Policy Contribution
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Executive summary

is currently at the centre of a global transformation, driven by four key trends: electri cation, autonomous driving, sharing and connected cars. While each of these interconnected trends is already visible in daily life, their full deployment is not yet guaranteed, nor is the speed of take-up.

investigates the position of the European automotive industry in a scenario in which electri cation substantially progresses.

encouraging for Europe: EU companies entered late the global electric ve-

the global electric vehicle race, its automotive industry will have to move into higher gear to meet the global – notably Chinese – competition. Nevertheless, industry needs the proper framework conditions as the basis for more ambitious investments in electri cation – as examples such as Norway or China demonstrate.

formulates a broad policy framework for deployment and production of electric vehicles in Europe, combining demand and supply-side instruments. Europe cannot follow China in the adoption of centrally-planned industrial policy measures. But it certainly can and should do more to stimulate the transformation of its automotive industry through more ambitious policies.

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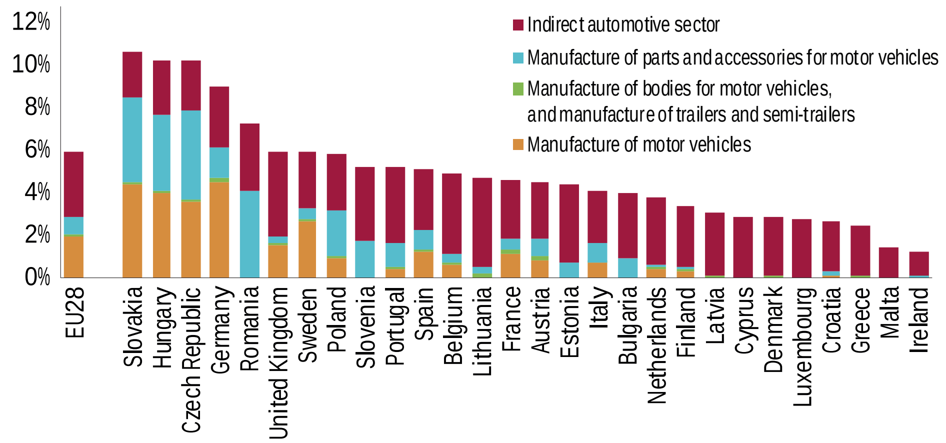
In the EU, the value added of all automotive sectors is considerable. In 2015, it represented almost 6 percent of overall value added, making it larger than other major sectors such as pharmaceuticals and machinery equipment manufacturing. In some EU countries (Slovakia, Hungary, the Czech Republic and Germany: henceforth the BIG4), the automotive sector accounts for more than 8 percent of their total value added (Figure 1).

e indirect sector accounts for half of overall automotive value added in the EU (Figure 1). e share of the indirect sector is uniform in all EU countries and is generally the largest component of overall automotive value added. When looking at the direct sectors, the manufacture of vehicles generates around 2 percent of total value added in the EU. It is especially important in the BIG4. e manufacture of vehicle parts also accounts for a large amount of value added in the BIG4 and in Romania, Slovenia and Portugal.

Figure 1: Share of the automotive sector in total value added (2015)



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Employment

In terms of employment, the automotive sector accounted for almost 3 percent of the EU's labour force in 2015 (Figure 2). In the EU and in most EU countries, the indirect sectors account for the greatest share of automotive employment, as they include the more labour-intensive services such as sales and maintenance. Employment in the capital-intensive direct sectors in the EU is concentrated in a few countries. e BIG4 accounts for most of the EU's direct automotive employment.

Figure 2: Share of the automotive sector in total employment in 2015

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Research and development

Internationally, only Japanese companies spend similar amounts on automotive R&D: Japanese scoreboard firms from the automotive sector spend more than €25 billion on R&D, or almost 30 percent of all R&D spending by all Japanese scoreboard firms. In the US, these figures amount only to €15 billion and 5 percent. South Korea and China account for even smaller absolute amounts and shares.

European automotive firms have traditionally held a dominant position in R&D, with the top 10 percent of European automotive R&D spenders proportionally outspending the biggest automotive spenders from other parts of the world (Figure 4). This strong position has even

In general, the sector is quite stable at the top. e ranking of top automotive R&D spending companies has remained largely unchanged in recent years; however some young firms in the sector have expanded quickly their R&D spending. The most important of these young companies come from outside the EU: US-based Tesla and several Chinese firms, which with considerable increases in their R&D spending, have climbed several dozen places in the scoreboard ranking (Table 1).

External competitiveness

Vehicles account for 9 percent of EU exports (Figure 5). Vehicles account for more than 10 percent of exports from the BIG4, but also from Slovenia, Spain, the United Kingdom and Sweden. About two-thirds of EU vehicle exports are traded between EU countries (intra-EU). The EU is the major destination and source for the automobiles of most member states. Extra-EU vehicle exports are as large as intra-EU exports only for Germany, Sweden and Italy. The UK is the outlier country, exporting most of its vehicles to non–EU countries.

If exports of vehicle bodies and vehicle parts are also taken into account, total automotive exports account for almost 15 percent of intra-EU exports, of which one-third comprises vehicle parts. Trade in vehicle parts reflects the integration of European value chains. For smaller countries, a substantial part of intra-EU automotive trade is in parts (ie suppliers in European value chains). This is the case for the Czech Republic, Romania, Poland, Hungary, Slovakia and Portugal.

Figure 5: Motor vehicle exports to the EU and to non–EU countries as a share of total exports of all goods (2017)

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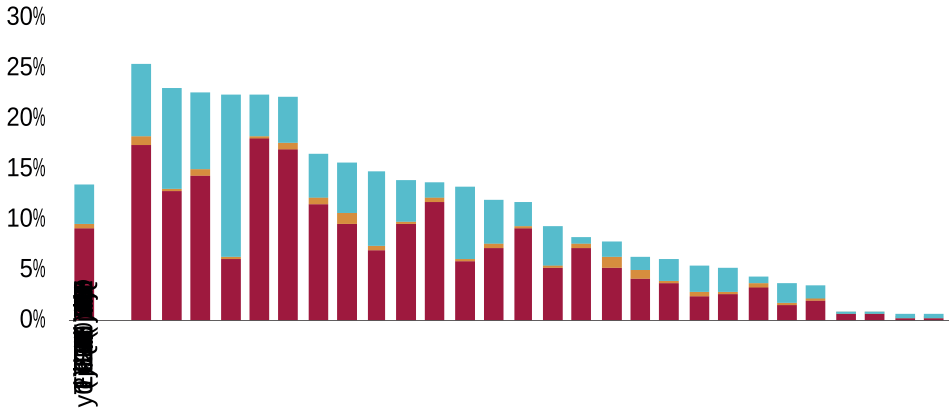
Figure 6: Motor vehicle, body and parts exports to EU countries as a share of total exports of all goods to EU countries (2017)



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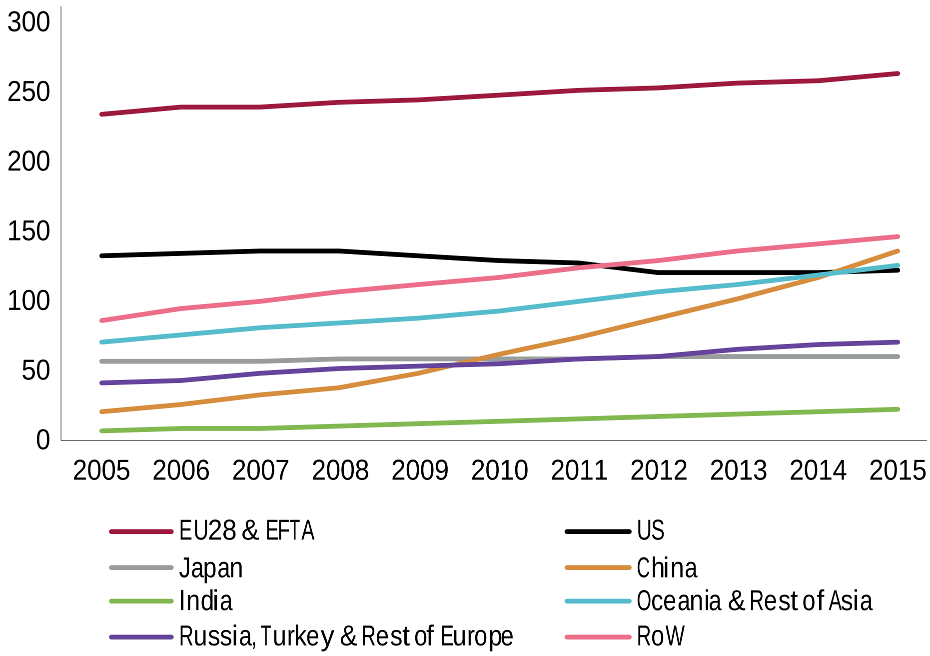
The power of the EU as a market

e strong position of the EU in the global automotive sector also comes from its market power. e EU and European Free Trade Area countries (Iceland, Liechtenstein, Norway, and Switzerland) combined have the world's largest stock of passenger cars, having grown from 235 million to 263 million cars between 2005 and 2015 (Figure 7). By contrast, the US car stock is decreasing. e number of cars in use in Japan has remained stable in the past decade but is relatively small (61 million in 2015). But the biggest growth comes from China, which is now already similarly sized to the US market. Growth in the Indian market has so far been below expectations.

Figure 7: Passenger cars in use



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On the supply side, the EU was traditionally the largest car producer in the world but has been overtaken by the spectacular growth of car manufacturing in China. Between 2006 and 2016, Chinese production shot up from ve million to almost 25 million cars per year. China's rise has not crowded out EU production volumes though, which were similar in

Figure 9: Patenting of major power-train technologies

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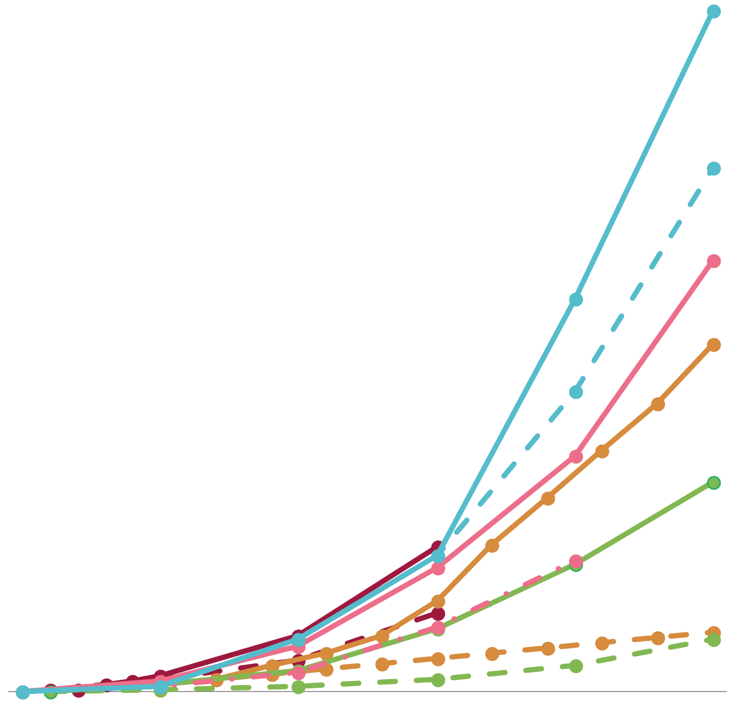
As EV technology has developed, technological improvements have reduced EV production costs, in particular by reducing battery costs, further nurhnoloulgelopts h Tm(tionr)1madugIPCL(y h)i-(I

Figure 10: Global EV deployment forecasts



The impact of EVs on automotive supply chains

EV market growth will have major consequences for traditional automotive supply chains, which are based on internal combustion. At the manufacturing stage, EVs represent a paradigm shift compared to ICE vehicles. The mechanical complexity of EVs is less, reducing manufacturing costs the number of workers required in the EV manufacturing process. This could mean a significant impact on jobs, requiring a shifting of skills from ICE to EV production and also reducing the number of manufacturing jobs.

In addition, EVs requires less maintenance than ICE vehicles as fewer parts need to be replaced over vehicles' lifetimes (UBS, 2017). This could have significant consequences for after-sales service providers that generate large shares of their revenues from service and maintenance (UBS, 2017; McKinsey, 2014).

The EV supply chain is also different from that for ICE vehicles. By comparing the content of a Chevrolet Bolt (EV) and a Volkswagen Golf (ICE), UBS (2017) found that almost 60 percent of the content of the Chevrolet Bolt originated from outside the traditional supply chain, the biggest difference being the battery packs in EVs (Figure 11). A value shift in the automotive supply chain implies challenges for EU carmakers and traditional suppliers. For one, it could jeopardise huge sunk ICE-related investments (eg in advanced diesel efficiency technology). There is also a risk that traditional suppliers and carmakers only capture a small share of the value of EVs. This could be especially likely if they lack unique competence in battery production and electric motor manufacturing.

However, EVs also provide new opportunities within the automotive sector. The transformation of the supply chain implies that new suppliers will emerge and capture value, especially in terms of critical battery technology. Furthermore, as EV production costs continue to fall, lower consumer prices will result in higher sales volumes. This can translate into greater economies of scale for manufacturers, further increasing the returns on EV-related investments (UBS, 2017). In addition, rapidly falling battery costs can improve margins for manufacturers of electric motors (McKinsey, 2016).

Figure 11: Breakdown of the manufacturing cost of ICE and electric vehicles ($)

Source: UBS (2017).

Even if in total EVs have a positive effect on automotive supply chains, the disruptive negative effects might be concentrated in certain regions affected strongly by local suppliers disappearing or relocating. Transport & Environment (T&E, 2017) aimed to quantify the income and employment effects of the transition to EVs. T&E (2017) highlighted that the EU will likely suffer job losses if traditional suppliers are unable to switch technologies or if engine and component manufacturers continue to invest in traditional power-train technologies. In that case, the overall number of jobs in the automotive sector would decrease. However, should the European automotive sector be able to produce competitive EVs, the overall number of jobs in the automotive sector could even grow.

4 The EU and electric vehicles

The EU and the global demand for EVs

Is the EU well-positioned to respond to the EV revolution? Data on registrations of EVs reveals two main features: the global EV market remains to date a small part of the overall car market, but it is growing rapidly.

In all major countries, EVs in 2017 had shares well below 5 percent of total vehicle reg-

In terms of the current specialisations of countries in power-train technologies, EU overall is well spread across the various technologies. Within the EU, Germany is by some margin the major patenting country. Like the other major patenting countries, Japan and Korea, it is spreading its power-train patenting across the four technologies. e US, Tesla notwithstanding, mostly focuses on the incumbent ICE technology. e newcomers India and China are still dwarves in terms of numbers of patents, but the patents they do hold are mainly in new power-train technologies.

5 How European automotive firms tackle the EV challenge

Although they were not the rst movers on EVs, European automotive rms have now become equally buoyant on the EV market. All have announced new EV models and ambitious annual EV sales targets to be achieved in the near future (Table 2).

Table 2: Automotive industry EV targets

Firms	Target dates	Sales targets
Volkswagen	2021-2025	20-30% of sales
Audi		25-30% of sales
BMW		15-25% of sales
Honda		Hybrid, plug-in hybrid, battery electric and fuel cell cars to make up two thirds of Honda's European sales by 2025
Mercedes		15-25% of sales
BYD		240k units
GM	2017-19	30k Bolts in 2017
Ford	2020-21	40% line-up, including hybrids
Volvo		1m cumulative by 2025
Tesla		1m by 2020
Toyota		1.5m
Nissan		20% of European sales
Changan		400k units cumulative
SAIC		600k units (200k domestic brand)

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With most of the investment in EVs still very recent and/or in the form of announced plans, hard evidence on actual investment by EU firms in EV manufacturing is not widely available. In order to assess the commitment of EU firms to EV technology, we turn to patent statistics to assess how active EU automotive firms have been in developing EV technology compared to their international competitors and compared to their activities in improving the incumbent ICE technology.

We rely on patent data relating to automotive and parts firms included the *EU Industrial R&D Investment Scoreboard*[5]. Looking at the recent patent activity of the automotive companies, we see that different regions exhibit vastly different patent patterns.

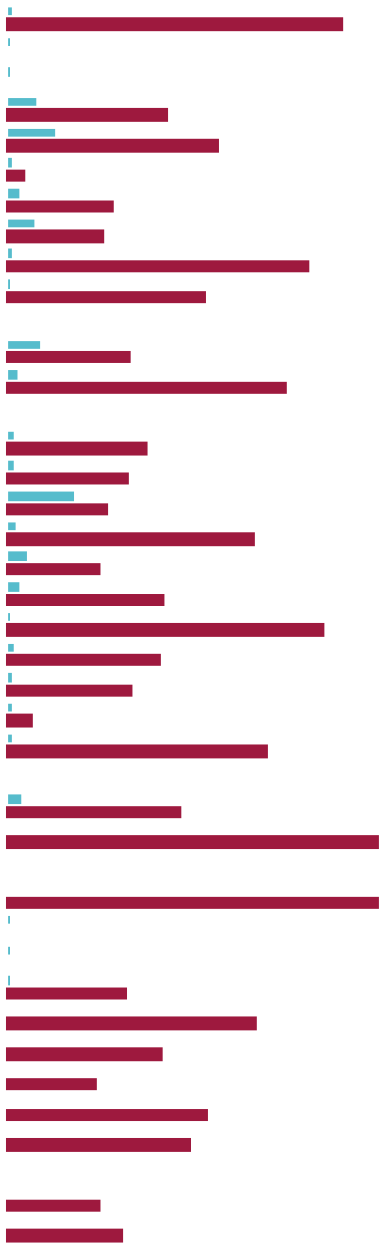
Figure 16 shows how the overall patenting activity of countries' and regions' automotive sectors is concentrated in a few leading firms. Although challenged by new entrants, the automotive sectors have been traditionally dominated by a few major companies. That is also reflected in the patenting activity. Patenting by South Korea's automotive sector is dominated by Hyundai; in the US it is General Motors and Ford. The EU and Japan, although they have big players such as Volkswagen and Toyota, show a more distributed structure of patenting activity with more major players involved.

Figure 16: Company shares per technology per region (top 50 automotive, JRC scoreboard, 2012-2014)

S : B *EU Industrial R&D Investment Scoreboard* 2016. N : C -50 ( ) R&D

There are major differences between the patenting activities of different companies.

Figure 17: Patenting structure of the top 50 R&D spending automotive companies (2012-14, R&D Scoreboard)



S : B *EU Industrial R&D Investment Scoreboard* 2016. N : C fi ; *ICE share per company* ICE ; C -50

6 Conclusions and policy recommendations

As this Policy Contribution has shown, automotive represents an important sector for the EU economy. Ensuring its long-term competitiveness is vital in order to preserve – and creinnovation funding should notably focus on next-generation early-phase technologies. This is particularly the case for batteries, such as solid-state batteries.

2) Rethinking transport taxation

Taxation is a key policy tool to switch demand to cleaner transport, fostering road transport decarbonisation. Different taxes apply throughout the transport system, from the initial purchase of a vehicle, to ownership taxes (such as annual registration taxes, company car taxation) and usage taxes (taxes on fuel, tolls, road space, parking, commuter tax deductions) (Green Fiscal Commission, 2010).

These taxes can be used to influence user decisions, and possibly also to influence the automotive industry's strategies. For instance, taxes can be differentiated on the basis of their carbon emissions. European countries still have very different transport taxation regimes. For example, only ten countries consider CO_2 emissions in the composition of their vehicle registration taxes (ACEA, 2017b). Fuel cost savings – which largely arise from the different taxation of gasoline and electricity – provide EVs with an important cost advantage. Savings are significant in Norway where running an EV can cost 64 percent less than running a diesel or petrol vehicle. In Germany, by contrast, the difference is only 25 percent (Lévay *et al*, 2017).

The EU should promote a new discussion among EU countries on the future of transport taxation, as is being done in the field of digital taxation (European Council, 2017). A harmonisation of mobility taxation throughout Europe would lead to less fragmentation and more certainty for business, thus increasing the incentives to invest in production of clean (electric) vehicles in Europe.

3) Cleaning-up cars: stricter emission standards and bans on diesel and petrol cars

In December 2018, the EU reached an agreement to reduce carbon dioxide emissions from new cars by 37.5 percent by 2030 compared with 2021 (Reuters, 2018). This represents a positive step, which will contribute to spur the move towards EVs and other alternatives to diesel and petrol cars. However, this is still not sufficient to ensure a deep decarbonisation of European transport by 2050. Raising the level of ambition in this field will be crucial in the next few years.

Since 2017, a series of countries and cities across Europe have introduced bans on diesel and petrol cars. In 2017, France and the United Kingdom announced plans to ban sales of diesel and petrol cars and vans by 2040 (Petroff, 2017). Paris is developing a plan to completely phase out diesel cars by 2024 and petrol cars by 2030 (Paris, 2018). Copenhagen is discussing

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Annex 1

Power train technologies and their respective IPC patent codes

Technology	IPC patent codes
Electric	B60L 11, B60L 3, B60L 15, B60K 1, B60W 10/08, B60W 10/24, B60W 10/26
Hybrid	B60K 6, B60W 20, B60L 7/1, B60L 7/20
Hydrogen	B60W 10/28, B60L 11/18, H01M 8
Internal combustion engine (ICE)	F02B, F02D, F02F, F02M, F02N, F02P

S[illegible]: A[illegible] *et al* (2016).