	Cars	Vans	Lorries ≤ 3500 kg	Lorries > 3500 kg	Buses	Industrial Tractors
2022	188.2	992.9	30,294.9	3,584.2	2,664.5	686.8	268.1	1,965.3
2023	187.1	1,026.4	30,537.1	3,596.1	2,608.0	694.2	283.9	2,038.9
2024	207.6	1,128.8	29,299.1	3,491.1	2,665.6	779.1	315.1	2,123.5

Table 6 shows the estimated average kilometres for each vehicle type across the three estimation exercises. **Figure 7** shows the estimate for 2024.

Table 6. Estimated average kilometres travelled by the vehicle population (2022–2024).

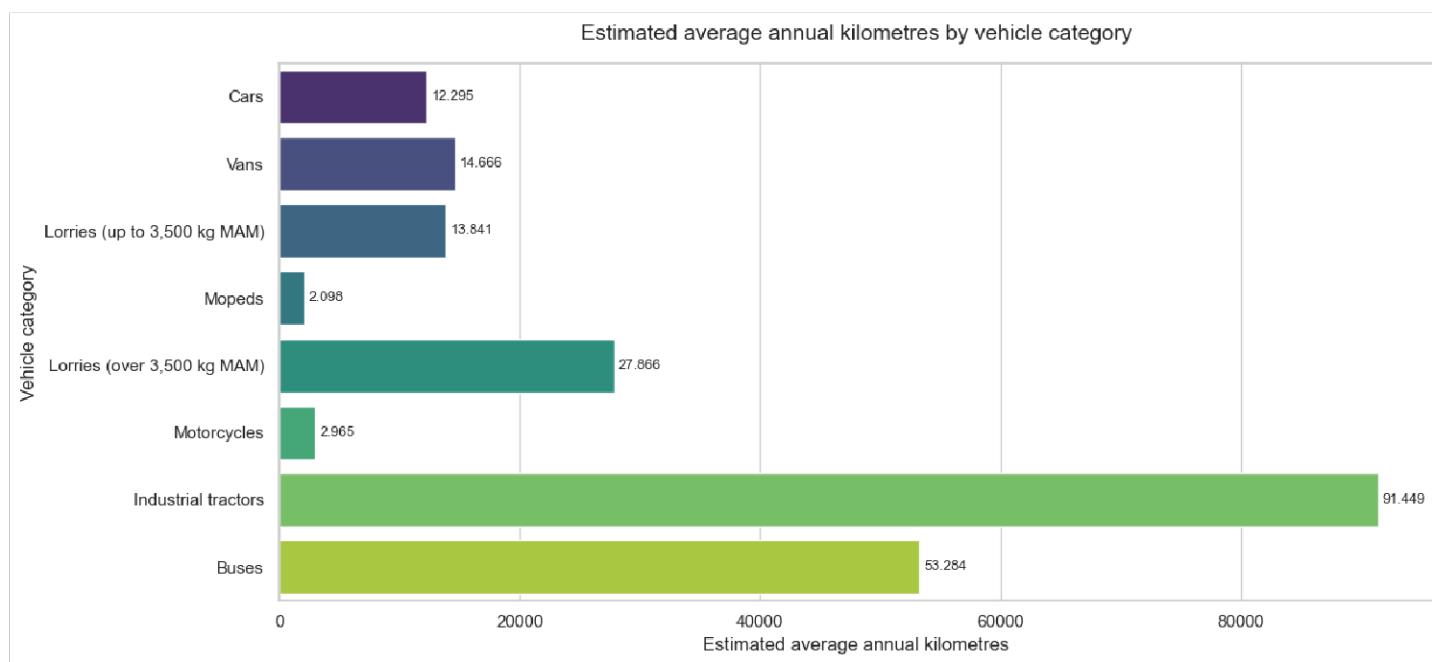| Year	Mopeds	Motorcycles	Cars	Vans	Lorries ≤ 3500 kg	Lorries > 3500 kg	Buses	Industrial Tractors
2022	1,759	2,831	13,073	15,815	13,642	25,235	46,607	88,291
2023	1,807	2,805	12,950	15,410	13,360	25,050	48,226	88,600
2024	2,098	2,965	12,295	14,666	13,841	27,866	53,284	91,449

Figure 7. Estimated annualised number of kilometres by vehicle type. Vehicle population on the road in 2024.

Table 7 presents the estimated average kilometres travelled by vehicle type and age, allowing us to compare annual usage across different segments of the vehicle population. In addition, **Figure 8** graphically illustrates these estimates for 2024.

Table 7. Estimated average kilometres by vehicle type and age. Vehicle population on the road in 2024.

| Year	Vehicle Age	Mopeds	Motorcycles	Cars	Vans	Lorries ≤ 3500 kg	Lorries > 3500 kg	Buses	Industrial Tractors
2024	0-4 years old	3,750	4,627	17,522	23,956	25,040	40,784	71,304	129,791
2024	5-9 years old	3,056	3,418	14,368	20,024	19,762	42,101	62,087	95,448
2024	10-14 years old	2,377	2,559	11,956	15,479	14,847	33,733	44,508	70,786
2024	15-19 years old	2,113	2,199	10,070	10,789	11,764	24,892	34,733	45,982
2024	20 and older	1,564	1,689	8,202	6,956	9,199	18,133	29,194	31,168
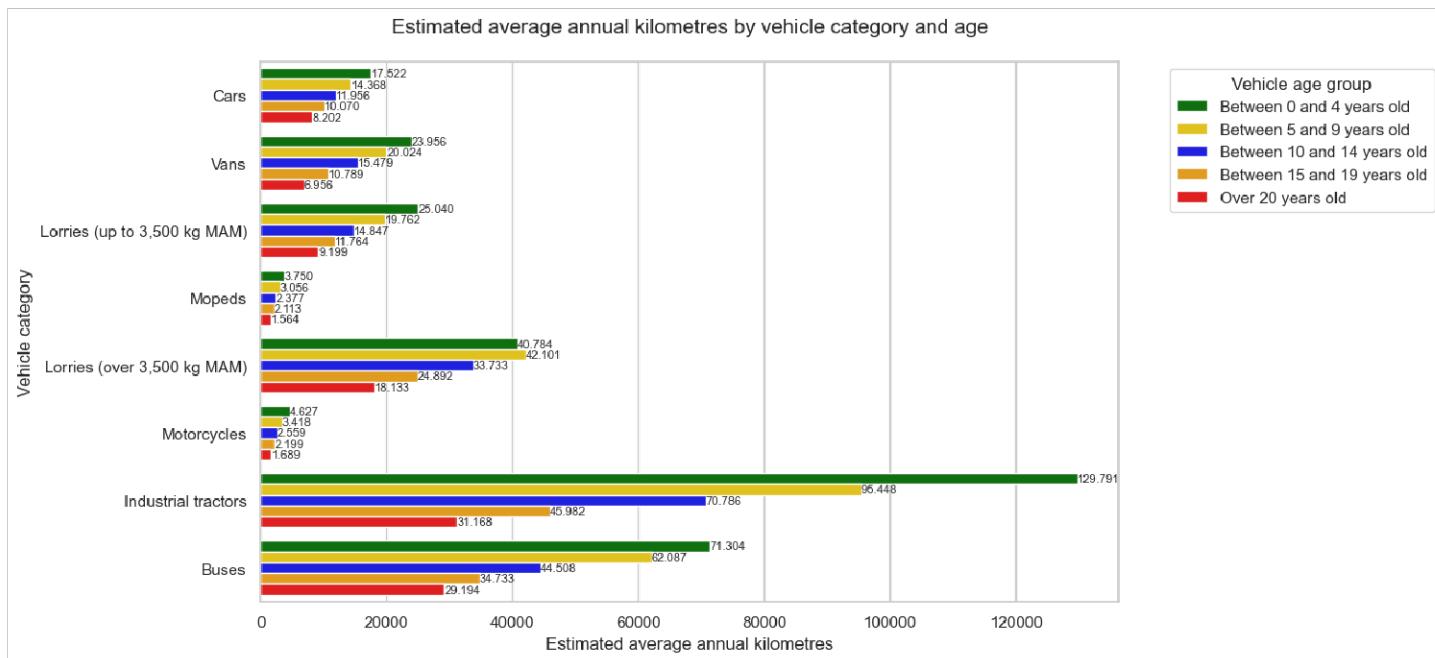
Figure 8. Estimated average kilometres by vehicle type and age. Vehicle population on the road in 2024.

Table 8 below shows the estimated average annual kilometres by type of propulsion and vehicle category. In addition, **Figure 9** and **Figure 10** graphically represent these results for 2024.

Table 8. Estimated average kilometres by type of vehicle and propulsion. Vehicle population on the road in 2024.

Year	Propulsion	Mopeds	Motorcycles	Cars	Vans	Lorries ≤ 3500 kg	Lorries > 3500 kg	Buses	Industrial Tractors
2024	Petrol	1,980	2,953	11,242	9,872	10,433	22,078	30,204	
2024	Diesel	3,932	6,457	12,925	15,114	13,904	27,792	53,176	91,449
2024	Electric	2,304	3,416	21,926	25,228	22,949	43,685	42,266	
2024	Other/Not specified	1,529	3,361	14,685	10,144	15,356	19,266	42,962	
2024	Butane		2,499	16,527	9,014	12,724	22,744	52,546	
2024	LPG (Liquefied Petroleum Gas)	1,601	3,730	19,504	20,220	19,417	31,980	63,518	
2024	CNG (Compressed Natural Gas)		7,131	22,522	21,684	24,200	28,229	59,340	

2024	LNG (Liquefied Natural Gas)	1,409	3,617	18,676	14,810	28,521	78,581	68,709
2024	Hydrogen			18,769	22,175		14,071	24,793
2024	Biomethane		4,127	13,664	29,031	5,768	29,181	55,426
2024	Ethanol			10,078				
2024	Biodiesel		2,590	12,110	20,005	32,430	72,674	86,963
2024	Other	1,529	3,361	14,685	10,144	15,356	19,266	42,962
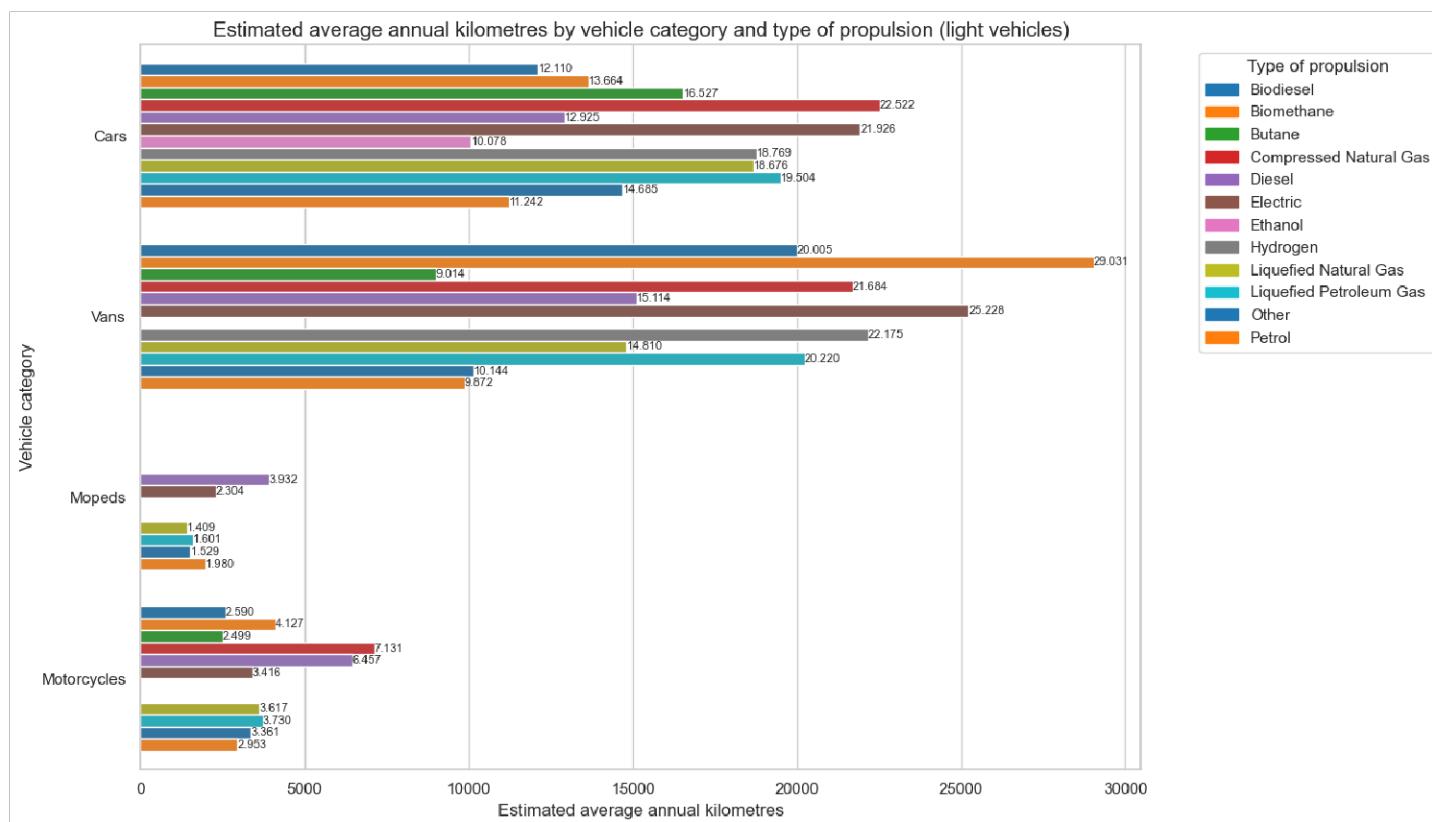
Figure 9. Estimated average kilometres by type of vehicle and propulsion for light vehicles. Vehicle population on the road in 2024.

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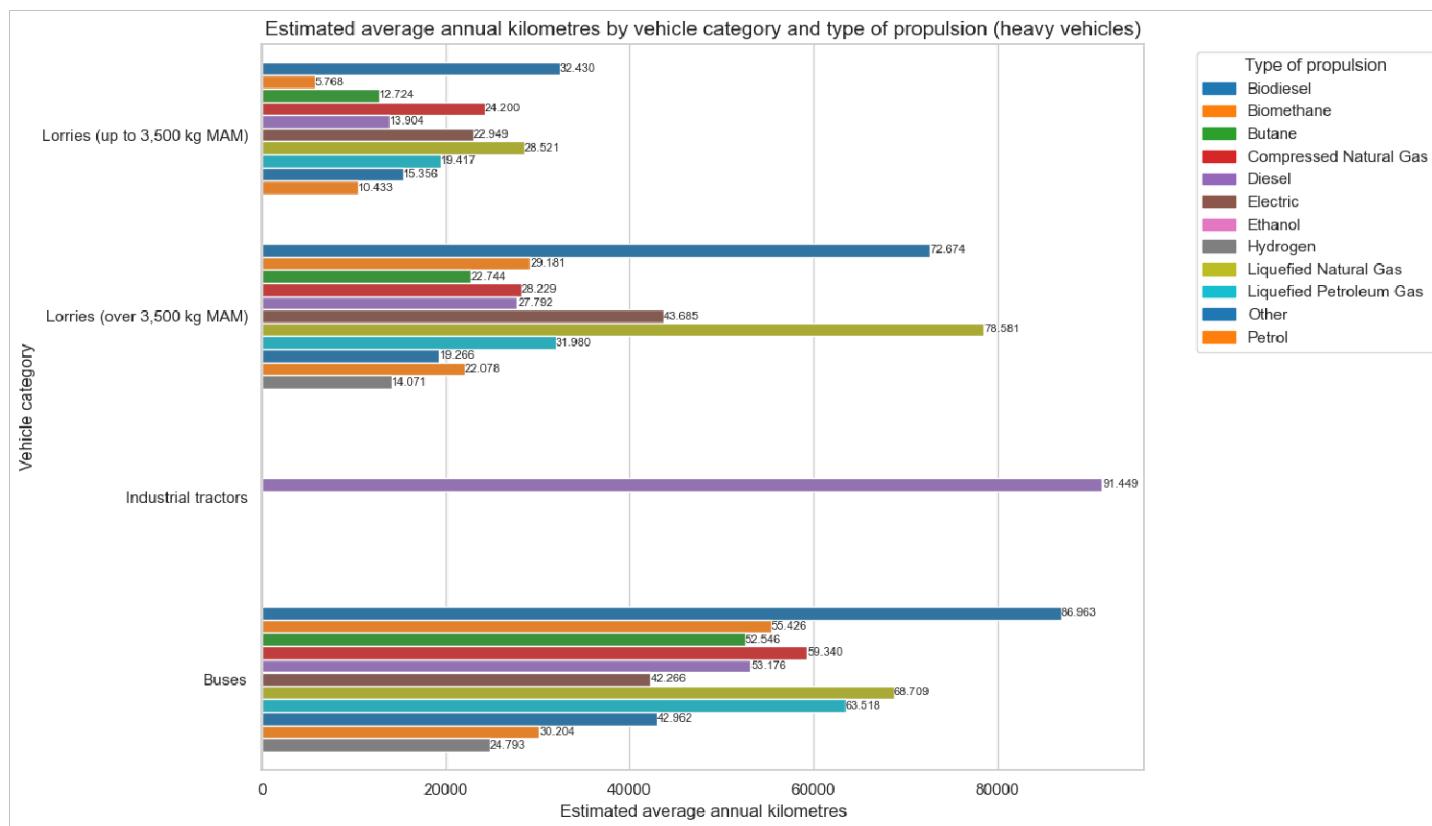
Figure 10. Estimated average kilometres by type of vehicle and propulsion for heavy vehicles. Vehicle population on the road in 2024.

Table 9 shows the estimated annualised number of kilometres for each autonomous region for the vehicle population on the road in 2024.

Table 9. Estimated average kilometres by type of vehicle and autonomous region for the vehicle population on the road in 2024.

Year	Autonomous Region	Mopeds	Motorcycles	Cars	Vans	Lorries ≤ 3500 kg	Lorries > 3500 kg	Buses	Industrial Tractors
2024	Andalusia	2,063	2,914	11,625	12,874	12,538	24,466	45,079	102,421
2024	Aragon	1,757	2,532	11,757	13,548	12,566	31,231	60,119	95,003
2024	Asturias	2,218	2,455	11,956	13,614	13,950	25,829	50,711	79,778
2024	Balearic Islands	2,553	3,152	11,331	13,382	12,575	23,402	50,745	38,027
2024	Canary Islands	3,137	3,532	13,208	11,648	13,077	20,231	50,171	34,086
2024	Cantabria	2,056	2,614	12,762	16,123	14,142	28,784	44,697	91,409

2024	Castile and Leon	1,606	2,231	11,599	13,852	12,466	27,074	48,102	82,291
2024	Castile-La Mancha	1,512	2,329	12,531	13,869	12,416	30,820	49,896	91,541
2024	Catalonia	2,336	3,280	11,861	14,348	13,946	31,453	47,511	83,037
2024	Valencia	2,273	3,027	11,408	14,253	13,341	30,730	46,935	93,475
2024	Extremadura	1,754	2,306	11,564	16,308	12,119	25,089	41,521	85,881
2024	Galicia	2,094	2,429	11,881	15,143	13,214	26,782	54,537	85,804
2024	Madrid	1,933	3,257	14,670	18,314	20,090	28,759	66,303	100,067
2024	Murcia	2,132	2,725	12,378	15,100	15,202	29,740	40,802	105,579
2024	Navarre	1,648	2,405	11,965	13,819	12,359	30,160	50,129	95,917
2024	Basque Country	1,895	2,718	11,648	13,974	13,223	30,397	70,278	87,814
2024	La Rioja	1,653	2,471	11,294	12,935	11,313	30,827	77,182	89,739
2024	Ceuta	2,943	3,702	12,044	9,034	9,581	12,970	45,347	42,942
2024	Melilla	2,762	3,249	8,703	8,181	9,286	20,190	31,501	33,277

Finally, the following graphs show the trends in kilometres travelled by motorcycles and cars. For 2014 to 2021, the average values obtained from odometer readings at roadworthiness tests are shown, while from 2022 onwards, estimates based on models are shown. Please refer to the attached documents for the graphs for other vehicles.
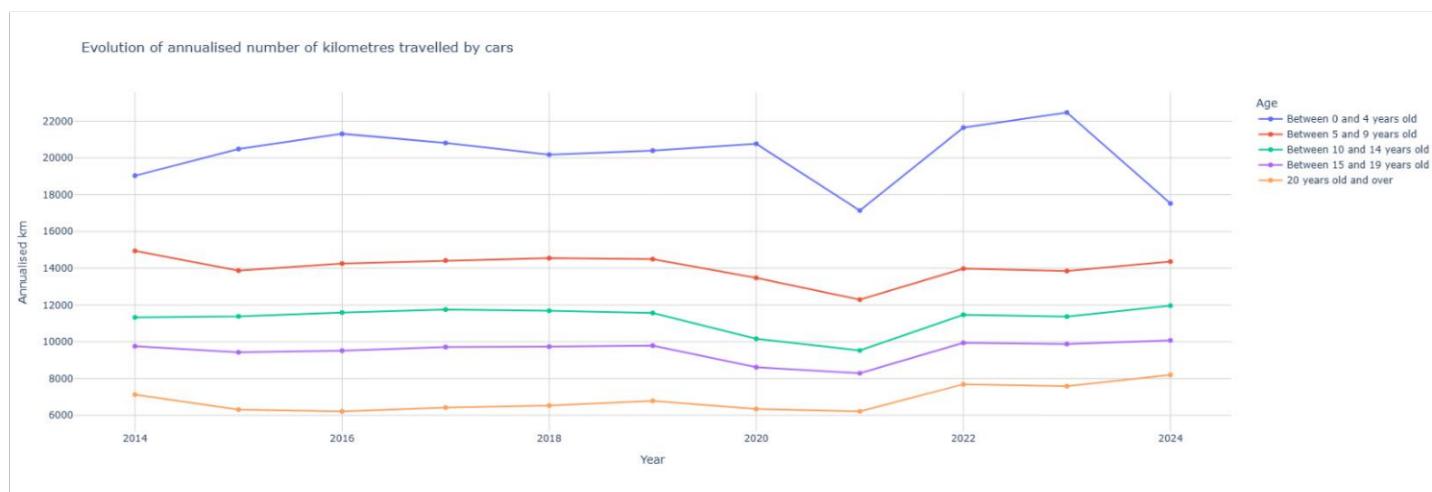
Figure 11. Evolution of kilometres travelled by the car population.
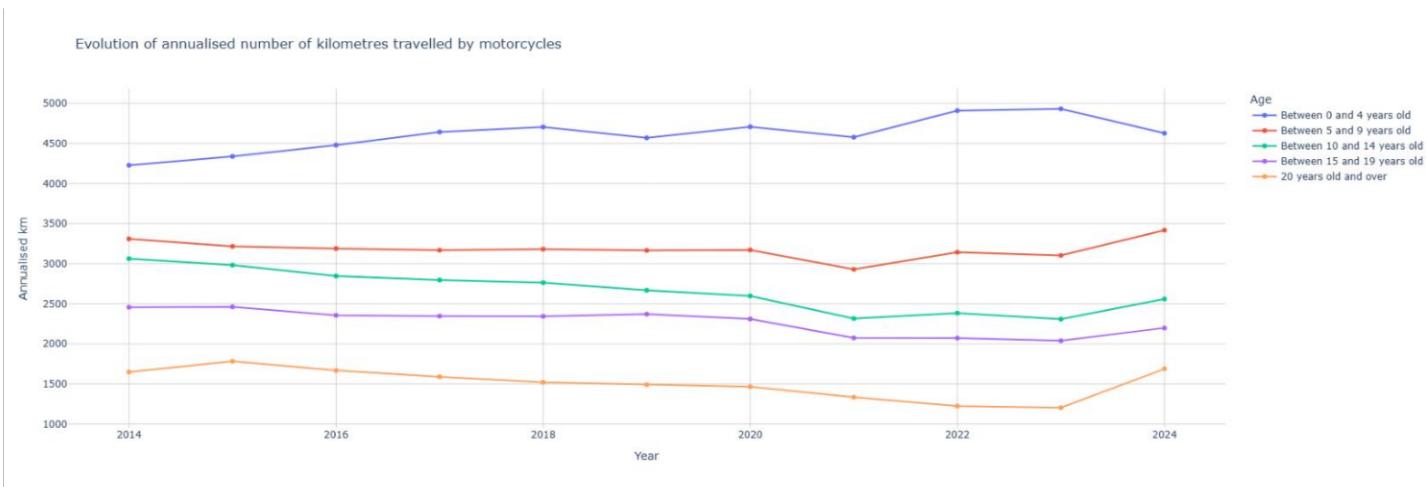
Figure 12. Evolution of kilometres travelled by the motorcycle population.

4. Conclusions

This study is a continuation of the exercise to estimate the kilometres travelled by the vehicle population for 2024, and confirms that the models used remain robust and can provide new reliable estimates for that year.

With regard to possible improvements in forecasting, new variables for the models will be studied, such as the vehicle model or insularity. The gradual incorporation of additional roadworthiness test (ITV) data, from years both prior to and after 2024, will also be considered in order to increase the system's predictive capacity.

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Annex I: List of vehicles by vehicle category

Mopeds

The following vehicles are included in the category of mopeds:

- TWO-WHEELED MOPED (L1e)
- THREE-WHEELED MOPED (L2e)
- LIGHT QUADRICYCLE (L6e)

Motorcycles

The category of motorcycles encompasses the remaining category L vehicles that are not mopeds:

- TWO-WHEELED MOTORCYCLE WITHOUT SIDECAR (L3e)
- MOTORCYCLE WITH SIDECAR (L4e)
- THREE-WHEELED MOTORCYCLE (L4)
- THREE-WHEELED CAR (L5)
- HEAVY QUADRICYCLE (L7e)
- DISABILITY CAR

Cars

The category of cars includes M1 category vehicles.

Vans

The following N1 category vehicles make up the category of vans:

- VAN
- MIXED-USE VAN
- AMBULANCE
- HEARSE
- PICKUP TRUCK
- ALL-TERRAIN VEHICLE

Lorries up to 3,500 kg MAM

The following N1 category vehicles[1] make up the category of lorries up to 3,500 kg MAM:

- LORRY
- FLATBED LORRY
- BOX LORRY
- CLOSED BOX LORRY

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[1] Motor vehicles designed and manufactured primarily for the carriage of goods, having a maximum mass not exceeding 3.5 tonnes.

- CURTAIN-SIDED LORRY
- TANKER
- CAGE LORRY
- REFRIGERATED LORRY
- MOBILE WORKSHOP LORRY
- QUARRY LORRY
- ARTICULATED LORRY
- ARTICULATED FLATBED LORRY
- ARTICULATED BOX LORRY
- ARTICULATED CLOSED BOX LORRY
- ARTICULATED CURTAIN-SIDED LORRY
- ARTICULATED TANKER
- ARTICULATED CAGE LORRY
- ARTICULATED REFRIGERATED LORRY
- ARTICULATED MOBILE WORKSHOP LORRY
- ARTICULATED QUARRY LORRY
- VEHICLE TRANSPORTER
- MIXED-USE LORRY
- CONTAINER LORRY
- REFUSE LORRY
- INSULATED LORRY
- SILO LORRY
- ADAPTABLE MIXED-USE VEHICLE
- ARTICULATED CONCRETE MIXER LORRY
- ARTICULATED TIPPER LORRY
- ARTICULATED CRANE LORRY
- ARTICULATED FIRE ENGINE

Lorries over 3,500 kg MAM

This category includes vehicles listed in the category "Lorries up to [sic] 3,500 kg MAM" from N2[2] and N3[3].

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[2] Motor vehicles designed and manufactured primarily for the carriage of goods, having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes.
[3] Motor vehicles designed and manufactured primarily for the carriage of goods, having a maximum mass exceeding 12 tonnes.

Buses

Vehicles in categories M2[4] and M3[5]:

- BUS
- ARTICULATED BUS
- MIXED-USE BUS
- MOBILE LIBRARY
- LABORATORY BUS
- MOBILE WORKSHOP BUS
- HEALTHCARE BUS

Industrial Tractors

This includes the following category T vehicles[6] and other agricultural vehicles[7]:

- TRACTOR
- TRACTOR UNIT
- TRACTOR WITH LOADING PLATFORM

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[4] Motor vehicles designed and manufactured primarily for the carriage of passengers and their luggage, comprising more than eight seats in addition to the driver's seat.
[5] Motor vehicles designed and manufactured primarily for the carriage of passengers and their luggage, comprising more than eight seats in addition to the driver's seat.
[6] Wheeled agricultural or forestry tractors having a maximum design speed exceeding 40 km/h.
[7] Other wheeled agricultural or forestry tractors, self-propelled machines (except single-axle machines), special-purpose trailers, towed machines and tractors with loading platforms.

Annex II: Vehicle population on the road

The vehicle population on the road is considered to comprise the motor vehicles for which an entry was made in the records of the Directorate-General for Traffic in the last ten years for the following reasons:

- Undergoing a roadworthiness test.
- Having compulsory insurance.
- Change of ownership.
- Re-registration after a temporary deregistration.
- Being the subject of a complaint.

These criteria are intended to reduce the impact of vehicles (particularly very old vehicles) that are no longer on the road or which were deregistered at an earlier date without following the proper administrative procedures. The criteria are considered conservative.

List of tables

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