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Keywords: automotive market, sustainable mobility, road transport decarbonization, electro-mobility, EU-car CO2 regulation

JEL classification: L62, Q55, Q58, R41

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The opinions expressed in this paper do not necessarily reflect the position of Fondazione Eni Enrico Mattei

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Abstract

This paper studies the effects of the latest European regulations on carbon emissions on the Italian car market and discusses the possibility of achieving climate neutrality of road transport through the "mere" replacement of cars currently on the road with new zero-emission cars. Since 2016, automakers' production strategies have changed dramatically, with an increasing number of zero (and low) emission models on car lists. To date, these changes on the supply side have not been matched by similar changes in purchasing habits. In recent years, not only have few zero (and low) emission cars been sold, but also few new cars. Unless epoch-making changes occur, it is completely unrealistic to think that we can achieve climate neutrality by 2050 by leveraging exclusively on the renewal of the fleet.

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01 Introduction

The global automotive industry is moving quickly along a path towards huge and widespread innovation whose ultimate goal is clearly greater sustainability. Indeed, the reduction of (adverse) environmental impacts is a global need that has already been felt for several decades, albeit with different continental histories.

In Europe, work has been going on since the 1970s to build a complex and shared framework of standards and rules (both for cars and for commercial light vehicles), which over time has become more and more binding, with stricter and stricter commitments to reduce emissions of carbon dioxide (CO₂), pollutants (nitrogen oxides, particulate matter, unburnt hydrocarbons) and noise pollution. Note the lack of measures to curb the size of cars.¹

At present, the EU approach, especially after the Commission's latest initiatives (in particular the so-called 'Fit for 55' package), seems to be primarily oriented towards the 'mere' replacement of the huge fleet of cars in circulation with new, electric-fuelled, ones. Leaving to others the burden (and the honour) of discussing the efficiency of the EU approach, in the following pages we will concentrate on discussing the effectiveness of the EU strategy. In particular, we will be asking ourselves how plausible it is, in the light of the latest production and registration dynamics, that new cars with zero tailpipe emissions will replace the 250 million cars on European roads in 2022 (ACEA, 2023) in a timeframe consistent with EU targets.

The answer we will come up with is unequivocal: unless there are epoch-making changes, it is a mission impossible. Despite the interventions promoted at various levels (EU, national, regional and local) and the - mandatory - changes on the supply side, the demand for zero tailpipe emission cars (primarily electric) and, more generally, the demand for new cars is by no means in line with the EU targets. Not only are we not selling enough electric cars to focus exclusively on electrics, but in fact we are not replacing enough cars in general to think we can achieve climate neutrality by 2050 by focusing on new car purchases alone. Other strategies must be explored if we do not want to miss the target.

In order to illustrate the results we came to and to substantiate them, we have opted to focus on Italy. The choice of case is justified by the role Italy plays within the European car market. With 40 million cars on the road (1.4 million of which will be registered in 2022), and more than 660 cars per 1,000 inhabitants, Italy is the third largest European market as per number of new cars purchased and the motorisation rate, and it has the second largest car fleet in Europe. Slightly less than 1/6 of the cars circulating in the EU travels on Italian roads. The average age of Italian cars is 12 years and 2 months, only two months older than the EU average (ACEA, 2023).

The paper is organised as follows. In section 2, the most recent constraints imposed by EU policies on the European automotive industry are explained. Section 3 discusses the effects of these regulations on car supply. Some data on car supply in Italy (number of models offered by fuel type) are also presented. Section 4 discusses the interventions (incentives

¹ There are neither penalties for large sized cars nor specific incentives for small sized ones.

and penalties) adopted by the Italian regulator to drive the demand for new cars towards zero- and low-emission options. Section 5 provides data on registrations in Italy. The timing of the renewal of the car fleet is quantified and the consistency of the most recent dynamics of demand (registrations) and supply (number of models by fuel) is detailed. Section 6 tackles the conclusions.

02 Ever stricter EU regulations

Even before the Fit for 55 package was approved, the Union had already committed to reducing net economy-wide greenhouse gas emissions by at least 40 per cent below 1990 levels by 2030. This path was in line with the Paris Agreement, whereby Parties committed to achieving carbon neutrality (i.e. zero net emissions, not zero emissions) by 2050.

The implication of the above for the automotive sector is that the coming years will inevitably see both a further reduction in CO₂ emissions from internal combustion engine vehicles, and a greater presence of so-called zero- and low-emission cars in the manufacturers' offer and, hopefully, on the roads.

In view of these targets, Regulation (EU) 2019/631 was adopted in 2019, abrogating Regulations EC 443/2009 and EU 510/2011. Regulation (EU) 2019/631 set a CO₂ emissions reduction target of 37.5 per cent for passenger cars (31 per cent for light commercial vehicles) below 2021 levels by 2030. The same regulation also set an "intermediate" CO₂ emission reduction target of 15 per cent (for both passenger cars and light commercial vehicles) below 2021 levels by 2025.

The above targets were tightened with the introduction of the Fit for 55 Package, which led to Regulation (EU) 2023/851.² The latter amended Regulation (EU) 2019/631 by retaining the CO₂ emission reduction target of 15 per cent by 2025, but increased the target for 2030 to 55 per cent for passenger cars (50 per cent for light commercial vehicles), and introduced a carbon-neutrality target to be achieved by 2035.

To date, the CO₂ emission reduction targets imposed by European regulations refer to exhaust emissions from vehicles. This choice effectively leaves room only for pure electric vehicles (with electrochemical batteries and/or hydrogen-fuelled fuel cells) as they are conventionally considered to have zero tailpipe emissions (see below).

Actually, the goal of climate neutrality could also be achieved by vehicles with internal combustion engines, for example, if they were powered by hydrogen.³ In this regard, following the approval of EU Regulation 2019/1242, which for the first time sets CO₂ emission performance standards for heavy-duty vehicles, hydrogen is expected to play an important role in the decarbonization of heavy-duty vehicles. If this were the case, an ad hoc distribution network would be developed and could be used by passenger cars too.

² Published in the Official Journal of the European Union on April 25, 2023.

³ Already engaged in this field are, for example, Toyota, the world's largest manufacturer of cars and motor vehicles, and Bosch, the world's largest manufacturer of cars' component.

03 The electrification of car supply is (almost) a must

The CO₂ emission reduction regulations that set targets for car manufacturers actually contain the rules for access to the European car market. Without going into the technicalities of the regulations, we think a few considerations are appropriate.

The goal of climate neutrality (zero net emissions) was and is not prejudicial to any drive system. But by setting tailpipe emission targets, the regulation actually favours technologies that minimise emissions at this stage. For the purposes of Regulation (EU) 2023/851 (as well as of Regulation (EU) 2019/631), the emissions generated during the extraction and production of raw materials, the emissions generated during the production and transport of electricity and fuel, the emissions generated during the manufacture and the disposal of vehicles, and the actual emissions generated during the operation of vehicles have to be excluded from the calculation of the climate impact of vehicles.

Electric (and fuel cell) cars are always zero-emission, regardless of the country in which they are produced and used. Therefore, by way of example, an electric car used in Sweden, France, Italy, Poland and Estonia is considered to be a zero-emission vehicle in the same way, even though the average emissions generated in these countries to produce the same kWh of electricity needed to charge the car's battery differ considerably: 9 g CO₂ in Sweden, 67 in France, 247 in Italy, 750 in Poland and almost 950 in Estonia (EEA, 2023). Although the gaps between countries are narrowing in the coming years, it is clear that this (non-calculation) criterion is the most important incentive for the production of electric cars. Since electric cars count zero, their sale significantly lowers manufacturers' average emissions and thus facilitates compliance with the emission standards imposed by the EU on car manufacturers.

European regulations grant a significant advantage to all cars equipped with batteries, i.e. to all cars equipped with one or more electric motors even in addition to the internal combustion engine. In this regard, it is worth pointing out that when calculating the average emissions of cars sold by the various car manufacturers (and thus verifying whether they comply with the emission constraints in force), the average mass of the cars registered in the year acts as a calming factor: the greater the mass, the less stringent the target (and vice versa). The aim is to not disadvantage larger, and thus heavier, cars to the detriment of smaller and inevitably lighter ones. And here we come to the paradox of criticising SUVs and promoting them from the outset. A distortion that has already led to a significant contraction in the supply of city cars, the A-segment super-utility cars (Figure 1).

Since 2018, the number of A-segment cars offered on the Italian market has begun to diminish: -15% on average per year, without a positive contribution from electric models (BEVs), which have not replaced the internal combustion engine models, so that by 2022

the number of A-segment cars on offer was half the amount available in 2012. That is quite a problem, given the small footprint of city cars.⁴

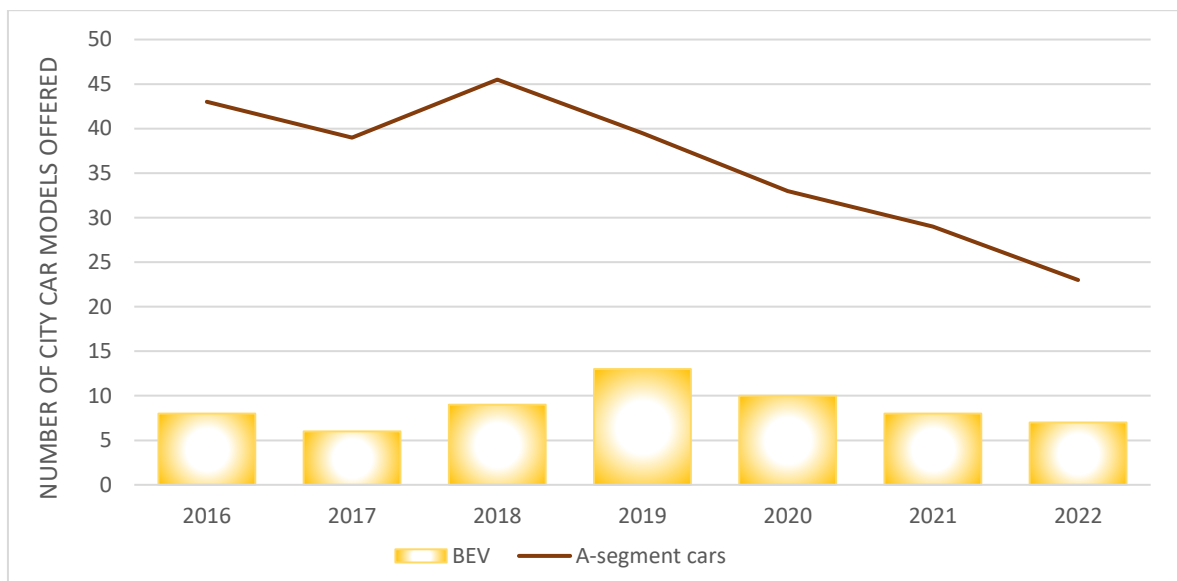


Figure 1. Number of A-segment car models offered, years 2016-2022. Source: our elaborations on list data.

03.1 The supply of cars in Italy

EU regulations have had a significant impact on the supply strategies of car manufacturers. The data presented and discussed below refer to Italy, but similar trends can also be observed in the other EU countries.

Figures 2 and 3 illustrate the development of car supply in terms of variety and, thus, number of models by fuel offered over the period 2016-2022. The time interval 2016-2022 was chosen as it allows the examination of the impact of the newest EU rules. After 2018, and thus with the entry into force of the new and more stringent commitments imposed by the EU regulations, a significant change in the supply of vehicles by fuel types can be seen: fewer petrol and diesel models and more electrified models. In fact, since 2018, against a 6% average annual decrease in the share of petrol- and diesel-powered models on offer, there has been a 6% average annual increase in the share of electrified cars. Faced with an almost compulsory choice, car manufacturers have changed their supply. Boosted by the EU regulations, the number of hybrid (HEV), plug-in hybrid (PHEV) and pure electric (BEV) car models increased from 10% in 2016-2017 to 43% in 2021-2022. One could say that this change in the models on offer is, in itself, a good thing since, even if in theory, these are cars with lower emissions than comparable non-electrified ones; but, as we shall see, what matters is the registrations and, therefore, the demand for cars.

⁴ However, it is hard to argue that a 3.7-metre car with a mass of just over a tonne, even if it is endothermic, can have more adverse environmental impacts than a 5-metre electric car with more than twice the mass and a 100 kWh battery pack.

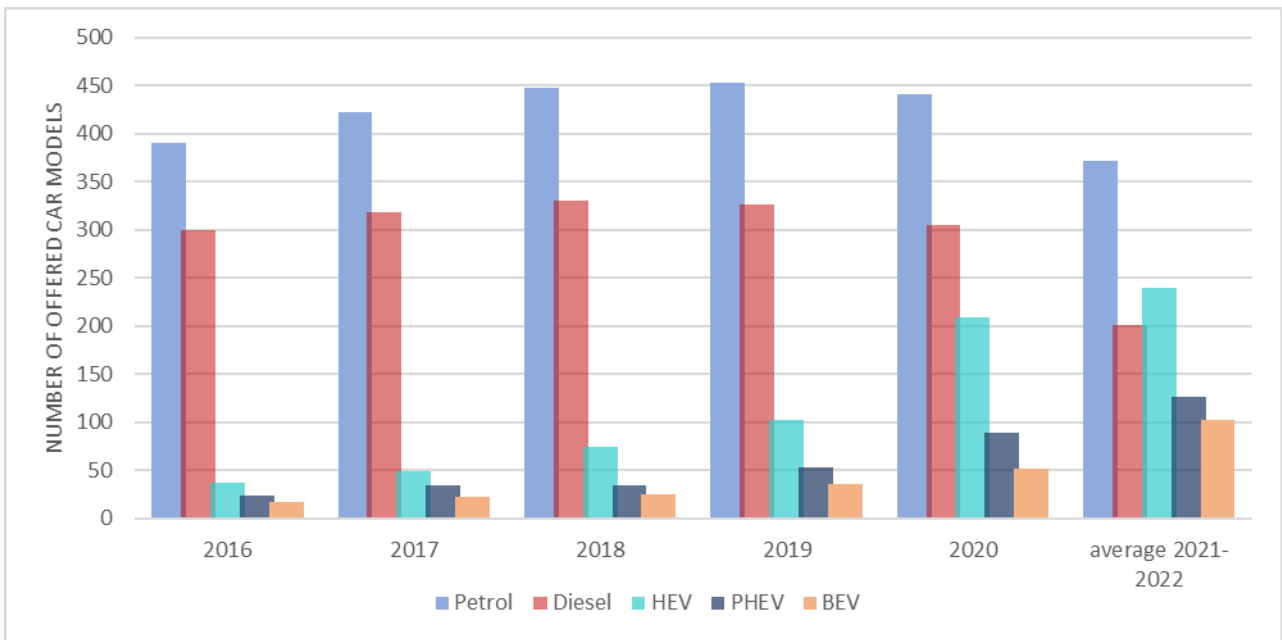


Figure 2. Number of models offered in Italy by fuel type (absolute values, only the most commonly used fuels are shown), years 2016-2022. Source: our elaborations on list data.

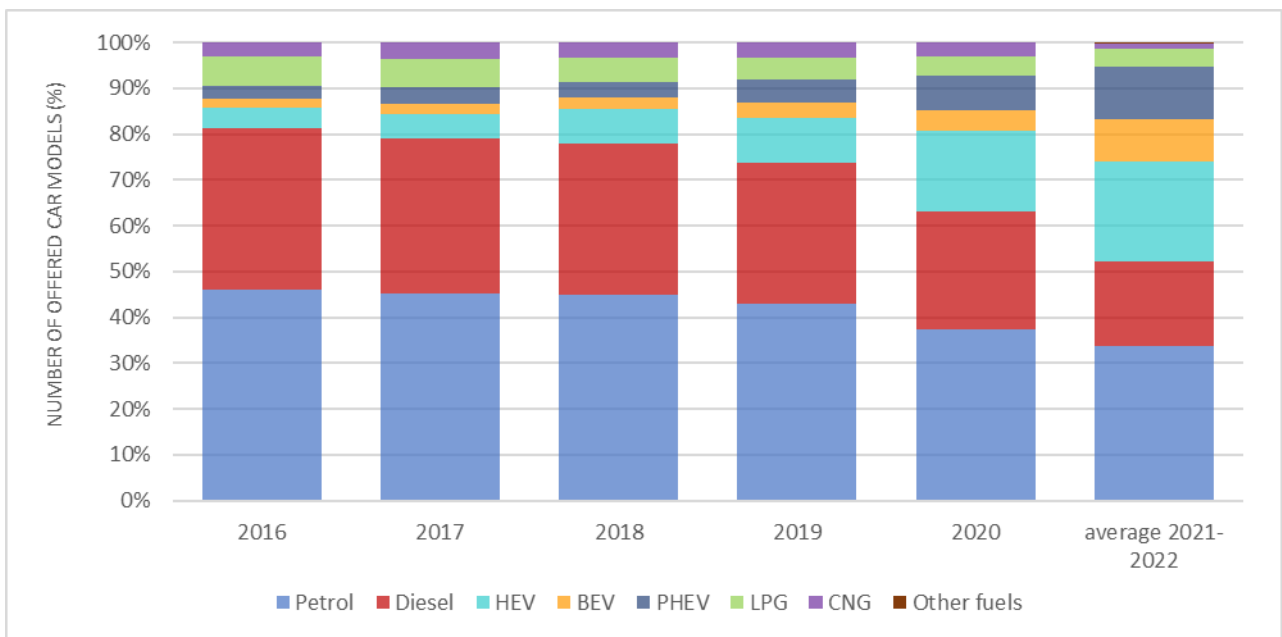


Figure 3. Number of models offered by fuel type (%), years 2016-2022. Source: our elaborations on list data.

04 Economic incentives for demand-side decarbonization of the Italian automotive market

As highlighted above, EU regulations aim to decarbonize the European automotive industry (and market) starting from the supply side. But there has been no shortage of interventions - complementary to those discussed thus far - on a nationwide scale. Since the end of the

last decade, in Italy as well as in the other EU countries, measures have been put in place to drive demand toward zero- and low-emission passenger cars.

04.1 Italy's (eco)bonus-(eco)malus formula

In the following we will briefly review the incentives and disincentives introduced in Italy for the purpose of influencing car purchase choices and orienting them toward electric cars, plug-in hybrids and, more generally, low-carbon emissions vehicles.

The first season of incentives-disincentives for the purchase of new cars, which began in 2019 with the 2019 Budget Law (Law 145/2018) and ended in 2021, was in no small part inspired by the bonus-malus écologique adopted in France since 2008: a rebate (bonus or ecobonus, in the form of a discount on the list price) for buyers who opted for low-emission versions and an increased tax (malus, in the form of a lump-sum tax to be paid in addition to other registration fees) for those who opted for models with a greater climate-changing impact.

The malus, scaled up according to increasing CO₂ thresholds, had the twofold purpose of discouraging the purchase of cars with high emission levels and ensuring dedicated revenue so that the measure would be budget neutral for the state. It quickly became clear that such a mechanism had to be well reasoned: on the one hand, because an excessive penalty would discourage the purchase of certain cars and, therefore, the receipt of revenue at all; on the other hand, because the mechanism "taxes" the potential emissions and not the actual ones that depend on the usage of the cars. From January 2019 to December 2020, the amount of the malus was set for four steps starting at 161 g CO₂/km, with unit taxes equal to: EUR 1,100; EUR 1,600; EUR 2,000; and EUR 2,500.

With the Budget Law 2021, the threshold values from which the malus would apply were raised due to the change in the homologation procedure (from NEDC to WLTP), which resulted in higher emissions recorded at the homologation stage.⁵

The reason for raising the emission threshold from which to pay the malus is the same as that which also explains the decision not to opt for a progressive tax system but for one with increasing tax brackets: a wide range of cars penalized and, therefore, greater risks of unpopularity of the measure. By 2022, the malus had been definitively abandoned.

The bonus (or ecobonus) became effective starting from March 2019 and is still in force. In the first three-year of its application, the incentives were adjusted annually to correct some initial distortions and adapt the mechanism to new developments, including regulatory ones.

⁵ The shift from the NEDC (New European Driving Cycle) procedure to the stricter WLTP (Worldwide harmonized Light vehicles Test Procedure), which from 2021 is the standard for measuring consumption and CO₂ emissions values for all cars registered in the European Union, seeks for as much as possible to bring the measurements as close as possible to the actual driving conditions.

In 2019, the emissions thresholds resulted in the ecobonus benefiting only two powertrains: pure electric and plug-in hybrids.

Since 2020, the bonus has been changed by lowering the access threshold (from 70 to 60 g CO₂/km).⁶ Supplementary measures (so-called extrabonus)⁷ were also introduced to benefit all cars with CO₂ emissions below 110 g/km, albeit with modest per-unit incentives (Table 1).

Table 1. Main features of the ecobonus and the extrabonus in the triennium 2019-2021.

g CO ₂ /km	Methodology	Year	Euro class of the car scrapped (EUR)		Amount ecobonus (€)		Amount extrabonus (€)		Maximum price of the new car, VAT incl. (EUR)	
			Ecobonus	Extrabonus (≥10 anni)	WS ⁸	W/OS ⁹	WS	W/OS	Ecobonus	Extrabonus
0-20	NEDC	2019	1-4	n.d.	6.000	4.000	n.d.	n.d.	61.000	n.d.
21-70	NEDC	2019	1-4	n.d.	2.500	1.500	n.d.	n.d.	61.000	n.d.
0-20	NEDC	2020	0-4	Qualsiasi	6.000	4.000	2.000	1.000	61.000	48.800
21-60	NEDC	2020	0-4	Qualsiasi	2.500	1.500	2.000	1.000	61.000	48.800
61-90	NEDC	2020	n.d.	Qualsiasi	n.d.	n.d.	1.750	1.000	n.d.	48.800
91-110	NEDC	2020	n.d.	Qualsiasi	n.d.	n.d.	1.500	750	n.d.	48.800
0-20	WLTP	2021	0-4	0-4	6.000	4.000	2.000	1.000	61.000	48.800
21-60	WLTP	2021	0-4	0-4	2.500	1.500	2.000	1.000	61.000	48.800
61-135	WLTP	2021	n.d.	Qualsiasi	n.d.	n.d.	1.500	0	n.d.	48.800

In 2021 we find again both the ecobonus and the extrabonus: the former with the same peculiarities as in 2020; the latter with some changes made necessary by, among other things, the transition from the NEDC to the WLTP homologation procedure. In the third quarter of 2021, incentives for the purchase of second-hand cars were also tested, actually without much success.¹⁰

Unlike the three-year "pilot" phase, the ecobonus for newly registered cars in 2022-2024 has uniform rules, which for non-electric and plug-in cars are linked to the scrapping of used cars. There are also ad hoc subsidies for car purchases by rental companies (Table 2).¹¹

⁶ Law 8/2020 which converted D.L. 162/2019, the so-called Milleproroghe, into law.

⁷ D.L. Rilancio, converted by Law 77/2020.

⁸ WS: including the scrapping of a used car.

⁹ W/OS: without the scrapping of a used car.

¹⁰ As of September 28, 2021, for only 95 days, subsidies were also provided for second-hand Euro 6 cars with emissions not exceeding 160 gCO₂/km and amounts ranging from EUR 750 up to EUR 2,000 for electric cars. Only 27.6 percent of the 45 million EUR allocated were used; the measure was not renewed in 2022.

¹¹ The measures summarized here do not take into account the incentives provided by local authorities (regions and municipalities), although these may be in addition to state incentives: local incentives for the purchase of electric and plug-in hybrid cars; local incentives for the installation of home charging points; and "soft" incentives (e.g., exemption from paying stamp duty, access to restricted traffic zones, free parking, up to the censorious exemption from power limits for cars that can be driven by novice drivers).

For 2022, additional subsidies have been introduced for taxpayers with ISEE below EUR 30,000, who can benefit from a 50 percent increase in the ecobonus subsidy.

Table 2. Main features of the ecobonus for the triennium 2022-2024.

gCO ₂ /Km	Euro class of the scrapped car	Amount with scrapping			Amount w/out scrapping			Maximum price of the new car, VAT included (EUR)
		base	ISEE<30KEUR	car-sharing	base	ISEE<30KEUR	car-sharing	
0-20	0-4	5.000	7.500	4.500	3.000	2.500	1.500	42.700
21-60	0-4	4.000	6.000	3.000	2.000	2.000	1.000	54.900
61-135	0-4	2.000	2.000	n.d.	n.d.	n.d.	n.d.	42.700

04.2 Incentive and disincentive schemes have not shifted demand

Looking at the data, the impact of the bonus-malus formula and of the incentives which have followed to promote the purchase of electric and plug-in hybrid cars has been smaller than expected: rather than a boosted electrification, there has been a hybridization of the demand for passenger cars. The car models that gained the largest market share were non-rechargeable hybrids. Indeed, the best-selling car in Italy in the more recent years is a hybrid model: the Panda (Figures 4 and 5).¹²

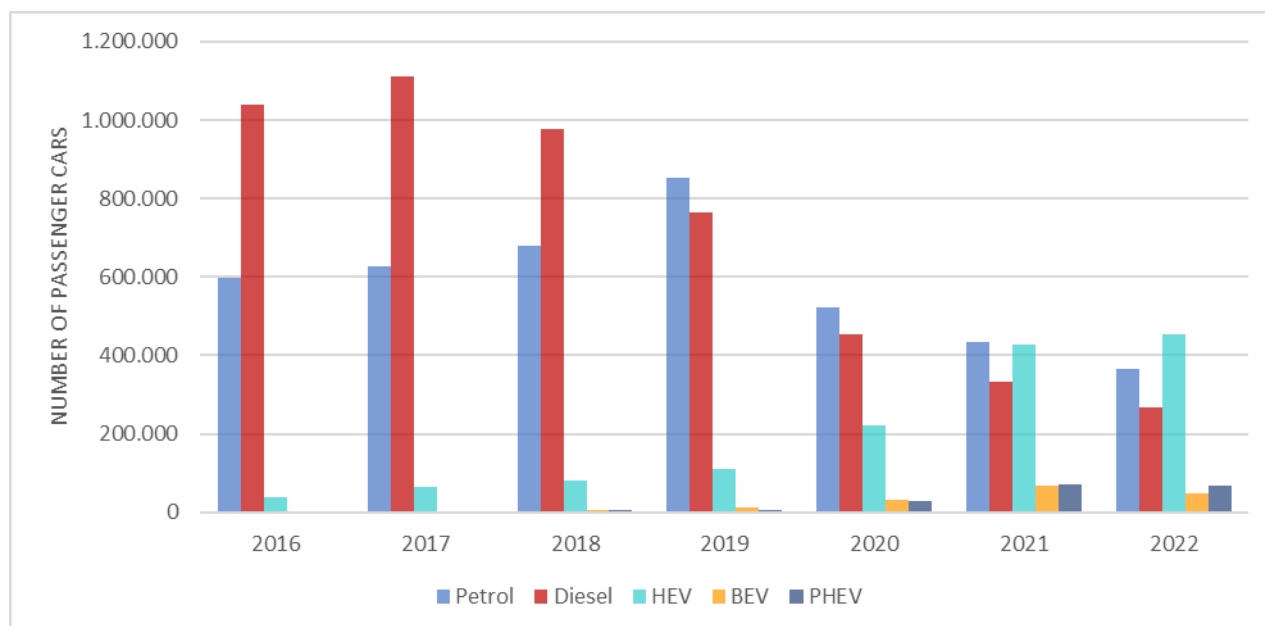


Figure 4. Car registrations by fuel type (absolute values, only the most commonly used fuels are shown), years 2016-2022. Source: ANFIA and UNRAE.

It should be noted that a substantial part of the state aid for electric and plug-in cars was not even applied for. At the end of 2019, more than 20 percent of the 60 million EUR of the

¹² The so-called "light hybrid," or Mild Hybrid, is a type of powertrain in which an endothermic engine (gasoline or diesel) is supported by a small electric motor and a small battery. Unlike the Full Hybrid, in the Mild Hybrid the electric part does not directly contribute to traction.

ecobonus fund allocated in the year had remained unused;¹³ the same can be said of the 12.5 percent of the 610 million EUR of the 2020 ecobonus fund and even 60 percent of the 445 million EUR of the 2022 fund dedicated to buyers of electric and plug-in hybrid cars. The 2022 débâcle, which is largely explained by the lowering of the maximum price to access the incentive and the exclusion of legal entities as eligible beneficiaries, does not seem justified, however, given the expansion of the number of models offered and the introduction of more affordable models.

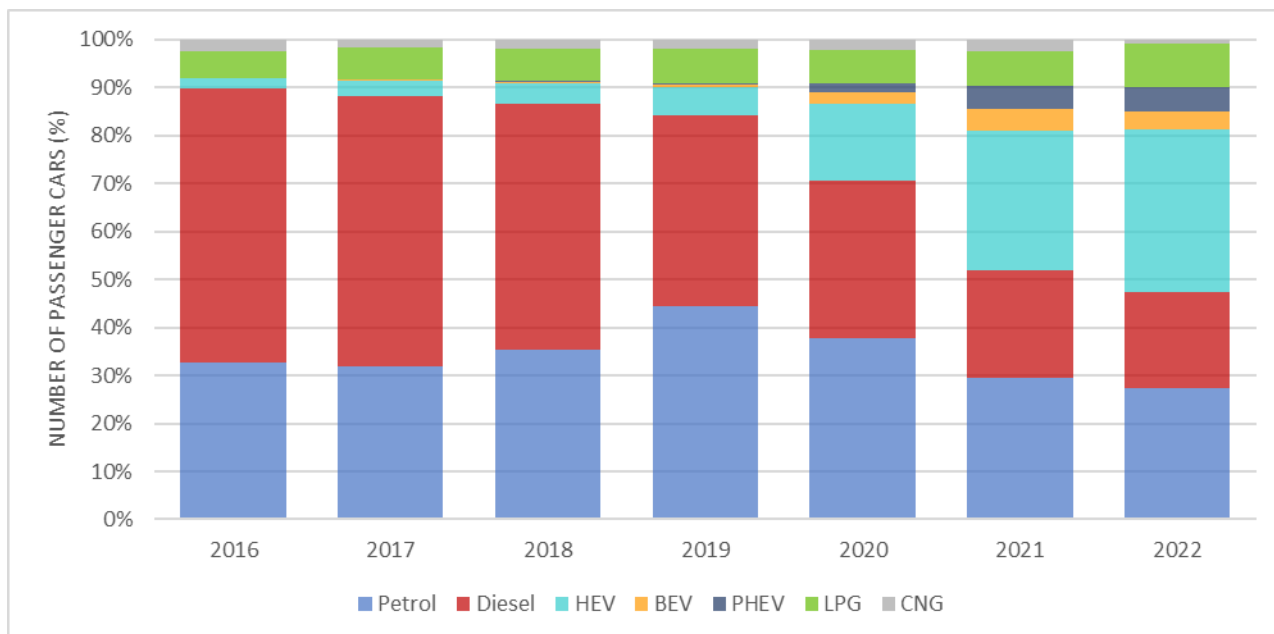


Figure 5. Car registrations by fuel type (%), years 2016-2022. Source: ANFIA and UNRAE.

Quite different has been the interest in the incentives for the purchase of endothermic cars. Notwithstanding the much smaller unit amounts and the "scrapping clause", the 50 million EUR allocated by the DL Rilancio in 2020 for cars with 61-110 g CO₂/km emissions were depleted within a week. The same happened to the 170 million EUR 2022 incentives for endothermic cars, which were claimed in full in less than 20 days.

Looking at consumer behaviour, the problem seems to lie not in the amount of the state rebate but rather in the product for which it is intended. As Figure 6 shows, the billions provided over the past four years for bonuses and extrabonuses have not been enough to invert the decline in the registrations of passenger cars.

We are far from the values of the beginning of the century. After the breakeven - in the decade 2010-2019 - of the registration figures that marked the 1980s, by 2020 the Italian car market was seemingly bound to return - slowly but inevitably - toward the registration rates of the 1970s.

¹³ Given the constraints on CO₂ emissions, the 2019, 2020, and 2021 ecobonus funds were, in fact, to benefit only buyers of electric and plug-in hybrid cars.

Unlike registrations, however, the vehicle fleet has continued to grow, first approaching asymptotically and then exceeding 40 million cars (Figure 7). This means that, in the absence of momentous changes, replacing the entire Italian vehicle fleet - the *full replacement rate*¹⁴ - would take about 30 years.¹⁵

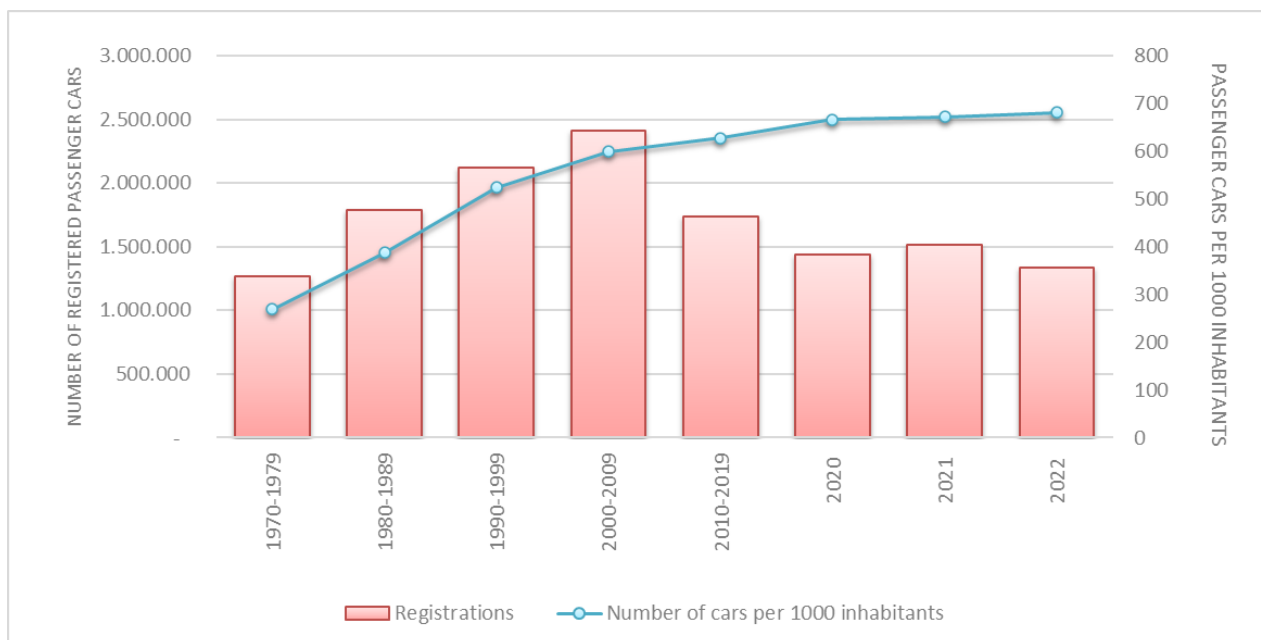


Figure 6. Registrations of new passenger cars and passenger cars per 1000 inhabitants, years 1970-2022. Source: ACI and ISTAT.

It must be kept in mind that the recent trend in passenger cars' registration has certainly been affected by first the outbreak of the Covid-19 pandemic and later by the microchip, semiconductor, and wire harness crises (exacerbated by the Russian-Ukrainian conflict), which have led to major constraints on the supply of new vehicles.

However, it is a fact that passenger car registrations in 2022 were worse than both the already weak 2021 and the even more sluggish 2020. New car registrations did not experience the rebound that characterized the economy in general. Note that, in the EU context, the Italian figure fits in as a confirmation rather than an exception. In 2022, the average drop in passenger cars' registrations in EU countries was 4.6 percent, with France recording -7.8 percent (2022 was the worst year since 1974), Spain -5.4 percent, and Poland -6 percent (ACEA, 2023).

¹⁴ The *full replacement rate* shown in Figure 7 (right axis), quantifies the number of years it takes to replace the current stock of passenger cars with new cars. This rate depends on the size of the car stock as well as on the annual registrations of new passenger cars. Ceteris paribus, the larger the size of the current stock of passenger cars and the lower the annual registrations of new vehicles, the more years it will take to completely replace the existing stock.

¹⁵ Note that this calculation is based on the heroic assumption that each new car registered replaces one of those already on the road and does not contribute to an increase in the stock of passenger cars; otherwise more years would be required than those in Figure 7.

In Italy, new car registrations in 2022 is the second worst value after 2013, since as far back as 1978.¹⁶ If, however, 2013 represented the lowest point in the market at the end of the great recession that followed the 2008 financial crisis, the lows reached in recent years are also rooted in the car market.

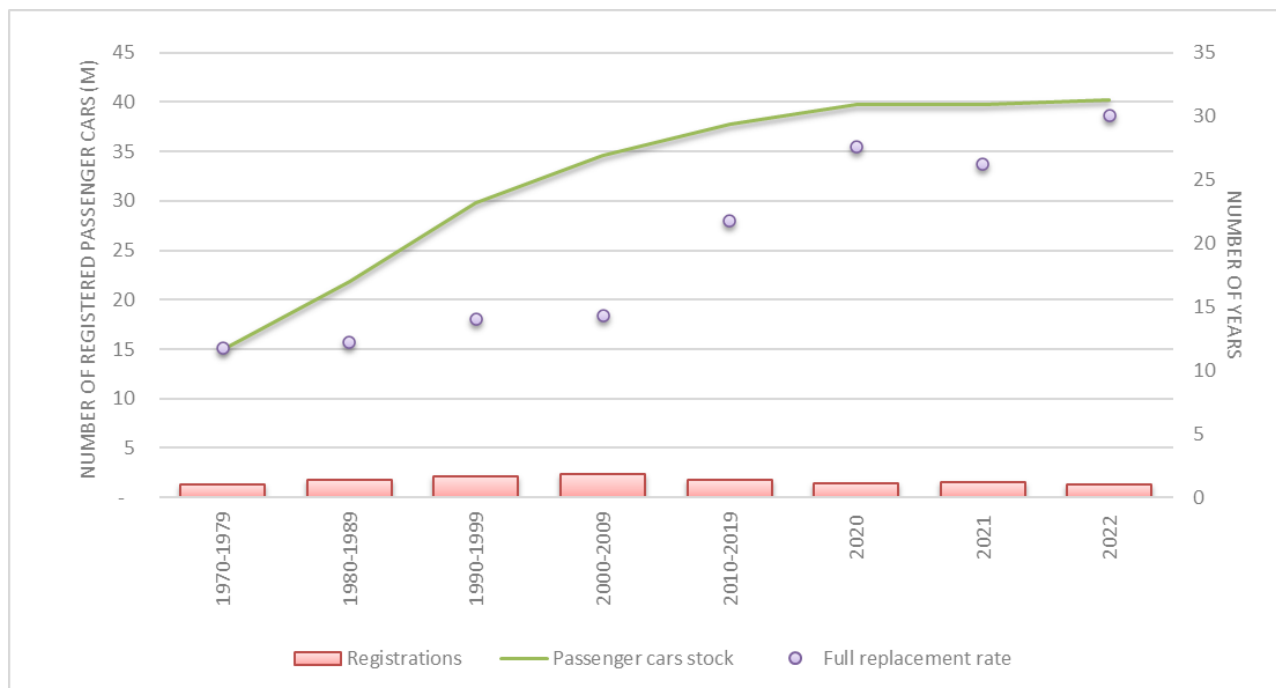


Figure 7. Passenger cars stock, registrations of new passenger cars and the full replacement rate in Italy: 10-year average for 1970-2019, annual data for 2020, 2021 and 2022. Source: our elaborations on ACI data.

05 A dramatically different supply of passenger cars that is not attractive to consumers

As mentioned earlier, EU regulations have significantly affected the choices of automakers and the new models offered. Across the EU, vehicle manufacturers have progressively and significantly increased the number of electrified models on their lists - first hybrids, in all configurations, and then electrics - and reduced both those with diesel and petrol engines (without electric auxiliaries) and those with LPG and CNG.

On their side, although with the differences also required by the priorities as well as the spending possibilities of different countries, governments have tried to drive demand by providing incentives and disincentives intended to align consumer choices with the new constraints on manufacturers.

Let us therefore try to understand the extent to which the EU-imposed dynamics experienced on the supply side of the automotive industry are meeting the needs of demand.

¹⁶ In 2022, the number of cars taken out of the circulating fleet decreased by 29.5% compared to 2021. In the first quarter of 2023, the number of cars taken out of the fleet decreased by 12.1 percent compared to the same period in 2022. The above is a clear indication of further growth of the passenger car stock.

As in the previous sections, we will focus on the Italian automotive market. The data shown refer to the period 2016-2022 and compare the demand and supply of new cars - passenger cars' registrations vs. number of models supplied - by fuel type (Figures 8-11).

Overall, demand and supply of petrol and diesel cars have always been fairly well balanced, with a slight (and decreasing) surplus of models offered for petrol fuels and a slight (and decreasing) abundance of demand for diesel fuels. Diesel models for sale, while never accounting for more than 35 percent of supply, have come to exceed 50 percent of demand (Figure 8).

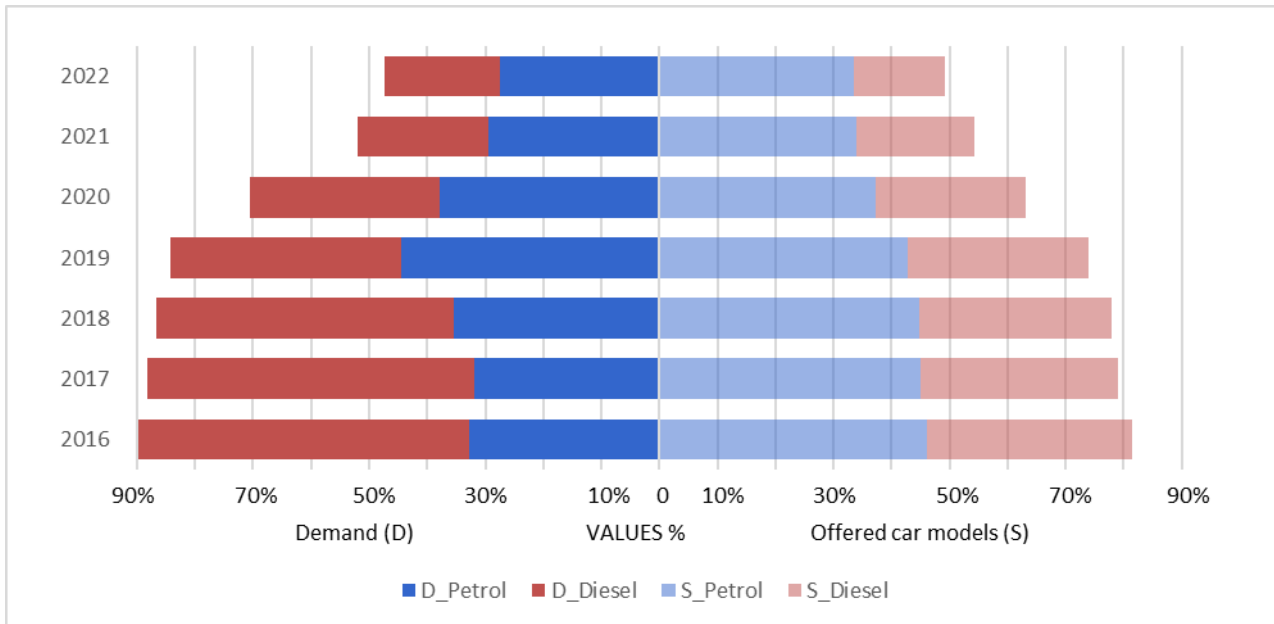


Figure 8. Registrations of new passenger cars (demand, D) and number of models offered (supply, S) in Italy for petrol- and diesel-powered cars: percentage values, years 2016-2022. Source: our elaborations on ACI and list data.

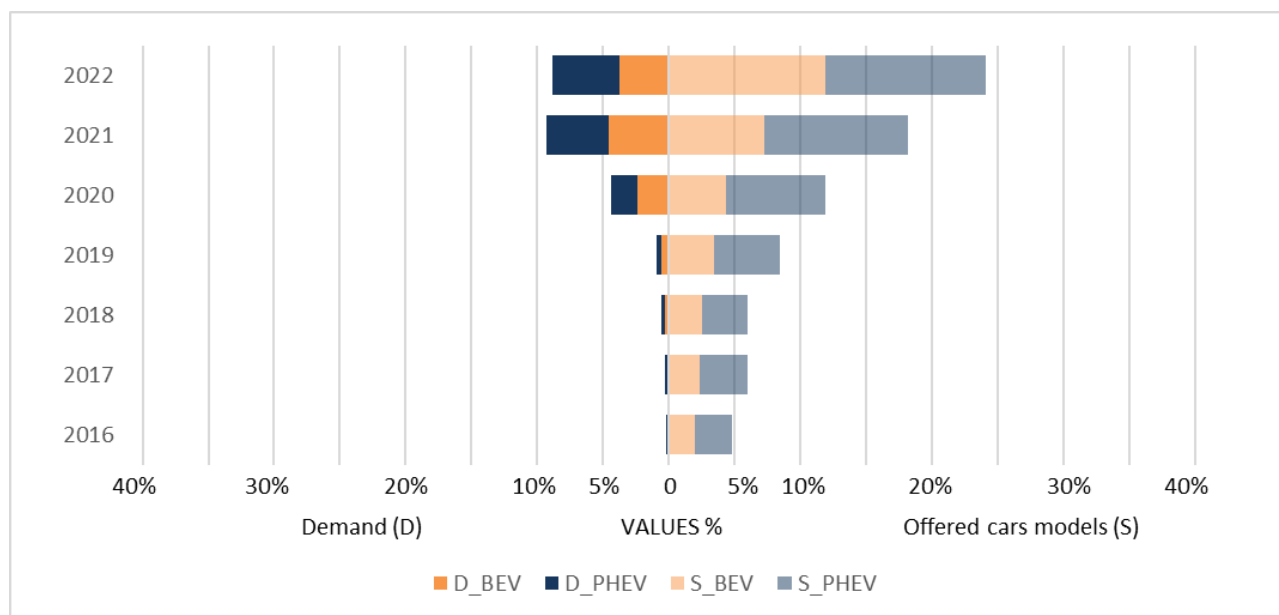


Figure 9. Registrations of new passenger cars (demand, D) and number of models offered (supply, S) in Italy for battery electric (BEV)- and plug-in (PHEV)-powered cars: percentage values, years 2016-2022. Source: our elaborations on ACI and list data.

The scenario for electric and plug-in hybrid fuels is quite different. Here as the number of models offered increased, there were no significant and symmetrical responses on the demand side. The last two years have seen peaks of over-supply of more than 10 percentage points (Figure 9); in fact, the increased and diversified supply of electric and plug-in models, which rose from 5 percent in 2016 to 24 percent in 2022, has been matched by a moderate increase in demand, which only exceeded the 5 percent threshold in 2022. This result jars with incentives (by government and local authorities), the introduction of more affordable models, and the increased availability of charging infrastructure.

On this last point we note that, net of the disparities on the Italian territory (58 percent of charging stations in the North, 22 percent in the Center and 20 percent in the South and Islands), the number of public access charging points at the end of 2022 was close to 37,000: certainly not few and certainly adequate for the number of cars on the road. In fact, for every 100 electric cars on the road in Italy, there are 21.5 public-access charging points, compared with 11.5 in France and 8.2 in Germany. Italy's advantage remains even if we narrow the comparison to fast (DC) charging points only: 2.6 points for public use per 100 electric cars, compared with 1.5 in Germany, France.¹⁷

¹⁷ As of December 31, 2022, there were 36,772 charging points: 19,334 located in charging infrastructure (or stations, or columns) and 14,048 in publicly accessible locations. Source: "Le infrastrutture di ricarica a uso pubblico in Italia", by Motus-E.

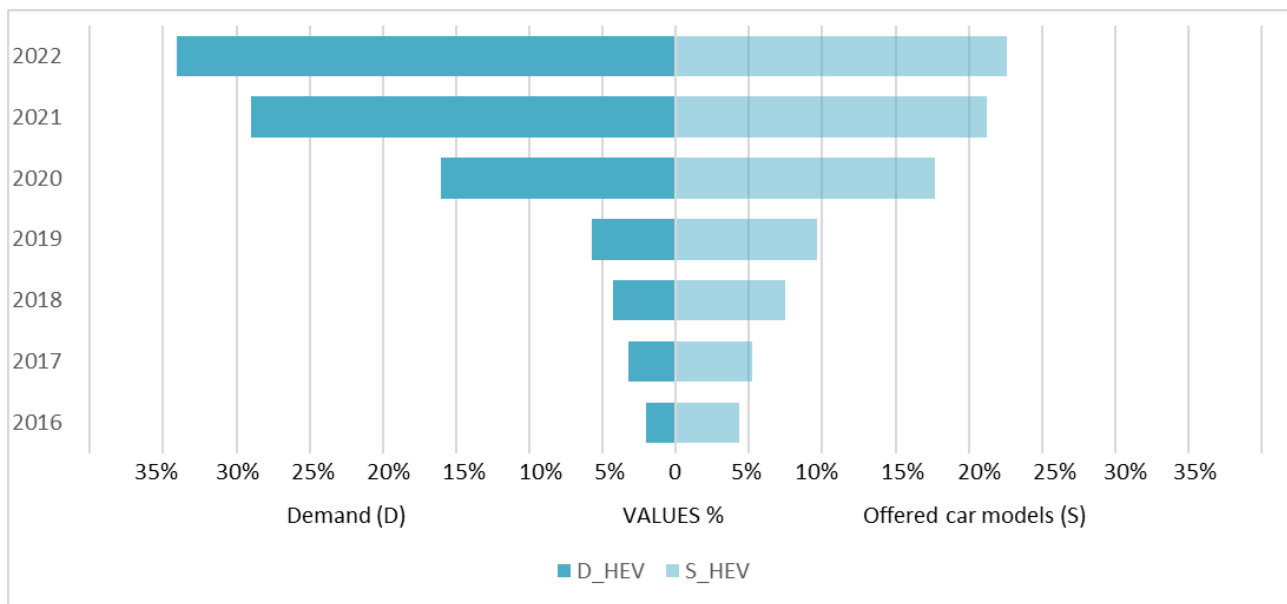


Figure 10. Registrations of new passenger cars (demand, D) and number of models offered (supply, S) in Italy for hybrid-powered (HEV) cars: percentage values, years 2016-2022. Source: our elaborations on ACI and list data.

The regulatory-rewarded expansion in the supply of rechargeable electric and hybrid models¹⁸ has taken space away from other powertrains, including non-rechargeable hybrids (Figure 10). Hybrid cars are those that have most convinced new car buyers, exceeding 22 percent of the total models purchased in 2022. This dynamic was driven by the entry of the hybrid Panda on the market in 2020. It should also be noted that the supply of hybrid-powered cars has grown almost mirroring the reduction in the supply of diesel and petrol models. During the period under review, a -17 percent in the supply of diesel and petrol models is marked against a +17 percent in the supply of hybrid models. In percentage terms, demand for this fuel over the past two years exceeds supply by more than 50 percent (Figure 10).

¹⁸ For instance, recall that Regulation (EU) 2019/631 has again provided for super-credits for cars with type-approval emissions below 50 g CO₂/km for the period 2020-2022. For the purpose of the calculation for meeting the target in the hands of manufacturers, such cars are counted twice in 2020; 1.67 times in 2021 and 1.33 times in 2022.

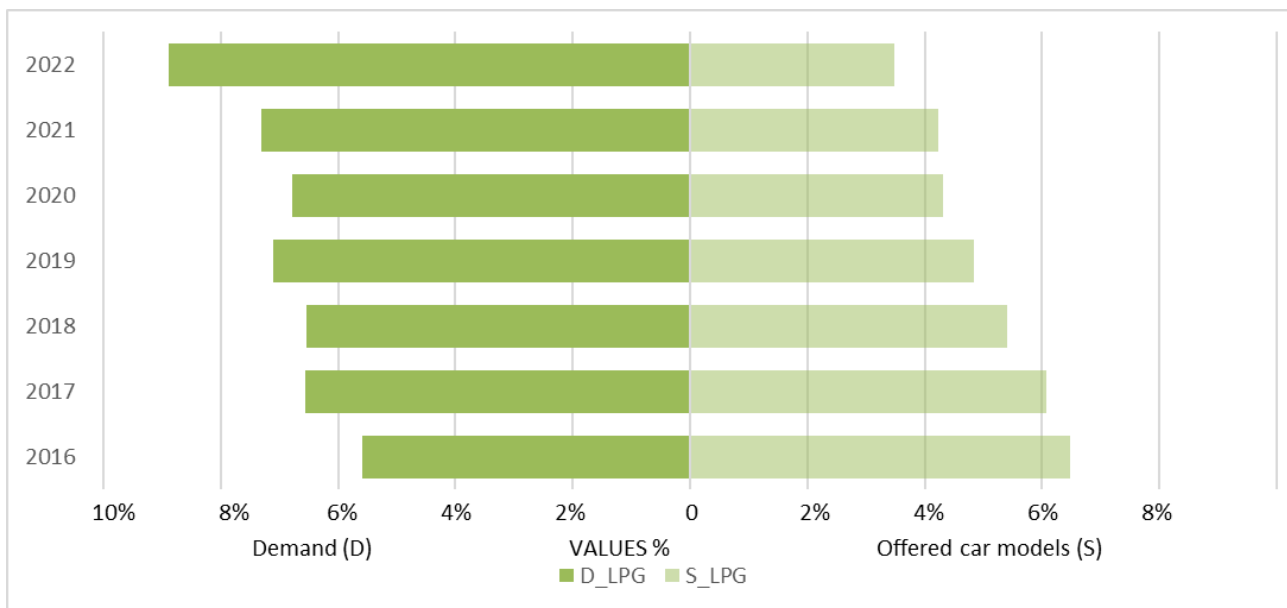


Figure 11. Registrations of new passenger cars (demand, D) and number of models offered (supply, S) in Italy for LPG-powered cars: percentage values, years 2016-2022. Source: our elaborations on ACI and list data.

Of particular interest, then, is the case of LPG-powered cars (Figure 11). In recent years the supply has shrunk and lost even more space - in relative terms - because of the expansion in the price lists of electrified cars. In contrast, consumer appreciation, especially in recent years, has been growing to a market share close to 10 percent (higher than that of electrics and plug-in hybrids added together) despite boasting seven times less models supplied.

06 Final remarks

This paper studied the effects of European regulations on carbon emissions on the automotive sector. Using available data on Italy, changes in the production strategies of automakers were first highlighted. Car manufacturers, proceeding on the path started years ago, have adapted the offer of new models (features and power supply) to the new policies. Therefore, on the price lists potential buyers find more and more efficient passenger cars and an increasing variety of electrified models. By changing the rules of the game, regulations passed by the EU have succeeded in forcing the supply side of the automotive industry (vehicle manufacturers) to change its behaviour.

But for the effects of the policies to translate into changes in the market, it is necessary that the new cars populating the lists move from the paper to the road. This is neither a negligible nor automatic step. Although we are unaware of any other work aimed at analysing this transition - neither for the Union nor for individual countries - it is an aspect that should not be taken for granted, because demand may follow logics that differ from those to which supply has had to conform: think of the huge stock of used vehicles for sale.

Still referring to Italian data, the paper analyses the trends in the registration of passenger cars. Empirical evidence leads us to conclude that changes on the supply side have not been matched, to date at least, by symmetrical changes on the demand side. The electrified

models that the supply side is forced to focus on (i.e. pure electric and plug-in) continue to sell poorly. In 2022 in Italy, less than 4 percent of new car buyers opted for a pure electric vehicle; only 5 percent chose a plug-in vehicle.

These are lower than in 2019 and previous years; yet, in the 2021-2022 biennium, the number of purely electric and plug-in models in the price lists were more than a quarter and almost a third of the total, respectively. When consumer needs are not met by the products offered, the only possible outcome of a market is crisis.

In contrast to what usually happens in high-tech product markets - a reference for automotive marketing - where technological innovation drives and, often, stimulates demand with products that anticipate customer desires, Italian consumers have not been enticed by new automotive offerings and indeed, in conjunction with the increased presence of electric and plug-in hybrid alternatives in the price lists, have revised their demand downward. According to data on new cars' registration, 2022 was the worst year in the last half century for many EU countries.

This dynamic was certainly conditioned by the pandemic (first) and the component crisis (then), valid reasons but which cannot suffice because the inexorable slump in passenger cars' registration jibes with the billions of euros allocated in incentives. Significant, in this regard, is the German episode of January 2023: the end of incentives for plug-in hybrids caused a 53.2 percent drop in registrations while the reduction of subsidies for pure electrics resulted in a 13.2 percent drop in sales compared to January 2022.

Someone might argue that the fact that few electric cars are being sold and that few cars are being sold in general is not a bad thing and that, indeed, reducing the motorization rate is a desired, though unstated, goal of EU policies. However, while sales have significantly contracted, car fleets have continued to grow: +0.3% in Italy, +1.2% on average in the EU in 2021 (ACEA, 2023).

In this paper we have opted for presenting Italian data because, unlike what it seems from the debate and from the media, Italy's specific weight in this context is relevant. As mentioned in the introduction, Italy is the third largest passenger car market in Europe both in terms of the number of new cars purchased and in terms of motorization rates; moreover, it hosts the second largest passenger car stock in Europe (ACEA, 2023).

Beyond the regulations, which are changeable by definition (the approval of the new car and light commercial vehicle regulation faced firm opposition from Bulgaria, Poland, Italy and Germany, overcome only by the agreement made with the latter on e-fuels)¹⁹ the success of electric vehicles will still depend on consumer choices.

¹⁹ Although new, e-fuels and climate-neutral fuels, both liquid and gaseous, like biofuels can be used by the whole passenger car stock and, more generally, by all existing motor vehicles.

As any dealer would argue, the best car - like any other product - is the one that sells well. In Italy, which has more clout in this area than Belgium, Denmark, the Netherlands and Sweden put together, despite the incentives and the development of a more than adequate charging infrastructure, electric car registrations are struggling to take off. The gap between supply and demand for new cars is growing, with supply moving toward pure electrics and plug-in models and demand leaning on hybrids and LPG. Not to mention that for every new car, two used ones are sold, and one of them is diesel-powered.

Among the determinants in the purchase of an electric car, at least for now, is certainly income, as is quite clear from the comparison of passenger car registration in EU countries. In this regard, it should be remembered that a good car can be defined as one having a set of features to which utility (satisfaction) is connected. This means that low-income individuals with an expensive good such as a car satisfy more needs than high-income individuals (who in fact can afford more than one car and/or alternative means of transportation to private car).

A comparison of the models offered by automakers and those purchased by motorists, certainly indicates that for many, the electric car is not (yet) a substitute for the internal combustion engine car. The case of city cars is paradigmatic. Indeed, with any A-segment car, including those that are more than ten years old, one can travel a long distance, at worst with less comfort and taking longer than with a car of a higher category. By contrast, with an electric city car, long highway journeys are simply out of reach. A fact that could also lead to a social problem of access to mobility.

To conclude, if the registration dynamics of recent years are not reversed, it is entirely unrealistic to assume a renewal of the passenger car stock in a finite timeframe. In the past four years, despite incentives - direct and indirect - allocated at several levels, the penetration of electric cars and plug-in hybrids in the Italian car fleet has not even approached 1 percent, with pure electric cars alone at around 0.4 percent.²⁰

The data used in this paper do not go beyond 2022; however, the recovery in registrations seen in the first four months of 2023 (almost +27% in overall registrations, +42% for electric cars alone) does not invalidate the points raised here. Pre-pandemic levels of volumes are still a long way off. The registrations of passenger cars in the first quarter of 2023 are more than 6% and almost 22% below those recorded in 2021 and 2019, respectively. There is a need to understand the reasons behind consumer reluctance and/or to explore alternative strategies. Excluding possibilities may not be the best solution, unless the EU want to give up the goal a priori (assuming that decarbonizing transports is the goal).

Shaping supply *ex-lege* cannot subvert the laws of supply and demand; not least because disappointed consumers will always be able to fall back on an abundant substitute for the new car: the used one.

²⁰ Source ACI, 2023.

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