Paradigm

Premium Performance or Standard Octane Rating? A Multi-Year Empirical Statistical Analysis of Fuel Consumption Efficiency and Major Brand Refueling Locations

Attila TURI*

Politehnica University Timisoara, Timisoara, Romania

**Corresponding author, attila.turi@upt.ro*

Abstract. *This multi-year time series research investigates the main drivers of automotive fuel efficiency, a heavily debated topic among motorists, but often obscured and clouded with scientifically unverified personal claims and/or regional biases. While most academic papers frequently question actual fuel saving claims and/or the cost-benefit ratio of high-octane fuels, little to no other studies provide a more extended dataset, with cross-border empirical data necessary to back up these technical claims in real-world conditions. This research utilizes an extensive dataset spanning over 5 years (2021–2025) and over 180,000 kilometers of transit across 6 European countries. Welch's t-test and both single and two-factor ANOVA were used within the study to address two main issues: the quantifiable efficiency gain of premium fuel (98+ RON) over the standard 95 RON petrol and how some fuel brands compare to the geographic location of refueling. The results confirm that premium fuels source a statistically significant efficiency gain of 4.72% (p = 0.016), resulting in a drop in average consumption of 0.345 L/100 km. Furthermore, while the analysis shows that major brands like Shell, OMV and/or MOL are essentially performing at the same technical level, the country of refueling proved to be a key determinant of variance (p = 0.031). This highlights that regional variables, such as road infrastructure, air quality and topography, have a more substantial influence on performance than the specific additives and fuel formulas used by different brands. The paper contributes to the field by shifting the focus from brand competition to the importance of where a driver refuels and differences in fuel chemistry. These findings offer a practical benchmark and new insights to high-mileage drivers, providing a reliable and solid statistical foundation for improving fuel savings and other operational costs through smarter fuel selection.*

Keywords: fuel efficiency analysis, premium fuels, standard fuels, refueling logistics, Shell, analysis of variance (ANOVA).

Introduction

Volatile energy market prices in recent years, a hesitant shift towards pushing for more EVs on the European automotive industry and the increasingly stringent EU environmental standards have once again brought into discussion the importance of fuel efficiency.

In today's complicated mix of traditional petrol and diesel (ICE), hybrids (MHEV, HEV, PHEV and REEV) and full electric engines (BEVs), all navigating the same road and energy networks, deciding how and where to refuel has shifted from a minor detail to an important operational issue and concern and sometimes even to a major strategic choice. For those who drive long distances, the decision at the pump, usually between standard and premium blends, is heavily influenced by loud marketing and claims about special additives. On the other hand, even though these fuels are found at almost every station, there is still a huge gap in real-world data showing their actual impact. This is because real-life driving across Europe involves so many unpredictable variables that it is difficult to prove exactly what these fuels deliver outside of a lab.

DOI: 10.2478/picbe-2026-0412

This paper addresses this gap by drawing on and synthesizing a vast dataset covering over 180,000 kilometers of actual travel recorded between 2021 and 2025. The vast majority of this distance (almost 170,000 kilometers, representing over 90% of total distance traveled) was driven using premium fuels. Unlike standard lab tests on a dynamometer, which often miss out on human, country-specific, or environmental factors, this study takes a long-term, real-world approach. By tracking fuel use across 15 different national infrastructures—with a specific focus on Romania, Hungary, Austria, Germany, France, and Croatia, where most of the journeys and refueling took place—the research separates variables that are often mixed up in shorter studies, such as seasonal changes, fluctuating mileage and regional topography.

The core question driving this research study is: how much do fuel types, unique brand formulas, and refueling locations actually shape a vehicle's efficiency over the long haul? To find out, the research looks at several specific angles: Does switching to premium high-octane blends actually deliver a statistically significant drop in fuel use compared to standard 95-octane petrol? How does the physical location of a gas station affect consumption when compared with the choice of a specific brand? Finally, is there a difference between major multinational fuel providers' high-octane blended fuels and their resulting consumption figures and driven range?

By linking theoretical fuel types and blends with actual refueling logistics data, this data-driven research sets out to offer insights and a decision support framework towards a more practical way to figure out the best adapted fuel buying strategy. The paper's ultimate goal is to determine whether the superior performance of premium fuel blends, coming at an additional price tag, is actually worth it and improves performance and/or consumption efficiency gains or if the real reasons for better mileage are found elsewhere (road infrastructure, seasonal weather, differences in driving style and random traffic conditions).

Literature review

Most arguments surrounding fuel performance and efficiency usually focus on how fuel characteristics interact with engine thermodynamics (Reitz et al., 2020) and the technical relationship between fuel types and blends. At the heart of this discussion lies the Octane Rating (COR), the standard measure of how well a fuel resists what is known as "knocking" or pre-ignition. In Europe, this is labeled as the Research Octane Number (RON) at the pump, typically ranging from 95 (standard) to 100 (premium), but 98 and 102 are also possible, being the typical values in some areas or regions. Standard automotive literature generally views fuel efficiency (L/100 km) as being tied to engine compression ratios, suggesting that higher-octane blends enable better ignition timing and higher thermal efficiency (Peng et al., 2022).

Experts and perspectives, both scientific and from the practical world, are still split on the actual benefits of premium fuel blends (Yuan et al., 2019). One common view, backed by chemical engineering studies, is that high-octane petrol only really pays off in high-compression, performance engines (Anderson et al., 2012) which are designed for these fuel types to fully reach their performance standards. However, newer research into modern Engine Control Units (ECUs) shows that today's cars can adjust to different fuel qualities. This means even standard engines might see efficiency boosts through better combustion cycles (Rojas-Reinoso et al., 2023). These debates often lead to what is called the "brand parity theory" (Dolsak, 2024), which suggests a level of technological overlap where there is almost no noticeable and/or perceivable difference between products. In mature industries, this makes sense: major multinational fuel providers and players in the fuel industry like Shell, OMV, MOL, and Total must follow and comply to strict European EN 228 standards. Because of this, their special additive packages (that are designed and intended to reduce friction and carbon deposits) are often seen as marketing tools rather than actually significant performance boosters (Elkelawy et al., 2025). That said, another group of researchers in transport economics points out that fuel chemistry is not the only thing at play. Those looking at the link between infrastructure and efficiency argue that outside factors like road quality, steepness, and national speed limits can cause consumption to swing by as much as 15% (Greene et al., 2017). This moves the conversation from a strictly chemical test to a broader, more holistic, geographically-oriented analysis.

The biggest research gap in current research is the total lack of long-term, cross-border field data. Most studies or research references are either restricted in a controlled laboratory setting, using dynamometer tests which miss out on the messy noise of real-world driving (traffic density, traffic jams, fluctuations in weather conditions and temperatures, etc.) or only look at short-term, single-region observations. It is very rare to find research that tracks the same vehicle across so many different national infrastructures over several years. This paper fills that void by combining long-term fuel performance (standard vs. premium) with actual travel data across 15 European countries. It offers a unique, real-world look at how fuel types, different gas stations, and main European transit arteries and corridors interact over 186,000 kilometers of driving.

Methodology

The research paper is based on an important personal and empirical 5 calendar year data-tracking project approach, covering 186,154 km of actual road driving time (2021-2025). While standard lab tests on a dynamometer often miss the mark because they cannot simulate real-life chaos (like changing seasons, weather fluctuations, random traffic jams and/or shifts in driving style), this study focuses strictly on on-road evidence. The goal was to see if fuel brand claims actually hold up for the average consumer. Data was personally gathered using a 2001 Dacia SuperNova (version: Rapsodie), equipped with a 1.4 MPI naturally aspirated petrol engine (a Renault 1.4 MPI) with little to no complex electronic interference found in newer vehicles. First, a baseline average consumption over 18,118 km using standard 95 petrol was established. Then, this initial data was compared against the 168,154 km driven on premium fuels. It is worth noting that premium octane ratings changed depending on the border: 98 RON in France and the Benelux region, 100 RON in places like Romania, Hungary, Austria, and Croatia, and even 102 RON when refueling at Aral stations in Germany.

The investigation is built upon 3 main research questions: first, does high-octane premium fuel (98+ COR) provide an improvement in fuel economy compared to regular standard 95 COR petrol? Second, do geographic variables (differences in national infrastructure, regional topography, refueling locations) exert a greater influence on consumption variance than actual fuel brand choice? Third, what are the consumption differences among major multinational fuel providers (Shell, OMV, MOL, Aral) and their resulting performance under similar driving conditions? To test these hypotheses, a robust statistical framework was employed. Welch's t-test (two-sample assuming unequal variances) was utilized to compare the efficiency of standard vs. premium fuels, specifically chosen to account for the disparity in sample sizes between the two groups. To analyze regional and brand-related variances, single-factor ANOVA was applied to country-level data. Furthermore, a two-way ANOVA without replication was conducted on brand performance across the 5-year timeline. This allowed for the isolation of temporal trends (year-to-year changes) from brand-specific performance, ensuring that the potential noise from vehicle aging or varying annual distances did not skew the results.

Data collection was performed via manual logging of every refueling event, noting the volume, fuel type, brand, and geographical location. This methodology aligns with previous research on real-world driving cycles (e.g., studies contrasting WLTP standards with empirical road data), which emphasizes the impact of external factors over controlled variables. All statistical processing, including the generation of p-values, F-statistics, and variance metrics, was executed using the Microsoft Excel Data Analysis Toolpak. Qualitative context was integrated by correlating consumption spikes with known regional specifics, such as Romanian lower road quality, France's largely segmented toll-gated motorway network or German legal high-speed driving on the Autobahn, providing additional insights to the numerical findings.

Results and discussions

The fuel consumption data analyzed reveals a rather stable dynamic across the 5-year observation period (2021-2025) with an average annual traveled distance of 33,630 km. Despite 2 notable fluctuations in traveled distance, peaking at 53,542 km (2023) and dipping to 18,284 km (2022), the aggregate consumption with premium fuels averages 6.96 L/100 km. An overview of fuel efficiency and statistical variance is provided in Table 1.

Table 1. Summary of annual premium fuel usage

average fuel consumption [liters / 100 km]	**2021**	**2022**	**2023**	**2024**	**2025**	**average**
Traveled distance [km]	33,061	18,284	53,542	30,095	33,172	**33,630**
year (aggregate %)	6.804	7.508	6.872	7.004	6.918	**6.961**
standard deviation	0.686	0.674	0.608	0.495	0.644	**0.621**
CV	0.100	0.089	0.088	0.070	0.093	**0.088**

Source: Authors' own research.

The overall efficiency is confirmed statistically by the low standard deviation (averaging 0.62) and Coefficient of Variation (CV) values consistently below 0.10, indicating that fuel usage is predictable and tightly controlled. Interestingly, 2024 stands out as the most consistent year, despite its consumption average ranking below the overall average. Even with no journeys made between June-September (4 months) it achieved the lowest CV (0.07) and standard deviation (0.495). On the other hand 2022 saw a slight consumption spike to 7.5 L/100 km, likely due to the significantly lower mileage caused by no journeys made between January-June (6 months), these being the only important points of variation within an overall well-balanced dataset. The gathered data shows a slight performance edge for premium fuels, delivering a marginal but tangible (almost 5%) efficiency gain of 0.345 liters per 100 km over the baseline with standard 95 fuels. An outline with comparative values is provided in Table 2.

Table 2. Comparison of fuel efficiency by type

Fuel type	**2021**	**2022**	**2023**	**2024**	**2025**	**average**	**Traveled distance [km]**	**Efficiency gain**
Standard (95)	N/A	N/A	N/A	N/A	N/A	**7.306**	18,118	baseline
Premium (98+)	6.804	7.508	6.872	7.004	6.918	**6.961**	168,154	enhanced
difference	0.501	-0.201	0.433	0.301	0.387	**0.345**	N/A	-4,725%

Source: Authors' own research.

While 2022 presented a minor statistical anomaly, the broader trend across the 168,154 km driven with premium fuels shows a rather consistent performance. Transitioning from standard 95 to premium blends reduced average consumption from 7.30 to 6.96 liters per 100 km

(2021-2025), with additional benefits in reduced engine strain and fuel waste. The 0.34 L/100 km saved by using premium fuels represents a relative gain of around 4.72% when compared to regular standard 95 fuels. Over longer distances, these fractional gains compound into significant savings (around 571 L in this case, averaging over 114 L/year), proving that higher-octane choices can source certain advantages for high-mileage drivers. In order to try and validate these preliminary observations, a t-test (two-sample assuming unequal variances or Welch's t-test) was conducted to assess whether premium is indeed better than standard or if there is no significant difference between these 2 types of petrol. The results are shown in Table 3.

Table 3. Welch's t-test: two-sample assuming unequal variances

variable	Standard 95 (n = 39)	Premium 98+ (n = 370)	t-stat	df	p-value
Mean (SD)	7.306 (0.69)	6.961 (0.41)	2.506	43	0.016

Source: Authors' own research.

The t-test results reveal a statistically significant difference in efficiency between the two fuel types (p = 0.016). Standard 95 fuel recorded a higher mean (7.30) compared to the Premium 98+ group (6.96). Premium fuels (98 RON in France and Benelux and 100 RON in all other countries) exploited a much larger sample size (370 records) and more consistent performance, indicated by a lower standard deviation. The efficiency gain of 0.34 L/100 km is statistically significant, thus based on our data we can claim with 95% confidence that premium is indeed better. To see if there is a significant difference between the overall quality of fuels within different countries transited, an often proclaimed statement by some motorists, a comprehensive dataset was compiled summarizing the average fuel consumption across the 6 main countries of refueling between 2021 and 2025. Table 4 presents these average fuel consumption figures for Romania, Hungary, Austria, Germany, France and Croatia.

Table 4. Mean fuel consumption by country of transit

Country/year	Romania	Hungary	Austria	Germany	France	Croatia	average
2021	6.93	7.31	6.57	6.73	6.55	6.50	**6.804**
2022	7.65	7.83	7.03	7.37	7.45	6.74	**7.508**
2023	7.19	7.19	6.55	6.86	6.84	6.58	**6.872**
2024	7.53	7.17	6.81	6.77	6.94	6.99	**7.004**
2025	7.19	7.16	7.04	6.68	6.82	6.76	**6.918**
average	**7.188**	**7.257**	**6.756**	**6.853**	**6.922**	**6.702**	**6.961**

Source: Authors' own research.

The average consumption data/country reveals a rather interesting pattern: Hungary (7.25%) and Romania (7.18%) recorded the highest annual averages, being the only 2 countries to score consumption figures above the 7% mark. Croatia (6.70%) maintains the most efficient consumption profile, but this is also explained by the specific period in which trips to the Adriatic country were made (May-October) throughout the analyzed years. Germany (6.85%) and France (6.92%) have rather similar consumption profiles and dynamics, both averaging consumption figures below the 7% mark, despite Germany having legal stretches on the Autobahn with no speed limit (increasing consumption) and travels in France also including urban traffic (bumper-to-bumper traffic). Austria has the most consistent data with very low variation from its 5-year mean (6.75%) and the min-max range is less than 0.5 liters, outlining a very stable overall performance. To test whether these differences are also statistically reliable a one-way analysis of variance was conducted based on each country's yearly average consumption figures, with results shown in Table 5.

Table 5. One-way ANOVA results for variance in mean fuel consumption

Source of Variation	SS	df	MS	F	p-value	F crit
Between groups	1.29	5	0.257	2.969	0.031	2.620
Within groups	2.08	24	0.086			
Total	3.37	29				

Source: Authors' own research.

The single factor ANOVA revealed a statistically significant variance between country averages and effect of the country of refueling on the outcome, with $F(5, 24) = 2.96$ and $p = 0.031$ (< 0.05). Since the F-statistic (2.969) exceeds the critical value (2.620), we can confidently conclude that these regional differences are not due to random fluctuations. This suggests that when the data is aggregated at country level, the resulting trends are notably amplified, indicating that geographic segmentation (granularity of country-level analysis) acts as a relevant driver for the observed variance. This piece of data can help improve interpretation of the underlying statistical patterns and better assess impact of some specific country-related factors: varied road quality in Romania, flat Hungarian topography, Austria's high-altitude terrain, Germany's unlimited speed zones or France's extensive toll-gated highway system. Ultimately though, the data confirms that consumption differences between these countries are indeed statistically significant.

When analyzing fueling data, Shell was the most frequent brand throughout all 5 years with yearly shares ranging between 45.21% (2025) and 66.73% (2023). OMV was second 3 years in a row (2021-2023) with a share ranging between 9.23% (2023) and 18.29% (2021) and 11.16% in 2025. MOL was the next most frequent refueling choice with shares ranging between 6.58% (2023) and 13.20% (2021) between 2021-2024. Total, with most refueling being done in France, was another constant refueling choice with shares ranging from 4.42% (2021) to 9.63% (2024) and twice being ranked third for annual brand refueling choice (2023 and 2024). INA from Croatia (owned by MOL Group) was another rather frequent choice with shares ranging between 2.89% (2023) and 10.06% (2025), as well as Aral in the last 3 years with shares ranging between 2.22% (2023) and 19.64% (2024), the German brand being ranked second in both 2024 and 2025. In terms of the most frequent fueling locations Timisoara, Sibiu and Arad are the top 3 in Romania (OMV and MOL brands mainly), with Hungary's Shell locations (Lajosmizse, Szeged and Mako) accounting for over 80% of all refueling stops. Strengberg accounts for over a third of all refueling locations in Austria, whilst a combined 25% are from Schwechat and Enns (all 3 being Shell stations). Germany's most frequent refueling location was Regensburg, with Frechen and Kleinostheim completing the top 3 (both Shell and Aral brands). Saint-Hilaire-Cottes was the main refueling station for Shell in France, with Beuvry's Total station having a share of over 20% of all refueling stops in France. Metz ranked third among locations with more than a third of all refueling being performed on the A26 (Autoroute des Anglais) motorway. INA was Croatia's main refueling brand with Split, Osijek and Vukova Gorica being the most common stopping locations. Bruxelles was the most common refueling location for the Benelux area, whilst other main Shell refueling stations were Brno and Ladna (Czech Republic) and Novi Sad (Serbia). An overview of the main refueling locations is highlighted in Figure 1.

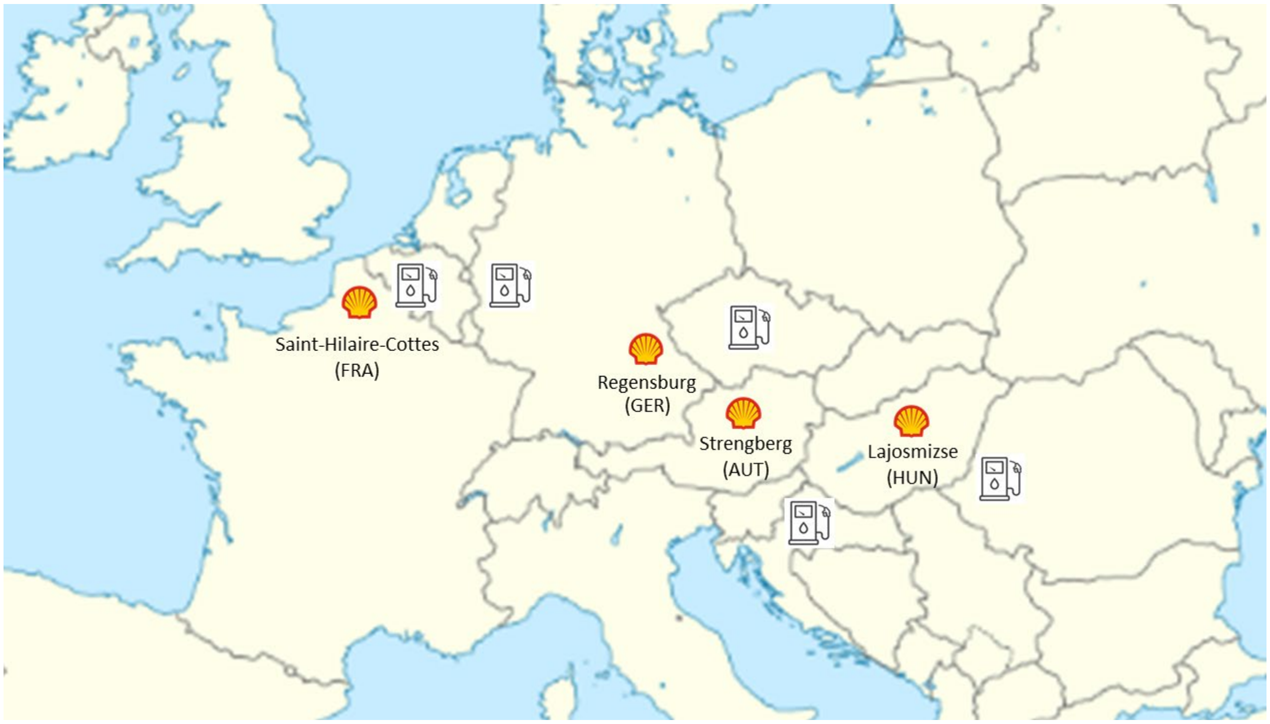

Figure 1. Main Shell and other brands refueling locations

Source: Authors' own research.

A further investigation was performed on the differences between petrol brands and the fuel consumption associated with their premium fuels (Shell V-Power Racing 98 or 100, OMV Maxx Motion 100 Plus, MOL EVO 100 Plus, INA 100 Class Plus Premium, Total Excellium SP98, Aral Ultimate 102) with an overview of data summarized in Table 6.

Table 6. Comparative annual mean fuel consumption by brand

brand	Shell	OMV	MOL	INA	Total	Aral	others (min)	others (max)
2021	6.77	7.09	6.74	6.46	7.21	N/A	6.19	6.79
2022	7.50	7.33	8.55	N/A	6.97	N/A	7.36	7.66
2023	6.87	6.96	7.12	6.64	6.83	6.89	5.79	7.81
2024	7.02	7.58	7.30	7.12	6.88	6.80	6.38	7.57
2025	7.06	7.19	6.01	6.66	6.72	6.68	6.25	7.47
average	**6.973**	**7.144**	**7.133**	**6.672**	**6.890**	**6.766**	N/A	N/A

Source: Authors' own research.

Over the five-year period, fuel efficiency across major brands shows notable volatility, likely reflecting differences in petrol mix additives and/or varied driving conditions. Shell maintains a remarkably consistent average of 6.97 L/100 km, while MOL displays the most dramatic fluctuations, peaking at 8.55% in 2022 before dropping to a lean 6.01% in 2025. Interestingly, INA emerges as the efficiency leader with a solid 6.67% average, but an important note to be made is the season in which fueling was done at INA (mainly summer). Aral's Ultimate 102 premium fuel was used between 2023-2025 as a direct comparison to Shell's V-Power Racing to see if the additional octane boost would source a slight difference in consumption efficiency, but no noticeable difference could be documented. Esso was the best-performing other brand in 2021, 2022 and 2024, with E.Leclerc (2023) and Tifon (2025) accounting for the other 2 years, albeit all 5 with only one tank of petrol which is not enough to formulate a relevant conclusion. The highest consumptions for other brands recorded were: Tifon (2021), AVIA (2022), Rompetrol (2023 and 2024) and Hip Hop (2025), with AVIA and Hip Hop having filled up 3 times each, whilst the others only once in those specific years. The 4 main brands highlighted (Shell, OMV, MOL, Total) seem to be converging toward a 7% baseline, with similar performance for INA (6.67%) and Aral (6.76%), proving that even minor gains require constant, year-over-year refinement. To statistically assess the validity of these differences a one-way analysis of variance was conducted based on each brand's annual consumption means, only brands with consumption figures in all 5 years were included (Shell, OMV, MOL and Total), with results shown in Table 7.

Table 7. Single factor ANOVA of fuel consumption by brand and year

Source of Variation	SS	df	MS	F	p-value	F crit
Between groups	0.26	3	0.087	0.340	0.796	3.238
Within groups	4.12	16	0.257			
Total	4.39	19				

Source: Authors' own research.

The one-way ANOVA compared the effect of fuel brand on consumption with results indicating no statistically significant difference between the 4 major brands. F (3, 16) = 0.340 and p = 0.79 suggests that fuel efficiency remained stable across all 4 major petrol brands during the 2021-2025 period. While the single-factor ANOVA identifies only marginal differences between brands, the two-factor analysis without replication targets isolating the specific impact of the "year" variable. With the additional control over temporal fluctuations (e.g. evolving road conditions or varying annual mileages) the two-way variance analysis enables a more rigorous and refined assessment of whether consumption differences are truly inherent to the petrol brands' used or not, the results of which are provided in Table 8.

Table 8. Two-way ANOVA of fuel consumption by brand and year

Source of Variation	SS	df	MS	F	p-value	F crit
Between brands	1.66	4	0.417	2.037	0.152	3.259
Between years	0.26	3	0.087	0.429	0.735	3.490
Error	2.45	12	0.204			
Total	4.39	19				

Source: Authors' own research.

The two-way ANOVA revealed no significant effect of fuel brand on consumption F(4, 12) with p = 0.152, nor a significant effect on the year of operation, F (3, 12) with p = 0.735. These findings suggest a notable degree of technological parity across the fueling industry converging toward a high degree of uniformity in fuel quality among the top providers analyzed. Furthermore the lack of significant variance across the 5-year period, with no specific brand emerging as a clear efficiency leader within the 5 years, indicates that external factors (vehicle aging, regional infrastructure differences) did not substantially impact fuel efficiency. A further analysis was carried out to see if there is a significant difference between the countries of origin for refueling, with Shell being chosen as the brand with the widest coverage. The segmented data, covering 4 main countries (Hungary, Austria, Germany and France) is summarized in Table 9.

Table 9. Shell: mean fuel consumption by country

Shell	Hungary	Austria	Germany	France	**average**
2021	7.32	6.57	6.73	6.38	**6.77**
2022	7.75	6.78	7.37	7.63	**7.50**
2023	7.23	6.56	6.85	7.02	**6.87**
2024	7.02	6.81	6.53	7.18	**7.02**
2025	7.19	7.04	6.70	7.05	**7.06**
average	**7.236**	**6.734**	**6.922**	**6.901**	**6.973**

Source: Authors' own research.

The data reveals both stable consumption profiles for each country, as well as years with lower performance of Shell's premium fuels. Although most consumption figures are rather stable, individual countries show distinct behaviors. Hungary remains the highest consumer on average, consistently exceeding 7% consumption with an average of 7.23% and a maximum of 7.75% (2022). Austria, on the other hand is the top performer with an average consumption of only 6.73% across the 5 years and a best performance of 6.57% achieved in 2021. Germany and France demonstrate more volatility, as their ranges fluctuate more: Germany from 6.53% (2024) to 7.37% (2022) marks a 0.84L difference, whilst France's range is from 6.38% (2021) to 7.63% (2022), more than 1L difference (1.25L). Overall, the aggregate average of 6.973 suggests a rather stable and steady consumption profile, despite these previously mentioned variations. In order to seek statistical validation an ANOVA Single Factor analysis was conducted, with results shown in Table 10.

Table 10. Single factor ANOVA of Shell fuel consumption by country

Source of Variation	SS	df	MS	F	p-value	F crit
Between groups	0.91	3	0.304	2.937	0.065	3.238
Within groups	1.65	16	0.103			
Total	2.57	19				

Source: Authors' own research.

Results are trending toward significance ($p < 0.05$), but are not strong enough to overcome the noise generated by the variations within each country's data. The ANOVA results thus indicate that variations in performance across the analyzed countries are not statistically significant. With a p-value of 0.065, the data narrowly misses the standard 0.05 threshold for significance. This is further confirmed by the F-statistic of 2.937, which remains below the critical value of 3.238. Essentially, the differences between these groups are likely due to random chance rather than structural factors. While there is a visible trend toward divergence (regional differences remain suggestive), the current evidence is not strong enough to claim a definitive impact, being statistically inconclusive at this point.

Conclusion

This 5-year research study offers an evidence-based data-driven perspective on the real-world factors that shape fuel efficiency across Eastern, Central and Western Europe. By examining over 186,000 kilometers of driving records, the research moves beyond circumstantial claims and/or evidence to offer a clearer and more detailed look and/or understanding at how fuel types, refueling locations and specific brand premium mixing formulas actually influence and/or impact a vehicle's mileage and/or performance.

The main value of this research is that it statistically backs up the benefits of premium fuel. Through Welch's t-test ($p = 0.016$), the data shows that switching from standard 95 to premium 98+ blends leads to a real efficiency gain of about 4.72%. While saving 0.345 L/100 km might seem small on its own, these gains add up to huge long-term savings. In this study alone, it meant over 570 liters less fuel used, which helps both the engine's health and the driver's wallet. Additionally, the analysis looks at how much the refueling location matters compared to the fuel type itself. The single-factor ANOVA ($p = 0.031$) proves that where you fill up is a bigger factor in consumption changes than the specific fuel brand. The data shows that major brands like Shell, OMV, and MOL are technically very similar, suggesting that regional roads, topography, and local speed limits have a much bigger impact on fuel economy than any special additive packages or formulas.

These findings offer useful tips for high-mileage commuters looking to cut their average consumption figures, although the lower fuel use doesn't always mean spending less money when choosing premium fuels over standard options and superior engine performance is difficult to quantify in short and medium term when using premium 98+ blends. The study suggests that premium fuels make sense for certain types of driving environments, especially in tough terrains like the Austrian Alps or on the underdeveloped motorway networks of Romania. Future steps for this research could apply this same approach to Hybrid Electric Vehicles (HEVs) or bring the extra cost per liter into the equation to see exactly where the breaking point for economic savings lies.

While this 5-year time series research study offers a deep look at the data, it does have its limitations. Since the figures come from a single-vehicle profile, the specific way this engine reacts to fuel might influence the results. Also, even with such a large dataset, real-world driving is naturally diverse: things like seasonal temperature shifts and fluctuations, random traffic jams and density (especially around capitals and/or major nodes), and small changes in driving style and behavior (unquantifiable) on any given day are very hard to measure exactly and include in the analysis. One specific issue is a seasonal bias in the data for Croatia, as those trips happened almost entirely in the summer months, which potentially may have skewed the results for that region. In the end, this research confirms that while fuel quality is now very consistent across the major brands, where you actually drive remains the most critical factor in the efficiency equation.

Acknowledgments: During the preparation of the final version of this work, the author used Gemini 3 Flash to a limited extent for the purposes of improving language and readability in the following sections of the current paper: Introduction, Literature review and Methodology. The entire data and content within this paper, as well as conceptual framework and all earlier and preliminary unpublished draft versions of the paper, are the sole and exclusive work of the researcher. Gemini 3 Flash was used as a final check for grammar and stylistic consistency to prevent excessive repetitive language clichés that are rather characteristic in the introductory parts of any research paper since the language used is rather standard to describe research design. Following the use of this AI tool, the author meticulously reviewed and revised the suggested content in the aforementioned sections as necessary and assumes full responsibility for the final content of the publication.

References

Anderson, J.E., DiCicco, D.M., Ginder, J.M., Kramer, U., Leone, T.G., Raney-Pablo, H.E. & Wallington, T.J. (2012). High octane number ethanol–gasoline blends: Quantifying the potential benefits in the United States, *Fuel*, 97, 585-594.

Dolsak, J. (2024). Competition and consumer prices in the fuel market: insights from a small EU country, *Applied Economic Analysis*, 32(95), 141–166.

Elkelawy, M., El Shenawy, E.A., Bastawissi, H.A.-E., Elsayed, S.S. & Mostafa, E. (2025). Impact of Gasoline Fuel Commercial Additive Properties on Engine Performance and Emissions Characteristics, *Pharos Engineering Science Journal*, 2(1), 87-105.

Greene, D.L., Liu, J., Khattak, A.J., Wali, B., Hopson, J.L. & Goeltz, R. (2017). How does on-road fuel economy vary with vehicle cumulative mileage and daily use?, *Transportation Research Part D: Transport and Environment*, 55, 142-161.

Peng, Q., Rockstroh, T. & Hall, C. (2022). The impact of fuel and injection strategy on combustion characteristics, emissions and efficiency in gasoline compression ignition operation, *Fuel*, 318, 123548.

Reitz, R.D., Ogawa, H., Payri, R., Fansler, T., Kokjohn, S., Moriyoshi, Y, Agarwal, A.K., Arcoumanis, D., Assanis, D., Bae, C., Boulouchos, K., Canakci, M., Curran, S., Denbratt, I., Gavaises, M., Guenthner, M., Hasse, C., Huang, Z., Ishiyama, T., Johansson, B., Johnson, T.V., Kalghatgi, G., Koike, M., Kong, S.C., Leipertz, A., Miles, P., Novella, R., Onorati, A., Richter, M., Shuai, S., Siebers, D., Su, W., Trujillo, M., Uchida, N., Vaglieco, B.M., Wagner, R.M. & Zhao, H. (2020). The future of the internal combustion engine, *International Journal of Engine Research*, 21(1), 3-10.

Rojas-Reinoso, V., Alvarez-Loor, J., Zambrano-Becerra, H. & Soriano, J.A. (2023). Comparative Study of Gasoline Fuel Mixture to Reduce Emissions in the Metropolitan District, *Sustainability*, 15(4), 2921.

Yuan, W., Frey, H.C., Wei, T., Rastogi, N., Vandergriend, S., Miller, D. & Mattison, L. (2019). Comparison of real-world vehicle fuel use and tailpipe emissions for gasoline-ethanol fuel blends, *Fuel*, 249, 352-364.