Learning From Diesel's Failure: Government and Producer Policy Surrounding Hybrid & Electric Vehicles

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Abstract

This paper will examine the role subsidies have played behind diesel's market share decline in relation to hybrid and electric vehicles as well as the deadweight loss they produce. In many respects, the near widespread integration of hybrid vehicles into the automobile market parallels that of diesel's past integration; diesel cars were given subsidies as they were seen as a fuel efficient and environmentally friendly option, similar to the way in which hybrids are marketed today. This premature acceptance of hybrid vehicles has led to technological deficits in the production of batteries, manifesting in current environmental destruction. The aim is to provide a pathway in which hybrid vehicles don't suffer the same fate as the diesel and can facilitate a clean and efficient transition to an electric, net-zero society over the coming half-decade.

Keywords: Diesel, Hybrid, Electric, Subsidies, Deadweight Loss

Examining the Policy Failures Concerning Diesel Cars in the Context of Premature Transition to Full-Electric from Hybrid Vehicles

Diesel vehicles have persisted in being attributed as 'dirty', 'odorous' and 'sluggish' in current America. It is thus no surprise that their obsolescence has been largely welcomed, with non-commercial diesel vehicles comprising 1.4% of total American auto sales in 2021 (Diesel Technology Forum, 2022). In Europe, they have been received relatively better due to historical tax incentives and made up 18.4% of the European market share in the second quarter of 2020 (S&P Global, 2021). These figures are dwarfed, however, in comparison to their pre-dieselgate 55% European market share in 2011 (Diesel Net, 2019). Currently, even hybrid vehicles are being threatened from their dominant stance, with prominent sentiments such as 'skipping'—going straight from gas to electric—circulating.

Emissions Scandal

The Volkswagen emissions scandal in 2015 involved Volkswagen cheating on diesel emission testing by installing defeat devices in their 'clean diesel' cars. This allowed them to market their cars at significantly higher fuel economy metrics, while meeting tightening emissions requirements while testing. This directly violated the US Clean Air Act of 1970, and brought global stigma to diesels, serving to reinforce previous sentiments. Henceforth, while their TDI lineup of diesel cars had remained popular in some parts of Europe, they began to shift their direction away from diesel engines to hybrids. This was a failure that was impossible to predict or fairly mitigate by economists (after all, bad marketing will surmount most monetary incentives), but prior to it, diesel was already beginning to spiral down a path of inevitable extinction.

The Muddled Scientific Consensus

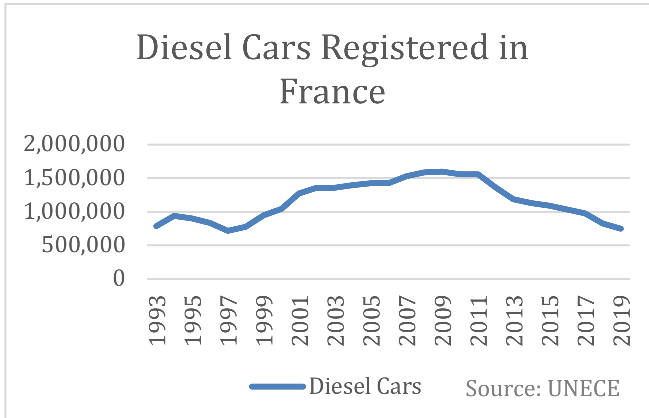
The conversation on the sustainability of diesel cars in relation to gasoline and hybrid ones has certainly been an open one; it has been well established that diesel vehicles emit less carbon dioxide and monoxide, but emit more soot and nitrogen oxides, which can create smog and cause a plethora of health-related ailments.

Current production diesel cars boast an array of emission devices. Modern diesel vehicles are equipped with a diesel particulate filter and exhaust gas recirculation systems, which both serve to drastically reduce particulate emissions. Furthermore, the somewhat new addition of diesel exhaust fluid or 'AdBlue' has allowed diesel vehicles to severely reduce their nitrogen oxide emissions through selective catalytic reduction. Hybrid vehicles were heavier, containing both a battery and gas tank, reducing their efficiency to shocking levels, of course pre-scandal. While on paper, hybrids were shown to have similar or slightly higher fuel economy than diesels, daily driving proved that diesel cars usually came out victorious. Take the two leading 2014 cars in their class, the Ford Fusion Hybrid rated at 47 mpg versus the Volkswagen Passat TDI rated at 43 mpg, a year before dieselgate. It seems as if the diesel was at a severe handicap, but real drives proved the opposite; the hybrid received an average of 36.8 mpg and the diesel 39.5 mpg (Braun, 2014). This was the case seen with countless other models in the years leading to dieselgate and was largely due to the biased manner in which the tests were conducted. Additionally, the batteries utilized in hybrid cars have been found to be incredibly toxic, with questionable labor practices recently coming under the public eye. This will be explored more vigorously later into the paper.

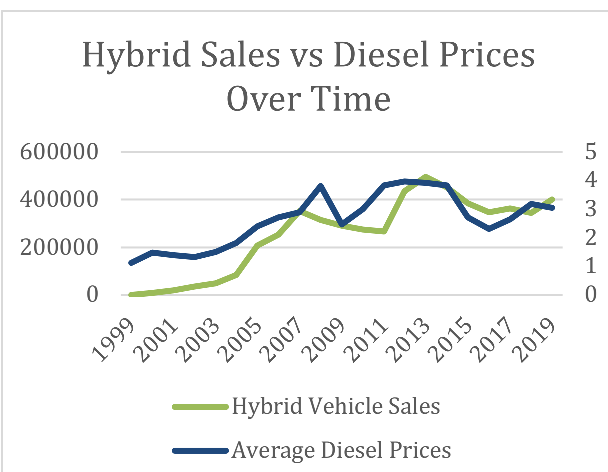
After Volkswagen was caught for cheating emissions, the company pledged to leave their dark, diesel past and reorient the company's research to hybrid and electric cars. The large-scale opportunity cost from this decision was catastrophic; diesel started to stagnate for the first time in years in terms of new innovations relating to performance, and more importantly, the environment.

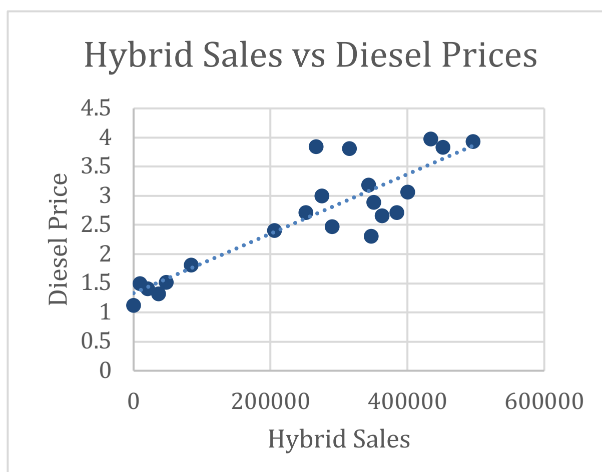
Policy Actions

The Energy Improvement and Extension Act of 2008 was the first instance of US large-scale investment into hybrids with the adoption of tax-credits for qualified plug-in models. In France, consumer subsidies favoring hybrids were also introduced as early as 2008, which was consequentially the peak for registration of new diesel vehicles there. The graph below depicts the effectiveness of such subsidies in the market for diesel cars in France; it is evident that diesels became unpopular long before the Volkswagen scandal. In combination with the subsidies, the French felt a personal obligation to take diesel vehicles out of their streets: the obligation to eliminate city smog. It has been well established in the scientific literature that diesel vehicles emit more soot and thus contribute to smog to a higher extent than gas and hybrid vehicles. Despite the validity of these claims, the literature is split over diesel's impact to global warming, as it is the question of whether the lower carbon dioxide levels outweigh the effect the soot and nitrogen oxides have on the environment. This is far beyond the scope of this paper, but the conclusion relevant to this analysis is the similarity between gas, diesel and hybrid vehicles during the time preceding 2015.



Since the creation of the hybrid, diesels have existed in the minds of consumers as a clear-cut substitute. The subsequent analysis compares diesel fuel prices and the demand for hybrid vehicles. Gasoline prices were omitted since in the US all hybrids run on gasoline and thus are viewed as complimentary goods. Compiled using data from the US Energy Information Administration and the Alternative Fuels Data Center, an R^2 value of 0.705 has been obtained, demonstrating a strong effect size between the two goods. It must be noted that the data has been limited by only utilizing data points per year, rather than by month; these graphs serve to give a general picture.

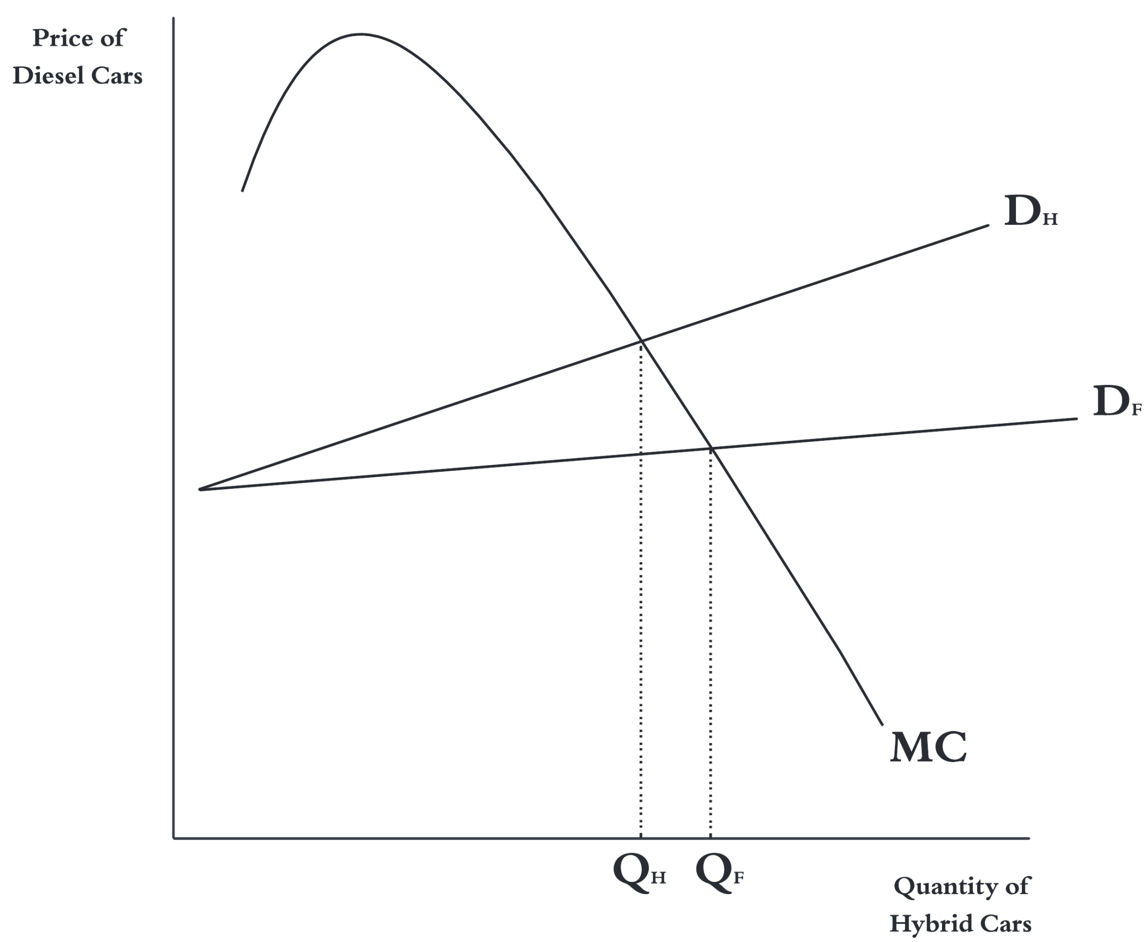




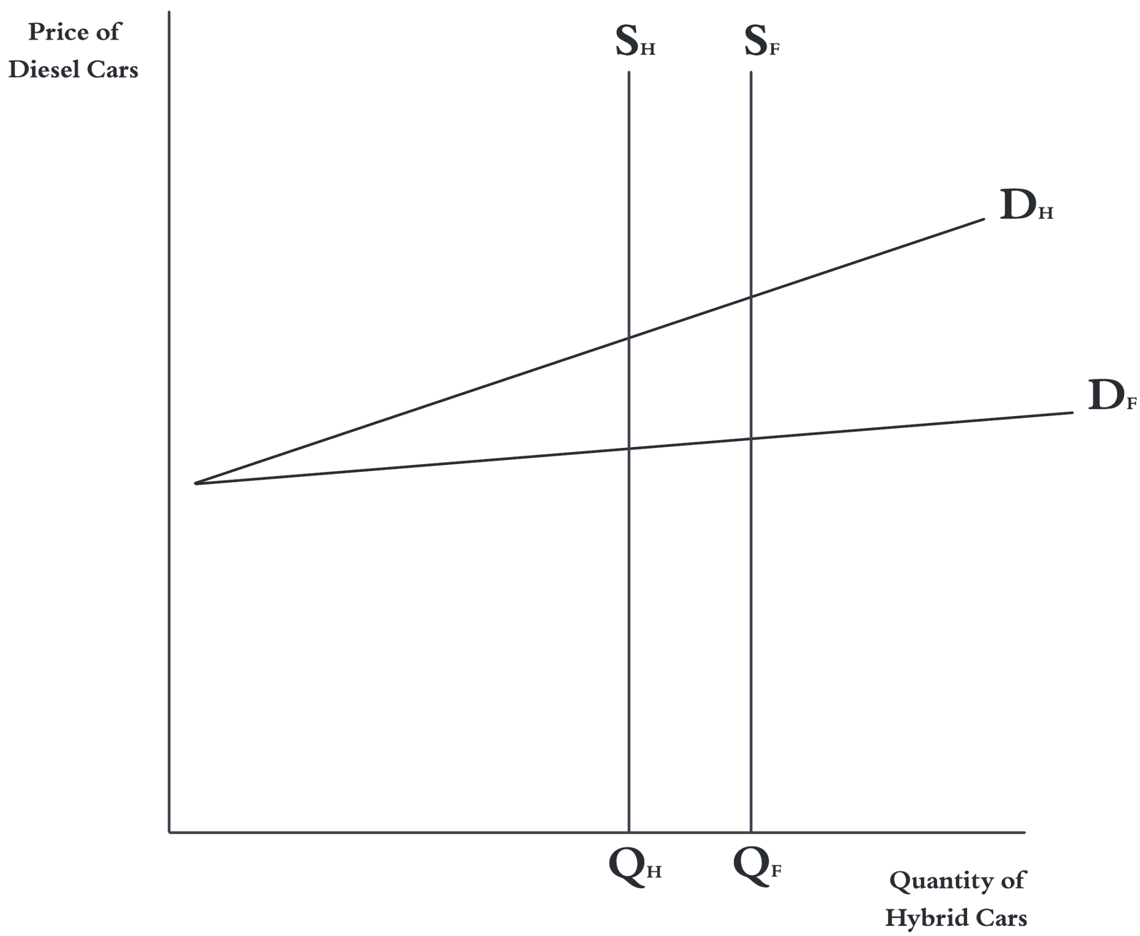
The average cross-price elasticity of demand between the demand for hybrid vehicles and diesel prices is calculated as 5.053, establishing that they are substitutes and that the demand for hybrid cars is heavily elastic on the price of diesel. Due to the analysis considering diesel prices rather than the price of diesel cars, the relationship is less direct, nonetheless strong; hybrids are an indirect substitute for diesel cars due to diesel, a compliment for diesel cars, having a positive cross elasticity. This is no surprise, but the extent of the elasticity is important in understanding consumers' willingness to transfer to hybrids as a result of a combination of prevailing public sentiment and subsidies.

Modeling

Applying the above findings to a theoretical model will help visualize these effects and will allow future consequences to be interpreted. The model will map the price of diesel cars in relation to the quantity of hybrid cars produced (the price of diesel cars will encompass diesel fuel and all other diesel-related prices consumers envision). This model is not meant to be an accurate representation of the current markets, but a general representation that can extrapolate future changes. Below is a seemingly bizarre yet consistent graph of the two goods through the lens of one firm.



D_H represents current consumer demand for hybrid vehicles when crossed with the price of diesel ones and is upward sloping due to them being substitutes; at a higher price of diesel cars, substantially more hybrid cars will be demanded. This first graph depicts a firm that produces both diesel and hybrid cars, with its marginal cost denoted MC. If a firm can reasonably sell diesel cars at a higher price, it will produce relatively less hybrid cars, and if diesel cars are being sold for a lower price, producing more hybrid cars is preferable to the firm. The equilibrium quantity of hybrid cars being produced is depicted as Q_H, and represents current output. In the future, it is expected that the cross-price elasticity of demand for hybrid cars will increase as it will become a more advantageous substitute to diesel cars not offering the same tax exemptions. Thus, the slope of demand will decrease, tending to perfect elasticity from the opposite direction as would be seen in a typical supply and demand graph. The future equilibrium quantity, Q_F, increases over time. Below is a graph representing the entire cross market for hybrid vehicles.



Here the difference lies in the vertical supply because in the aggregate picture, the quantity of hybrid cars produced is largely independent of the price of diesel cars. The supply will increase over time due to the vox populi and subsidies, as well as it being more profitable for firms as demonstrated in the previous graph.

It is very well possible that diesel and fully gas cars will be replaced by hybrid ones soon in this model, with the cross-price elasticity of demand for electric vehicles in relation to the prices of gasoline and hybrid vehicles being positive and high. It will thus be observed that electric cars will be produced at a higher rate, as the cross-elasticity demand curve tends to perfect elasticity.

Battery Sustainability

Batteries in hybrid and electric cars have progressed significantly since their first introduction in terms of both performance and sustainability. Nevertheless, current practices used to harvest, produce and recycle these batteries are still raising serious environmental concerns. While hybrid batteries are substantially differentiated from their electric counterparts in terms of size and environmental impact, they often utilize the same types, and, for the purposes of this study, electric cars will prove a more dominant focus as they are the next subject of transition.

Most electric and hybrid vehicles now use lithium-ion batteries; to find environmental problems one need not look further than the production of their very source: lithium. The mining of lithium requires an exuberant amount of water to be pumped down into salt flaps, with 500,000 gallons of water pumped per ton of lithium (Katwala, 2018). The geography of the extraction exacerbates the problem; over half of the Earth's lithium supply is in the Lithium Triangle, stretching across the Andean Mountains in Argentina to Chile and Bolivia. In one of Chile's mining regions, lithium mining activities capture 65% of the water there, causing major environmental detriments such as groundwater depletion and soil degradation (UNCTAD, 2020). Furthermore, local and regional developing economies are hurt the most as they hold the largest concentration of lithium mining. Cobalt is also extensively used in the production of lithium-ion batteries; the UN finds that over two-thirds of global production of cobalt takes place in the DRC and other central African regions, where roughly 20% of cobalt is produced by the labor of 40,000 children who work in truly abhorrent conditions. Environmentally, cobalt production translates into sulfuric acid production which has a lasting negative effect on biodiversity and various ecosystems.

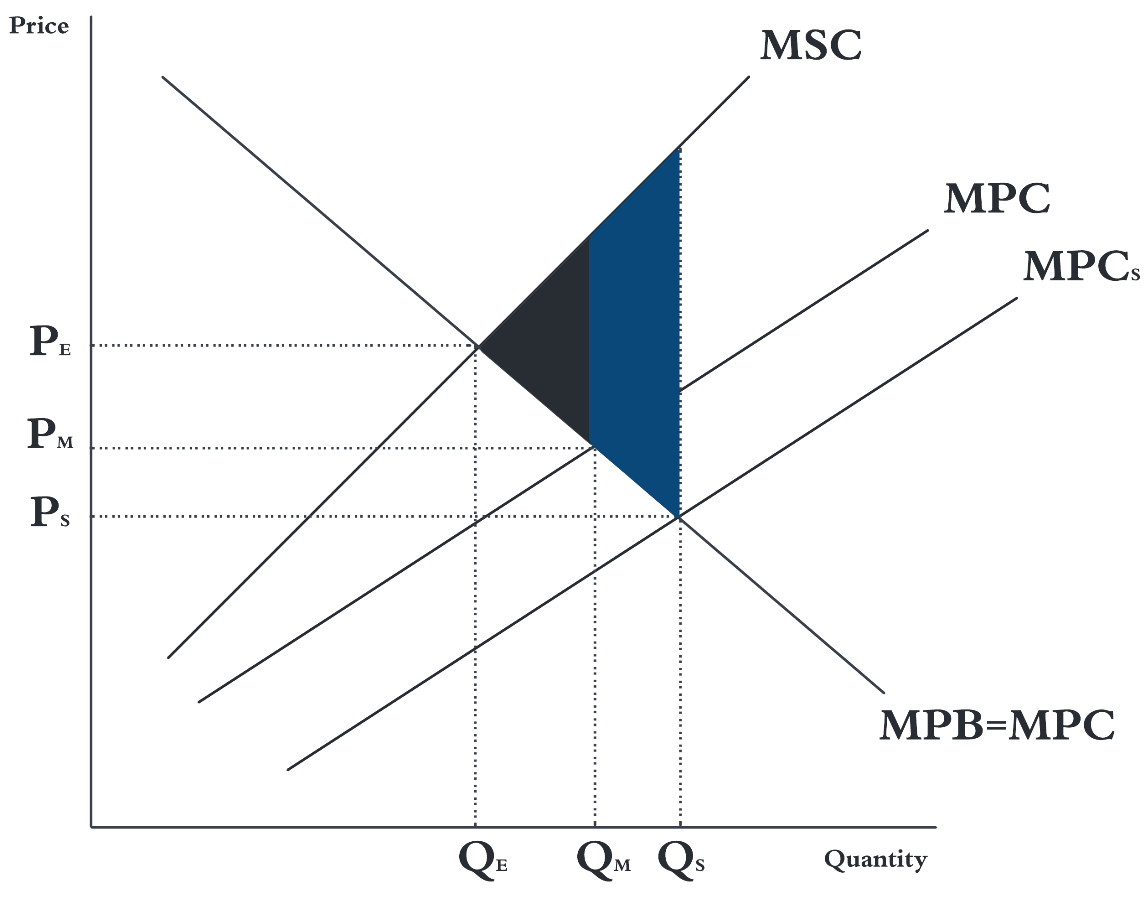
The production phase has been found to be the most damaging, with the phase emitting up to 2 times the amount of greenhouse gases than that of the respective one of full combustion vehicles (Sheldon, 2022). Of course, the charging of electric vehicles while in use is derived in the most part from unrenewable sources, despite the power grid gradually becoming more renewable. After use, only 5% of lithium batteries are recycled, with most of the rest being dumped in landfills which are a huge contributor to global warming. This entire problem is growing in severity as the demand for lithium is increasing at an exponential pace in the status quo and little effort is being devoted to address the problems with each stage of an EV's life.

All of the above is not to say that electric vehicles are overall less sustainable, as multiple studies have proven that over an EV's life, the environmental benefits outweigh the harms, but is a warning that our current thirst for batteries as a result of high demand for EVs is not sustainable without preserving current gas-dependent hybrid cars and infrastructure. Building a fracking well, for instance, may be more damaging than mining lithium, but the reality is that the US and other countries have enough of them already, and the maintenance of wells and extraction of the oil itself will produce nowhere near the environmental effects that each battery requires.

It is now necessary to preserve the dominance of the hybrid cr, which in comparison to the electric, sees a more sustainable battery process overall.

The Irony of Subsidies

Examining the work of late scholar and student Jim Pagels, current and past policy surrounding hybrid and electric vehicles has been and continues to be counter-productive through the lens of deadweight loss. Electric and hybrid cars, by the essence of being cars, create negative externalities, not including their immense impact with batteries through environmental damage and human rights abuses. Spillover costs include traffic congestion, accidents, air and noise pollution, costs for landscaping, and brake pad microplastic emissions (Pagels, 2021). This creates a higher marginal social cost to society that isn't reflected in the marginal private cost, forming deadweight loss. The graph below represents the market for hybrid/electric vehicles.



The higher marginal social cost, denoted MSC, creates an equilibrium quantity and price Q_E and P_E respectively that reflects the socially optimal outcome. In the hypothetical free market, only the marginal private cost, denoted MPC, is reflected—creating an outcome Q_M and P_M that forms deadweight loss by eliminating much social surplus. The appropriate policy action, as prescribed in the most basic of microeconomic teachings, is to tax the producers of the good to decrease supply and bring the market to optimal equilibrium. Rather, governments have chosen to subsidize this negative externality as they would with a positive one, lowering marginal private cost to MPC_S. This increases the quantity and price to Q_S and P_S, bringing the quantity even further away from the optimal amount. This creates additional deadweight loss (shaded blue) that largely builds upon the existing loss (shaded black). In this scenario, producer subsidies are being depicted, while in reality it is a combination of both producer and consumer ones, ever enlarging the loss to total welfare.

The argument against this stance is that every trip in an electric or hybrid vehicle exactly replaces every potential trip in a diesel and gas car proportionately. This is simply false; the purchase of an electric or hybrid vehicle will undoubtedly replace more travels previously taken not only by car but by biking, taking a bus etc. The theoretical spillover costs of diesel and other internal combustion vehicles may be higher than that of electric and hybrid vehicles, but regardless, they are not being subsidized and are thus experiencing less or comparable levels of deadweight loss. It should further be noted that electric cars will experience more deadweight loss than hybrids due to the sheer number of subsidies given and canceling-out environmental effects. This furthers the notion that diesel vehicles were meaninglessly driven to antiquation and serves as a warning to preserve hybrid vehicles until electric vehicles cease in being heavily subsidized and unsustainable.

Conclusion

Policymakers have achieved their precise goal in reducing the amount of non-commercial diesel cars on roads today, even if that has meant higher deadweight loss and more environmental degradation. In foresight, the opportunity cost of the overwhelming hybrid and electric investment following 2015 is far-reaching in that current diesel technology could've been phenomenal. It is surely too late to revive the diesel, but the previous general analysis has shown that hybrid technology has a chance to facilitate the best possible permutation of the electric revolution if it is still seen as an acceptable option in the near future, rather than being largely replaced by hypersubsidized electric cars too soon. Electric vehicles will find their place in the future that will ultimately allow for a more sustainable, clean world; it is a matter of timing, and to repeat the faux pas that was the policy surrounding the diesel-hybrid transition would indeed be an unforgiving error.

References

Braun, P. (2014, March 23). *Diesel versus hybrid: The battle for eco-friendly supremacy*. Digital Trends. Retrieved April 23, 2022, from https://www.digitaltrends.com/cars/diesel-vs-hybrid-get-answer-might-surprise/

EU market share of diesel cars falls to 39.5%. news: EU market share of diesel cars falls to 39.5%. (2018, March 27). Retrieved March 5, 2022, from https://dieselnet.com/news/2018/03eu.php

Katwala, A. (2018, August 5). *The spiralling environmental cost of our lithium battery addiction*. WIRED UK. Retrieved April 25, 2022, from https://www.wired.co.uk/article/lithium-batteries-environment-impact

Maps and Data. Alternative Fuels Data Center: Maps and Data. (n.d.). Retrieved April 25, 2022, from https://afdc.energy.gov/data/

Pagels, J. (2021, March 24). *Electric vehicles are negative externalities*. Medium. Retrieved April 25, 2022, from https://jpagels.medium.com/electric-vehicles-are-negative-externalities-869423ddcd35

Perkins, R. (2021, July 23). *Europe's gasoline, diesel car sales slump to 60% of market as evs gain ground*. S&P Global Commodity Insights. Retrieved March 5, 2022, from https://www.spglobal.com/commodity-insights/en/market-insights/latest-news/oil/072321-europes-gasoline-diesel-car-sales-slump-to-60-of-market-as-evs-gain-ground

Sheldon, A. (2022, April 20). *Are Electric Car Batteries Bad for the environment?* Your AAA Network. Retrieved April 25, 2022, from https://magazine.northeast.aaa.com/daily/life/cars-trucks/electric-vehicles/are-electric-car-batteries-bad-for-the-environment/

U.S. no 2 diesel retail prices (dollars per gallon). (n.d.). Retrieved April 25, 2022, from https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMD_EPD2D_PTE_NUS_DPG&f=A

U.S. Vehicle Sales Dashboard. https://www.dieselforum.org. (2022). Retrieved March 5, 2022, from https://www.dieselforum.org/vehiclesales/u-s-vehicle-sales-dashboardc

UNCTAD. (2020, July 22). *Developing countries pay environmental cost of electric car batteries*. UNCTAD. Retrieved April 25, 2022, from https://unctad.org/news/developing-countries-pay-environmental-cost-electric-car-batteries

UNECE Statistical Database. Select table - UNECE Statistical Database. (n.d.). Retrieved April 24, 2022, from https://w3.unece.org/PXWeb2015/pxweb/en/STAT/