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The gravity of electromobility

An early investigation of structural change in automotive industry

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Contents

Abstract

In this paper we examine the role of the electromobility transformation for exports of the automotive sector. To do so, we propose a novel mapping of granular codes of automotive products into three categories: (i) combustion-specific, (ii) neutral, and (iii) electric-specific. We estimate a standard gravity model of the trade flows of automotive products, comparing the three categories with each other. We demonstrate that key drivers of export of the electric-specific products are similar to the combustion-specific ones. However, exports related to electric vehicles are more technologically intensive and supported by either a domestic R&D potential or international knowledge spillovers through FDI. In particular, export-oriented production of electric-specific intermediates proves to be to a large extent R&D intensive. Our results also suggest that the ongoing structural change in the automotive industry leads rather to intra-industry reorganization than to more fundamental restructuring of existing Global Value Chains.

Keywords: automotive industry, international trade, gravity model of trade, structural change, electric vehicles, electromobility, Global Value Chains.
JEL Classification Numbers: F14, L16, L62.

1 Introduction

The global automotive sector is currently undergoing the electromobility revolution, which means the gradual transition from the production of vehicles with internal combustion engines (ICEVs) to the production of electric vehicles (EVs). The fundamental difference between these types of vehicles lies in their power source. While in traditional internal combustion engine vehicles energy comes from burning fuels (gasoline, diesel, or liquified petroleum gas), in the case of their electric counterparts, energy is supplied by batteries. The electromobility revolution thus involves the need for adjustments in the production process and international supply chains, which poses a significant challenge for the global automotive sector.

The sales of electric cars have been very dynamically rising over the last years. In 2023, the global sales of electric cars were almost 14 million (compared to 2.2 million in 2019), making 18% of all cars sold. In 2024 electric car sales were expected to continue to grow, likely reaching 17 million, the one-fifth of global car sales (International Energy Agency, 2024). However, electric car sales are still concentrated mostly in China, Europe, and the United States, with these three regions making nearly 95% of global electric car sales (International Energy Agency, 2024). Global fleet of electric vehicles is expected to grow dynamically over the next decade, likely reaching twelve times the size it was 2023 by 2035 (International Energy Agency, 2024).

The transition from vehicles with internal combustion engines (ICEVs) to electric vehicles (EVs) is a necessity to reach the CO2 emission reduction goals as emissions from the road transport constitute a substantial share of overall emissions. For instance, in the European Union, transport emissions represent more than 20% of greenhouse gas emissions, the vast majority of which come from road transport. Within road transport, passenger cars and vans are responsible for more than 70% of all CO2 emissions (European Commission, 2023).

Policies introduced in developed countries and China support rapid electrification of road transport. Despite decreasing in recent years, the price of electric cars is still higher than that of their counterparts with internal combustion engines in Europe and the United States. To reduce the price differential and stimulate the demand for EVs, countries have introduced tax exemptions, tax credits or direct subsidies for electric car purchases. For instance, under the Inflation Reduction Act the US consumers who buy an EV can qualify for a 7500 USD tax credit. Financial incentives have indeed positively stimulated the EV adoption (Münzel et al., 2019). An example of supply-side stimulation is the EU setting CO2 emission targets for the fleet of new passenger cars and vans. The CO2 emission targets will be gradually reduced and from 2035 onward the CO2 emission target will be 0 g CO2/km, which means reaching 100% of zero-emission cars sales in 2035. Finally, governments can support the development of the complimentary infrastructure to stimulate electromobility adoption (Neves and Marques, 2025). For instance, in the European Union, public fast chargers will be required along main transport corridors.

EVs differ from ICEVs in the number of ways, but from the perspective of this study, the technical differences are key. Differences in propulsion systems mean that several parts present in ICEVs are absent in EVs (e.g., a combustion engine, fuel and exhaust systems). On the other hand, EVs require new parts not found in ICEVs (e.g. an electric engine, a battery, an inverter, an onboard charger and a charging port). At the same time, many parts are identical or very similar in both ICEVs and EVs (e.g., road wheels, suspension systems, airbags, seats).

Moreover, the production of electric vehicles requires fewer parts, and powertrains in particular are much simpler in EVs than those in ICEVs. While the powertrain of ICEVs consists of 45 different structures, the power train of EVs consists of only 27 structures (Murmann and Schuler, 2023). The relative importance of modules is also very different in the two types of cars. While the engine is the most valuable part of a powertrain of ICEVs, in EVs it is the battery (Murmann and Schuler, 2023).

In a broader context, there is no consensus on whether the shift towards electromobility will be labor-saving. On the one hand, technical differences between EVs and ICEVs imply that labor requirements are substantially higher for the production of a conventional powertrain than for the production of a powertrain for EVs (Bauer et al., 2019; Herrmann et al., 2020; Galgóczi et al., 2023). In particular, the ongoing shift to EVs will reduce the length and complexity of the automotive sector production chain and is expected to have a negative impact on employment in the sector (Bauer et al., 2019; Mönnig et al., 2019; CLEPA, 2021; Galgóczi et al., 2023). In fact, Celasun et al. (2023) find that the electromobility transition has already had a negative impact on employment growth in the automotive sector in Europe. On the other hand, recent empirical studies provide evidence suggesting that electrification will stimulate demand for automotive workers. For example, Weng et al. (2024) document that assembly of EV is more labor-intensive than that of conventional cars. Even if these differences are temporary due to technology adoption, it should be mentioned that the battery manufacturing could be a key driver of the EV employment and could absorb expected fall in demand for labor engaged in production of traditional ICEVs and related components (Cotterman et al., 2024).

Given that the automotive sector production is highly fragmented and intensively integrated into global value chains, such a shortening of the sector's GVCs might have a substantial impact on trade flows. Automotive products accounted for 9.0% of global merchandise trade in 2023 [1]. The transition to the production of the EVs might be a particular challenge for countries heavily dependent on the automotive sectors such as Germany or Eastern European economies such as Slovakia, Czechia, and Hungary (the respective shares of automotive products in the countries' merchandise exports were 19.4%, 37.4%, 22.1%, and 22.2% in 2023). Murmann and Schuler (2023) report that EVs, although technologically simpler than ICEVs, are characterized by slightly more technological dependencies between different components compared to ICEVs. They suggest that this feature will foster strong integration of value chains with leading roles of existing automotive multinationals, as observed in the production of ICEVs. The impact of electromobility transformation will likely be differentiated across countries in respect to size and timing due to different functional specialization patterns of economies (Delanote et al., 2022; Pavlínek, 2023). Particularly, periphery countries, such as the CEE economies, are likely to lag behind the Western European economies in implementating electromobility in both manufacturing and sales (Galgóczi et al., 2023). Countries with strong specialization in ICEV-specific components might face a challenging demand shift that threatens their automotive sectors.

To scrutinize the main drivers of international trade related to electromobility we provide a new systematic classification of the granular automotive products into three categories: (i) automotive products, which consist of both combustion-based vehicles and necessary intermediates used only in production of these goods, (ii) products that are specific to electric vehicles, and (iii) neutral automotive products that can be used in manufacturing of both ICEVs and EVs. The classification is then used to aggregate highly detailed product trade data into the three categories of automotive products for bilateral trade flows.

Our contribution to the literature is twofold. First, we document that the exports of electromobility-related products are driven by the same fundamentals as the exports of ICEV-related products. A key difference between these flows is the

[1] Data source: WITS. Automotive was defined here as section 34 (Motor vehicles and trailers; parts and accessories for motor vehicles) in NACE Rev. 1 system.

technology intensity. In fact, the exports of EVs and EV-related products are to a greater extent stimulated by either domestic R&D activity or technology transfers from multinational enterprises via capital linkages. Importantly, the exports of EV-related intermediates are particularly innovation-dependent. Second, our empirical evidence indicates that the initial structural change in the internationally fragmented automotive industry is primarily occurring within existing supply chains. This, in turn, suggests that the fundamental reorganization of the supply chains of the automotive industry is likely to remain limited.

Importantly, our key findings pass several robustness checks. First, the documented patterns are apparent both in highly disaggregated product data, when we estimate a gravity model based on highly granular data instead of the aggregates. Second, our main results are also quite robust when we analyze the extensive margin of bilateral trade by applying logistic regression for bilateral trade flows.

The remainder of the article is organized as follows. In Section 2, the data sources and the empirical strategy are discussed. Section 3 provides baseline gravity model estimates for exports of specific product groups of automotive sector, total vehicles and parts category, and products of total manufacturing sector. Robustness checks are discussed in Section 4. Finally, Section 5 concludes.

2 Empirical strategy and data

In this section, we discuss the research strategy and data sources.

2.1 Mapping of electromobility-related products

A key problem that we face when analyzing the electromobility in the context of international trade is the lack of available taxonomies that would distinguish electromobility–related products from other goods. In this vein, existing mapping strategies in the associated literature focus rather on technology intensity rather than on the powertrain types (see Amighini and Gorgoni, 2014). To overcome this issue, we propose our own classification which groups automotive products by their exposure to the electromobility transition. We identify three categories of automotive products: electric-specific, combustion-specific, and neutral.

The first category, **electric-specific** automotive products, includes products that are directly related to the electromobility. Apart from the final products, i.e., electric vehicles, this category also encompasses intermediates that are used in their production but are not required for the manufacturing of vehicles with a combustion engine. For instance, electric-specific automotive products include electric engines, batteries, inverters, onboard chargers, and charging ports.

The second category, the **combustion-specific** automotive products, is composed of products that are solely related to the production of internal combustion engine vehicles. As in the case of the electric-specific category, it contains both final goods and intermediates. It should be noted that apart from combustion engines, there is a variety of parts that are used only in production of ICEVs, e.g., fuel and exhaust systems, radiators, clutches or sparking plugs.

To close the classification, we also identify the **neutral** automotive products. This category includes i) parts that are required in production of both EVs and ICEVs, ii) motorcycles, tractors, and special-purpose vehicles, and iii) hybrid (HEV) and plug-in hybrid (PHEV) passenger cars. Although HEVs and PHEVs are relatively new products with increasing market shares, their inseparable use of an internal combustion engine prevents them from being classified as electric-specific products. Hence, the first category of products will benefit from the electromobility transformation, the second one will lose, while the third will remain neutral to these opposing trends.

Our mapping strategy for automotive products uses highly disaggregated product codes, represented at the 6-digit level, from the HS 2017 classification. The detailed classification is delegated to Appendix A. Our choice of the HS 2017 classification is the result of a trade-off between precision and data availability. On the one hand, with more recent versions of traded goods nomenclature one might expect more precise mapping of products related to the electromobility transformation. Given that we are interested in the structural change within the automotive industry, it should be mentioned that in extreme cases new products (mostly electric-specific) were not previously traded, making it difficult to identify their role with the older versions of traded products classifications. On the other hand, the more recent classifications substantially limit the available time dimension. Thus, we chose the HS 2017 classification as a compromise between the two issues.

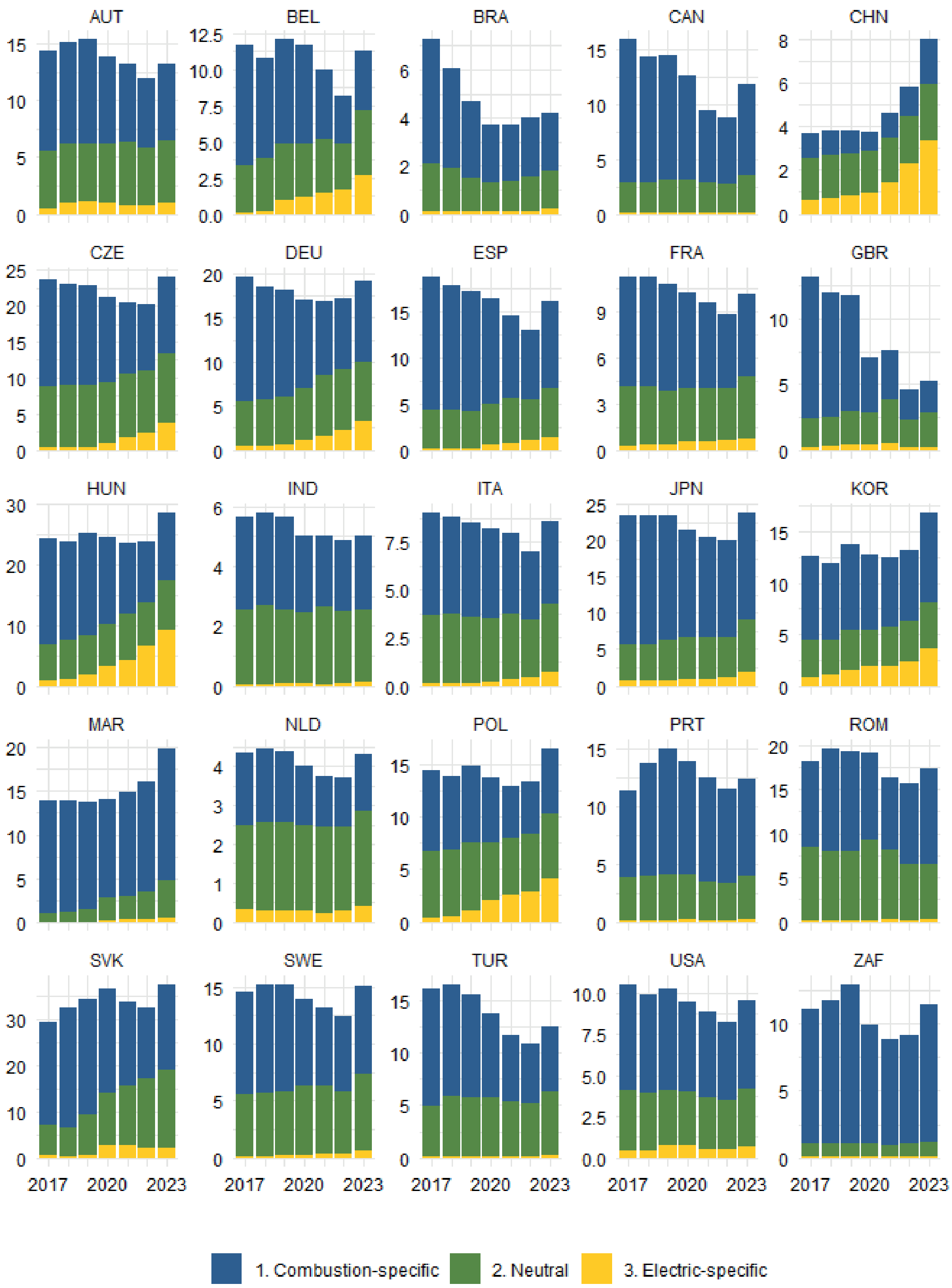
For the empirical analysis, we apply our classification of automotive products to the UN Comtrade trade data. This allows us to identify bilateral trade flows for 104 product groups over the period 2017-2023. These product-level data are further aggregated into categories related to electromobility. In addition, the available data can also be mapped to intermediates and final goods, with the corresponding matching presented in Appendix A.[2] In our empirical investigation, the dataset consists of trade flows between 127 exporters and 154 importers.

Note that the codes included in our mapping of the automotive products come from various chapters of the HS classification, and therefore our understanding of the automotive products is broader than the products classified under the HS 87 chapter (Vehicles other than railway or tramway rolling-stock, and parts and accessories thereof). For instance, electric engines and car batteries, which are crucial for the electromobility, are classified under the HS 85 chapter (Electrical machinery and equipment).

To illustrate recent developments in the trade in automotive products, the share of the automotive industry and its three categories in total merchandise exports is portrayed for the 25 largest exporters (see Figure 1) or for a larger sample of economies (see Figure 2). Looking at these series, one can notice that the share of automotive products in exports showed substantial changes in many countries between 2017 and 2023. It can be explained in two ways. First, during this period, the automotive industry experienced some unfavorable developments. In particular, car manufacturers faced prolonged periods of disruptions in global value chains after 2020. Additionally, there has been a decline in the relative prices of automotive products to other goods as the price of energy commodities, energy-intensive commodities, and food increased following the COVID-19 lockdowns.

[2] The detailed classification is also available at the link: github.com/jakubmuck/electromobility.

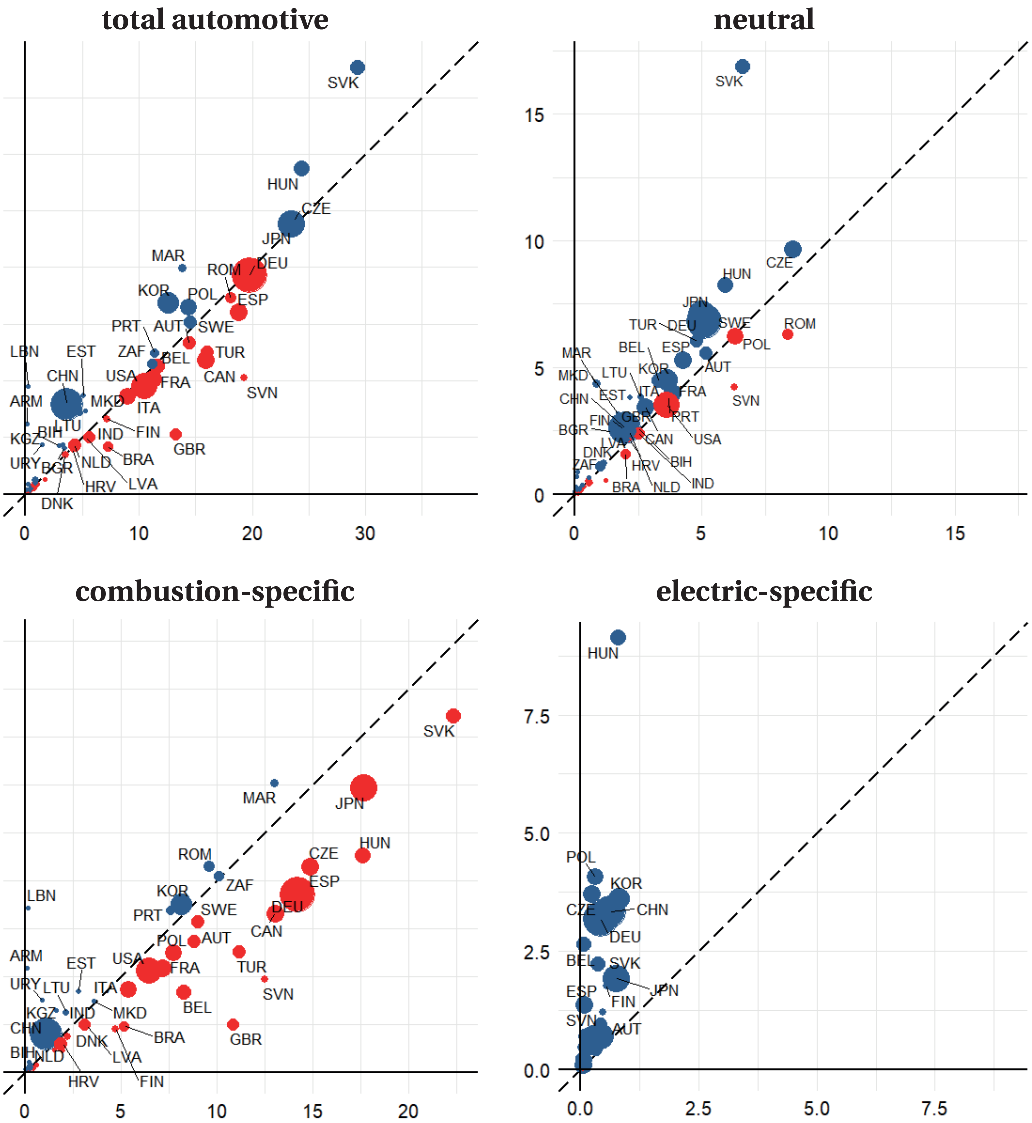
Figure 1: The share of automotive products in total exports among top exporters



A second explanation for the fluctuating importance of automotive products in trade could be related to a structural change within the automotive industry. In 2017, exports of the automotive industry in most economies were dominated by combustion-specific products, while the relatively high share of neutral products can be attributed to specialization in production of intermediates. Since 2017, the importance of combustion-specific products has been decreasing. At the same time, the role of electric-specific automotive products has been steadily increasing from very low levels (cf. Figure 2), and in some countries (e.g. China, South Korea, Hungary, Poland) the rising importance of this group stabilized or even expanded the overall share of automotive products in total exports.[3] Moreover, since the production of electric vehicles requires fewer components than the production of ICEVs, the electromobility transformation will likely shorten the GVCs of the automotive sector and subsequently we cen reasonably expect that the negative trend for the combustion-specific products will outweigh the positive trend for the electric-specific products.

[3]As of 2023, the largest share of electric-specific products in total exports was noted in Hungary, Poland, South Korea, Czechia, China, and Germany. Hungary experienced a particularly strong expansion of electric-specific exports. China was globally the largest exporter of electric-specific automotive products and stood out from other large automotive exporters with high relative importance of electric-specific products to other automotive products.

Figure 2: The share of automotive products in total merchandise exports in 2017 (horizontal axis) and 2023 (vertical axis)



Note: Blue dots indicate countries where the share of a given aggregate has increased, while red ones indicate countries where it has decreased. The size of the dots corresponds to the value of the total automotive exports in USD in 2023 (that is, the higher the value of the automotive exports, the larger the dot). The detailed classification is delegated to Appendix A.

2.2 Econometric model and data

In our empirical investigation we use a standard gravity model framework to analyze bilateral trade flows between economies:

$$EX_{ijst} = \exp\left(\beta x'_{ijst}\right) + \varepsilon_{ijst}, \tag{1}$$

where EX_{ijt} is the exports of the sth product or aggregate from the ith exporter to the jth importer at the moment t, β is the vector of underlying parameters, x_{ijts} is the set of explanatory variables, and ε_{ijst} is the error term.

In the set of explanatory variables, i.e., x'_{ijst} in (1), we include the standard gravity variables: geographical distance between trading economies and GDP of exporting and importing countries. These variables are in logs.

The automotive industry is relatively research-intensive. To examine whether exports of electric-specific automotive products are to the same extent driven by innovation the typical proxies of the R&D activity are included in (1). In particular, we use the ratio of the R&D expenditures to the gross value added in the industry C29 according to the NACE Rev. 2 classification.

Alternatively, technology innovations can be directly imported from technological leaders instead of being developed by domestic firms. The resulting technology spillovers usually follow capital linkages between multinational enterprises and their affiliates operating in the domestic market. To capture this channel of technology adoption, we extend x'_{ijst} with the stock of foreign direct investment. Specifically, we take the ratio of the inward FDI stock to the gross value added, both considered for the industry C29.

In addition to the R&D and FDI variables, an interaction term between them is introduced to account for possible complementarity or substitutability between the two sources of innovation: (i) domestically produced innovations, which are captured by the R&D expenditure, and (ii) innovations imported via capital linkages, which in turn are measured by the stock of FDI.

Moreover, we control for the complex nature of trade linkages within the Global Value Chains including measures of sector's downstreamness and upstreamness. On the one hand, export-oriented production could depend heavily on imported intermediates. In such case firms backwardly participate in the GVCs. To account for this, we use the share of foreign value added in gross exports, which is a typical indicator of backward participation in the GVCs. On the other hand, exporting firms could be mainly specialized in the production of intermediates. Viewed from the perspective of long and complex supply chains, the produced intermediates can be very close to the final demand or at the beginning of the multistage production process. Therefore, we also control for the downstreamness of export-oriented production by using the forward participation index, which measures the share of domestic value added in gross exports that is subsequently used in the export-oriented production of the importing economy. The summary of all explanatory variables with the data sources is presented in Table 1.

Table 1: Description of variables

Variable	Description	Source
Distance	Distance between the largest cities of trade partners (in km)	CEPII
GDP_o	GDP in origin country (in USD)	World Bank
GDP_d	GDP in destination country (in USD)	World Bank
EU	Membership in European Union of both partners (1 - both partners are members of EU, 0 - otherwise)	CEPII
R&D	Ratio of R&D to value added in C29 (or C for total manufacturing) sector (NACE rev. 2) in origin country (2015-2022 average, in %)	OECD
FDI	Ratio of FDI stock to value added in C29 (or C for total manufacturing) sector (NACE rev. 2) in origin country (2015-2022 average, in %)	OECD
Backward_GVC	Backward participation of origin country in global value chains – the share of foreign value added in gross exports (in %) in C29 (or C for total manufacturing) sector (NACE rev. 2) in previous year	Eurostat
Forward_GVC	Forward participation of origin country in global value chains (GVC) – the share of domestic value added in other countries' exports (in %) in C29 (or C for total manufacturing) sector (NACE rev. 2) in previous year	Eurostat

The estimation results of (1) will be compared with estimates for exports of manufactured goods. Thus, the FDI, R&D as well as the GVC participation indices are also measured for total manufacturing.

In the econometric estimation, we use the PPML estimation of the gravity model (see Silva and Tenreyro, 2006). Due to the limited time dimension, estimation exploits mostly the cross-country variation. To control for cyclical factors and prolonged disruptions in supply chains, the time dummies are added in (1).

For the sake of comparability, we also present the results for more general aggregates, i.e. for total vehicles and their parts (chapter 87 of HS 2017) and products of manufacturing sector (section C from NACE rev.2) exports. Furthermore, in Section 4, we cross-check the robustness of the baseline results by considering (i) the time-variant effects of R&D, FDI, and GVC-related variables, (ii) product-level variation by performing an estimation on highly disaggregated product-level data, and (iii) the distinction between final and intermediate goods. Moreover, we also run the logit estimations for the presence of non-negligible bilateral trade flows for each category.[4]

[4]For the logistic regression, we use a dependent variable which takes value 1 if the value of automotive exports from the country i to the country j in the year t was larger than 1 million USD. Since the GVC participation variables require the automotive sector's exports to be non-zero, they are excluded from the investigation of the extensive margin.

3 Results

We start the discussion of the empirical results with the comparison of estimation results from three categories of interest (electric-specific, combustion-specific, and neutral automotive products). The detailed results are presented in Tables B.1-B.3. The first column in each table corresponds to the results for the most parsimonious specification, which is gradually extended with additional variables (R&D and FDI intensity and the GVC measures) in the following columns. The results for the broadest model specification, with all explanatory variables included, are our baseline results (column (4)). To provide a broader context of these estimates, we compare them with the results for two other aggregates: (i) vehicles and parts which can be linked to the automotive industry (chapter 87 of HS 2017 classification), and (ii) all products of the manufacturing sector[5]. Detailed estimation results for these aggregates are presented in Tables B.4 and B.5. A comparison of estimates for the broadest model specification for all considered product categories (combustion-specific, neutral, electric-specific, all automotive products, all manufactured products) is presented graphically in Figure 3.

The comparison of estimates reveals several empirical patterns. First, the role of traditional gravity variables is very similar for all analyzed categories of automotive products. Although there are some differences between the estimates, they are not substantial.

Second, the exports of electric-specific automotive products are largely dependent on the availability of new technologies. This pattern is illustrated by comparing estimates on the R&D and FDI. Estimates for electric-specific goods are the largest for both R&D and FDI. It highlights the role of innovation-intensity in increasing the exports share. Because electric-specific products are at relatively early stage in their life-cycle, their production potentially requires more frequent adjustments or modifications, which can be achieved by domestic R&D activity or can be supported by a transfer of knowledge from multinational enterprises. Apart from these variables, an interaction term between them is introduced.

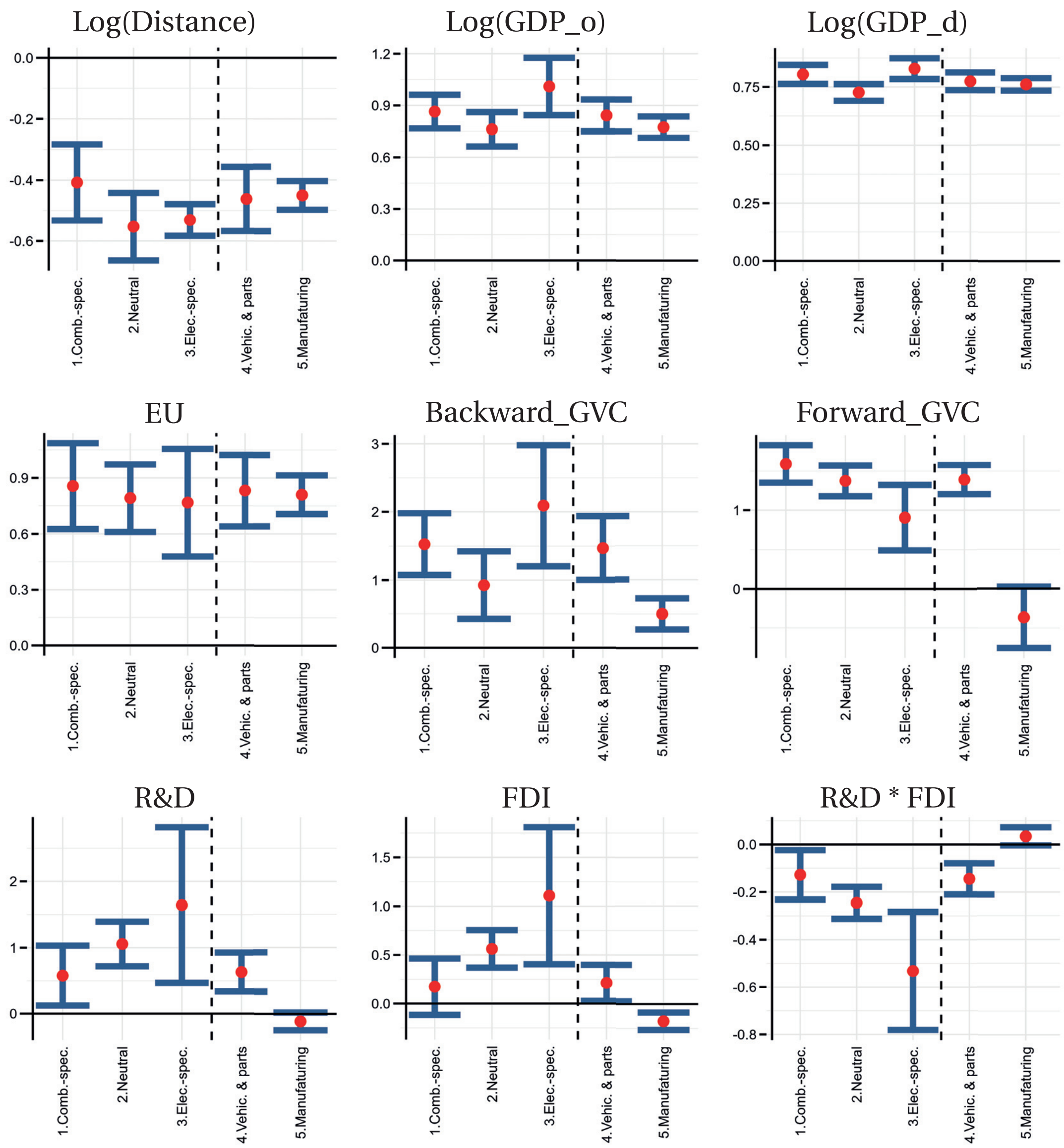
Third, the role of GVC participation for exports of electric-specific automotive products is slightly different from its role for the foreign sales of combustion-specific and neutral products. Looking at the differences in the three underlying categories, one can see that exports of electric-specific products are relatively more dependent on imported intermediates (larger role of the backward GVC participation).

[5] We consider the manufactured goods as there are systematic differences between other general categories, e.g., energy commodities or food and agriculture products (see Borchert et al., 2022).

The disparity is more evident in relation to neutral than combustion-specific products. At the same time, exports of electric-specific goods are less linked to the role of a country as a supplier of intermediates (smaller role of forward GVC participation), especially compared to combustion-specific goods. This can be attributed to the smaller dependence of the production of new goods on existing linkages compared to traditional combustion-specific ones. However, in general, the differences in the role of GVC participation (both backward and forward) for exports of analyzed product aggregates are not prominent enough to infer substantial reorganization in the value chains of the automotive industry.

The potential explanation of the GVCs stability could be related to their sticky nature. As synthesized by Antràs and Chor (2022), the cost of searching for new suppliers is non-negligible and, simultaneously, there could be barriers to the diffusion of information. As a result, the transition toward the EV manufacturing could take place to a large extent within existing supply chains. The resilience of existing GVCs could also be supported by so-called mirroring in production (Alochet et al., 2022). According to this mechanism, automakers organize their production of EV in a manner analogous to the production of ICEVs. This could potentially cover external sourcing arrangements.

Figure 3: Estimates of gravity model for product aggregates



Note: red dots denote point estimates, and blue vertical lines represent 90% confidence intervals. A detailed description of explanatory variables is provided in Table 1, while the product classification into neutral, combustion-specific, and electric-specific is presented in Table A.1.

4 Robustness analysis

In this section, we cross-check the robustness of our main findings. In particular, we consider (i) an estimation with time-variant parameters for R&D, FDI, and backward/forward GVC participation variables on the same annual 2017-2023 sample, ii) similar estimation with time-varying parameters, however on alternative pooled 2017Q1-2025Q1 sample, (iii) an estimation of the gravity model on highly disaggregated product-level data, (iv) an estimation with a distinction between final and intermediate goods, and (v) an analysis of the extensive margin in bilateral trade using the logistic regression.

First, we analyze the stability of the parameters over time. We start with the same sample of yearly data, covering years from 2017 to 2023. The singular R&D and FDI intensity, as well as the backward and forward GVC participation variables, are replaced by their interactions with year dummies. This allows us to capture potential changes in the relationship between exports and these four variables across years.

This extension of the model specification reveals meaningful time variation in parameters for electric-specific products, indicating that technology and supply chain participation had evolving importance for the exports of new products (see Figure 4 and Table B.7 for detailed results). At the beginning of the sample (2017-2019), the intensities of R&D and FDI were particularly high, but started to decrease slightly from 2020 onward. At the same time, GVC participation-related variables showed the opposite pattern: while from 2017 to 2019 they were not statistically significant, in later years they became substantially more important. For backward participation, the parameter gradually increased, eventually significantly exceeding the counterpart for combustion-specific and neutral goods. For forward participation, the estimate reached the value of its counterpart for neutral products. These results suggest that at the beginning of new product development the export activity is concentrated in the most technology-oriented locations; later, production (and consequently exports) is located more often in countries strongly involved in the sector's global value chains.

Second, to further verify the evidence in favor of relevant time-changing role of these four factors for analyzed trade flows, we estimate the parameters on alternative, quarterly 2017Q1-2025Q1 sample for EU countries[6]. In this case we do not estimate the parameters basing on separate subsamples for each of our 3 cat-

[6]Source: Eurostat.

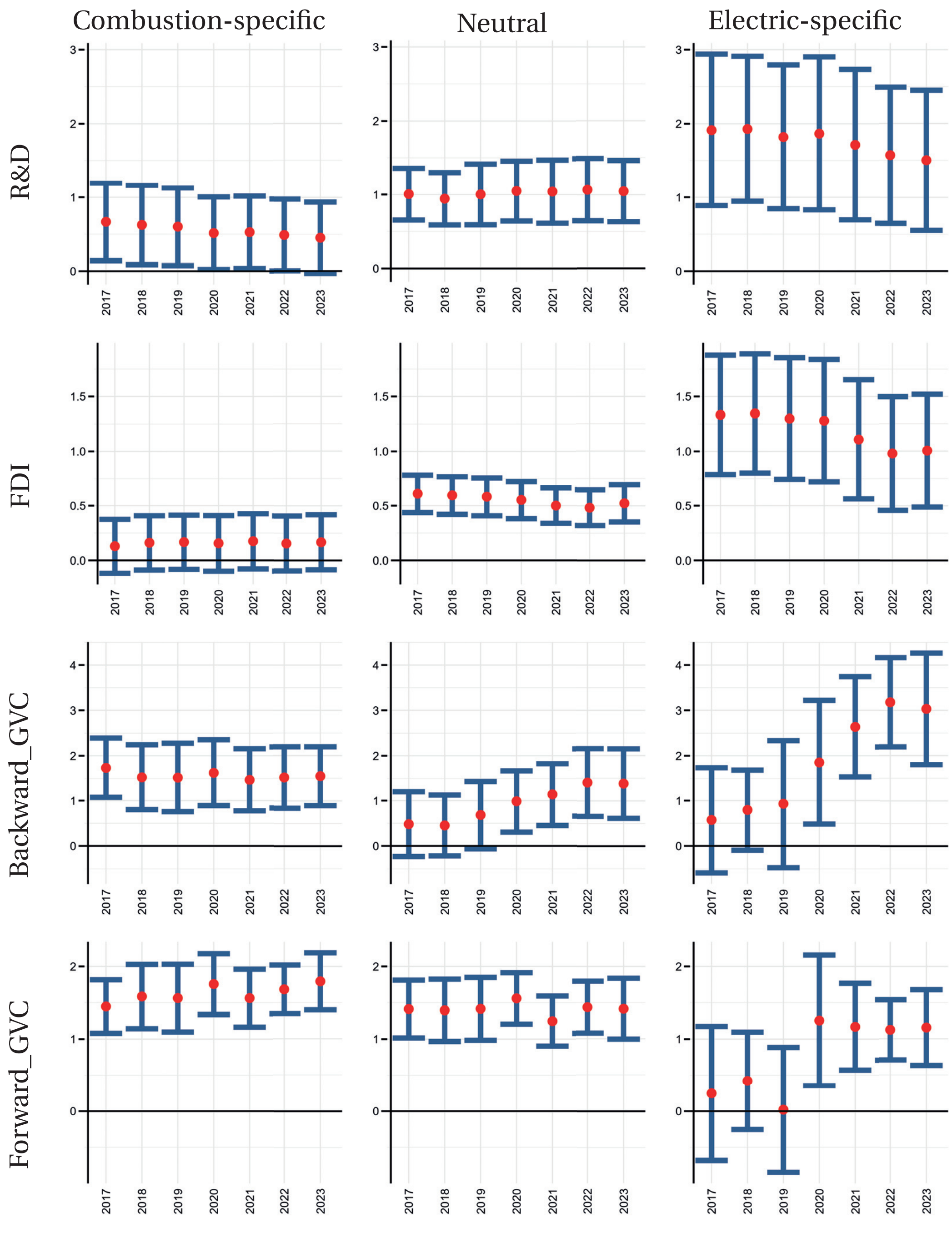
egories of goods like before, but instead operate on a one pooled dataset. For this reason we alter the specification of gravity model by interacting the variables with time and category controlling dummies. This way, we are able to capture additional effects of technological intensity and GVC participation-related factors for exports of combustion-specific and electric-specific goods. The equation is given the following form:

$$EX_{ijst} = \exp\left(\beta_{st} x'_{ijst}\right) + \varepsilon_{ijst}, \tag{2}$$

where β_{st} is the time-varying group-specific parameter.

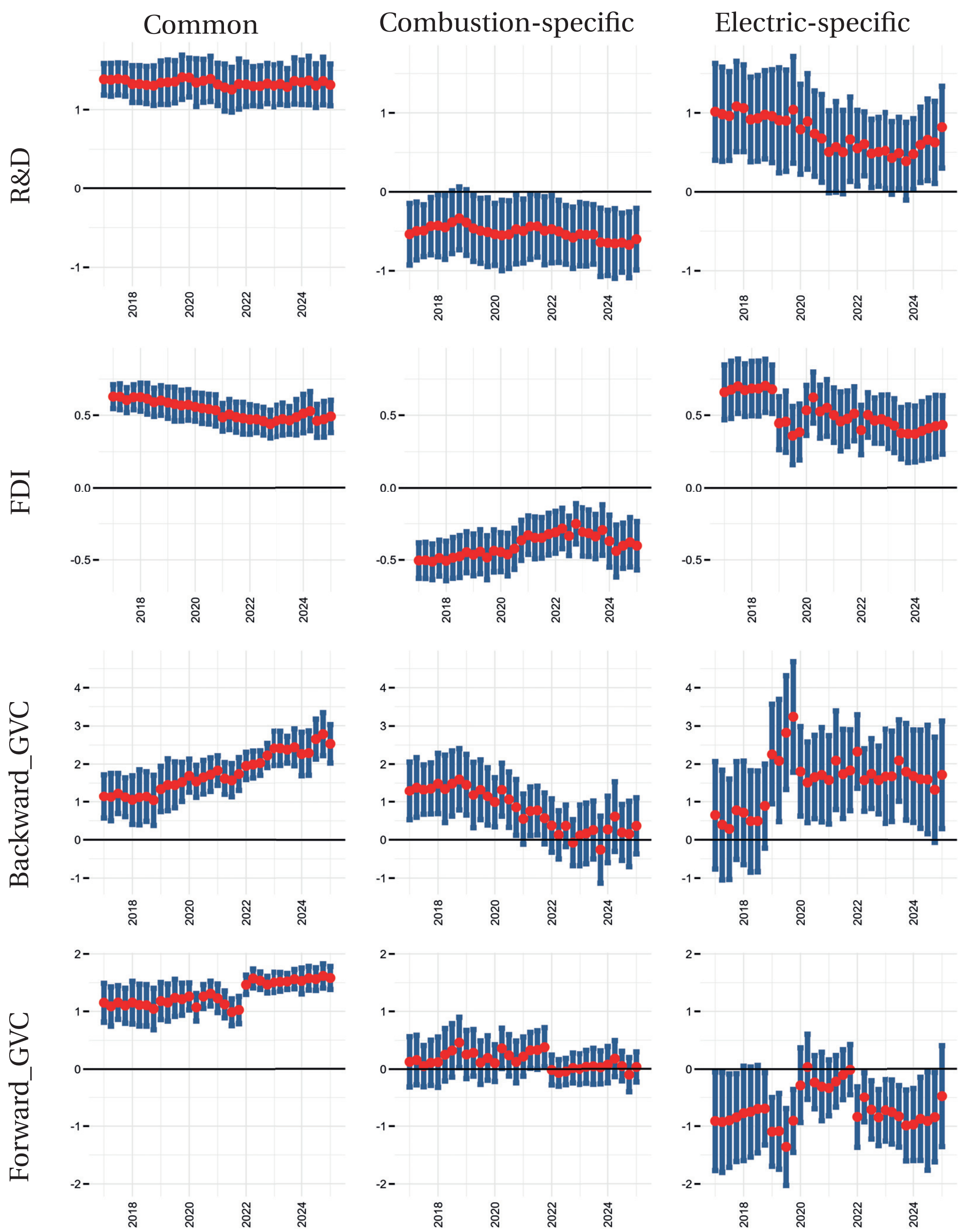
The results are displayed in Figure 5. They are in line with the already presented yearly data-based results i.e. they show little to no difference in values of parameters estimates. Consequently, they indicate identical trends of their role for determining trade flows of each goods category as in previously discussed analysis: in particular, high additional effects of R&D and FDI intensities for electric-specific goods at the beginning of sample with slightly declining trend later, as well as emerging additional positive effect of backward GVC participation in later part of the sample.

Figure 4: Estimates of gravity model - specification with time-variant coefficients



Note: red dots denote point estimates, and blue vertical lines represent 90% confidence intervals. A detailed description of the explanatory variables is provided in Table 1, while the product classification into neutral, combustion-specific, and electric-specific is presented in Table A.1.

Figure 5: Estimates of gravity model - specification with time-variant coefficients for quarterly data



Note: red dots denote point estimates, and blue vertical lines represent 90% confidence intervals. A detailed description of the explanatory variables is provided in Table 1, while the product classification into neutral, combustion-specific, and electric-specific is presented in Table A.1.

Third, we assess the robustness of the baseline results to product aggregation. Specifically, the parameters are estimated based on the disaggregated product level data (104 6-digit HS 2017 codes). To identify potential differences between products belonging to different categories, the parameters of (1) are interacted with indicator variables for the combustion-specific and electric-specific categories, in the same way as in above discussed quarterly data-based estimation. Apart from year dummies, standard product effects are also included. In addition, we perform an estimation for a specification with time-varying coefficients, in order to check the robustness of results discussed in the previous paragraph.

The results of these estimations are consistent with the baseline results, as they identify the same set of determinants and demonstrate similar differences between trade drivers for the analyzed categories (see Table B.8 for the specification with time-invariant parameters and Table B.9 for the specification with time-variant parameters). More specifically, they show a higher dependence of the exports of electric-specific products on the backward GVC participation, FDI intensity, and partners' GDPs, but a smaller role of forward GVC participation. Furthermore, the substitutability between R&D and FDI and its especially strong role for exports of electric-specific goods is also prominent. In case of the role of R&D intensity, the time variation is crucial: while there is no statistically significant additional effect for electric-specific products, there was an additional positive effect from 2017 to 2019, which is consistent with the conclusions for a time-variant extension of the baseline specification. This result further supports the evidence of higher importance of R&D at the earlier-than-later stages of product development for its exports.

Fourth, we cross-check our main findings by re-estimating the parameters on a sample of six aggregates, where each category of automotive products (neutral, electric-specific, and combustion-specific) is further split into two, depending on whether a particular product is an intermediate or a final good. This sample allows us to identify more heterogeneity and validate whether documented differences between exports of different categories of automotive products can be attributed to final goods or intermediates. We also estimate a specification with time-varying coefficients. The results are presented in Tables B.10 and B.11.

The baseline results are relatively robust to distinguishing between intermediate and final goods, however several differences should be noted. First, for both combustion-specific and electric-specific products, the technology intensity plays a greater role for the intermediates, while the GVC participation is more important for exports of final goods. This divergence is particularly strong for electric-specific products. For neutral products, however, this pattern does not hold: technology intensity is more important for final goods, which may partly reflect the inclusion of hybrid (HEV) and plug-in hybrid (PHEV) vehicles in this category. Overall, these results suggest that production of parts (i.e. electric accumulators) relies more heavily on advancement in existing technologies. For instance, over the last several years, battery production has undergone substantial technological improvements, leading to greater variety of available technologies and a sharp decline in prices (Ziegler and Trancik, 2021). In addition, the notably high coefficient for backward GVC participation in the case of final electric-specific goods (i.e., electric cars and buses) suggests not only that their production depends strongly on the imported intermediates, but also that it follows existing geographical patterns.

The logistic regression results are presented in Table B.12. In this set of regressions, the outcome variable is redefined to measure the extensive margin. Namely, the dependent variable is the binary variable that takes the value 1 if there is an export of automotive products of particular category between two countries of value at least 1 million USD. Eyeballing the result is straightforward to observe that the similar factors are linked to the probability of the automotive exports for all three categories. The innovative activity, either with domestic R&D or FDI-linked technology transfer, is positively related to probability of bilateral trade in the automotive sector. However, there are two notable differences between categories. The effect associated with the GDP of the destination country is weaker in case of the combustion-specific category compared to the neutral category, and stronger in case of the electric-specific category compared to the neutral category. It suggests that the exports of electric specific products are more dependent on the size and income of the buyer's country than the combustion-specific products. This finding well correlates with the observation that the electromobility transformation is still concentrated in a bunch of the largest economies (mostly US, European Union, and China). Moreover, the results suggest that probability of non-negligible exports of electric-specific products is less FDI and R&D dependent compared to other categories.

5 Conclusion and discussion

In this paper we examine the role of the ongoing electromobility transformation for exports of the automotive sector. Since the electromobility transformation is a new phenomenon, the literature on this subject is still relatively scarce. To our knowledge, there is no other study investigating the trade flows related to the electromobility transformation. Hence our study offers an insight into a little-explored but highly relevant area due to the importance of automotive products in global trade.

One of the challenges to analyzing electromobility-related trade is the lack of a classification that distinguishes products related to electric vehicles. To overcome this problem, we propose a novel mapping of granular codes of automotive products into three categories depending on their exposure to electromobility. Our mapping splits the automotive products into: (i) combustion-specific automotive products, that are required in vehicles with an internal combustion engine (ICEVs) but not in electric vehicles (EVs), (ii) the electric-specific automotive products, that are required in EVs, but not in ICEVs, and (iii) neutral automotive products, that are required in production of both EVs and ICEVs. The electromobility transformation will likely trigger the decline of production and trade in products of the first category, but expansion in the case of products of the second category. Whether this expansion will fully offset the decline in the long run remains uncertain.

We begin the empirical analysis by reporting the results of applying our mapping to trade data for several top automotive exporters. It reveals that the relative importance of the three categories of automotive products in countries' exports changed significantly between 2017 and 2023: the share of combustion-specific exports declined markedly, while the share of electric-specific exports expanded. This shows that the electromobility transformation has already been significantly reshaping trade flows in the automotive sector.

Then, our research objective was to examine whether electromobility leads to fundamental changes in trade patterns in the automotive sector. To do so, we employed a standard gravity model set-up for trade flows of automotive products. We confront the results for the three categories of automotive products to each other to identify potential pattern changes. We demonstrate that key drivers of exports of the electric-specific products are similar to the combustion-specific ones. We document that the ongoing transition from traditional vehicles with combustion engines to electric ones started reorganizing trade linkages within the automotive industry. However, our early assessment shows that this reorganization is taking place within existing trade linkages, rather than creating completely new ones, as the key determinants of exports are very similar.

A key difference between ICEV-related and EV-related products is that exports of electric-specific automotive products require relatively more innovation, as they are more intensively supported by higher domestic R&D expenditure or international transfer of knowledge via the FDIs. This finding can be easily explained by positions the two categories occupy in the product life cycle. As ICEVs are mature products on the brink of decline, their production is associated with low innovation intensity. In contrast, EVs are relatively new products in the growth stage characterized by high innovation intensity. Our results are robust to robustness checks such as estimating the gravity model on product level data and a split between intermediate and final goods.

Given that the role of typical characteristics of the automotive industry is very similar for the extensive margin of exports of both electric-specific and combustion-specific products, one might expect only a slight reshaping of existing trade linkages rather than the creation of entirely new supply chain patterns. The greater importance of two typical channels of product improvement, i.e. domestic R&D activity and international spillovers through FDI, also supports the conclusion that electromobility is driving a reorganization of activities within industries rather than a fundamental restructuring of supply chains.

Our finding suggesting no substantial reorganization of value chains due to electromobility aligns with the literature. For instance, Gracia et al. (2024) show that Germany has secured its core position within Europe's automotive sector regarding the EV products. In a similar vein, Murmann and Schuler (2023) predict that changes in the organization of the automotive sector will be confined and original equipment manufacturers (OEMs) will secure control over the EV value chains similar to their control position over the ICEV value chains. Pavlínek (2023) predicts that the transition from the ICEV to EV production will be delayed in Eastern Europe compared to Western Europe, due the former's periphery position in the automotive sector's value chains with a low share of high value-added activities such as R&D. Pavlínek's claim aligns with our finding that the EV-related trade is more R&D dependent than the ICEV-related trade.

However, our analysis is very early evidence of patterns of trade in EV-related products. Due to the new nature of the electromobility transformation and changes in the HS product classification, our main sample covers only the years 2017-2023, and additional quarterly sample used for one of the robustness analyses covers quarters 2017Q1-2025Q1. This is a relatively short period of time, and our findings may not necessarily hold as new data arrive. It is because electric vehicles are still at an early stage of product life cycle, still experiencing a lot of innovation which might have a substantial impact on trade patterns in the future. A further potential reservation is that our results might be influenced by unfavorable developments of the COVID-19 pandemic and subsequent disruptions in global value chains, which strongly hit the automotive sector. Finally, our analysis does not account for protectionist measures, which can potentially distort trade flows.

The transition to electromobility will have a profound impact on many aspects of economic activity besides its impact on international trade flows. Due to more technical simplicity of electric vehicles one can expect the shortening of the automotive sector's value chains and the reduction in the sector's employment. Electromobility will also imply the demand shift for components, threatening numerous intermediate suppliers, and complementary technologies. Moreover, the electromobility transition will likely result in changes in skill demand (maintenance and repair of electric vehicles differ from combustion engine vehicles). The implementation of electromobility will also have a negative impact on demand for fossil fuels, while the supply of strategic rare earth metals crucial for electromobility technologies might be a key challenge. Overall, the structural change associated with the electromobility transition is a multifaceted phenomenon that will undoubtedly attract considerable future research.

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A Mapping of product codes to combustion-specific, electric-specific and neutral automotive products

Table A.1: A classification of products in the automotive industry according to the HS17 Nomenclature

HS code	Group	Type	Description
381900	neutral	inter	Hydraulic brake fluids and other prepared liquids for hydraulic transmission, not containing or containing less than 70 % by weight of petroleum oils or oils obtained from bituminous minerals
382000	combustion-specific	inter	Anti-freezing preparations and prepared de-icing fluids
700910	neutral	inter	Rear-view mirrors for vehicles
840731	combustion-specific	inter	Reciprocating piston engines of a kind used for the propulsion of vehicles of Chapter 87 - Of a cylinder capacity not exceeding 50 cm^3
840732	combustion-specific	inter	Reciprocating piston engines of a kind used for the propulsion of vehicles of Chapter 87 - Of a cylinder capacity exceeding 50 cm^3 but not exceeding 250 cm^3
840733	combustion-specific	inter	Reciprocating piston engines of a kind used for the propulsion of vehicles of Chapter 87 - Of a cylinder capacity exceeding 250 cm^3 but not exceeding 1000 cm^3
840734	combustion-specific	inter	Reciprocating piston engines of a kind used for the propulsion of vehicles of Chapter 87 - Of a cylinder capacity exceeding 1000 cm^3
840820	combustion-specific	inter	Compression-ignition internal combustion piston engines (diesel or semi-diesel engines) - Engines of a kind used for the propulsion of vehicles of Chapter 87
840991	combustion-specific	inter	Parts suitable for use solely or principally with the engines of heading 8407 or 8408 - Suitable for use solely or principally with spark-ignition internal combustion piston engines
850131	electric-specific	inter	Other DC motors; DC generators, other than photovoltaic generators - Of an output not exceeding 750 W
850132	electric-specific	inter	Other DC motors; DC generators, other than photovoltaic generators - Of an output exceeding 750 W but not exceeding 75 kW
850133	electric-specific	inter	Other DC motors; DC generators, other than photovoltaic generators - Of an output exceeding 75 kW but not exceeding 375 kW
850134	electric-specific	inter	Other DC motors; DC generators, other than photovoltaic generators - Of an output exceeding 375 kW
850151	electric-specific	inter	Electric motors and generators (excluding generating sets) - Other AC motors, multi-phase - Of an output not exceeding 750 W
850152	electric-specific	inter	Electric motors and generators (excluding generating sets) - Other AC motors, multi-phase - Of an output exceeding 750 W but not exceeding 75 kW
850153	electric-specific	inter	Electric motors and generators (excluding generating sets) - Other AC motors, multi-phase - Exceeding 75 kW
850161	combustion-specific	inter	Electric motors and generators (excluding generating sets) - AC generators (alternators) - Of an output not exceeding 75 kVA
850162	combustion-specific	inter	Electric motors and generators (excluding generating sets) - AC generators (alternators) - Of an output exceeding 75 kVA but not exceeding 375 kVA
850163	combustion-specific	inter	Electric motors and generators (excluding generating sets) - AC generators (alternators) - Of an output exceeding 375 kVA but not exceeding 750 kVA
850164	combustion-specific	inter	Electric motors and generators (excluding generating sets) - AC generators (alternators) - Of an output exceeding 750 kVA
850511	electric-specific	inter	Permanent magnets and articles intended to become permanent magnets after magnetisation - Of metal
850519	electric-specific	inter	Permanent magnets and articles intended to become permanent magnets after magnetisation - Other
850710	combustion-specific	inter	Electric accumulators, including separators therefor, whether or not rectangular - Lead-acid, of a kind used for starting piston engines

Continued on next page

Table A.1 – continued from previous page

HS code	Group	Type	Description
850750	combustion-specific	inter	Electric accumulators, including separators therefor, whether or not rectangular - Nickel-metal hydride
850760	electric-specific	inter	Electric accumulators, including separators therefor, whether or not rectangular - Lithium-ion
851110	combustion-specific	inter	Sparking plugs
851120	combustion-specific	inter	Ignition magnetos; magneto-dynamos; magnetic flywheels
851130	combustion-specific	inter	Distributors; ignition coils
851140	combustion-specific	inter	Starter motors and dual purpose starter-generators
851150	combustion-specific	inter	Other generators
851180	combustion-specific	inter	Other equipment
851190	combustion-specific	inter	Electrical ignition or starting equipment of a kind used for spark-ignition or compression-ignition internal combustion engines (for example, ignition magnetos, magneto-dynamos, ignition coils, sparking plugs and glow plugs, starter motors); generators (for example, dynamos, alternators) and cut-outs of a kind used in conjunction with such engines - parts
851220	neutral	inter	Electrical lighting or signalling equipment (excluding articles of heading 8539), windscreen wipers, defrosters and demisters, of a kind used for cycles or motor vehicles - lighting or visual signalling equipment other than of a kind used on bicycles
851230	neutral	inter	Electrical lighting or signalling equipment (excluding articles of heading 8539), windscreen wipers, defrosters and demisters, of a kind used for cycles or motor vehicles
851240	neutral	inter	Windscreen wipers, defrosters and demisters
851290	neutral	inter	Electrical lighting or signalling equipment (excluding articles of heading 8539), windscreen wipers, defrosters and demisters, of a kind used for cycles or motor vehicles - Parts
870110	neutral	final	Road tractors for semi-trailers - Single axle tractors
870120	neutral	final	Road tractors for semi-trailers
870130	neutral	final	Road tractors for semi-trailers - track-laying tractors
870191	neutral	final	Tractors (other than tractors of heading 8709) of an engine power Not exceeding 18 kW
870192	neutral	final	Tractors (other than tractors of heading 8709) of an engine power Exceeding 18 kW but not exceeding 37 kW
870193	neutral	final	Tractors (other than tractors of heading 8709) of an engine power Exceeding 37 kW but not exceeding 75 kW
870194	neutral	final	Tractors (other than tractors of heading 8709) of an engine power Exceeding 75 kW but not exceeding 130 kW
870195	neutral	final	Tractors (other than tractors of heading 8709) of an engine power Exceeding 130 kW
870210	combustion-specific	final	Motor vehicles for the transport of ten or more persons, including the driver With only compression-ignition internal combustion piston engine (diesel or semi-diesel)
870220	neutral	final	Motor vehicles for the transport of ten or more persons, including the driver With both compression-ignition internal combustion piston engine (diesel or semi-diesel) and electric motor as motors for propulsion
870230	neutral	final	Motor vehicles for the transport of ten or more persons, including the driver With both spark-ignition internal combustion piston engine and electric motor as motors for propulsion
870240	electric-specific	final	Motor vehicles for the transport of ten or more persons, including the driver with only electric motor for propulsion
870321	combustion-specific	final	Other vehicles with only spark-ignition internal combustion piston engine of a cylinder capacity not exceeding 1000 cm^3
870322	combustion-specific	final	Other vehicles with only spark-ignition internal combustion piston engine of a cylinder capacity exceeding 1000 cm^3 but not exceeding 1500 cm^3
870323	combustion-specific	final	Other vehicles with only spark-ignition internal combustion piston engine of a cylinder capacity exceeding 1500 cm^3 but not exceeding 3000 cm^3
870324	combustion-specific	final	Other vehicles with only spark-ignition internal combustion piston engine of a cylinder capacity exceeding 3000 cm^3

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Table A.1 – continued from previous page

HS code	Group	Type	Description
870331	combustion-specific	final	Other vehicles with only compression-ignition internal combustion piston engine of a cylinder capacity not exceeding 1500 cm³
870332	combustion-specific	final	Other vehicles with only compression-ignition internal combustion piston engine of a cylinder capacity exceeding 1500 cm³ but not exceeding 2500 cm³
870333	combustion-specific	final	Other vehicles with only compression-ignition internal combustion piston engine of a cylinder capacity exceeding 2500 cm³
870340	neutral	final	Other vehicles, with both spark-ignition internal combustion piston engine and electric motor as motors for propulsion, other than those capable of being charged by plugging to external source of electric power (HEV)
870350	neutral	final	Other vehicles, with both compression-ignition internal combustion piston engine (diesel or semi-diesel) and electric motor as motors for propulsion, other than those capable of being charged by plugging to external source of electric power (HEV)
870360	neutral	final	Other vehicles, with both spark-ignition internal combustion piston engine and electric motor as motors for propulsion, capable of being charged by plugging to external source of electric power (PHEV)
870370	neutral	final	Other vehicles, with both compression-ignition internal combustion piston engine (diesel or semi-diesel) and electric motor as motors for propulsion, capable of being charged by plugging to external source of electric power (PHEV)
870380	electric-specific	final	Other vehicles, with only electric motor for propulsion
870421	combustion-specific	final	Motor vehicles for the transport of goods with only compression-ignition internal combustion piston engine (diesel or semi-diesel) Of a gross vehicle weight not exceeding 5 tonnes
870422	combustion-specific	final	Motor vehicles for the transport of goods with only compression-ignition internal combustion piston engine (diesel or semi-diesel) Of a gross vehicle weight exceeding 5 tonnes but not exceeding 20 tonnes
870423	combustion-specific	final	Motor vehicles for the transport of goods with only compression-ignition internal combustion piston engine (diesel or semi-diesel) Of a gross vehicle weight exceeding 20 tonnes
870431	combustion-specific	final	Motor vehicles for the transport of goods with only spark-ignition internal combustion piston engine Of a gross vehicle weight not exceeding 5 tonnes
870432	combustion-specific	final	Motor vehicles for the transport of goods with only spark-ignition internal combustion piston engine Of a gross vehicle weight exceeding 5 tonnes
870510	neutral	final	Special purpose motor vehicles, other than those principally designed for the transport of persons or goods - crane lorries
870520	neutral	final	Special purpose motor vehicles, other than those principally designed for the transport of persons or goods - mobile drilling derricks
870530	neutral	final	Special purpose motor vehicles, other than those principally designed for the transport of persons or goods - fire fighting vehicles
870540	neutral	final	Special purpose motor vehicles, other than those principally designed for the transport of persons or goods - concrete-mixer lorries
870590	neutral	final	Special purpose motor vehicles, other than those principally designed for the transport of persons or goods - other
870600	neutral	final	Chassis fitted with engines, for the motor vehicles of headings 8701 to 8705 - Chassis for tractors of heading 8701; chassis for motor vehicles of heading 8702, 8703 or 8704, with either a compression-ignition internal combustion piston engine (diesel or semi-diesel) of a cylinder capacity exceeding 2500 cm³ or with a spark-ignition internal combustion piston engine of a cylinder capacity exceeding 2800 cm³
870710	neutral	inter	Bodies
870810	neutral	inter	Bumpers and parts thereof
870821	neutral	inter	Safety seat belts
870829	neutral	inter	Other parts and accessories of bodies
870830	neutral	inter	Brakes and servo-brakes; parts thereof

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Table A.1 – continued from previous page

HS code	Group	Type	Description
870840	combustion-specific	inter	Gear boxes and parts thereof
870850	neutral	inter	Drive-axles with differential, whether or not provided with other transmission components, and non-driving axles; parts thereof
870870	neutral	inter	Road wheels and parts and accessories thereof
870880	neutral	inter	Suspension system and parts thereof
870891	combustion-specific	inter	Radiators and parts thereof
870892	combustion-specific	inter	Silencers (muffets), exhaust pipes and parts thereof
870893	combustion-specific	inter	Clutch and parts thereof
870894	neutral	inter	Steering wheels, steering columns and steering boxes; parts thereof
870895	neutral	inter	Safety airbags with inflator system; parts thereof
870899	neutral	inter	Other parts and accessories
870911	neutral	final	Works trucks, self-propelled, not fitted with lifting or handling equipment, of the type used in factories, warehouses, dock areas or airports for short distance transport of goods; tractors of the type used on railway station platforms; parts of the foregoing vehicles - vehicles - electrical
870919	neutral	final	Works trucks, self-propelled, not fitted with lifting or handling equipment, of the type used in factories, warehouses, dock areas or airports for short distance transport of goods; tractors of the type used on railway station platforms; parts of the foregoing vehicles - vehicles - other
870990	neutral	inter	Works trucks, self-propelled, not fitted with lifting or handling equipment, of the type used in factories, warehouses, dock areas or airports for short distance transport of goods; tractors of the type used on railway station platforms; parts of the foregoing vehicles - parts
871110	neutral	final	Motorcycles (including mopeds) and cycles fitted with an auxiliary motor, with or without side-cars; side-cars - With internal combustion piston engine of a cylinder capacity not exceeding 50 cm^3
871120	neutral	final	Motorcycles (including mopeds) and cycles fitted with an auxiliary motor, with or without side-cars; side-cars - With internal combustion piston engine of a cylinder capacity exceeding 50 cm^3 but not exceeding 250 cm^3
871130	neutral	final	Motorcycles (including mopeds) and cycles fitted with an auxiliary motor, with or without side-cars; side-cars - With internal combustion piston engine of a cylinder capacity exceeding 250 cm^3 but not exceeding 500 cm^3
871140	neutral	final	Motorcycles (including mopeds) and cycles fitted with an auxiliary motor, with or without side-cars; side-cars - With internal combustion piston engine of a cylinder capacity exceeding 500 cm^3 but not exceeding 800 cm^3
871150	neutral	final	Motorcycles (including mopeds) and cycles fitted with an auxiliary motor, with or without side-cars; side-cars - With internal combustion piston engine of a cylinder capacity exceeding 800 cm^3
871160	neutral	final	Motorcycles (including mopeds) and cycles fitted with an auxiliary motor, with or without side-cars; side-cars - With electric motor for propulsion
871190	neutral	final	Motorcycles (including mopeds) and cycles fitted with an auxiliary motor, with or without side-cars; side-cars - other
871610	neutral	final	Trailers and semi-trailers; other vehicles, not mechanically propelled; parts thereof - Trailers and semi-trailers of the caravan type, for housing or camping
871620	neutral	final	Trailers and semi-trailers; other vehicles, not mechanically propelled; parts thereof - Self-loading or self-unloading trailers and semi-trailers for agricultural purposes
871631	neutral	final	Trailers and semi-trailers; other vehicles, not mechanically propelled; parts thereof - Other trailers and semi-trailers for the transport of goods - Tanker trailers and tanker semi-trailers
871639	neutral	final	Trailers and semi-trailers; other vehicles, not mechanically propelled; parts thereof - Other trailers and semi-trailers for the transport of goods - Other
871640	neutral	final	Trailers and semi-trailers; other vehicles, not mechanically propelled; parts thereof - Other trailers and semi-trailers

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Table A.1 – continued from previous page

HS code	Group	Type	Description
871680	neutral	final	Trailers and semi-trailers; other vehicles, not mechanically propelled; parts thereof - Other vehicles
871690	neutral	inter	Trailers and semi-trailers; other vehicles, not mechanically propelled; parts thereof - Parts
940120	neutral	inter	Seats of a kind used for motor vehicles

Notes: own elaboration.

B Detailed estimation results

Table B.1: Estimates of gravity model for combustion-specific products

	Combustion-specific			
	(1)	(2)	(3)	(4)
log(Distance)	−0.393***	−0.390***	−0.397***	−0.408***
	(0.0602)	(0.0649)	(0.0635)	(0.0637)
log(GDP_o)	0.846***	0.591***	0.680***	0.864***
	(0.0302)	(0.0387)	(0.0417)	(0.0498)
log(GDP_d)	0.852***	0.863***	0.804***	0.804***
	(0.0255)	(0.0257)	(0.0211)	(0.0210)
EU	1.434***	0.877***	0.950***	0.856***
	(0.116)	(0.129)	(0.119)	(0.117)
log(Backward_GVC)		−0.355		1.527***
		(0.220)		(0.231)
log(Forward_GVC)		1.430***		1.590***
		(0.162)		(0.122)
log(R&D)			1.588***	0.577**
			(0.233)	(0.232)
log(FDI)			0.976***	0.174
			(0.138)	(0.148)
log(R&D)*log(FDI)			−0.428***	−0.128**
			(0.0471)	(0.0529)
Constant	−24.81***	−17.91***	−22.26***	−31.93***
	(1.444)	(1.884)	(1.275)	(2.270)
Year dummies	✓	✓	✓	✓
Observations	131050	44720	20800	20800
R^2	0.099	0.133	0.251	0.267

Note: the superscripts ∗∗∗, ∗∗ and ∗ denote the rejection of a null hypothesis of parameters' insignificance at 1%, 5% and 10% significance level, respectively.

Table B.2: Estimates of gravity model for neutral products

	Neutral			
	(1)	(2)	(3)	(4)
log(Distance)	−0.442***	−0.437***	−0.541***	−0.553***
	(0.0466)	(0.0509)	(0.0561)	(0.0566)
log(GDP_o)	0.891***	0.657***	0.685***	0.762***
	(0.0279)	(0.0360)	(0.0437)	(0.0506)
log(GDP_d)	0.782***	0.787***	0.725***	0.726***
	(0.0235)	(0.0239)	(0.0183)	(0.0183)
EU	1.536***	1.025***	0.880***	0.791***
	(0.0844)	(0.0958)	(0.0959)	(0.0922)
log(Backward_GVC)		−0.328***		0.925***
		(0.127)		(0.254)
log(Forward_GVC)		1.333***		1.374***
		(0.119)		(0.100)
log(R&D)			1.772***	1.056***
			(0.193)	(0.172)
log(FDI)			1.134***	0.563***
			(0.104)	(0.0983)
log(R&D)*log(FDI)			−0.471***	−0.245***
			(0.0365)	(0.0342)
Constant	−24.55***	−18.13***	−20.55***	−25.68***
	(1.269)	(1.774)	(1.059)	(2.220)
Year dummies	✓	✓	✓	✓
Observations	131050	44720	20800	20800
R^2	0.126	0.150	0.193	0.206

Note: the superscripts $***$, $**$ and $*$ denote the rejection of a null hypothesis of parameters' insignificance at 1%, 5% and 10% significance level, respectively.

Table B.3: Estimates of gravity model for electric-specific products

	Electric-specific			
	(1)	(2)	(3)	(4)
log(Distance)	-0.304^{***}	-0.283^{***}	-0.529^{***}	-0.531^{***}
	(0.0584)	(0.0570)	(0.0296)	(0.0265)
log(GDP_o)	1.022^{***}	0.692^{***}	0.748^{***}	1.010^{***}
	(0.0851)	(0.0920)	(0.0669)	(0.0849)
log(GDP_d)	0.800^{***}	0.797^{***}	0.827^{***}	0.829^{***}
	(0.0246)	(0.0244)	(0.0228)	(0.0228)
EU	1.568^{***}	1.353^{***}	0.876^{***}	0.767^{***}
	(0.122)	(0.186)	(0.159)	(0.147)
log(Backward_GVC)		-1.147^{***}		2.091^{***}
		(0.299)		(0.453)
log(Forward_GVC)		1.340^{***}		0.907^{***}
		(0.216)		(0.212)
log(R&D)			1.867^{***}	1.643^{***}
			(0.470)	(0.599)
log(FDI)			1.433^{***}	1.107^{***}
			(0.287)	(0.358)
log(R&D)*log(FDI)			-0.627^{***}	-0.532^{***}
			(0.0992)	(0.127)
Constant	-32.07^{***}	-20.14^{***}	-27.99^{***}	-43.20^{***}
	(2.480)	(3.390)	(2.176)	(3.640)
Year dummies	✓	✓	✓	✓
Observations	131050	44720	20800	20800
R^2	0.110	0.182	0.191	0.218

Note: the superscripts $***$, $**$ and $*$ denote the rejection of a null hypothesis of parameters' insignificance at 1%, 5% and 10% significance level, respectively.

Table B.4: Estimates of gravity model for vehicles & parts (HS 87 section)

	Vehicles & parts			
	(1)	(2)	(3)	(4)
log(Distance)	-0.402^{***}	-0.396^{***}	-0.452^{***}	-0.462^{***}
	(0.0520)	(0.0562)	(0.0538)	(0.0538)
log(GDP_o)	0.869^{***}	0.622^{***}	0.667^{***}	0.842^{***}
	(0.0281)	(0.0378)	(0.0395)	(0.0471)
log(GDP_d)	0.816^{***}	0.824^{***}	0.774^{***}	0.775^{***}
	(0.0250)	(0.0254)	(0.0196)	(0.0195)
EU	1.477^{***}	0.960^{***}	0.929^{***}	0.832^{***}
	(0.0992)	(0.111)	(0.101)	(0.0976)
log(Backward_GVC)		$-0.349{**}$		1.471^{***}
		(0.174)		(0.238)
log(Forward_GVC)		1.313^{***}		1.390^{***}
		(0.146)		(0.0948)
log(R&D)			1.523^{***}	0.632^{***}
			(0.213)	(0.151)
log(FDI)			0.926^{***}	0.213^{**}
			(0.124)	(0.0946)
log(R&D)*log(FDI)			-0.407^{***}	-0.145^{***}
			(0.0426)	(0.0334)
Constant	-24.09^{***}	-17.28^{***}	-20.14^{***}	-29.45^{***}
	(1.318)	(1.840)	(1.156)	(2.153)
Year dummies	✓	✓	✓	✓
Observations	131050	44720	20800	20800
R^2	0.114	0.144	0.244	0.260

Note: the superscripts $***$, $**$ and $*$ denote the rejection of a null hypothesis of parameters' insignificance at 1%, 5% and 10% significance level, respectively.

Table B.5: Estimates of gravity model for products of the manufacturing sector

	Total manufacturing			
	(1)	(2)	(3)	(4)
log(Distance)	−0.460***	−0.418***	−0.460***	−0.451***
	(0.0258)	(0.0253)	(0.0250)	(0.0240)
log(GDP_o)	0.827***	0.899***	0.661***	0.774***
	(0.0327)	(0.0349)	(0.0244)	(0.0318)
log(GDP_d)	0.760***	0.746***	0.763***	0.761***
	(0.0153)	(0.0152)	(0.0141)	(0.0137)
EU	0.835***	0.827***	0.858***	0.810***
	(0.0589)	(0.0637)	(0.0578)	(0.0530)
log(Backward_GVC)		0.419***		0.499***
		(0.0877)		(0.116)
log(Forward_GVC)		−0.942***		−0.365*
		(0.209)		(0.199)
log(R&D)			0.101***	−0.112
			(0.0298)	(0.0686)
log(FDI)			−0.0496***	−0.176***
			(0.0103)	(0.0455)
log(R&D)*log(FDI)			−0.0202***	0.0344*
			(0.00550)	(0.0195)
Constant	−25.33***	−26.04***	−20.72***	−24.07***
	(0.990)	(1.485)	(0.866)	(1.565)
Year dummies	✓	✓	✓	✓
Observations	144425	44720	32240	30160
R^2	0.192	0.257	0.298	0.321

Note: the superscripts $***$, $**$ and $*$ denote the rejection of a null hypothesis of parameters' insignificance at 1%, 5% and 10% significance level, respectively.

Table B.6: Baseline estimates

	Comb.-spec.	Neutral	Elec.-spec.	Vehic.&parts	Manufact.
log(Distance)	-0.408^{***}	-0.553^{***}	-0.531^{***}	-0.462^{***}	-0.451^{***}
	(0.0637)	(0.0566)	(0.0265)	(0.0538)	(0.0240)
log(GDP_o)	0.864^{***}	0.762^{***}	1.010^{***}	0.842^{***}	0.774^{***}
	(0.0498)	(0.0506)	(0.0849)	(0.0471)	(0.0318)
log(GDP_d)	0.804^{***}	0.726^{***}	0.829^{***}	0.775^{***}	0.761^{***}
	(0.0210)	(0.0183)	(0.0228)	(0.0195)	(0.0137)
EU	0.856^{***}	0.791^{***}	0.767^{***}	0.832^{***}	0.810^{***}
	(0.117)	(0.0922)	(0.147)	(0.0976)	(0.0530)
log(Backward_GVC)	1.527^{***}	0.925^{***}	2.091^{***}	1.471^{***}	0.499^{***}
	(0.231)	(0.254)	(0.453)	(0.238)	(0.116)
log(Forward_GVC)	1.590^{***}	1.374^{***}	0.907^{***}	1.390^{***}	-0.365^{*}
	(0.122)	(0.100)	(0.212)	(0.0948)	(0.199)
log(R&D)	0.577^{**}	1.056^{***}	1.643^{***}	0.632^{***}	-0.112
	(0.232)	(0.172)	(0.599)	(0.151)	(0.0686)
log(FDI)	0.174	0.563^{***}	1.107^{***}	0.213^{**}	-0.176^{***}
	(0.148)	(0.0983)	(0.358)	(0.0946)	(0.0455)
log(R&D)*log(FDI)	-0.128^{**}	-0.245^{***}	-0.532^{***}	-0.145^{***}	0.034^{*}
	(0.053)	(0.034)	(0.127)	(0.033)	(0.0195)
Constant	-31.93^{***}	-25.68^{***}	-43.20^{***}	-29.45^{***}	-24.07^{***}
	(2.270)	(2.220)	(3.640)	(2.153)	(1.565)
Year dummies	✓	✓	✓	✓	✓
Observations	20800	20800	20800	20800	30160
R^2	0.267	0.206	0.218	0.260	0.321

Note: the superscripts $***$, $**$ and $*$ denote the rejection of a null hypothesis of parameters' insignificance at 1%, 5% and 10% significance level, respectively.

Table B.7: Estimates of gravity model - baseline specification extended by adding time-variant parameters

	Comb.-spec.	Neutral	Elec.-spec.	Vehicles&parts
log(Distance)	-0.408^{***}	-0.553^{***}	-0.530^{***}	-0.463^{***}
	(0.0638)	(0.0562)	(0.0280)	(0.0535)
log(GDP_o)	0.868^{***}	0.774^{***}	1.063^{***}	0.854^{***}
	(0.0508)	(0.0501)	(0.0857)	(0.0483)
log(GDP_d)	0.804^{***}	0.727^{***}	0.830^{***}	0.775^{***}
	(0.0210)	(0.0181)	(0.0222)	(0.0194)
EU	0.852^{***}	0.788^{***}	0.766^{***}	0.827^{***}
	(0.118)	(0.0890)	(0.152)	(0.0961)
log(Backward_GVC) × 2017	1.732^{***}	0.480	0.573	1.416^{***}
	(0.402)	(0.436)	(0.708)	(0.396)
log(Backward_GVC) × 2018	1.523^{***}	0.452	0.794	1.275^{***}
	(0.439)	(0.409)	(0.542)	(0.410)
log(Backward_GVC) × 2019	1.516^{***}	0.683	0.930	1.358^{***}
	(0.464)	(0.455)	(0.857)	(0.476)
log(Backward_GVC) × 2020	1.622^{***}	0.985^{**}	1.851^{**}	1.564^{***}
	(0.446)	(0.415)	(0.835)	(0.470)
log(Backward_GVC) × 2021	1.466^{***}	1.137^{***}	2.638^{***}	1.574^{***}
	(0.421)	(0.419)	(0.674)	(0.444)
log(Backward_GVC) × 2022	1.516^{***}	1.405^{***}	3.179^{***}	1.768^{***}
	(0.414)	(0.456)	(0.601)	(0.437)
log(Backward_GVC) × 2023	1.546^{***}	1.382^{***}	3.032^{***}	1.739^{***}
	(0.396)	(0.468)	(0.751)	(0.448)
log(Forward_GVC) × 2017	1.447^{***}	1.413^{***}	0.247	1.351^{***}
	(0.225)	(0.243)	(0.565)	(0.177)
log(Forward_GVC) × 2018	1.585^{***}	1.395^{***}	0.420	1.416^{***}
	(0.270)	(0.261)	(0.411)	(0.201)
log(Forward_GVC) × 2019	1.563^{***}	1.416^{***}	0.0206	1.371^{***}
	(0.285)	(0.264)	(0.526)	(0.247)
log(Forward_GVC) × 2020	1.756^{***}	1.559^{***}	1.255^{**}	1.575^{***}
	(0.255)	(0.216)	(0.550)	(0.242)
log(Forward_GVC) × 2021	1.563^{***}	1.247^{***}	1.169^{***}	1.323^{***}
	(0.243)	(0.210)	(0.365)	(0.236)
log(Forward_GVC) × 2022	1.684^{***}	1.437^{***}	1.124^{***}	1.464^{***}
	(0.204)	(0.219)	(0.254)	(0.210)
log(Forward_GVC) × 2023	1.794^{***}	1.416^{***}	1.155^{***}	1.495^{***}
	(0.240)	(0.256)	(0.320)	(0.257)
log(R&D) × 2017	0.666^{**}	1.006^{***}	1.913^{***}	0.670^{***}
	(0.320)	(0.215)	(0.626)	(0.239)
log(R&D) × 2018	0.625^{*}	0.943^{***}	1.928^{***}	0.623^{**}
	(0.328)	(0.218)	(0.599)	(0.248)
log(R&D) × 2019	0.601^{*}	1.002^{***}	1.819^{***}	0.620^{**}
	(0.321)	(0.252)	(0.594)	(0.263)
log(R&D) × 2020	0.514^{*}	1.048^{***}	1.866^{***}	0.585^{**}
	(0.299)	(0.249)	(0.632)	(0.247)
log(R&D) × 2021	0.526^{*}	1.040^{***}	1.713^{***}	0.588^{**}
	(0.299)	(0.262)	(0.622)	(0.251)
log(R&D) × 2022	0.489^{*}	1.066^{***}	1.570^{***}	0.577^{**}
	(0.297)	(0.257)	(0.563)	(0.245)

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Table B.7 – continued from previous page

	Comb.-spec.	Neutral	Elec.-spec.	Vehicles&parts
log(R&D) × 2023	0.452	1.047***	1.501***	0.527**
	(0.295)	(0.252)	(0.579)	(0.238)
log(FDI) × 2017	0.129	0.610***	1.333***	0.203**
	(0.150)	(0.105)	(0.332)	(0.0977)
log(FDI) × 2018	0.161	0.595***	1.346***	0.218**
	(0.150)	(0.106)	(0.332)	(0.0971)
log(FDI) × 2019	0.167	0.582***	1.299***	0.216**
	(0.150)	(0.107)	(0.338)	(0.0990)
log(FDI) × 2020	0.156	0.552***	1.280***	0.198*
	(0.154)	(0.105)	(0.340)	(0.103)
log(FDI) × 2021	0.175	0.501***	1.108***	0.178*
	(0.153)	(0.0987)	(0.333)	(0.0994)
log(FDI) × 2022	0.155	0.483***	0.978***	0.147
	(0.153)	(0.0997)	(0.317)	(0.0996)
log(FDI) × 2023	0.167	0.523***	1.004***	0.166
	(0.153)	(0.104)	(0.315)	(0.103)
log(R&D)*log(FDI)	−0.122**	−0.240***	−0.546***	−0.137***
	(0.0530)	(0.0333)	(0.112)	(0.0329)
Constant	−32.71***	−24.54***	−39.63***	−29.65***
	(2.939)	(2.642)	(4.611)	(2.760)
Year dummies	✓	✓	✓	✓
Observations	20800	20800	20800	20800
R^2	0.268	0.210	0.233	0.263

Table B.8: Estimates of gravity model for disaggregated data (HS 6-digit codes level)

	Common	× combust.-spec.	× electric-spec.
log(Distance)	-0.558^{***}	0.156^{*}	0.00295
	(0.0560)	(0.0852)	(0.0640)
log(GDP_o)	0.817^{***}	-0.0223	0.470^{***}
	(0.0525)	(0.0714)	(0.129)
log(GDP_d)	0.728^{***}	0.0744^{***}	0.108^{***}
	(0.0183)	(0.0277)	(0.0293)
EU	0.758^{***}	0.133	-0.116
	(0.0902)	(0.148)	(0.175)
log(Backward_GVC)	1.169^{***}	0.0416	1.986^{***}
	(0.236)	(0.340)	(0.617)
log(Forward_GVC)	1.254^{***}	0.466^{***}	-0.742^{**}
	(0.112)	(0.158)	(0.309)
log(R&D)	1.123^{***}	-0.632^{**}	1.052
	(0.189)	(0.309)	(0.858)
log(FDI)	0.607^{***}	-0.486^{***}	0.859^{*}
	(0.0997)	(0.183)	(0.507)
log(R&D)*log(FDI)	-0.271^{***}	0.174^{***}	-0.429^{**}
	(0.0371)	(0.0655)	(0.187)
Constant		-33.27^{***}	
		(2.402)	
Year dummies		✓	
Product FEs		✓	
Observations		2,142,400	
R^2		0.133	

Note: the superscripts $***$, $**$ and $*$ denote the rejection of a null hypothesis of parameters' insignificance at 1%, 5% and 10% significance level, respectively.

Table B.9: Estimates of gravity model for disaggregated data (HS 6-digit codes level) with time-variant parameters

	Common	× comb.-spec.	× elec.-spec.
log(Distance)	-0.553***	0.145*	0.0183
	(0.0561)	(0.0848)	(0.0622)
log(GDP_o)	0.776***	0.0910	0.302***
	(0.0506)	(0.0712)	(0.101)
log(GDP_d)	0.727***	0.0776***	0.102***
	(0.0181)	(0.0276)	(0.0287)
EU	0.787***	0.0648	-0.0422
	(0.0896)	(0.147)	(0.173)
log(Backward_GVC) × 2017	0.699*	0.907**	0.744
	(0.395)	(0.384)	(0.554)
log(Backward_GVC) × 2018	0.640	0.769**	0.755
	(0.397)	(0.383)	(0.502)
log(Backward_GVC) × 2019	0.735*	0.712*	0.983
	(0.398)	(0.385)	(0.633)
log(Backward_GVC) × 2020	0.976***	0.641*	1.060*
	(0.354)	(0.382)	(0.556)
log(Backward_GVC) × 2021	1.105***	0.418	1.362***
	(0.332)	(0.364)	(0.504)
log(Backward_GVC) × 2022	1.286***	0.382	1.656***
	(0.348)	(0.367)	(0.476)
log(Backward_GVC) × 2023	1.277***	0.385	1.663***
	(0.352)	(0.372)	(0.563)
log(Forward_GVC) × 2017	1.506***	-0.112	-0.745
	(0.270)	(0.354)	(0.622)
log(Forward_GVC) × 2018	1.484***	0.0463	-0.682
	(0.289)	(0.376)	(0.462)
log(Forward_GVC) × 2019	1.438***	0.0895	-0.940
	(0.283)	(0.374)	(0.676)
log(Forward_GVC) × 2020	1.549***	0.205	-0.210
	(0.237)	(0.340)	(0.516)
log(Forward_GVC) × 2021	1.227***	0.368	-0.166
	(0.201)	(0.295)	(0.407)
log(Forward_GVC) × 2022	1.381***	0.378	-0.388
	(0.213)	(0.278)	(0.314)
log(Forward_GVC) × 2023	1.354***	0.513	-0.285
	(0.243)	(0.318)	(0.394)
log(R&D) × 2017	1.116***	-0.510	1.251*
	(0.220)	(0.313)	(0.667)
log(R&D) × 2018	1.043***	-0.476	1.214*
	(0.226)	(0.315)	(0.655)
log(R&D) × 2019	1.028***	-0.461	1.208*
	(0.234)	(0.315)	(0.674)
log(R&D) × 2020	1.041***	-0.526*	0.906
	(0.224)	(0.315)	(0.657)
log(R&D) × 2021	1.021***	-0.461	0.586
	(0.222)	(0.313)	(0.644)
log(R&D) × 2022	1.010***	-0.441	0.434
	(0.215)	(0.313)	(0.601)
log(R&D) × 2023	0.997***	-0.483	0.418
	(0.214)	(0.317)	(0.587)
log(FDI) × 2017	0.616***	-0.487***	0.765**
	(0.107)	(0.185)	(0.369)
log(FDI) × 2018	0.602***	-0.443**	0.785**
	(0.108)	(0.186)	(0.365)
log(FDI) × 2019	0.585***	-0.419**	0.761**

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Table B.9 – continued from previous page

	Common	× comb.-spec.	× elec.-spec.
	(0.108)	(0.186)	(0.380)
log(FDI) × 2020	0.553***	-0.396**	0.740**
	(0.105)	(0.188)	(0.369)
log(FDI) × 2021	0.501***	-0.323*	0.610*
	(0.0994)	(0.184)	(0.355)
log(FDI) × 2022	0.483***	-0.324*	0.500
	(0.101)	(0.185)	(0.341)
log(FDI) × 2023	0.522***	-0.350*	0.481
	(0.105)	(0.187)	(0.340)
log(R&D)*log(FDI)	-0.240***	0.118*	-0.310***
	(0.0336)	(0.0632)	(0.120)
Constant		-45.66***	
Year dummies		✓	
Product FEs		✓	
Observations		2,142,400	
R^2		0.141	

Table B.10: Estimates of gravity model for final goods and intermediates without time-variant parameters

	Combustion-specific		Neutral		Electric-specific	
	inter	final	inter	final	inter	final
log(Distance)	-0.461^{***}	-0.390^{***}	-0.587^{***}	-0.494^{***}	-0.407^{***}	-0.622^{***}
	(0.0797)	(0.0603)	(0.0629)	(0.0489)	(0.0429)	(0.0405)
log(GDP_o)	0.764^{***}	0.891^{***}	0.856^{***}	0.643^{***}	0.738^{***}	1.461^{***}
	(0.0563)	(0.0574)	(0.0384)	(0.0715)	(0.113)	(0.127)
log(GDP_d)	0.758^{***}	0.820^{***}	0.737^{***}	0.710^{***}	0.868^{***}	0.795^{***}
	(0.0224)	(0.0211)	(0.0200)	(0.0217)	(0.0305)	(0.0231)
EU	0.775^{***}	0.888^{***}	0.832^{***}	0.782^{***}	1.314^{***}	0.325^{*}
	(0.136)	(0.122)	(0.105)	(0.0902)	(0.106)	(0.180)
log(Backward_GVC)	0.395	1.870^{***}	0.660^{***}	1.362^{***}	0.466	4.429^{***}
	(0.302)	(0.244)	(0.209)	(0.297)	(0.637)	(0.593)
log(Forward_GVC)	1.640^{***}	1.618^{***}	2.105^{***}	0.356	1.247^{***}	1.448^{***}
	(0.157)	(0.134)	(0.0817)	(0.224)	(0.252)	(0.422)
log(R&D)	2.419^{***}	0.232	0.499^{**}	1.941^{***}	4.145^{***}	-0.549
	(0.749)	(0.224)	(0.223)	(0.254)	(1.556)	(0.559)
log(FDI)	1.422^{***}	-0.0853	0.428^{***}	0.752^{***}	2.912^{***}	-0.673^{*}
	(0.454)	(0.138)	(0.133)	(0.156)	(0.885)	(0.369)
log(R&D)*log(FDI)	-0.527^{***}	-0.0459	-0.166^{***}	-0.359^{***}	-1.097^{***}	0.0410
	(0.159)	(0.0486)	(0.0472)	(0.0590)	(0.306)	(0.135)
Constant	-30.48^{***}	-33.70^{***}	-27.52^{***}	-25.82^{***}	-40.75^{***}	-57.43^{***}
	(3.906)	(2.417)	(1.959)	(2.790)	(7.805)	(5.115)
Year dummies	✓	✓	✓	✓	✓	✓
Observations	20800	20800	20800	20800	20800	20800
R^2	0.136	0.291	0.154	0.277	0.255	0.184

Note: the superscripts $***$, $**$ and $*$ denote the rejection of a null hypothesis of parameters' insignificance at 1%, 5% and 10% significance level, respectively.

Table B.11: Estimates of gravity model for final goods and intermediates with time-variant parameters

	Combust.-spec.		Neutral		Electric-spec.	
	inter	final	inter	final	inter	final
log(Distance)	-0.461^{***}	-0.390^{***}	-0.587^{***}	-0.497^{***}	-0.404^{***}	-0.622^{***}
	(0.0795)	(0.0604)	(0.0625)	(0.0488)	(0.0419)	(0.0439)
log(GDP_o)	0.772^{***}	0.893^{***}	0.866^{***}	0.663^{***}	0.755^{***}	1.671^{***}
	(0.0573)	(0.0581)	(0.0381)	(0.0716)	(0.120)	(0.128)
log(GDP_d)	0.758^{***}	0.820^{***}	0.738^{***}	0.710^{***}	0.869^{***}	0.795^{***}
	(0.0222)	(0.0211)	(0.0198)	(0.0216)	(0.0303)	(0.0223)
EU	0.774^{***}	0.884^{***}	0.834^{***}	0.758^{***}	1.313^{***}	0.320^{*}
	(0.134)	(0.123)	(0.102)	(0.0881)	(0.108)	(0.188)
log(Backward_GVC) × 2017	0.345	2.114^{***}	0.459	0.709	−0.319	2.890^{***}
	(0.576)	(0.432)	(0.419)	(0.463)	(0.920)	(0.854)
log(Backward_GVC) × 2018	0.138	1.915^{***}	0.314	0.871^{*}	−0.341	3.184^{***}
	(0.466)	(0.476)	(0.351)	(0.515)	(0.829)	(0.575)
log(Backward_GVC) × 2019	0.148	1.908^{***}	0.463	1.241^{**}	−0.187	3.446^{***}
	(0.441)	(0.504)	(0.370)	(0.613)	(0.875)	(0.954)
log(Backward_GVC) × 2020	0.553	1.970^{***}	0.784^{***}	1.422^{**}	−0.273	5.075^{***}
	(0.433)	(0.490)	(0.275)	(0.688)	(1.048)	(1.162)
log(Backward_GVC) × 2021	0.702	1.704^{***}	0.878^{***}	1.448^{**}	0.246	6.033^{***}
	(0.478)	(0.451)	(0.295)	(0.601)	(0.992)	(1.026)
log(Backward_GVC) × 2022	0.633	1.794^{***}	0.991^{***}	1.902^{***}	1.431	6.079^{***}
	(0.503)	(0.450)	(0.324)	(0.647)	(1.130)	(0.629)
log(Backward_GVC) × 2023	0.605	1.849^{***}	0.989^{***}	1.910^{***}	1.389	5.953^{***}
	(0.399)	(0.450)	(0.314)	(0.669)	(1.098)	(0.839)
log(Forward_GVC) × 2017	1.512^{***}	1.485^{***}	2.191^{***}	−0.458	0.615	−0.326
	(0.412)	(0.256)	(0.227)	(0.377)	(0.643)	(1.136)
log(Forward_GVC) × 2018	1.672^{***}	1.617^{***}	2.261^{***}	−0.577	0.739	−0.320
	(0.378)	(0.309)	(0.201)	(0.420)	(0.585)	(0.865)
log(Forward_GVC) × 2019	1.738^{***}	1.584^{***}	2.282^{***}	−0.184	1.045^{*}	−1.059
	(0.386)	(0.321)	(0.229)	(0.386)	(0.533)	(0.958)
log(Forward_GVC) × 2020	1.803^{***}	1.787^{***}	2.261^{***}	0.543	1.344^{**}	2.158^{**}
	(0.397)	(0.275)	(0.155)	(0.432)	(0.581)	(1.018)
log(Forward_GVC) × 2021	1.550^{***}	1.587^{***}	1.946^{***}	0.480	1.405^{***}	2.294^{***}
	(0.413)	(0.261)	(0.171)	(0.395)	(0.516)	(0.643)
log(Forward_GVC) × 2022	1.628^{***}	1.727^{***}	2.005^{***}	0.847^{**}	1.400^{***}	2.211^{***}
	(0.381)	(0.238)	(0.159)	(0.408)	(0.489)	(0.327)
log(Forward_GVC) × 2023	1.812^{***}	1.825^{***}	2.061^{***}	0.755^{*}	1.495^{***}	2.079^{***}
	(0.388)	(0.285)	(0.183)	(0.424)	(0.516)	(0.439)
log(R&D) × 2017	2.412^{***}	0.349	0.538^{**}	1.938^{***}	4.694^{***}	−0.532
	(0.819)	(0.356)	(0.245)	(0.318)	(1.519)	(0.589)
log(R&D) × 2018	2.384^{***}	0.299	0.417^{*}	1.994^{***}	4.479^{***}	−0.241
	(0.777)	(0.354)	(0.239)	(0.327)	(1.510)	(0.529)

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Table B.11 – continued from previous page

	Combust.-spec.		Neutral		Electric-spec.	
	inter	final	inter	final	inter	final
log(R&D) × 2019	2.415***	0.264	0.456*	2.034***	4.327***	−0.313
	(0.786)	(0.340)	(0.262)	(0.356)	(1.512)	(0.606)
log(R&D) × 2020	2.460***	0.137	0.500**	1.944***	4.026***	−0.307
	(0.784)	(0.312)	(0.239)	(0.398)	(1.545)	(0.736)
log(R&D) × 2021	2.441***	0.151	0.459*	1.907***	3.987***	−0.523
	(0.782)	(0.301)	(0.266)	(0.375)	(1.544)	(0.676)
log(R&D) × 2022	2.396***	0.116	0.456*	1.942***	4.072***	−0.930*
	(0.767)	(0.302)	(0.260)	(0.366)	(1.553)	(0.543)
log(R&D) × 2023	2.360***	0.0834	0.461*	1.905***	4.142***	−1.125**
	(0.767)	(0.296)	(0.254)	(0.355)	(1.573)	(0.552)
log(FDI) × 2017	1.423***	−0.140	0.447***	0.777***	2.994***	−0.541*
	(0.463)	(0.139)	(0.136)	(0.157)	(0.879)	(0.326)
log(FDI) × 2018	1.439***	−0.106	0.435***	0.762***	2.976***	−0.496
	(0.460)	(0.139)	(0.135)	(0.161)	(0.878)	(0.326)
log(FDI) × 2019	1.444***	−0.0982	0.435***	0.755***	2.980***	−0.649**
	(0.462)	(0.139)	(0.137)	(0.160)	(0.876)	(0.331)
log(FDI) × 2020	1.419***	−0.110	0.410***	0.758***	2.974***	−0.592*
	(0.465)	(0.141)	(0.134)	(0.166)	(0.873)	(0.344)
log(FDI) × 2021	1.374***	−0.0683	0.374***	0.730***	2.920***	−0.836**
	(0.462)	(0.140)	(0.134)	(0.156)	(0.870)	(0.334)
log(FDI) × 2022	1.384***	−0.100	0.366***	0.705***	2.827***	−0.990***
	(0.455)	(0.142)	(0.133)	(0.157)	(0.858)	(0.331)
log(FDI) × 2023	1.406***	−0.0921	0.390***	0.753***	2.884***	−0.980***
	(0.456)	(0.143)	(0.133)	(0.162)	(0.859)	(0.330)
log(R&D)*log(FDI)	−0.524***	−0.0391	−0.160***	−0.360***	−1.103***	0.0771
	(0.161)	(0.0478)	(0.0462)	(0.0560)	(0.296)	(0.117)
Constant	−30.40***	−34.65***	−27.41***	−23.08***	−39.06***	−56.52***
	(4.939)	(3.274)	(2.412)	(3.259)	(7.841)	(5.807)
Year dummies	✓	✓	✓	✓	✓	✓
Observations	20800	20800	20800	20800	20800	20800
R^2	0.137	0.293	0.156	0.283	0.302	0.199

Table B.12: Estimates of logistic regression for probability of non-negligible (at least 1 million USD) exports of automotive products

	(1)			(2)		
	Common	x comb.	x elec.	Common	x comb..	x elec.
log(Distance)	−0.839***	0.053	0.111	−0.954***	0.0412	0.088
	(0.089)	(0.044)	(0.083)	(0.100)	(0.094)	(0.102)
log(GDP_o)	1.205***	−0.047	0.036	1.132***	−0.0613	−0.139
	(0.081)	(0.036)	(0.092)	(0.109)	(0.052)	(0.142)
log(GDP_d)	0.570***	−0.132***	0.257***	0.858***	−0.129***	0.352***
	(0.032)	(0.019)	(0.040)	(0.054)	(0.027)	(0.038)
EU	2.356***	−0.192	−0.297	1.440***	−0.011	−0.025
	(0.295)	(0.164)	(0.255)	(0.261)	(0.138)	(0.331)
log(Backward_GVC)				2.235***	1.019***	−0.312
				(0.576)	(0.301)	(0.676)
log(Forward_GVC)				−0.092	0.690***	0.806***
				(0.335)	(0.100)	(0.308)
log(R&D)				1.644***	0.072	−1.324***
				(0.357)	(0.291)	(0.503)
log(FDI)				0.737***	−0.202	−1.176***
				(0.226)	(0.174)	(0.376)
log(R&D)*log(FDI)				−0.335***	0.046	0.364***
				(0.084)	(0.065)	(0.139)
Constant		-41.00***			-56.38***	
		(2.46)			(5.23)	
Year dummies		✓			✓	
Observations		393,150			62,400	

Note: the superscripts $***$, $**$ and $*$ denote the rejection of a null hypothesis about parameters' insignificance at 1%, 5% and 10% significance level, respectively.

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