WHAT DRIVES DECARBONIZATION OF NEW PASSENGER CARS?

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Overview

Passenger cars are a major contributor to the carbon dioxide (CO_2) emissions, the most important greenhouse gas contributing to climate change. In the European Union (EU), there we 251 million passenger cars on the road in 2015, producing 770 million metric tons of CO_2 emissions, 22.2% of the EU total CO_2 emissions of the year (Mock, 2015). Reducing CO_2 emissions of passenger cars is critical for the EU to achieve its abatement targets.

To promote the transition towards a low-carbon passenger car fleet, the EU has stipulated a series of climate policies to decarbonize new passenger cars. One important, supply-push strategy is that manufacturers' new cars sold on the EU market are subject to mandatory CO_2 emission targets (European Parliament and the Council, 2009). On the demand-pull side, the EU directiveon car labelling requires disclosure of the CO_2 information to consumers (European Parliament and the Council, 2000) and Member States have implemented a variety of fiscal instruments to shift consumer preferences towards low CO_2-emitting cars. Examples of those fiscal instruments include CO_2-based vehicle taxes imposed on the registration and/or use of cars, rebates for the purchase of green cars, and fees for the purchase of high CO_2-emitting cars (Verboven, 2014).

In Finland, the average CO_2 emissions from newly registered passenger cars have decreased quite dramatically over the past dozen years. An average new car in Finland emitted 118.8 grams of CO_2 per kilometer in 2017, 35% (63.8 g/km) lower than the 2002 level. What drove the dramatic decrease in the average CO_2 emissions of the Finnish new-car fleet during the past decade? Was it just a scam due to test manipulation (e.g., the Volkswagen scandal) or was there real progress? Answering these questions is important because it can help the EU and Finland assess the climate policies to decarbonize new passenger cars, identify facilitators and obstacles, and make better informed policy decisions.

In general, the average CO_2 emissions of newly registered cars can decrease owing to the following factors: 1) *technical change*, i.e., car models available on the new car market become more CO_2 efficient (less CO_2 emitted per unit of transportation service produced); 2) *efficiency change*, i.e., the proportion of new cars with higher CO_2 efficiency rises; 3) *attribute change*, i.e., new cars become lighter and/or less powerful at the same time as the CO_2 efficiency improves; 4) *structural change*, i.e., the proportion of new cars powered by low CO_2-emitting fuels rises; 5) *test manipulation*, i.e., the measured CO_2 value may be subject to cheating or underestimation in type-approval tests.

Methods

The purpose of this study is to investigate the roles of different factors in driving the drastic decline in the average CO_2 emissions of Finland's new passenger cars.

Consider that the fleet of new passenger cars registered in year *t* comprises different cohorts of new cars by fuel type (gasoline, diesel, or alternative fuels such as compressed natural gas, electricity, biofuels, etc.). In order to examine the drivers for the decarbonization of new cars, the present study proposes a two-stage decomposition approach: 1) at the first stage we use index decomposition analysis to decompose changes in the average CO_2 emissions from the new-car fleet into two components representing the effects of structural change and average-emissions change at the cohort level; 2) the second-stage decomposition is built upon emissions generating functions estimated by convex nonparametric least squares, which allows us to further decompose the average-emissions change in each cohort of new cars into technical change, efficiency change, and attribute change.

What about the last source of change: test manipulation? Various sources indicate that there has been a widening gap between type-approval and real-world CO_2 emissions for passenger cars (Tietge et al., 2016). To take this issue into account, we choose to adjust *ex post* the estimated decomposition results, as available data on the real-world CO_2 emissions of passenger cars are scattered.

Results

Table 1 reports the main results of this paper. Looking at the bottom row of the table, we see that the aggregate average (type-approval) CO_2 emissions of new passenger cars in Finland decreased, on average, by 2.90% per year between 2002 and 2014. This decline was hardly due to changes in the composition of gasoline and diesel cohorts

(ΔSC), but could almost all be attributed to changes in the cohort-average CO_2 emissions (ΔAEC); the average effect of ΔSC was merely 0.9994, while the average effect of ΔAEC was 0.9716, significantly less than unity. Further, the decreasing effect of ΔAEC was, on average, induced mainly by aggregate technical change (ΔTC) and slightly by aggregate efficiency change (ΔEC), but hindered by aggregate attributed change (ΔAC).

Table 1: Decomposition results for the Finnish new-car fleet, 2002–2014.

Period		ΔFleetAverage	ΔSC	ΔAEC	ΔTC	ΔEC	ΔAC
2002–03		0.9935	0.9999	0.9936	0.9878	0.9984	1.0075
2003–04		1.0048	0.9997	1.0052	0.9848	1.0097	1.0109
2004–05		0.9954	0.9998	0.9956	0.9865	0.9994	1.0099
2005–06		0.9979	0.9996	0.9983	0.9868	1.0003	1.0114
2006–07		0.9864	0.9991	0.9873	0.9725	1.0062	1.0090
2007–08		0.9191	0.9944	0.9243	0.9753	0.9832	0.9639
2008–09		0.9628	1.0007	0.9622	0.9660	0.9861	1.0101
2009–10		0.9496	1.0000	0.9496	0.9583	0.9941	0.9968
2010–11		0.9635	1.0000	0.9635	0.9402	1.0114	1.0133
2011–12		0.9659	0.9996	0.9663	0.9538	1.0061	1.0070
2012–13		0.9488	0.9996	0.9492	0.9567	0.9954	0.9967
2013–14		0.9679	1.0004	0.9675	0.9757	0.9988	0.9928
g-mean	2002–07	0.9956	0.9996	0.9960	0.9837	1.0028	1.0097
	2007–14	0.9538	0.9992	0.9546	0.9608	0.9964	0.9971
	2002–14	0.9710	0.9994	0.9716	0.9703	0.9990	1.0023

Note: *g*-mean denotes geometric mean.

Conclusions

In this study, we have developed a two-stage decomposition approach specifically for assessing driving factors behind the decarbonization of new passenger cars. The proposed approach has three major benefits. First, we have combined the traditional index decomposition analysis with a frontier-based decomposition analysis, which allows us to systematically distribute changes in the average CO_2 emissions from new passenger cars to a series of factors representing structural change, technical change, efficiency change, attribute change, and discrepancy change. Second, the frontier-based decomposition analysis at the second stage is built upon convex nonparametric least squares and thus can handle random noise without the need to assume *a priori* any particular form for the emissions generating function and take the heterogeneity of different car models explicitly into account. Third, the proposed approach possesses the desirable properties of time reversal, factor reversal, and zero-value robustness.

The proposed approach was applied to identify and quantify the driving factors for the development of the average CO_2 emissions from new passenger cars in Finland during the period 2002–2014. Based on the decomposition results, we have argued that the decarbonization process was not very satisfactory, or partly satisfactory if focusing on the type-approval (rather than real-world) CO_2 emissions of new passenger cars.

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