Department for Business & Trade

# APC Impact Evaluation

Final Report

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# List of abbreviated terms

| Abbreviation | Description |
|---|---|
| ABS | Annual Business Survey |
| APC | Advanced Propulsion Centre |
| APC UK Ltd. | APC legal entity |
| BSD | Business Structure Database |
| BERD | Business Expenditure on Research and Development |
| BEV | Battery Electric Vehicle |
| GVA | Gross Value Added |
| HEI | Higher education institutions |
| ICE | Internal combustion engine |
| MRL | Manufacturing readiness level |
| OEM | Original Equipment Manufacturer |
| ONS | The Office for National Statistics |
| PHEV | Plug-in Hybrid Electric Vehicle |
| PPM | Post-project monitoring |
| R&D | Research and Development |
| SME | Micro, small or medium enterprise |
| TRL | Technological readiness level |
| VfM | Value for money |

# Executive summary

Ipsos UK, Ecorys, and George Barrett were commissioned by the Department for Business and Trade (DBT) to undertake an impact evaluation of the Advanced Propulsion Centre R&D programme in May 2023. This report sets out the findings of the evaluation.

## Advanced Propulsion Centre

The Advanced Propulsion Centre (APC) was established in 2013 by the UK Government and the Automotive Council to support the delivery of the Coalition Government's Industrial Strategy for the automotive sector. The APC programme aims to achieve significant progress in developing low carbon and zero emission vehicle propulsion technologies, anchor and attract research and development and manufacturing capability to the UK and leverage high value manufacturing opportunities that market exploitation may provide.

The APC provides public support for late-stage R&D and manufacturing process innovation research projects. By 2022/23, the programme had committed funding to 91 projects involving 428 partners, with a total grant value of £608m.

## Methodology

The evaluation was based on an analysis of administrative and monitoring records collected through delivery of the programme, consultations with key stakeholders, nine project level case studies, and five case studies investigating the broader impacts of the programme on the five organisations receiving the largest amounts of funding. The evaluation also involved a programme of data-linking and econometric analysis to explore the causal effects of the scheme on R&D activity, employment, turnover, investment, output, and productivity.

## Project inputs and activities

A total of 91 R&D projects were funded over the 26 competition rounds between 2013 and 2022. This involved the commitment of £608m in public funds towards projects costing £1.3bn in total. Projects closely aligned with the aims of the APC in seeking to address technical and manufacturing barriers to integrating technologies into vehicles and/or support supply chain partners to develop capability to supply future demand for low carbon technologies. Projects were largely motivated by the need to comply with changes in carbon emissions legislation, meet growing consumer demand for Battery Electric Vehicles (BEVs), and maintain competitiveness with overseas competitors.

A total of 43 projects had been completed by 2022/23 with 48 projects ongoing. Completed and ongoing projects involved a commitment of approximately £608m of public funds (around 47% of project costs).

The case studies of APC funded projects indicated that most were on course to meet their technical objectives at the time of the research. However, 13 projects had been withdrawn early or were terminated due to technical failure or supplier withdrawal. Approximately a half of sampled projects were delivered on time with delays occurring in the remainder of projects.

Programme monitoring information records indicated that significant progress was achieved in advancing the maturity of low and zero carbon technologies during the delivery of the grant funded projects. The relevant technologies – on average - also delivered larger reductions in $CO_2$ emissions at the tailpipe than originally expected with 59% of projects delivering or expecting to deliver at least their forecast savings at application stage (though there was considerable variation across the portfolio, with around 40% of projects delivering or expecting to deliver smaller reductions than expected at application). The findings of the evaluation also indicated that around

80% of technologies attracted further investment following completion of the project, with 42% reaching TRL9 and/or MRL10 at the time of the research and 63% of projects eventually resulting in the integration of the technology outputs into vehicles launched for commercial sale.

## Impacts on R&D activity

The findings of the evaluation indicated that the APC has been highly effective in stimulating additional R&D activity:

- **Impacts on R&D spending:** It was estimated that the programme encouraged firms awarded funding to increase their R&D expenditure by 7% (over and above what they may have invested in the absence of the programme). This effect endured for some seven years following the award of APC grants implying that the programme stimulated significant levels of follow-on investment following the completion of projects. This expenditure was wholly contained within the UK, highlighting the role of the programme in anchoring domestic R&D activity.
- **Additionality:** It was estimated that 67% of R&D spending supported by APC grants would not have been brought forward in the absence of the programme. This indicates that the public funding for the programme has utilised economically with limited levels of deadweight. Case studies highlighted the importance of the funding in reducing the risk associated investments, addressing deficiencies and gaps in the UK supply chain, and enabling UK operations of global companies to compete for globally mobile R&D programmes. While several firms that were declined grant funding did manage to take forward their proposed projects, this was typically only possible with significant reductions in scope and budgets as well as extended timeframes.
- **Leverage:** It was estimated that the programme resulted in a total increase in R&D spending of £1bn between 2013 and 2022. The findings imply that the programme leveraged £2.20 of private R&D spending for every £1 of public spending over the period. This also implies that APC competition funding has been more effective at leveraging private R&D activity than R&D tax credits.
- **Impacts on R&D employment:** This expansion of R&D spending was also accompanied by an expansion of the R&D workforce and the programme was estimated to have created or safeguarded around 8,300 R&D employment years between 2013 and 2022.

## Exploitation impacts

A total of 10.5m vehicles integrating APC technologies had been sold by the end of 2022/23, and projections provided by applicants expected to sales to expand significantly over the medium term (with a total of 98m vehicle sales expected by 2037/38). However, commercialisation levels were lower than expected at the point of applications. This is driven by a number of factors including the early closure of a project that would have led to integration into a large number of vehicles but which was not technically viable. In addition, external factors such as the COVID-19 pandemic have forced manufacturers to adjust expectations and revise down near-term forecasts.

## Impacts on firms awarded funding

The findings of the evaluation indicated that APC competition funding had been effective at encouraging firms to invest in their production capabilities linked to the manufacturing of technologies refined with the support of the programme and had led to significant increases in output.

- **Capital expenditure:** Econometric evidence identified significant impacts on net capital expenditure for firms receiving grant funding. The findings indicate that each APC grant led to an expansion in net capital investment of 25% per annum. Impacts were not persistent and begin four years after an APC grant was awarded. This suggests that firms began to expand facilities in anticipation of production towards the end projects or just after projects had completed given an average length of project of 3.3 years. The analysis gives an estimate of total impact on total net capital investment of £88m by 2022.

The APC competition funding was also shown to have significant impacts on wider firm outcomes including overall employment, turnover and GVA. This indicated that APC competition funding has enabled firms to expand for production of vehicles with APC developed technologies and capitalise on increased revenues:

- **Employment**: Each APC grant is estimated to have led to an expansion in the employment of applicants by 5% and took hold from one year after grant award and persisting for eight years. This pattern mirrors that found for R&D employment and results in an estimated 35,000 job years safeguarded or created by 2022, indicating that most of these positions are likely to be non-R&D roles.

- **Turnover**: The findings also suggested that each APC grant led to an increase in the turnover of lead applicants of around 8%. Impacts to appear after three years and persist for the next five.

- **GVA**: Each grant awarded led to an increase of around 10% in total firm output. These effects appear after three years and persist until around least seven years past project award.

The findings of the evaluation indicated that APC competition funding had boosted short term productivity and improved workers' wages:

- **GVA per worker:** Productivity impacts were identified in the econometric analysis through effects on GVA per worker. Effects on GVA per worker of 3.6% to 4% were identified three to four years after funding was granted. This lines up with the timing of capital expenditure and GVA impacts observed above and implies that productivity rose as technologies began to be exploited.

- **Wages**: Wage impacts were also found with wages for workers at lead applicants increasing 1.6%. No effects on hours worked were identified and wage effects were constrained to high skill jobs.

## Indirect outcomes and impacts

Analysis of the spatial impacts of APC competition funding shows that funding stimulated local economic growth through the expansion of firms awarded funding and also through wider spillovers (including the attraction of firms to relevant areas):

- **Local economic growth**: Evidence indicated that APC grants had a positive net economic impact on local economic growth and productivity. Grants appeared to encourage an increase in the number of firms located in the immediate vicinity of firms receiving grants by 7% - indicative of local clustering effects (though there was less evidence of these types of outcomes from the case studies). There were also significant ongoing effects on total employment (12%) and turnover (15%) in these areas (with smaller positive impacts on areas further away).

- **FDI:** The case studies found limited evidence of overseas firms establishing new production locations or R&D facilities in the UK as a direct consequence of APC funding. However, there were examples of expansions of existing production lines as a direct result of APC funding and other support provided to the sector – though the main effect of the programme appears to have been in terms of safeguarding existing facilities rather than attract new manufacturing operations to the UK.

- **Knowledge spillovers:** Knowledge spillovers were most commonly internal where knowledge developed through the project was applied to adjacent or unrelated areas of the applicants' operations. There were no clear examples of external spillovers where technologies developed through the programme found alternative application in related industries (though potential applications were identified in the aerospace and marine industries). Grants attracted firms to the areas that grant recipients were located in with the total number of firms in the are increasing by 7%. There was also a significant effect on total employment (12%) and turnover (15%) effects on firms in OAs with grant recipients. Effects were also present for areas further away but were much smaller, declining with distance.

## Economic evaluation

- The lifetime resource cost of grants awarded through the APC – covering the costs of administering the programme and past and future R&D and capital investments – were estimated at £1.8bn between 2013 and 2029 (in present value terms). Most of these costs were expected to be incurred by the private sector, highlighting the role of the programme in leveraging private investments in R&D and capital.

- The principal benefits of the programme, related to the productivity gains associated with APC grants, were estimated:

  - **Short-term improvements in productivity/profitability**: The programme was projected to result in productivity gains of £885m in present value terms between 2013 and 2029 arising from its direct effects in raising GVA per worker.

  - **Output safeguarded by protecting high productivity jobs:** The programme was also effective in protecting high productivity employment in automotive firms and the supply chain (with modelling indicated the programme would be expected to safeguard 62,000 employment years between 2013 and 2029). Evidence from historic automotive plant closures indicates that workers displaced are likely to find alternative employment rapidly, albeit in lower productivity occupations. However, there is some uncertainty in relation to the magnitude of the productivity effect arising from safeguarding jobs in the sector. Modelling based on a plausible range for the size of these productivity gains indicated that the value of output safeguarded between 2013 and 2029 could range from £1.6bn to £3.1bn (in present value terms).

- The implied lifetime return on public sector investment (treating additional costs incurred by the private sector as a disbenefit) was estimated at £2.12 to £5.17 per £1 of public sector spending. A full social welfare analysis relating the total social costs of the programme to the resultant productivity gains produced a Benefit-Cost Ratio of £1.31 to £2.15 – reflecting that a high share of the programme's costs was driven by additional investment spending by the private sector.

- These results do not account for the leakage of profits overseas (a potential issue given the number of overseas owned companies benefitting from the programme) or the positive environmental benefits of the programme. There is a significant degree of uncertainty associated with each of these factors – though it is likely that any repatriation of profits overseas will be at least offset by the positive environmental benefits of the programme.

## Conclusions

The findings of the evaluation indicated that the APC has proven to be a highly successful programme and has largely delivered against all of its intended objectives. The programme has successfully supported the commercialisation of APC technologies and has supported the creation or safeguarding of significant numbers of R&D and production jobs.

In achieving the objectives set out above, the programme was found to have delivered value for money with a low level of deadweight and a high leverage ratio of R&D spending.

Despite the success of the programme, the industry continues to face a number of external threats. While the programme has proven effective in safeguarding UK based activity, it has not attracted new manufacturing to the UK in significant volumes and was potentially insufficient on its own to reverse declining levels of employment in the industry. More recent initiatives in conjunction such as the ATF could be expected to tackle some of these issues.

# 1 Introduction

Ipsos UK, Ecorys, and George Barrett were commissioned by the Department for Business and Trade (DBT) to undertake an impact evaluation of the Advanced Propulsion Centre R&D programme in May 2023. This report sets out the findings of the evaluation.

## 1.1 Advanced Propulsion Centre

The Advanced Propulsion Centre (APC) was established in 2013 by the UK Government and the Automotive Council to support the delivery of the Coalition Government's Industrial Strategy for the automotive sector. The APC programme aims to achieve significant progress in developing low carbon and zero emission vehicle propulsion technologies, anchor and attract research and development and manufacturing capability in the UK and leverage high value manufacturing opportunities that market exploitation may provide.

The APC provides public support for late-stage R&D and manufacturing process innovation research projects. The UK Government and the automotive industry made a ten-year commitment in 2013 to invest £1bn (including £0.5bn in public subsidies) in R&D projects aimed at commercialising low carbon propulsion technologies. Both funding and the timelines for the programme were subsequently extended, and by 2022/23, the programme had committed funding to 91 projects involving 428 partners, with a total grant value of £608m.

## 1.2 Evaluation aims and objectives

The key questions to be addressed by the evaluation were set out in the Invitation to Tender and are set out in the following table.

**Table 1.1 Evaluation questions**

| Theme | Evaluation questions |
|---|---|
| Economic benefits | • How far has the availability of APC funding led to – or encouraged – the initiation of new R&D projects in new vehicle technologies and manufacturing process innovations?<br>• How far has APC funding leveraged additional (direct) expenditure on new automotive technologies, both amongst beneficiaries of APC funded R&D projects and their suppliers? How much of this would not have taken place at all/at a slower rate/at higher risk/outside the UK?<br>• How far has APC funding created or safeguarded high value jobs in R&D and longer-term manufacturing jobs in the UK which otherwise might have been lost or moved overseas?<br>• How far has APC funding started to influence the plans of automotive companies to locate production in the UK, resulting in commitments for manufacturing jobs? |
| Technology benefits | • How far has there been commercial impacts because of APC funding, for example, taking products to market?<br>• How far has APC funding accelerated the development of new vehicle technologies and manufacturing readiness levels? |

| Theme | Evaluation questions |
|---|---|
| Environmental benefits | • Did APC funding contribute to reducing scope 1, scope 2, and scope 3 emissions[1]? Has APC funding led to increased resource efficiency? |
| Collaboration | • How far has APC funding influenced the development of partnerships and patterns of collaboration across UK firms, universities, and research organisations, or introduced new ones? What additional benefits are realised by beneficiaries who have formed APC consortiums?<br>• How far does the involvement of firms across different tiers of the supply chain in APC consortiums bring additional benefits?<br>• How far have APC funded projects helped to deliver spillover benefits, such as agglomeration and local clustering, as well as knowledge spillovers outside of project consortia? |
| International comparisons | • How do any impacts arising from the APC compare against similar international automotive business support schemes? |

## 1.3 Methodology

The evidence generated as part of this evaluation was collected using the following methods:

- **Analysis of management and secondary data:** An analysis of administrative and monitoring records collected through the delivery of the programme was completed to provide an overview of the performance of the APC portfolio against expectations at an aggregate level and to identify sources of variability across the projects funded.
- **Post project monitoring survey (PPM):** An online survey was conducted between September 2023 and February 2024 to obtain evidence on the medium- and long-term outcomes of APC projects and to understand the extent to which unsuccessful applicants continued their R&D projects. The target populations for the survey comprised recipients of APC funding where the project had completed, and lead applicants associated with project proposals that were declined. The survey achieved a total of 27 responses from closed successful projects (out of a population of 43) and 20 from unsuccessful applicants (out of a total of 423).
- **Stakeholder consultations**: Eleven stakeholder consultations were completed between December 2023 and March 2024 to gather strategic views on the impacts of the portfolio of projects funded through the APC to date, and how the context in which the programme operated has evolved. The organisations engaged included the APC, The Automotive Council, the Department for Business and Trade and the Society of Motor Manufacturers and Traders (SMMT).
- **Case studies:** A sample of successful APC applicants were invited to take part in 14 theory-based case studies, which began in December 2023 and completed in May 2024. These case studies explored the underlying intervention logic of each project to develop an understanding of its anticipated and realised outcomes and the decision-making context within which it was

[1] Scope 1 emissions cover those directly generated by a business whilst scope 2 emissions are those generated indirectly for example through the energy produced on a firm's behalf for heating. Scope 3 emissions are those that the organisation is indirectly responsible for, up and down its value chain whether that be from suppliers or the use of products by customers.

designed and delivered. Each case study included a review of application and monitoring information, wider information describing the market context for the project, and interviews with lead and collaborating partners. The evidence was triangulated to provide an assessment of the contribution of APC funding to the outcomes observed.

Project case studies were sampled purposively to include a mix of projects with different characteristics across the following factors: technology and vehicle type, grant funding sought, application quality, consortium size, duration, and competition round / project end date. Two types of case study were conducted:

  - **Organisation level case studies:** Several OEMs and SMEs were involved in multiple linked projects and so five case studies were used to consider the overall impact of the APC on these organisations. These case studies explored the effects of the totality of APC funding on the relevant organisations.
  - **Project level case studies:** Project level case studies of successful projects (9) where case study research had not already been completed in past research activity. These focussed on project level impacts.

- **Data-linking and econometric analysis**: The Company Reference Numbers (CRNs) of applicants for APC funding were linked to administrative and secondary datasets held within the ONS Secure Research Service to provide longitudinal data describing their R&D activity, employment, turnover, investment, output, and productivity. A series of econometric analyses were completed using these data sources to quantify the firm and worker level impacts of the programme. The data was also used to explore spill-over effects mediated by clustering of economic activity in proximity to those firms that were awarded grants. The econometric analyses were largely driven by comparisons between firms that were awarded funding and those that made an application but were declined. Details of the econometric analysis – including steps taken to minimise potential biases driven by differences between the treatment and the comparison group – are set out in the Technical Annex.
- **Synthesis**: The evidence was synthesised by mapping the results to the evaluation framework agreed with DBT at the outset of the study. Contribution analysis was used to provide an assessment of how far APC funded produced its intended results in each case. Where the data sources produced contrasting results (such as differences between views of stakeholders or between the overall assessment of stakeholders and applicants), these differences were analysed - and as far as possible reconciled - by weighting the evidence collected by quality, consistency, and broader context (such as the likely interests of different stakeholders) and validated as far as possible using objective data.

## 1.4 Report structure

The remainder of the report is structured as follows:

- Section 2 presents the programme Theory of Change and its context.
- Section 3 presents an overview of the technical progress of projects and factors influencing success including collaborations.
- Section 4 presents the evidence on the additionality and outcomes of projects. This includes R&D activity, integration of new technology into vehicles, and environmental outcomes.
- Section 5 presents the direct outcomes and impacts of the programme on firms receiving funding for APC projects.
- Section 6 presents evidence on the indirect outcomes of the programme, covering spill-over effects, and follow-on capital expenditure resulting from APC funding.

- Section 7 reports the economic evaluation findings and the results of the cost benefit analysis.
- Section 8 concludes with the evidence summarised against the key evaluation questions.

# 2 Advanced Propulsion Centre

This section presents an overview of the programme, including the logic model describing the intended path from inputs to impacts and describes the economic, technological and political context for the programme. The final section outlines and describes similar international initiatives aiming to support the automotive sector.

## 2.1 Programme overview and rationale

The Advanced Propulsion Centre (APC) was launched by the UK Government and the Automotive Council in 2013 as part of the Coalition Government's Industrial Strategy. The objectives of the programme are to:

- Achieve significant progress in developing low carbon and zero emission vehicle propulsion technologies; and,
- Anchor and attract research and development (R&D) and manufacturing capability in the UK, and leverage high value manufacturing opportunities that market exploitation may provide.

The APC involves two main elements:

- **Collaborative R&D funding competitions:** The UK Government and the automotive industry made a ten-year commitment in 2013 to invest £1bn (including £0.5bn in public subsidies) in R&D projects aimed at commercialising low carbon propulsion technologies.
- **The Advanced Propulsion Centre UK Ltd**: The creation of an independent body (referred to from here on as APC UK Ltd.) tasked with }~
inating automotive R&D activity in the technology area. The role of the APC envisaged in the Business Case included maintaining technology roadmaps for the automotive sector, matching products to customers, and catalysing new collaborations between government, industry, and academia. The services offered by the APC have expanded in scope to include support for applicants in engaging with the competition process developing consortia bids, implementation of parallel schemes (such as the SME focussed Technology Developer Accelerator Programme (TDAP) and the more recent Automotive Transformation Fund[2]), management and delivery of international events, contributions to the co-ordination of inward investment opportunities, and business and sector intelligence gathering (understanding where there is unmet demand for production in the UK, and other types of policy relevant studies in relation to aspects such as critical minerals resilience).

The activities of APC UK Ltd – including the outcomes and impacts of the Automotive Transformation Fund - are outside of the scope of this evaluation, which focuses exclusively on public grant funding for R&D activities. However, as the activities of the APC UK Ltd are likely to enable some of the anticipated outcomes and impacts of the funding competitions, its supporting role needed to be understood through the impact evaluation.

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[2] The Technology Developer Accelerator Programme (TDAP) is a phased 18-month programme available to SMEs combining workshops and peer to peer support alongside a grant of up to £170,000 to support the development of early-stage transport technology concepts. The Automotive Transformation Fund is a capital and R&D funding programme created to support the development of high-value end-to-end electrified automotive supply chain in the UK.

## 2.2 Rationale

### 2.2.1 Strategic case

The Climate Change Act of 2008 placed a legal requirement on the UK to reduce its emissions to 80% of 1990 levels by 2050. As a key contributor to UK emissions, the automotive and transportation sectors have been identified as a priority area in which transformative low and zero carbon propulsion technologies are needed. The implication is that supply chains centred on the production of conventional internal combustion engines (ICEs) will be replaced by a supply chain focused on the production of new types of low and zero carbon propulsion technology.

These pressures have become more acute since the development of the original Business Case for the programme in 2013. The target for emissions reduction, set out in law, was increased to 100% by 2050 in 2019 (the 'net zero' emissions target), and the Government's approach for achieving these aims was set out in the 2019 Net Zero Strategy. This included a range of measures for decarbonising the transport sector, including ending the sale of new petrol and diesel cars and vans by 2030 (changed to 2035 in September 2023) and putting in place regulation requiring minimum percentages of manufacturer's new car and van sales to be zero emissions in each year from 2024 (the Zero Emissions Vehicle mandate). Additionally - and partly driven by air quality concerns - municipal authorities have also put in place measures to increasingly incentivise the adoption of low and zero carbon vehicles in urban areas. These measures are typically more stringent than the relevant environmental legislation. For example, the Ultra-low Emissions Zone - introduced in London in 2019 - imposes charges on diesel passenger vehicles that do not meet a minimum of Euro 6 emissions standards (which have applied to manufacturers since 2014).

These changes were expected to create both a threat and an opportunity to the sector in the UK owing to the large automotive manufacturing base and its specialisation in the production of thermal propulsion systems. On the one hand, it was anticipated that these changes could diminish the long-term competitiveness of the automotive sector if Original Equipment Manufacturers (OEMs) and the supply chain were unable to respond to regulatory drivers and other economic pressures. However, if firms in the UK could acquire a first-mover advantage in the development of the relevant capabilities, there may be opportunities to reverse the trend in weakening sector supply chains observed since the 1980s.

There was significant uncertainty as to the likely technology standard that would be adopted to meet these goals when the programme was launched in 2013. However, clarity has since emerged that battery electric vehicles are the most viable route to meeting emissions standards in the short term (at least for passenger and light commercial vehicles). The economics of battery manufacturing attenuates both the opportunities and threats highlighted above, owing to the high costs of transporting finished batteries to vehicle assembly plants (driven both by safety requirements and their weight). The move to electric vehicle production also requires materially different manufacturing capabilities (with an emphasis on electrical rather than mechanical engineering). As such, major investments in production facilities will be needed to support the transition, and decisions regarding the location of these investments will be less influenced by existing centres of excellence.

### 2.2.2 Economic case

Several arguments have been put forward to suggest that the private sector will not respond to these challenges in the absence of intervention:

- **Network externalities:** The widespread adoption of zero emissions carbon vehicles will require a network of complementary infrastructure. It was anticipated that technical 'lock-in' will likely emerge once a technology standard is reached, making investment in R&D projects inherently risky. While this market failure was relevant in 2013, it has likely receded owing to a growing consensus that has emerged around battery electric vehicles (BEVs) as a solution for passenger vehicles. However, owing to the specific challenges involved in decarbonising off-highway and heavy goods vehicles, such issues may persist in these segments of the market. Additionally, the rapid evolution of technology may cause hold-ups elsewhere if infrastructure systems (for example chargepoints) are unable to keep up with advances, potentially constraining EV adoption, the potential revenues that can be earned by automotive producers, and incentives to undertake R&D.

- **Transactional frictions:** The development of new forms of propulsion system may require OEMs to build relationships with firms outside of traditional automotive supply chains to obtain the required expertise. In the case of electrification, OEMs and Tier One businesses were reportedly increasingly focused on developing links with organisations that have expertise in chemical processing (for example in the production of cathode active materials needed to produce battery cells). There are a range of market failures that may prevent collaboration emerging, even if the expected returns on investment are sufficiently high. Project success can depend on the commitment of all partners involved which cannot always be rigorously monitored, creating incentives for partners to 'free ride' on the activities of others. Consultations also highlighted that disruptions to supply chains during COVID-19 and associated production stoppages have made greater levels of vertical integration more attractive to OEMs. The risk that OEMs seek to internalise production of critical inputs may also act to inhibit collaboration across supply chains.

- **Positive externalities associated with 'anchor tenants':** Large OEMs and Tier One businesses that receive APC funding to conduct R&D in the UK are likely to produce several benefits for automotive supply chain businesses and Higher Education Institutions (HEIs) with which they are, or are intending, to collaborate. Several studies have shown the importance of large R&D intensive companies with capabilities in specific technologies ('anchor tenants') that produce scale economies for other companies co-located in the region. These companies tend to encourage greater levels of technology transfer from universities, act as an attractor for complementary resources (such as skilled labour) and provide a route to market for smaller companies. Attracting R&D activity to the UK - or safeguarding existing R&D facilities - would be expected to generate positive externalities, providing further justification for public subsidies to achieve these results.

- **Knowledge spillovers:** Knowledge spillovers may also inhibit investment in low carbon vehicles. The inability of producers to internalise the full benefits associated with R&D will lead to sub-optimal levels of investment (for example, owing to the accumulation of tacit knowledge amongst workers which is transferred to new producers when they move companies). Knowledge spillovers may arise from localised production models resulting from the low inventory processes used in the automotive industry. Initial investments in R&D will create external economies of scale such as labour market pooling and local knowledge exchange, boosting the development of the industry in the UK, including through attracting foreign direct investment. In this case, the presence of these positive externalities provides a rationale for providing public grants to compensate producers and technology developers for those benefits of R&D investment they are unable to capture.

- **International competition between Governments:** The potential benefits from the development of clusters of expertise has been recognised by several overseas governments which have also developed programmes of support for the development of similar technologies. The availability of analogous support for development of zero carbon propulsion technologies in other territories could also lead to an initial concentration of expertise outside of the UK. If these territories build a comparative advantage as a result, investment may be drawn away from the UK in the long term. Again, publicly funded grants for R&D may help mitigate against these issues. Stakeholders consulted as part of the familiarisation exercise suggested that these issues have become significantly more prominent due to the US Inflation Reduction Act which provides extensive public support to anchor electric vehicle production in the US.

These measures involve subsidies throughout the value chain (including the consumer) and have reportedly influenced OEMs to prioritise investments in North America. The Green Deal Industrial Plan in the EU can be seen as a response to this. The Plan aims to provide a more supportive environment for the scaling up of the EU's manufacturing capacity for the net-zero technologies and products required to meet Europe's climate targets. It builds predominantly on relaxing State aid rules further, thus allowing more national support, including through tax benefits.

## 2.3 Theory of change

This section provides an overview of the expected processes through which the activities funded through the APC funding competitions will deliver their intended outputs, outcomes, and impacts.

### 2.3.1 Inputs

The APC involves a ten-year commitment of £1 billion of investment activity into low carbon propulsion technologies (£500m of this capital will be supplied by the public sector, matched by applicants in the form of their own resources, expertise, and assets). DBT and Innovate UK help deliver the APC through providing the staff resources, expertise and platforms employed in co-ordinating competitions for APC funding, assessing applications in terms of their technical quality and value for money (VfM), and monitoring the delivery and performance of projects. Co-ordination of the programme is supported by the APC. which is funded by a 3.5% levy on project costs.

The realisation of the longer-term impacts of the APC will also involve further costs to the degree that late-stage R&D projects leverage additional investment in production facilities (capital expenditure) or follow-on R&D. These costs may be funded by the private sector or potentially the public sector (via parallel schemes such as the Faraday Battery Challenge or the Automotive Transformation Fund).

### 2.3.2 Activities

The activities of the APC can be broken down into three key components:

- **Competitions for R&D subsidies:** R&D subsidies are allocated over a sequence of funding rounds through a competitive application process. The eligibility criteria for the scheme are such that applicants must produce proposals where the technology is at a minimum level of technical development (they must be at least at the point at which a prototype can be tested in a realistic environment (TRL5), and where the prototype can be produced in a laboratory environment (MRL4)). Applications must involve collaboration with other firms, including an OEM or Tier One, to demonstrate the project has a route to market. The competition process involves:

    - **Application process:** Applicants must complete an application form describing the technical details of the project, its commercial potential, and a case for public sector investment elaborating on why the project would not go forward without intervention. Applicants are also required to provide quantitative projections describing the anticipated outcomes of the R&D project, including sales forecasts, improvements in the emissions profile of vehicles produced, and the number of R&D and production jobs that would be created.

    - **Project selection:** Applications are judged through a dual appraisal process involving a technical and an economic appraisal. The technical appraisal focuses on the strength of the scientific, engineering, and commercial rationale for the project, while the economic appraisal (undertaken in line with HM Green Book principles) focuses on estimating its potential value for money (allowing for factors such as deadweight, displacement, multiplier effects, potential spill-over benefits from R&D spending and risk). Applications must reach minimum scores under both appraisals to be considered fundable.

- **Due diligence and contracting:** Applicants awarded funding must complete a due diligence process in which the financial strength of the applicants is determined by Innovate UK's finance team, and a contracting process defining a set of milestones that will be achieved over the course of the project (that forms the basis of monitoring). This process requires the collaborating applicants to sign a collaboration agreement defining the roles and responsibilities of partners and how the intellectual property generated through the project will be shared.

- **Monitoring:** A set of monitoring arrangements are implemented to monitor how far a project is on course to deliver the projected results on which the funding decision was based, and to highlight any need for corrective actions to be made.

- **Delivery of R&D projects:** The main activities associated with the APC are the implementation of the R&D projects set out in applications. This will largely involve refinement of prototype subsystems and systems of increasing fidelity and in increasingly realistic environments (though some projects may also involve activity at lower TRL levels, such as modelling and simulation activity).

- **APC UK Ltd.:** As explained above, APC UK Ltd. is tasked with coordinating R&D and supply chain activity and provides application support to prospective applicants. This function involves development and distribution of marketing materials to promote grant competitions, the development of technology roadmaps communicating the key priorities of the UK automotive sector (in terms of technologies and products to be developed), strategic collaboration and co-ordination activities (including the networking activities and the identification of positive opportunities to create links between R&D and manufacturing firms), and the delivery and management of parallel initiatives (such as the Technology Development Accelerator Programme, the DBT funded Automotive Transformation Fund, and the Niche Vehicle Network[3]), research and analysis on a range of policy relevant issues in relation to supporting the development and safeguarding of R&D and manufacturing capability in the UK, and facilitation of inward investment.

### 2.3.3 Outputs

The main outputs of the APC R&D programme result from the delivery of R&D competitions funded. APC R&D projects deliver a range of outputs over the course of their delivery (24 to 42 months), including:

- **Prototype refinement:** R&D funding is used to refine the prototypes developed in laboratory conditions and enhance their characteristics.

- **Testing results:** R&D programmes typically involve testing of individual components in increasingly realistic conditions for durability and other characteristics to understand any specific issues that might be encountered once integrated with other componentry, in production, or to highlight areas in which performance might be optimised. The modular nature of propulsion technologies means that it may sometimes be better to understand each APC project as a collection of smaller R&D projects rather than as a single project.

- **Manufacturing plans:** Many of the prototype components forming the focus of R&D projects will have only been produced in the laboratory, and project proposals also describe plans for developing strategies for manufacturing the components at scale. This could include

[3] The Niche Vehicle Network is an independent network of UK niche vehicle manufacturers, specialist technology, design, and engineering organisations that include supporting competitions to help facilitate annual grant funding for niche vehicle manufacturers to develop zero emission and low carbon vehicle technology.

development of manufacturing processes, identification of manufacturing risks, specification and manufacture of the machine tools required to produce the components and assemble the propulsion systems at scale (though it is not expected that applicants will be ready to enter low-rate production at the end of projects in most cases).

The technology focus of R&D projects can also be broadly organised into technology areas based on the technology roadmaps developed by APC UK Ltd. on behalf of the Automotive Council in collaboration with industry (with the most recent update in 2021). These have identified the following areas central to the UK's future competitive advantage in the low and zero carbon vehicles sectors:

- Fuel cells.
- Thermal propulsion systems (improvements to the efficiency of diesel and petrol engines - for off-highway or difficult to decarbonise applications)
- Power electronics.
- Electric machines.
- Lightweight vehicle and powertrain technologies.
- Electric energy storage.

Kinetic energy recovery systems (such as flywheels) were also included in previous technology roadmaps.

### 2.3.4 Outcomes

In turn, the APC funding competitions are expected to deliver a broad range of outcomes:

- **R&D expenditure and employment:** Funding provided through the APC R&D programme may produce changes in levels of R&D expenditure and employment. To the degree that the programme has funded 'marginal' projects that may not have been funded without public support (or would have been taken forward outside of the UK), it is expected that R&D spending and employment might increase over the duration of the funded project. The APC competition funding may also leverage additional private R&D spending if there are requirements for follow on investments in further technical development or complementary projects.
- **Technical progress:** Technological progression is a key performance measure. The APC aims to take R&D projects from TRL5 and MRL4 to TRL8 and (at least) MRL6, meaning that the propulsion system will have been demonstrated to operate effectively in a working vehicle, and at least to the point at which a manufacturing plan for producing the propulsion system has been prepared.
- **Collaboration**: The core APC R&D competitions are only open to collaborative applications[4]. Collaboration is deemed important for several reasons. Successful technical development requires specialist inputs in a range of areas of design, engineering, and manufacturing, given the modular and complex nature of automotive technologies. Collaboration between OEMs, Tier One businesses and SMEs provides a more certain exploitation strategy for SMEs. APC funding also ensures that OEMs first collaborate with organisations based in the UK (helping to

[4] The Advanced Route to Market Demonstrator allowed single company applications but is not in the scope of this study.

anchor R&D in the country) and is also expected to encourage new or improved collaborations between businesses and/or academic institutions.

- **Capital investment:** Firms may be encouraged to undertake capital investments to manufacture technologies developed through the APC projects (for example retooling existing plants or greenfield investments in new plants). Larger OEMs, Tier One and SMEs may be able to fund these investments from debt or from equity. However, some SMEs may find raising the sums needed for significant capital investments challenging and may seek an exit to a larger company better able to (a) support fundraising at the required levels, (b) offer greater certainty with the route to market, and (c) provide other benefits (such as the ability to offer warranties).

- **Integration of APC funded technology into new vehicle models:** It is anticipated that APC funded technology will be integrated into new vehicle models (contingent on successful completion of the R&D project). This could occur via the integration of the entire propulsion system, or through the integration of individual components, into an array of new vehicles. In the absence of funding, OEMs may be otherwise forced to import technologies from overseas if they are unable to progress their R&D projects with sufficient speed. Licensed technologies are typically not at the technology frontier, potentially diminishing the competitiveness of UK based producers.

- **Skills development and knowledge transfer:** APC project delivery may lead to an accumulation of skills and knowledge amongst the R&D workers involved. This can occur formally, through training programmes or apprenticeships, or informally (tacitly) via accelerating learning whilst working. In turn, this may lead to feedback effects, either through the genesis of new ideas or intellectual property due to continued technology development or mediated through knowledge exchange.

- **Strategic decision making:** The delivery of the APC as a ten-year programme has meant that some OEMs and other firms have received funding for multiple (sometimes interlinked) projects. The availability of this funding may also have a broader influence on strategic decision making (such as locations to take forward R&D programmes, investments in new R&D facilities, or production).

### 2.3.5 Impacts

In turn, these outcomes might be expected to produce a range of impacts and other improvements in social welfare:

- **Safeguarding of economic activity:** The development of technologies enabling OEMs to meet environmental standards in the UK would be expected to anchor (and possibly expand) automotive R&D and manufacturing activity in the UK. This would be visible in the number of workers employed by firms, overall levels of output (GVA), and levels of export sales - as well as other measures such as the avoidance of plant closures and/or opening of new plants.

- **Turnover and exports:** The programme may also enable firms in the value chain to expand their revenues - by improving their competitiveness or by allowing them to enter the supply chains of major OEMs. This could result in lower import dependency amongst domestic OEMs or greater levels of exports to OEMs based elsewhere.

- **Productivity gains**: The automotive sector is characterised by high levels of productivity. Safeguarding jobs in the automotive sector may raise productivity - as while any workers that may have otherwise been displaced may find alternative employment, studies of automotive plant closures (for example MG Rover) have shown these workers often find lower productivity jobs in the service sector. The integration of technologies developed with APC funding may also enable firms to meet environmental standards more efficiently (or more rapidly) than they otherwise may have been able to, raising productivity levels. Productivity gains may also feed into higher wages for workers.

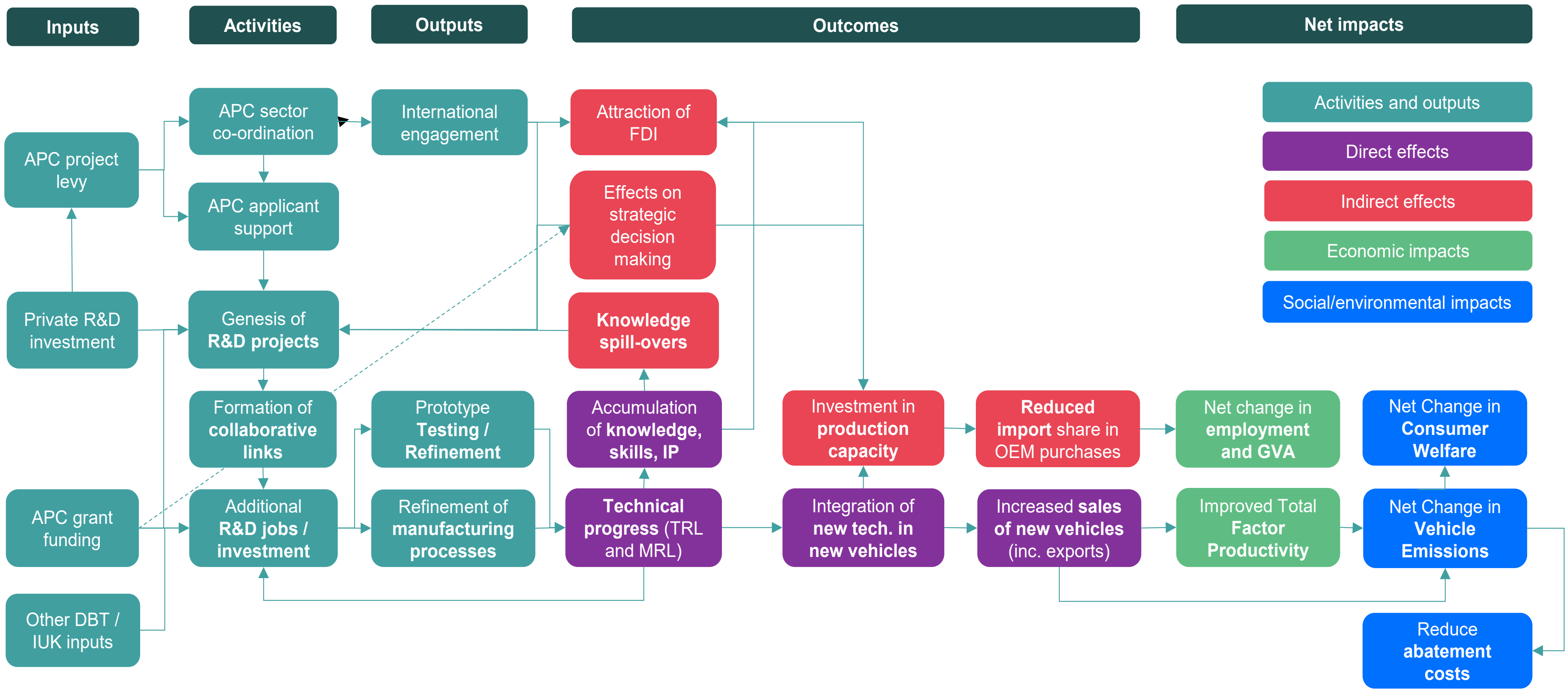
- **Displacement and crowding out**: These positive economic impacts will be partly offset if firms benefitting from the programme are able to expand their market share at the expense of domestic competitors (displacement) or if the demand for workers and other inputs places pressure on wages or prices (causing other firms to reduce their levels of economic activity).

- **Emissions, noise, and health impacts:** Positive externalities may arise in the form of improved fuel efficiency, reduced emissions, and noise pollution. However, it is important to note that these benefits will only be additional if vehicles integrating APC funded technology displace the sales of vehicles with inferior characteristics (if the programme merely displaces vehicles with similar levels of environmental performance, then its impacts will be primarily economic in nature).

- **Knowledge spillovers:** The benefits of the programme may extend to third parties not directly involved in APC projects. The exchange of skills and knowledge between project participants may also be applied in other projects, leading to improvements beyond the confines of the APC funded projects. Movement of workers between firms may also lead to the application of knowledge or skills acquired elsewhere in the economy. Spillovers may also arise if competitors can 'reverse-engineer' systems in ways that avoid infringement of patent rights.

- **Agglomeration effects**: Firms may also seek to locate their own activities closer to hubs of activity or skills, infrastructure, or capabilities developed through the programme to take advantage of external economic of scale. These clustering effects may arise both from the co-location advantages in production (for example avoidance of the high transport costs associated with transporting batteries) or R&D. Increases in economic density induced by the programme may have spillover benefits by raising the productivity of local economic activity and/or by contributing to reducing regional economic disparities.

## Figure 2.1: APC logic model



## 2.4 Programme context

This subsection presents a summary of the economic, political, and technological context in which the programme has been delivered.

### 2.4.1 Economic context

The UK automotive sector experienced growth in the early half of the last decade but has since faced challenges as a result of changing market conditions:

- **Current state of the sector:** Between 2008 and 2009, the output of the automotive sector fell from £10.0bn to £6.0bn in the wake of the global financial crisis. Sector output then expanded consistently until 2014 where it reached a peak of £18.9bn. Since then, sector output has consistently fallen and, as of 2021, the output of the automotive manufacturing sector in the UK was £10.1bn[5]. The total revenues of the automotive sector had also fallen 29% on its peak of £78bn in 2018. In terms of international trade, the UK maintained an automotive trade deficit with imports totalling £43.9 billion worth of goods and exports amounting to £30.0bn, a net deficit of £13.8bn in 2020. The sector continues to export over 80% of its passenger and light commercial vehicle output[6].

  In 2022, the automotive sector employed around 758,000 jobs[7] with the majority of these in the automotive retail sector. Automotive manufacturing accounted for 22% of total jobs and these were on average paid 30% more than retail jobs. Manufacturing is concentrated in the West Midlands and the North East.

- **Recent headwinds**: Since 2014, some major OEMs in the UK have made announcements to cease UK production, including Honda and the closure of its Swindon plant. This is primarily due to decreased demand for diesel fuel vehicles, which dominated UK production in the years following the financial crash. The COVID-19 pandemic is seen as a major factor affecting recent performance and vehicle registrations fell drastically following the onset of the pandemic in 2020. Sector output fell 37% between 2019 and 2020, the sharpest decline for any year post 2009.

- **Transition to electrification**: While electrification has become a clear priority for the sector, this transition continues to present challenges for the UK and other major vehicle producing countries. Skills and capability gaps in current supply chains present challenges. The rise of Chinese BEV capability, in particular, is a growing challenge to the UK, US and the EU as Chinese firms reportedly have access to large tax breaks and subsidies for BEVs. China sold the most EVs worldwide in both 2021 and 2022 and accounted for 60% of global electric car sales in 2022. This has precipitated a race to reduce production costs with companies targeting significant reductions in the cost of battery production.

Despite the recent headwinds, BMW announced it would invest £600 million into its Oxford plant to convert Mini production to all electric by 2030, with two electrified models starting production in 2026. The previous Vauxhall plant at Ellesmere Port (now owned by Stellantis) will also now become the first all-electric vehicle production plant in UK following a £100 million investment. JLR owner Tata Group have also committed to the production of a gigafactory in Somerset, investing £4bn and aiming to produce batteries from 2026. Nissan and AESC also announced a £2bn investment in 2023 for the production of two all-electric lines (Qashqai and Juke models) in the

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[5] Data taken from ONS Annual Business Survey Regional gross value added (balanced) by industry figures.
[6] Data on international trade obtained from ONS trade figures and SMMT reporting.
[7] IMI 2023 Baseline Report: Automotive sector on a roller coaster. IMI. 2013 Available at: https://tide.theimi.org.uk/industry-latest/news/imi-2023-baseline-report-automotive-sector-roller-coaster

North East. This follows a £1bn investment from Nissan in 2021 in the EV36Zero electric vehicle hub.

### 2.4.2 Policy context

A range of political and regulatory drivers have increased pressure on automotive manufacturers to find low carbon propulsion solutions more rapidly than was anticipated in 2013. These include:

- **Emissions and air quality concerns:** The 'dieselgate' scandal of 2015 and increasing public concern in relation to air quality have increased pressure on Government and municipal authorities to support and legislate for a more rapid transition to low emissions vehicles. In the UK, this was reflected in the publication of the 'Road to Zero Strategy'[8] which set out the Government's ambitions to see at least half of new cars sold in the UK be ultra-low emissions by 2030, and the Air Quality Strategy which set out plans to end the sale of new conventional petrol and diesel cars and vans by 2040[9].

- **2050 Target Amendment:** The provisions of the 2008 Climate Change Act were made more ambitious in July 2019, with the Government committing to the UK reaching net zero carbon emissions by 2050[10]. Subsequent interim targets established in 2021 set out the aim to reduce emissions by 78% and achieve a net zero power generation system by 2035. However, in late 2023, the 2030 end of sales of new petrol and diesel cars and vans which do not have significant zero emissions capability, first announced in 2020[11], was delayed until 2035 (though now also includes hybrid vehicles). In January 2024, the zero emission vehicle mandate also became law and sets out the percentage of new zero emission cars and vans manufacturers that are required to be produced each year up to 2030. A total of 80% of new cars and 70% of new vans sold in Great Britain will need to be zero emission by 2030, increasing to 100% by 2035.

- **Trade and Corporation Agreement (TCA):** The TCA was signed in December 2020 and enabled traded goods between the UK and EU to be carried out with zero tariffs and quotas if the goods originate in the UK or EU. If they do not, they face a 10% import tariff. Originate is defined as:

  - EVs must have 55% UK/EU content and must have an originating battery pack.

  - An originating battery pack must have either 65% UK/EU content for the cells or 70% for the battery pack.

  This was to be introduced from the start of 2024 but was delayed until 2027 in December 2023. By 2027, materials produced outside EU/UK cannot exceed 30% of battery packs, 35% of battery cells and 45% of the total value of vehicle to avoid the 10% import tariff.

- **Complementary public funding:** Since the inception of the APC, other public sector commitments have been made to support the development of low and zero carbon propulsion systems and the sector more generally, as summarised in the Automotive Sector Deal[12]. Initiatives include a range of subsidies to lever private investment into R&D of low and zero carbon vehicles systems and demand side policies to incentivise consumers to purchase low

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[8] HM government (2018). *The Road to Zero - Next steps towards cleaner road transport and delivering our Industrial Strategy.* Available at: https://bit.ly/2DvPWM7. Date accessed: 02/09/19.
[9] DEFRA (2019). *Clean Air Strategy 2019.* Available at: https://bit.ly/2AJ8kNZ. Date accessed: 02/09/19.
[10] HM Government (2019). *The Climate Change Act 2008 (2050 Target Amendment) Order 2019.* Available at: https://bit.ly/2jYhjpl. Date accessed: 02/09/19.
[11] Following an initial announcement in 2017 of a ban on the sale of such vehicles by 2040.
[12] BEIS (2018). *Automotive Sector Deal.* Available at: https://bit.ly/2DsjLNd. Date accessed: 02/09/19.

and zero carbon vehicles. However, central Government support for capital investment through regional aid schemes has been scaled back with the closure of the Regional Growth Fund to new applicants in 2015 (though some projects have been later supported via ‘exceptional RGF’).

The UK Government published its Advanced Manufacturing Plan in late 2023 that aims to invest in the future of manufacturing, open up markets, and remove obstacles for businesses. It announced £4.5 billion to support strategic manufacturing sectors like automotive (including batteries) and aerospace and aims to prioritise long-term investment in manufacturing. The 2023 UK Battery Strategy set out the ambition to invest in research and development to drive innovation in battery technology, support businesses to establish and expand battery manufacturing facilities and develop skills and training programs. The Automotive Transformation Fund also provides funding for capital and R&D programmes created to support the development of high-value end-to-end electrified automotive supply chain in the UK.

### Technology context

The technological landscape in which the APC supports R&D projects has evolved since it was launched in 2013. However, many of the factors discussed in the APC Technology Roadmaps, prepared on behalf of the Automotive Council and through consultation with the sector, remain valid:

- **Electrical energy storage:** The UK has expertise in the early-stage development of EV batteries and a key focus for R&D is developing an understanding of how to produce at scale both effectively and efficiently. Beyond the AESC battery plant in Sunderland (largely supplying the Nissan Leaf), the capability of the UK to produce at the required scale and unit cost is limited. However, the investments in a second AESC plant in Sunderland, and the South West by Tata Agratas mentioned above will expand this capacity. Lithium-ion batteries are the technology standard in the short term, although other cell chemistries are in development, such as lithium-sulphur. The UK has a strong academic research base in battery electrochemistry and development of battery cells and modules. Remaining key challenges include securing a sustainable supply of raw materials, the need to upgrade existing pilot production lines, and challenges relating to the safety of systems and toxicity of components, and battery design and integration.

- **Electric machines and power electronics:** A range of power electronics, including stop/start functionality, low-cost electronics, accessory electrification, and power electronics to drive motion, remain emerging technologies in the automotive sector. Progress in this area includes development in electric machines to convert energy and/or make motors more efficient and in batteries, power electronics motors and drives, driven by the move towards EVs.

- **Thermal Propulsion Systems:** Incremental improvements to the efficiency and emissions control capability of petrol ICEs remain a key priority for the UK to support the transition to low carbon vehicles (especially true for heavy-duty commercial vehicles). ICE development was expected to continue, especially for commercial and off-highway markets, and fuel cell development was also expected due to increased pressures on electricity markets caused by anticipated BEV adoption. However, the emphasis on incremental improvements for light passenger vehicles has shifted as the sector further leans towards BEV production to meet future demand.

- **Lightweight powertrain structures**: Emissions standards and improved efficiency can also be partly achieved through lightweighting of the powertrain whilst maintaining the required material strength and flexibility. While lightweighting of vehicle shells with novel alloys is common, miniaturisation and downsizing of all vehicle components (including engines, components packaging, power electronics and other drive train components) has been a key trend in recent years. Stakeholders reported future lightweighting would focus on three areas: the design of systems and componentry, the development of new materials and the introduction of new manufacturing processes. The UK has traditionally been a key developer of lightweighting technologies, but several challenges remain: implementing lightweighting technologies into mass-produced vehicles that use standardised components and are assembled in different locations is not always possible; adoption of new materials is constrained as existing infrastructure favours processing of steel; and lightweighting solutions can produce trade-offs that may affect consumer preferences (such as noise).

- **Fuel cells:** The Fuel Cells Roadmap was published in 2020 and reflects a growing and renewed interest in fuel cell technologies. Whilst it is expected the demand for BEVs will continue, fuel cell vehicles may begin to compete in some areas such as aviation, maritime, rail and heavy-duty vehicles where heavy battery packs are a constraint on range and efficiency. The global energy consumption for heavy goods vehicles grew by 50% over the 2000–2015 period (IEA, 2017) and its demand is projected to rise by a further 70% by 2030. Currently there is a lack of low carbon HGVs and hydrogen technology could potentially fill this gap, however it will likely require substantial government support.

## 2.5 International comparisons

Research was undertaken to identify potential comparator schemes from across the EU and US with a view to providing comparisons of the effectiveness and value for money of different options for supporting low carbon vehicle R&D and production. This section summaries the schemes identified.

This exercise identified a scheme analogous in Germany that provided EUR 1 billion in 2021 (Zukunftsfonds Automobilindustrie) to support the development and production of climate-friendly vehicles as the German industry grappled with challenges caused by the COVID-19 pandemic. The funding was available for collaborative projects mainly from the automotive industry with research and science partners in all consortiums, and a focus on including SMEs. Funding is distributed/supported by FI Group to help support R&D in Germany and internationally. There are two funds in total supporting battery cell production and green battery development.

Other support provided to the automotive sector varies with the majority of support provided in the form of subsidies to manufacturers or consumers. For example, the U.S. Inflation Reduction Act (IRA) includes tax subsidies to cut emissions and boost domestic manufacturing in certain industries whilst France has provided support through the COVID-19 pandemic as well as other subsidy support for a gigafactory in Northern France, announced in summer 2023.

In the U.S. support takes the form of policy incentives like grants, tax credits, and loans for research and development in electric vehicles and other low-emission technologies. For instance, the Department of Energy's Advanced Technology Vehicles Manufacturing (ATVM) Loan Program has provided billions of dollars to support the production of fuel-efficient, advanced technology vehicles and components in the United States. The Clean Air Act and Corporate Average Fuel Economy (CAFÉ) standards also incentivise manufacturers to develop more fuel-efficient vehicles.

The European Union (EU) has and continues to provide substantial support to the automotive industry, especially with respect to promoting innovation and sustainability. Historically, there was The European Green Cars Initiative, launched in 2008 as part of the European Economic Recovery Plan. This initiative was aimed at supporting research and development in the area of energy-efficient vehicles and infrastructures. The European Investment Bank (EIB) provides loans to automotive companies investing in R&D and innovation, particularly for projects that aim to reduce emissions and improve fuel efficiency. Established in October 2017, the European Battery Alliance aims to accelerate the development and production of batteries in Europe to support strategic autonomy in this key sector.

However, no estimates of impacts were found for any of these, and comparisons in terms of the relative effectiveness of programmes were not possible.

# 3 Project inputs and activities

This section presents an analysis of the portfolio of projects funded through the APC, with a focus on the characteristics of the portfolio and progress in project delivery. The results generated in this section were informed by an analysis of application and monitoring data, views provided by key stakeholders and evidence from case study projects.

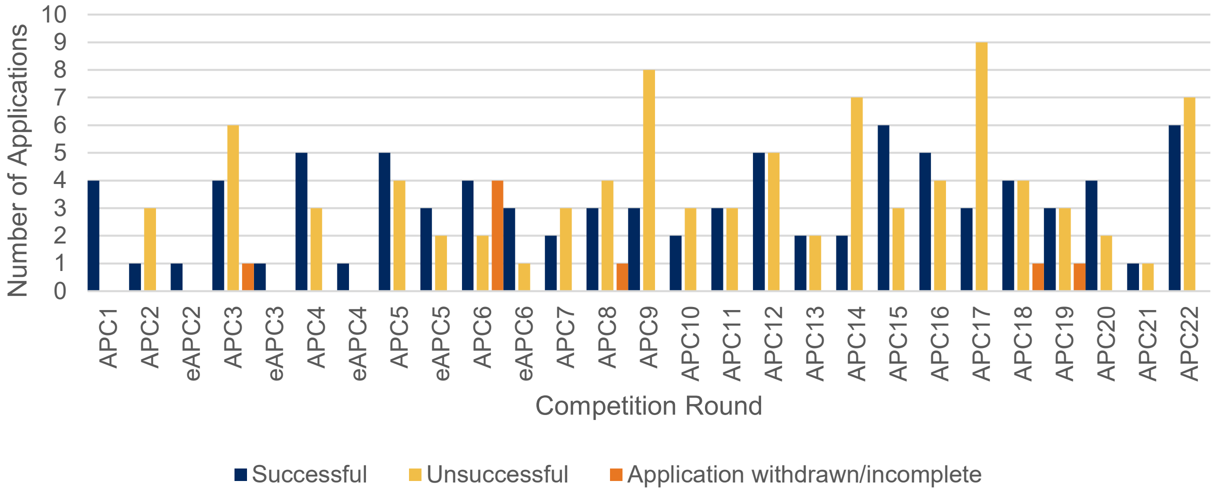
## Key findings

- A total of 91 projects were funded over the 26 rounds of APC competitions between 2013 and 2022. This involved the commitment of £608m in public funds towards projects with a total cost of £1.3bn. A total of 14,800 R&D and 156,000 production job years were expected to be created and/or safeguarded across the portfolio of projects with 180m sales of vehicles incorporating APC developed technologies projected by 2037/38.
- Most projects had their origins in programmes of earlier-stage R&D. These were predominantly funded internally where they were not building on past APC projects.
- Projects were closely aligned closely with the aims of the APC and largely sought to address technical and manufacturing barriers to integrating technologies into vehicles and/or support supply chain partners to develop capability to supply future demand for low carbon technologies. Projects were motivated by the need to comply with changes in carbon emissions legislation and expectations, meet growing consumer demand for BEVs and other low carbon vehicles, and maintain competitiveness with overseas competitors.
- Analysis of VfM records indicated that there had been significant progress in technological and manufacturing readiness levels which continued past project completion. The case studies of APC funded projects indicated that most were on course to meet their technical objectives at the time of the research. However, 13 projects had been withdrawn early or were terminated due to technical failure or supplier withdrawal.
- On average, projects have delivered larger $CO_2$ savings than expected at the application stage (though there was considerable variance across the portfolio of projects funded).

## 3.1 Project inputs and expectations

Across the 26 rounds of the APC (22 standard competition rounds and four exceptional – eAPC - rounds) a total of 182 applications were submitted with 91 successful applications, an overall success rate of 50%. A total of 43 projects had completed by 2022/23. The figure below illustrates the number of applications submitted per competition round using data taken from programme management information.

**Figure 3.1: Distribution of applications across competition rounds APC1 to APC22**



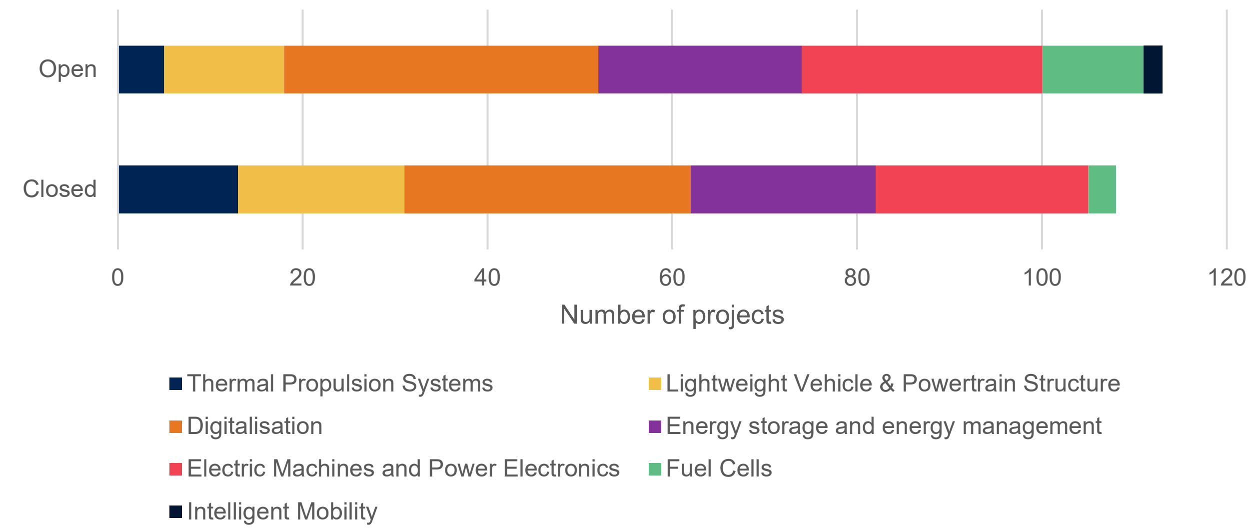

Source: APC Panel Sheets and APC Monitoring Records; Core Comps Consortia Details V43.

## 3.2 Funding commitments

The allocation of funding to projects can be summarised as follows:

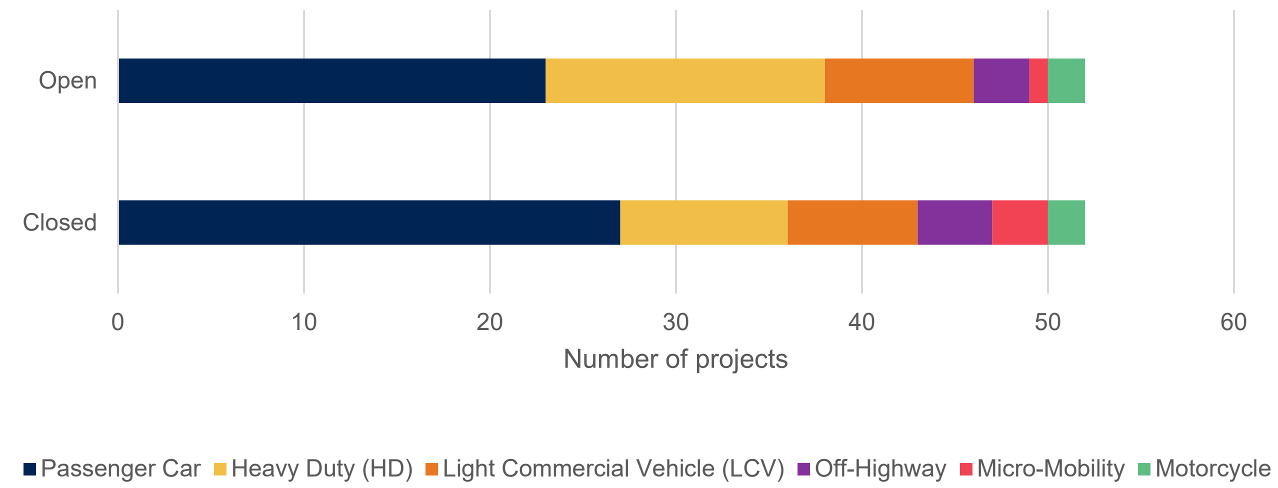
- **Project costs and grant commitments**: The total lifetime costs across the 91 funded projects were expected to be just under £1.3bn in total. The awards involved a commitment of approximately £608m of public funds (around 47% of project costs). The average total cost of approved projects was £15.4m with an average grant per project of just under £7.3m.
- **Technology focus:** Figure 3.2 outlines the distribution of projects by technology focus. There was an initial emphasis in early competition rounds on improving the efficiency of thermal propulsions systems and lightweighting technologies. The growing importance of electrification as the principal route to achieving net zero emissions in passenger vehicles is visible in the evolution of the technology focus of funded projects. In terms of their other – secondary - technology focus, most projects involved some form of digitalisation of design and engineering processes (71% of projects), with electric machines and power electronics the second most frequent secondary focus (54%).
- **Commitments by vehicle type:** Most projects (55%) were developing technologies for passenger cars, with heavy duty vehicles and light commercial vehicles accounting for 26% and 12% of the portfolio respectively. Based on comparisons between completed and live projects – there are some signals that the emphasis of the programme has shifted from passenger cars to commercial vehicles over time (although these changes were predominantly at the margin).

**Figure 3.2 Distribution of projects by technology type - open vs closed projects**




Source: APC Monitoring Records: Accessed November 2023, Base: 91 projects – projects can be allocated multiple technologies

**Figure 3.3: Distribution of projects by vehicle type - open vs closed projects**




Source: APC Monitoring Records: Accessed November 2023, Base: 91 projects

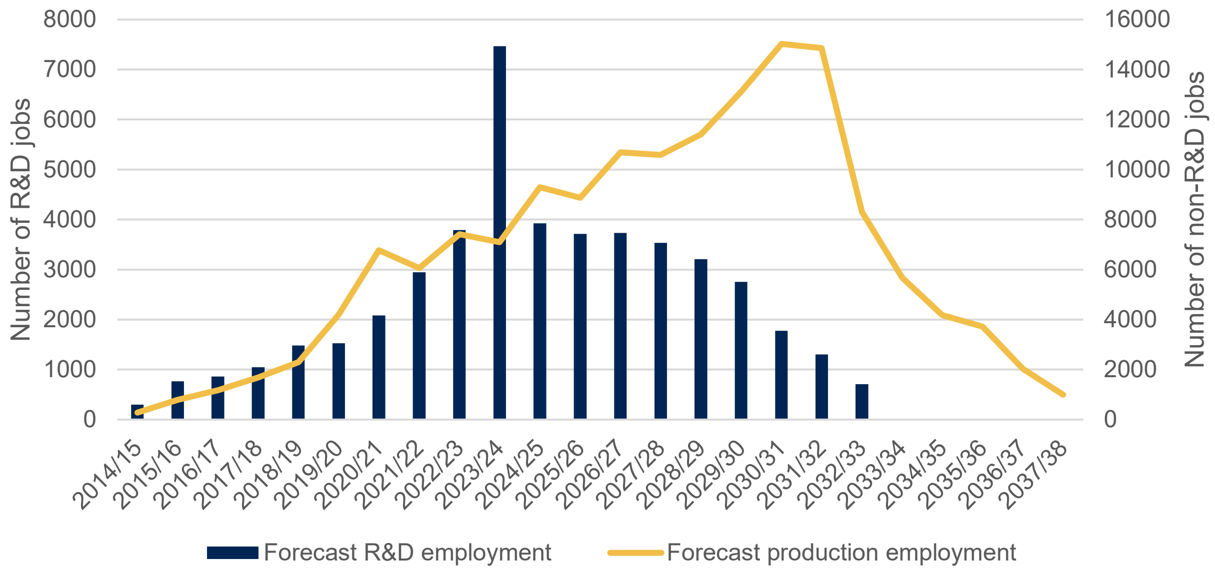
## 3.2 Expected outcomes

The expected outcomes of the projects funded by the APC are examined as part of the Value for Money (VfM) assessment undertaken in the project appraisal and selection process. VfM forms are completed by applicants and provide expectations of the future costs and benefits associated with the project – including improvements in technical performance, vehicle sales, and the creation or safeguarding of jobs. These are adjusted in light of the APC's assessment of the risks involved and the likelihood the project would proceed without public intervention. Analysis of the monitoring information and VfM forms demonstrated the following expected benefits:

- **Net benefits:** The net lifetime benefits expected across the portfolio under review totalled £2.4bn after adjustments for deadweight, displacement effects, and risk[13].
- **Distribution of benefits:** Expected benefits were distributed across different categories: jobs, training and wider benefits, the latter of which captures $CO_2$ and other emissions reductions (which account for approximately 48% of the total net benefits expected).
- **Employment:** Projections of the number of R&D and non-R&D jobs (largely production jobs) that will be created and safeguarded by projects were also made at the application stage. Analysis of these projections indicated that at the application stage, 14,800 R&D and 156,000 production employment years were expected to be created and/or safeguarded across the portfolio of projects.
- **Vehicle sales:** Applicants also provide projections of vehicle sales integrating technologies developed with APC funding. Funded applicants expected to sell a total of 180m vehicles incorporating APC developed technologies by 2037/38 (tapering off from 2030 onwards). Most vehicle sales were expected to occur outside of the timeframe covered by this evaluation.
- **Technical performance:** Applicants provided expectations regarding the performance of the technologies developed in terms of reductions in emissions. At the application stage, a total of 1.35bn tonnes in global $CO_2$ savings was expected between 2014/15 and 2037/38.

Figures 3.4 and 3.5 below outline the distribution of expected jobs (R&D and non-R&D), vehicle sales and $CO_2$ savings at the point of project approval. As might be expected, production jobs, vehicle sales, and resultant $CO_2$ savings were projected to lag initial investments in R&D.

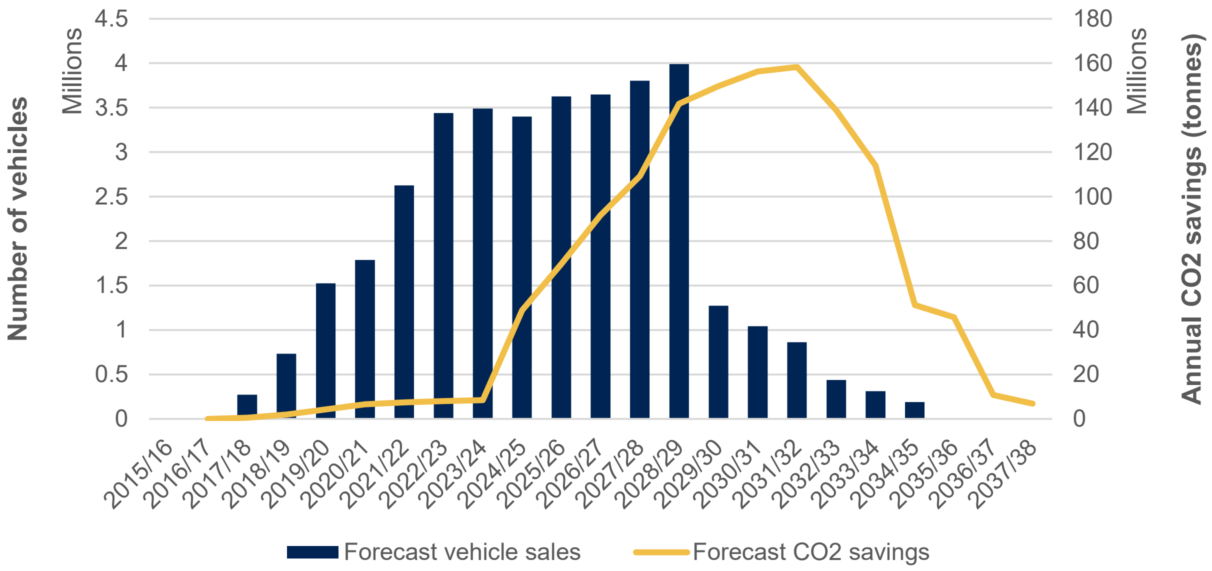
**Figure 3.4: Distribution of expected gross R&D and non-R&D jobs created or safeguarded (employment years)**




Source: APC monitoring data (Accessed Oct '23), Base: 90 projects

[13] These are the costs upon which the VfM assessment was based, not the level of grant funding agreed in the Grant Confirmation Letter or subsequent change requests.

**Figure 3.5: Expected vehicle sales with APC technologies integrated and annual $CO_2$ emissions savings**




Source: APC monitoring data (Accessed Oct '23), Base: 90 projects

## 3.3 Project background

This subsection provides an analysis of the background to the APC projects, drawing primarily on project application data, monitoring information, and evidence from the project and organisation level case studies.

### 3.3.1 Prior programmes of R&D

Analysis of case study transcripts indicated that 15 of the 24 APC funded projects sampled had their origins in programmes of earlier-stage R&D. These were predominantly funded internally where they were not building on past APC projects. Of the 24 projects, three were building on past APC projects whilst the remainder built upon internal projects (typically small at that stage). Three other ongoing projects were continuations of APC funded projects though, highlighting the interlinking of R&D projects. This was more likely to be the case for projects sampled as part of the organisation level case studies with a number of these also building upon each other. Where prior research had previously been completed, funding was sourced internally or through programmes such as the APC and other public support programmes.

The availability of funding over a 10-year period enabled firms to continually build upon past projects and develop the technical maturity of their projects further.

### 3.3.2 Motivations to apply for funding

Projects were typically closely aligned to wider corporate objectives for R&D and the aims and objectives of the projects sampled in case studies aligned closely with the aims of the APC. Projects generally sought to:

- Address technical and manufacturing barriers to integrating technologies into vehicles and/or
- Support supply chain partners to develop capability to supply future demand for low carbon technologies, for example battery manufacturing.

The rationale for developing new low carbon vehicles was driven by the need to comply with changes in carbon emissions legislation and expectations that consumer demand for BEVs and other low carbon vehicles will increase in the future:

- **Meeting demand for low carbon vehicles:** A key motivation for undertaking the R&D supported by the APC programme was the perceived need for manufacturers to meet growing demand from consumers for low carbon vehicles. In particular, there was a need to move to address increasing demand and focus on plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). Many stakeholder and case study projects stated that consumers preferences have already shifted away from mild hybrid electric vehicles (MHEVs) and will continue to move further towards BEVs and fuel cell electric vehicles (FCEVs).

- **Maintaining competitiveness:** Funding was also sought for projects to support the competitiveness of UK based manufacturing to ‘catch up’ with overseas competitors. Large OEMs and Tier One firms based in the UK were seeking to develop domestic capability to reduce reliance on imported components and reduce costs. Reducing costs of BEV components has become an increasingly important focus for UK firms as overseas competitors benefit from significantly lower costs. For example, Chinese manufacturers reportedly benefit from easier access to raw materials and government subsidies that lower the cost of producing BEVs inside China. There was a recognised need to develop UK based expertise and capabilities to address rising costs caused by frictions with overseas trade (such as tariffs and trading uncertainty) and battery supply chain requirements.

### 3.3.3 Role of APC in supporting project development

Stakeholders and project leads consulted described the role of the APC in the initial development of project proposals. The main mechanism through which the APC influenced project development, was through the development of the publicly available Technology Roadmaps:

- **Development of Technology Roadmaps:** Stakeholders expressed generally positive views on the extent to which the Technology Roadmaps guided the development of novel proposals. Interviewees for the project level case studies mentioned the roadmaps as having encouraged them to take a more novel approach and reallocate R&D from other projects. However, some stakeholders stated that they felt the roadmaps reflected current plans of OEMs.

- **Alignment with project objectives:** Whilst many project applications were closely aligned with the aims of the APC and mapped neatly to the roadmaps, some stakeholders reported that some project applications were seen to be closely aligned with the technical aims of the programme but needed clearer evidence and communication of the commercial opportunities.

## 3.4 Rationale for and composition of collaborations

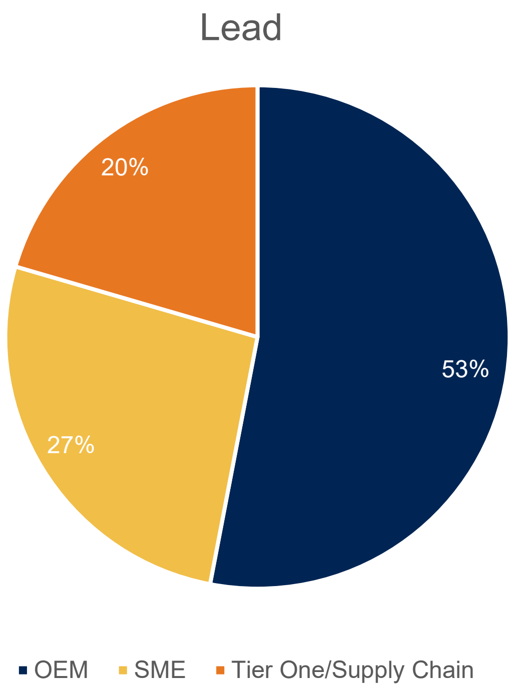
All APC projects required some form of collaboration. The APC requires the involvement of at least one SME and encourages involvement of firms outside the traditional UK automotive supply chain. This sub-section discusses the collaborations within the APC project portfolio, including the rationale and nature of collaborative links, and their associated costs and benefits.

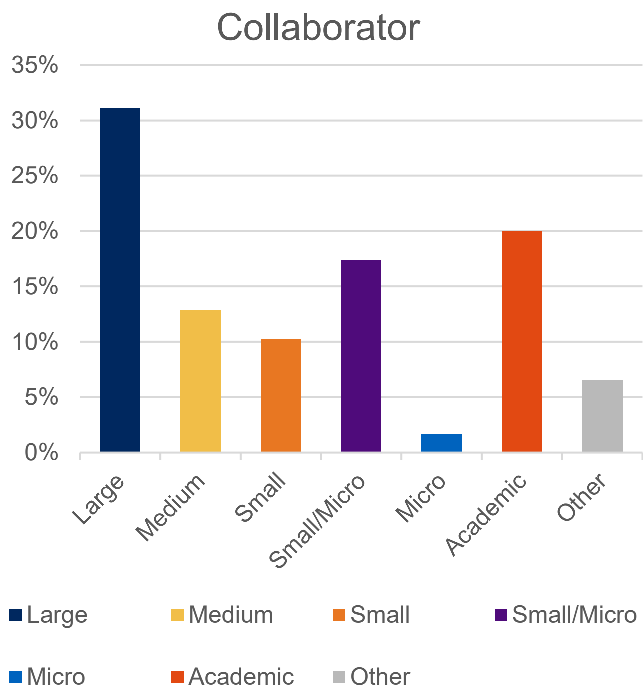
### 3.4.1 Composition of collaborations

A total of 428 partners (of which 262 were distinct businesses) were involved in the 91 funded projects. The number of partners involved in successful projects ranged from two to 12, with an average of approximately five partners. Most lead applicants were OEMs, accounting for 53% of projects.

A total of 27 partners from 20 projects withdrew from collaborations by 2022/23, including 14 partners involved in projects now completed. Most lead partners were large firms (66%) while the spread of partner type is more varied among collaborating partners.

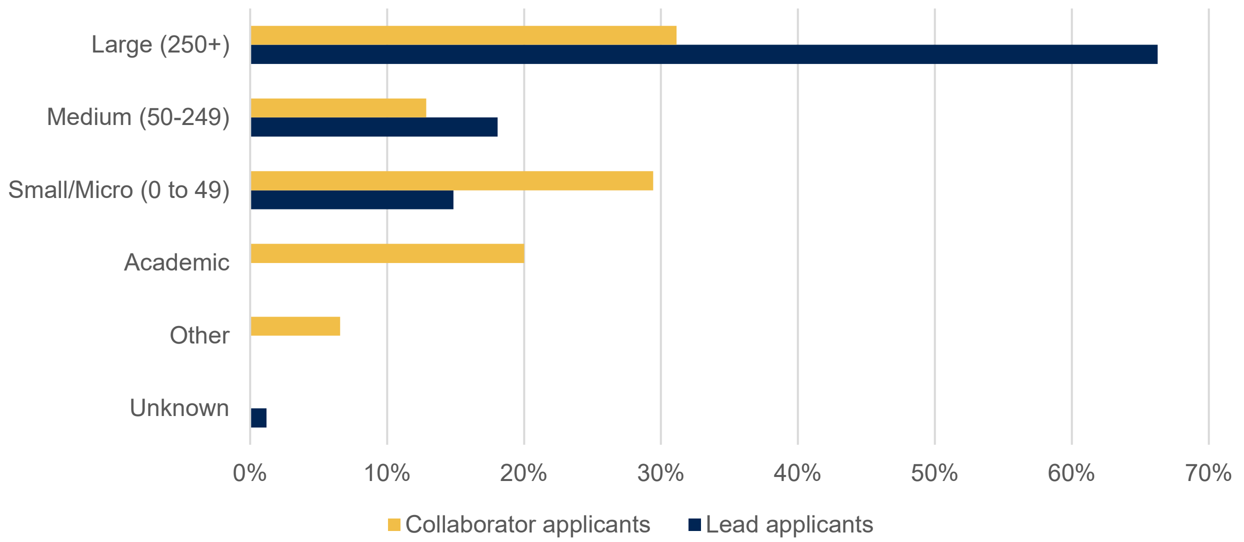
**Figure 3.6 Distribution of partner types among lead applicants and collaborator**




Source: APC Monitoring Records: Accessed October 2023, Base: 428 project partners

**Figure 3.7: Size of partners – leads and collaborators**




Source: APC Monitoring Records: Accessed October 2023, Base: 428 project partners

### 3.4.2 Rationale for collaboration

Survey evidence and case study research suggested that projects often had more than one reason for establishing partnerships. The development of consortia typically had three main drivers:

- **Leveraging of skills and capabilities:** Many projects led by large OEMs and SMEs appeared to involve collaborations centred on access to skills and capabilities provided by suppliers and research institutions. Partners generally provided a distinct set of skills, capabilities, expertise, and experiences designed to offer the competencies required to develop technologies to the point of commercialisation. Skills and expertise provided by partners filled gaps as lead partners had either typically used specialist consultants for R&D in the past and therefore not developed these capabilities in-house or the skills required were novel and there was not time for these to have been built up internally. Project leads looked to engage the most appropriate experts (or specialists/pioneers) in the field or area. Five of the nine project level case studies were projects in which the intention was to leverage specialist partner skills.

- **Access to specialist facilities:** Related to the above, several projects required specialist technical equipment for testing and development which were often in high demand. In two projects sampled, access to testing facilities for the testing of hydraulic and high voltage components was necessary. Partners were sought to provide access to such facilities with the capacity, availability, and skills to utilise them.
- **Development of supply chain capabilities**: Across the projects sampled for case studies, the lead firm often provided the route to market, with collaborators brought on board to fill gaps in the supply chain that would be required for commercialisation. Some collaborations were therefore developed with the intention for the SME to fill a gap in the supply chain relevant to the technology being developed. For example, one sampled project involved an SME being brought in with specialist knowledge of hydraulics that is now part of the lead Tier One's supply chain.

### 3.4.3 Role of APC in supporting consortia formation

Those engaged in the case studies and stakeholders reported that APC has supported the development of collaborative links that would not have been created otherwise (although several consortia included long term partners). Three of the nine project level case studies involved collaborations that would not have been brought about without the influence of the APC. Stakeholders highlighted several factors as important:

- **Regular announcement of funding opportunities** – periodic and well communicated funding announcements have made it easier to identify eligible proposals for funding and plan the composition of consortia. Project leads mentioned the need to have sufficient time prior to the submission of applications to the APC to bring together a working consortium, which could take up to six months. Combined with the regularity with which the APC funds project applications via funding rounds, the APC was reported to have contributed positively to the UK funding landscape for R&D in low carbon technologies for the UK automotive sector, enabling decisions on which R&D projects to pursue in the future to be made effectively.
- **Brokered, facilitated and validated consortia relationships** – Several cases were highlighted in which the APC brokered or facilitated relationships that would benefit project consortia. These interventions were often made where a technical partner required a manufacturing partner or vice versa. In these cases, the APC either suggested potential partners or project leads asked the APC for assistance in brokering potentially beneficial partnerships.

## 3.5 Project delivery

By the end of 2022/23, the total level of grant spending by projects funded was £327m (54%) of a total £608m committed. Assuming a linear spend profile, this compares to £345m expected to be spent by the end of 2022/23. Monitoring records indicated a total of 13 projects (14% of funded projects) had been withdrawn or terminated early. These were primarily because key partners dropped out or because the technology was no longer considered viable. For example, one supplier appears to have pulled out of a project with cash flow issues related to the pandemic. Another project terminated early because the priorities of the lead partner changed and resource to cover project management was not allocated.

### 3.5.1 Technological progress

The APC provides funding to support R&D activities aiming to accelerate the development of low and zero carbon propulsion technologies. This subsection provides an analysis of the technical objectives and outcomes that have been achieved by APC projects to date. When reading this subsection, it is important to bear in mind that:

- All R&D projects involve a level of technical risk, and there is an expectation that some projects will inevitably not deliver the anticipated improvements in vehicle performance.
- APC projects are complex, often involving the development of several technologies with the potential to be exploited independently. Projects may result in the development of components or sub-systems that can be successfully integrated into other vehicle or engine platforms.
- Success in achieving technological objectives does not necessarily imply that the technology will eventually be commercialised. Firms may face wider barriers in commercialising technologies, such as difficulties in securing the investment to produce the technology at scale.

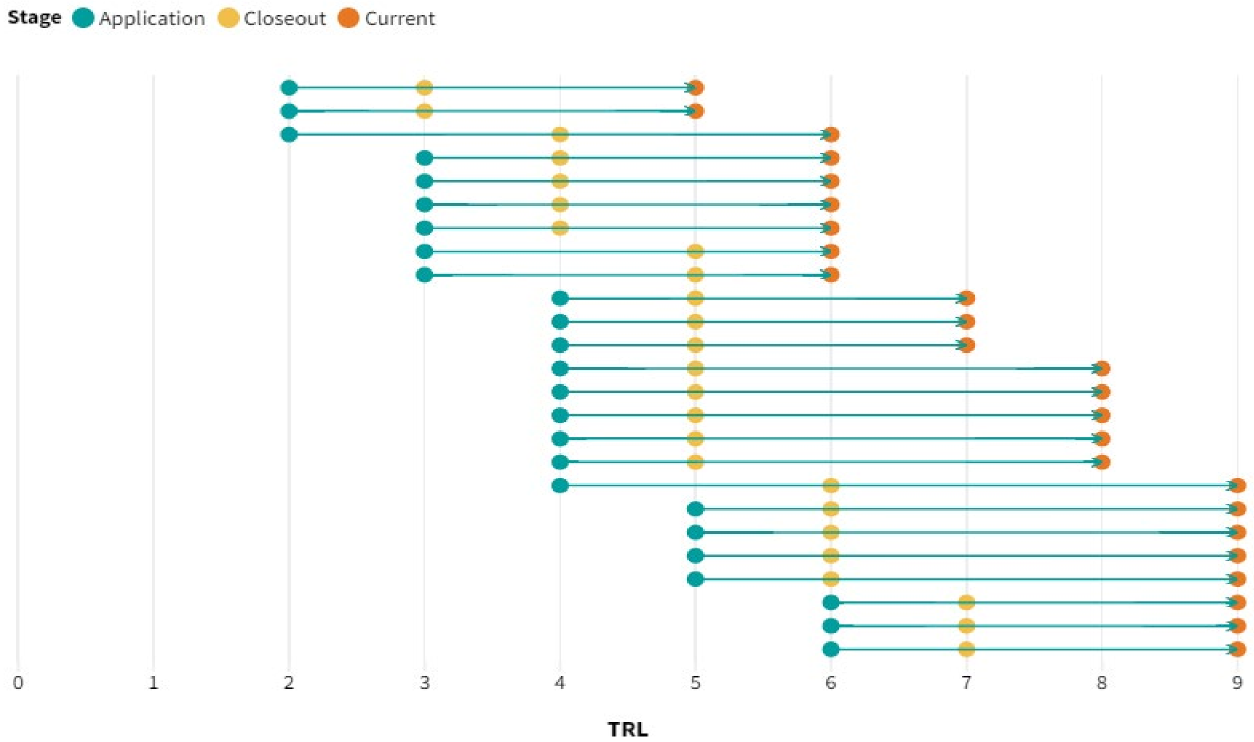
The technical progress of R&D projects can be quantified using the Technological and Manufacturing Readiness Level scales (TRL and MRL). These scales describe the progression of technologies through a sequence of tests of increasingly high-fidelity prototypes in increasingly realistic environments. Applicants provided an assessment of both baseline levels of technical development and expectations with respect to the advancements that would be made by the end of the APC project. Records of technical progression achieved was obtained from VfM forms completed by all projects at the closeout stage, and augmented with additional VfM forms for 27 projects collected through the PPM survey (noting that there may be potential for bias in terms of the firms responding to the PPM survey if those responding differ to non-responders).

The results showed a significant degree of progression was achieved for those technologies that were developed using APC funding:

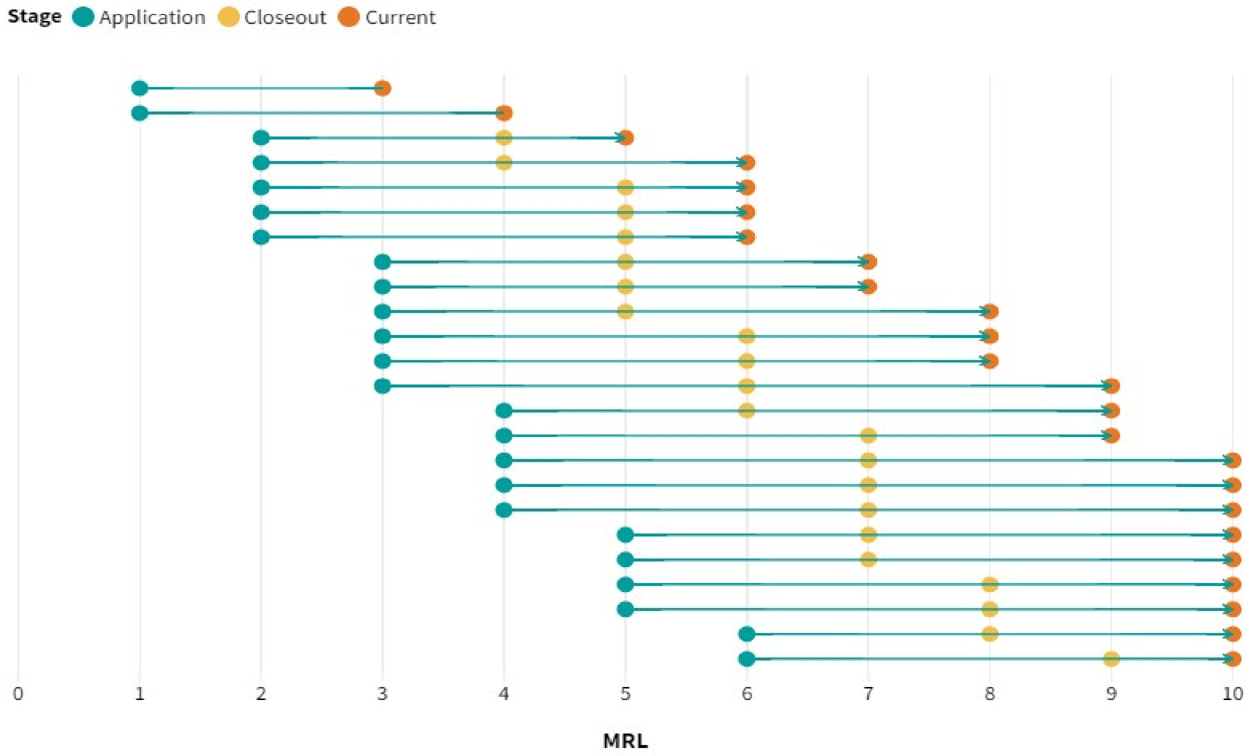
- **Technology Readiness Levels:** Of the 27 projects with updated VfM forms collected in the survey, 33% had reached TRL9 by 2023. This suggests that a significant proportion of APC projects led to some form of commercialisation. Across all grant recipients, technologies under development had progressed significantly with 22% moving up one level, 57% moving up two levels and 21% moving up three levels.
- **Manufacturing Readiness Levels:** Of the 27 projects with updated VfM forms collected in the survey, 36% had reached TRL10 by 2023.

The figures below present the application, closeout, and current assessments of the TRL and MRL levels associated with each of the projects responding to the PPM survey.

**Figure 3.8: Progress made in Technology and Manufacturing Readiness Levels reported by PPM survey respondents**




Source: 25 projects with application, closeout and current VFMs available




Source: 24 projects with application, closeout and current VFMs available

**Examples of TRL progression**

**HP-LiSD**: Aimed to develop a lightweight module design for a high-power lithium-ion storage device. The project sought to develop several packages of the technology to TRL 8 with several reaching TRL 9 by the end of the project. Of the six component packages, three had reached TRL 9 including the battery pack, module, and cooling solution. Multiple prototypes were built, tested and validated.

**HIPERCAR II**: The HIPERCAR 2 project set out to develop a high-performance car using novel energy storage and management, lightweight powertrain, electric motor technologies and a low manufacturing cost. The project completed in 2022 reaching TRL and MRL 8 having started at TRL 5 and MRL 3. The project concluded with a tested and validated product and initial production underway with proven manufacturing processes.

**ALIVE6:** The main aim of the project was to develop several technologies to TRL8, reducing $CO_2$ emissions by 20% on the core volume specification 6-cylinder engine and introducing a mild hybrid 6-cylinder petrol engine into the lead partners product line. The project resulted in a total saving of $CO_2$ emissions equating to 12%.

### 3.5.2 $CO_2$ emissions savings

APC monitoring records contained details of the expected $CO_2$ savings associated with APC technologies. Analysis indicated some significant variations between the expected performance of technologies in delivering $CO_2$ savings and those achieved in practice. On average, projects delivered larger $CO_2$ savings than expected. This was partly driven by a single project that delivered much larger efficiency gains than expected. Without this project, forecast emission reductions in 2023 are still 50% higher than expectations at the application stage. However, 41% of projects delivered less than 50% of the anticipated $CO_2$ savings.

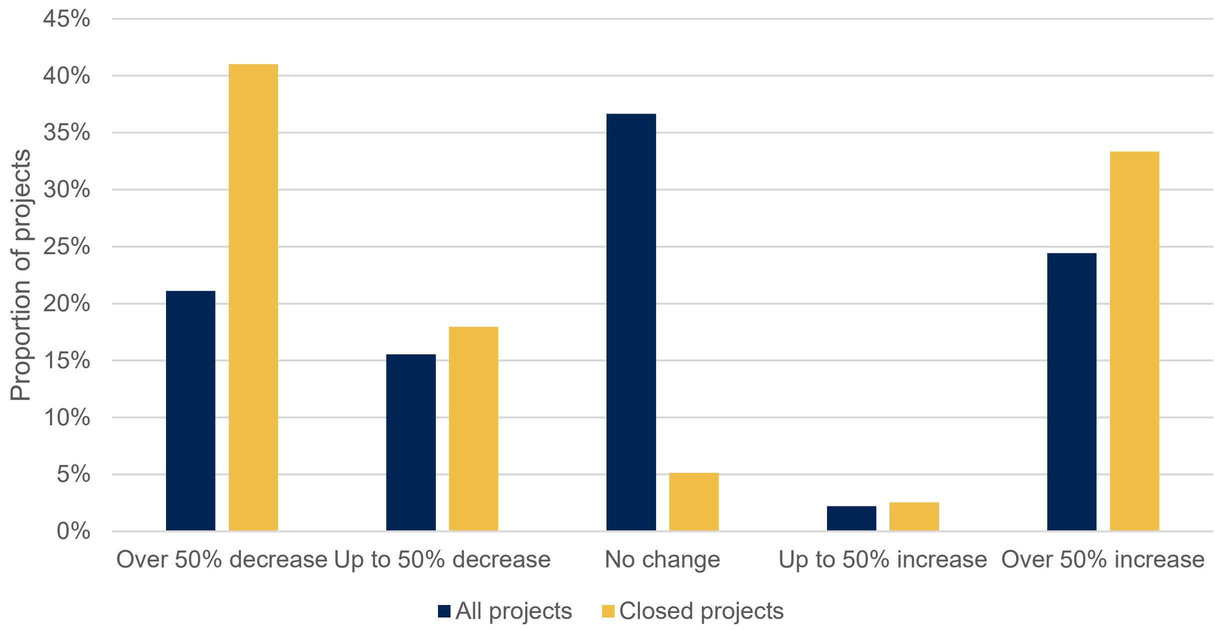
Projects sampled in the project level case studies described two main causes for changes in expected $CO_2$ savings:

- **Actual vs expected technology capabilities:** Development and testing of technologies enabled some partners to understand the technical limitations of their innovations and in doing so allowed for a more accurate reflection of the potential $CO_2$ savings related to the technology.

- **Commercialisation:** The achievement of $CO_2$ savings is dependent upon sales of vehicles integrating the relevant technology and challenges associated with commercial viability dampened $CO_2$ savings in some cases. In one project sampled, the lead faced challenges when a key partner dropped out and could not be replaced without costs increasing significantly. In addition, the changing context for the automotive sector between 2013 and 2022 altered the focus of many firms, including expediting a transition to BEVs. This meant that some MHEV production was de-prioritised with associated knock-on impacts for APC technologies intended for these vehicles.

The figure below illustrates the expected change in $CO_2$ savings as of the most recent forecasts versus the level of savings expected at application stage. Analysis of the VfM forms provided by successful applicants responding to the PPM survey showed that 21 of the 27 projects had achieved some $CO_2$ savings by 2022/23 with projects achieving 74% of those expected by that stage at the end of their project. Overall, these firms were forecasting to achieve 93% of total $CO_2$ savings by 2037/38.

**Figure 3.9: Proportional change in expected project $CO_2$ savings at present relative to application**




Source: APC Monitoring Information: Accessed October 2023, Base: 90 projects

### 3.5.3 Determinants of project success

The key factors determining project success and barriers to achievement of aims were explored through analysis of the case studies and views provided by stakeholders. The key factors determining success comprised:

- **Alignment of partner aims:** A shared goal/vision for the project was seen to be beneficial in focussing partners on their roles. It was important for each partner to feel they had a significant stake in the project and that the benefits for them match their organisations' wider R&D aims and objectives.

- **Composition of consortia:** Minimal competitive overlap amongst partners and complementary skills were highlighted as facilitating factors. Complementary skills included technical skills and capabilities but also included other non-technical skills such as project management that could be shared between partners. The size of consortia was also a factor in so far as smaller consortia with established partners that had worked together in the past were better able to adapt to challenges.

**Example of new working relationships**

**DDISPLACE**: Aimed to develop innovative hydraulic systems and a family of modular products for off-highway OEM equipment manufacturers. The APC gave the lead partner a lot of insight into what it would take to make the technologies they were developing viable and supportable and facilitated the development of links with the two partner SMEs through proactive work to identify other UK success stories to partner with.

- **Effective management of technical challenges:** Unexpected technical challenges generally resulted in delays or the need to postpone development of some technologies. These may have required other options to be explored by consortia members and, whilst this was expected, the ability to effectively assess and manage such challenges was beneficial for project progress. An inability to pinpoint the nature or scale of these made it difficult to set contingency budgets or assess potential timing implications. Effective communications and project management functions were considered important.

- **Effective response to external factors:** In three of the 24 projects included in the case studies, supplier changes and rescoping were necessary as suppliers dropped out. In one case the COVID-19 pandemic placed financial pressures on some of the firms involved and forced the withdrawal of a supplier offering test facilities which were subsequently found elsewhere at additional cost.

- **Effective project management:** Key aspects included firm strategy, team composition, shared vision, clear ways of working and lines of communication and clear and detailed project plans. Both staff turnover and shortages of specialist staff were barriers to project progress that required effective management to deal with. One project partner sampled encountered difficulties hiring a key engineer to lead a work package for months following project commencement delaying the project. Staff shortages reportedly also worsened during the COVID-19 pandemic.

# 4 Impacts on R&D activity

This section presents an analysis of the effect of APC funding on the R&D activity of firms awarded grants. Evidence used to develop the findings in this section was compiled from the programme of data-linking and econometrics, an analysis of application and monitoring data, analysis of sampled case studies and the perspectives of key stakeholders.

## Key findings

The evaluation identified significant impacts from APC competition funding on R&D activity:

- Case study analysis indicated that claims made by applicants as to why projects would not have moved forward without APC funding were mostly valid where they related to high levels of technical risk for development and UK supply chain deficiencies. Arguments were also made in relation to internal competition within international firms as to where to locate new R&D programmes. However, it was not always clear why large OEMs could not fund the necessary development work, especially given the need to meet legislated emissions targets to maintain competitiveness.
- Evidence from the PPM survey on the progress of projects forming the focus of declined applications indicated that most unfunded projects proceeded in some form but at a significantly reduced scope with longer timescales, smaller budgets and less collaboration.
- Econometric analysis exploring the impact of the programme on R&D activity provided evidence that the APC led to an on-going expansion of R&D spending and employment amongst applicants. These effects were estimated at 7% and 12% respectively and estimated to endure for seven or eight years. This is substantially longer than the typical duration of an APC project (3.3 years), suggesting that the funding had led to a significant amount of additional R&D activity beyond the initial APC project.
- The findings imply that APC competition funding led to a total increase in R&D spending of £1bn by the end of 2022. This implies that the programme leveraged £2.20 of private R&D spend per £1 of public sector spending by 2022/23. This suggests that the APC programme was a highly economical use of public funding with a relatively low degree of deadweight and led to the crowding in of significant amounts of additional R&D investment.
- **T**he findings also indicated that the programme has supported the creation or safeguarding of around 8,300 R&D job years (which compares with a gross figure of 14,800 expected at the application stage in VfM forms).

## 4.1 Additionality

APC funding was expected to increase levels of spending on the development of low and zero carbon propulsion technologies amongst firms receiving grants. This was expected to occur by leveraging additional resources into R&D projects that would not have otherwise been funded (or would not have been delivered at the same scale, over the same timescales, or in the UK). It is important to note, however, that there are a complex range of possible effects. Even if these objectives are met, subsidies could divert private funds from alternative R&D programmes or place pressure on prices (wages of R&D technicians) leading to reductions in R&D activity elsewhere in the economy (crowding-out). This subsection provides evidence on the impact of the APC on R&D activity at the level of both the projects funded and firms receiving grants.

### 4.1.1 Project additionality

Application to the APC must explain why the project would not go ahead without public support. Application assessors make a judgement as to the likelihood projects would go ahead without public sector support (deadweight). x Such an assessment has limited validity on its own (as respondents have strategic incentives to overstate the impact of grants and may have not have strategic insights into the relevant decision-making context – particularly where such decisions are made by parent companies based overseas). Personnel in large organisations may also sometimes have limited knowledge of decisions taken at the organisational level. However, the arguments made provide some insight into the relevance of the market and system failures put forward to justify public spending on the APC.

Case studies sampled highlighted a number of reasons for public funding was needed, including:

- **Technical risk**: Lead applicants across all of the sampled projects cited high levels of technical risk that prevented internal and debt-based funding of projects. In particular, smaller applicants such as SMEs and niche vehicle manufacturers reported smaller R&D budgets from which projects could be funded and private finance was unavailable due to high levels of risk and limited track records in undertaking such R&D projects. For some larger OEMs sampled, when project applications were submitted, the project would reportedly have taken resources away from other more commercially certain projects. However, as the market context changed these projects which were initially considered ambitious in relation to legislative targets became necessary. This implies that APC funding may have enabled firms to get a head start on R&D in relation to more advanced low and zero carbon technologies that they would have otherwise needed to invest in at a later stage.

- **Competition within international organisations:** Three large OEMs from the organisation level case studies cited APC funding as being key to securing R&D activity within the UK that may otherwise have been shifted to the EU or further afield. Cost reductions were the main driver for offshoring of R&D activity – alongside commercial advantages associated with closer proximity to suppliers of key inputs involved in vehicle manufacturing (such as battery pack production). For these organisations, the availability of APC funding and the requirement for the activity to take place in the UK was seen as important in securing this activity and lobbying internally for future investment. However, cost drivers appear to be significant and without a UK based supply chain with capacity to support UK R&D and production, group level decisions in the future may be at risk of being driven by cost considerations.

- **Supply chain development:** A need to develop capability in the supply chain was noted by all five OEMs sampled in the organisational level case studies. They reported a lack of certain capabilities and scale in the UK supply chain preventing private R&D investment, and highlighted concerns that existing suppliers could not meet the high-volume and quality requirements to become an approved supplier. While in-housing of capabilities was an option for large OEMs, for example in areas of testing and validation, the required individual investments in physical infrastructure were not thought to be commercially viable given the associated risks identified above.

### 4.1.2 Outcomes associated with unsuccessful applications for funding

Given the challenges in validating the self-reported accounts of firms receiving APC funding in relation to its impact on their R&D activity, evidence was also obtained on the outcomes associated with unsuccessful applications for APC funding through the PPM survey to help understand what occurred in the absence of grant funding. A total of 20 unsuccessful applicants responded to the survey (five OEMs and 15 SMEs). The analysis showed that:

- **Scaling back of project ambitions:** Of the 20 unsuccessful applicants responding to the survey, 16 stated that the project still proceeded in some form with the other four projects cancelled following application. However, of the 16 proceeding, 13 were scaled back in terms of the scope and ambition of their project objectives. This provides some support to claims that APC funding was needed to meet the scale of the challenge before applicants.

- **Reduced pace of development:** 12 unfunded projects were also scaled back in terms of the pace of development, potentially reflecting a longer time over which the necessary funds would become available from other sources.
- **Reduced collaboration:** A total of 12 unsuccessful projects continuing after application for APC funding also involved a scale back of the extent of collaboration with supply chains (whilst ten involved reduced levels of collaboration with academic institutions and Research and Technology Organisations RTOs).

The survey analysis of the outcomes associated with unsuccessful applications for funding provides some evidence that APC was critical in enabling projects to proceed (either at all, or at the anticipated speed or scope). Only a small minority of projects in the survey that proceeded with increased scope/scale, speed, and collaboration despite not receiving APC funding.

## 4.2 Impacts on R&D activity

### 4.2.1 Econometric analysis

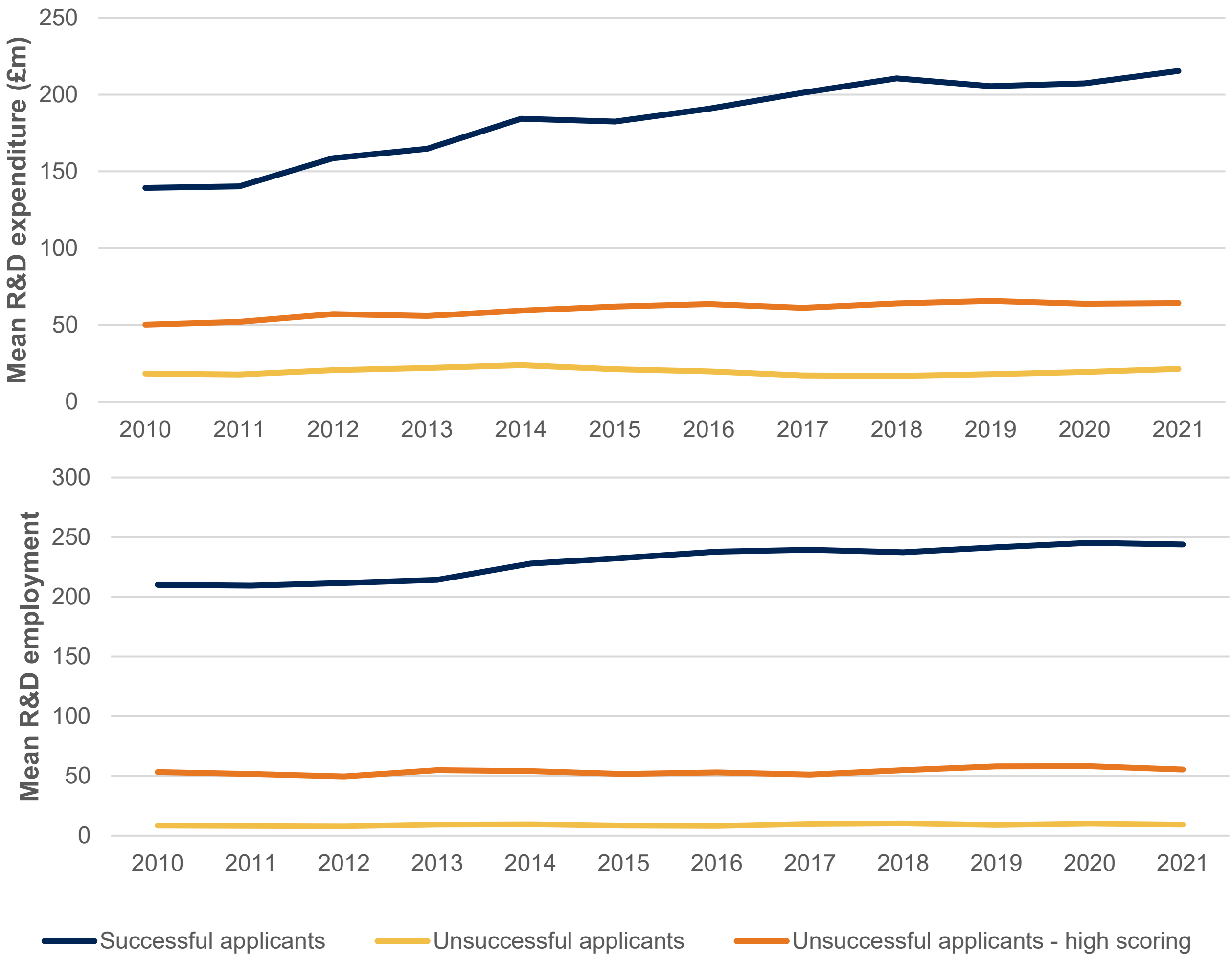
The findings above provide some indications that APC funding influenced the ability of applicants to take forward projects. However, the strength of these results is limited by the self-reported nature of the qualitative accounts put forward by those receiving funding, the small number of observations from those that applied but were declined funding, and issues regarding the equivalence of funded and non-funded projects (in terms of levels of commercial and/or technical risk).

A series of econometric analyses were completed to help explore these issues in greater depth and help quantify the magnitude of the effects involved. These involved examining the overall R&D spending and employment of those awarded APC funding relative to a variety of comparison groups (including declined applicants, declined applicants that were awarded high scores and internal comparisons between those awarded funding at an early and later stage). The Technical Annex details the analyses completed in more depth. The data driving the analysis was gathered from the ONS Business Expenditure on R&D (BERD) survey provides annual measures of R&D activity for a large sample of UK based firms.

Analysis of the data indicated shows that the firms that secured a grant saw their R&D employment and annual expenditure increase between 2010 and 2021, whilst for firms that did not secure a grant activity these metrics remained stable:

- **R&D employment**: Firms securing APC grants saw R&D employment increase by 16% on average (from 210 to 244) between 2010 and 2021. R&D employment for firms that did not receive grants increased slightly from eight to nine FTE jobs on average over the same period.
- **R&D expenditure:** Average R&D expenditure rose consistently between 2010 and 2021 for firms that received APC grants (from £139m to £215m – 54%), in comparison to growth of £3m (17%) amongst unsuccessful applicants. High scoring unsuccessful applicants saw average R&D spending rise from £54m to £64m (a 28% increase) over the same period.

**Figure 4.1 Trends in R&D activity for successful and unsuccessful applicants**




Source: Business Expenditure on R&D survey, ONS, Ipsos analysis.

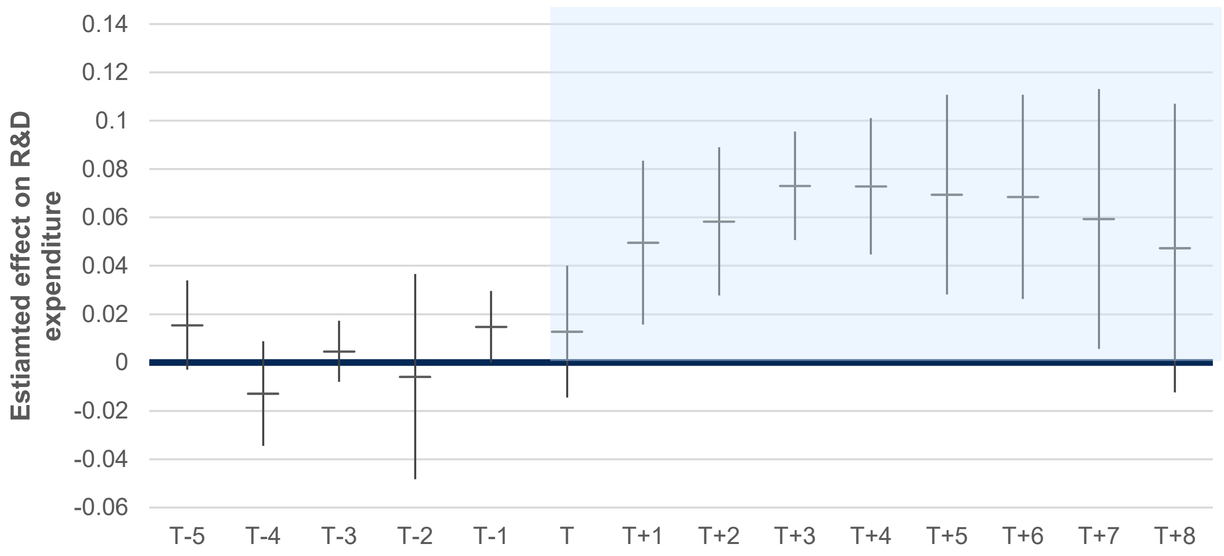
The econometric analysis sought to control as far as possible for both observable and unobservable differences between firms awarded funding and the relevant comparison group. The analysis showed that:

- **Effects on R&D spending and employment:** The results suggested that APC grants had an impact on both R&D expenditure and employment at the overall level. The most robust model identified an on-going impact on annual R&D expenditure of 7% (relative to the group of firms that were not awarded funding). APC grants also led to an on-going expansion in R&D employment of 12% overall.

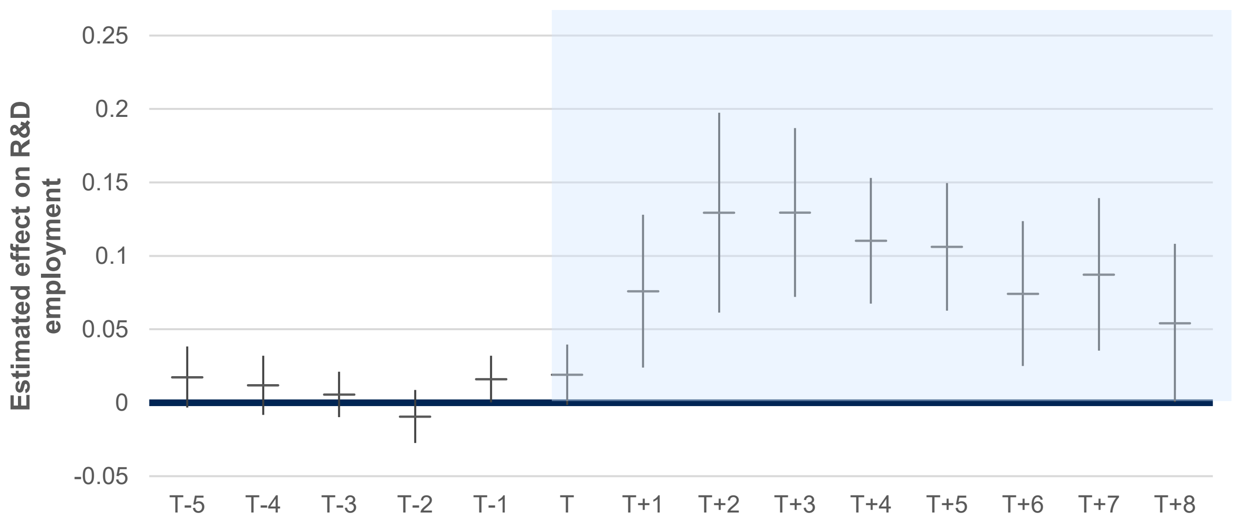
- **Persistence of effects:** Further analysis of the persistence of impacts showed that the effects of APC grants persisted for seven to eight years. This is substantially longer than the typical duration of an APC project (3.3 years), suggesting that the funding led to a significant amount of additional R&D activity beyond the initial APC project. This could be associated with the same technology developed through the APC project, but it may also be in part explained by additional projects and/or technologies developed off the back of the initial APC funded project.

- **Spending on UK based R&D versus non-UK:** The analysis found that the effects of the programme on R&D activity were wholly confined to the UK with no leakage overseas. The programme was estimated to have led to increase UK R&D spending by 6% on an on-going basis, with no impact on overseas R&D activities.

**Figure 4.2: Persistence of effects on R&D expenditure and employment**




Source: Business Expenditure on R&D survey, ONS, Ipsos analysis. Post grant effect period shaded light blue. Error bars indicate 95% confidence intervals.




Source: Business Expenditure on R&D survey, ONS, Ipsos analysis. Post grant effect period shaded light blue. Error bars indicate 95% confidence intervals.

- **Effects by partner role:** APC grants had a larger positive effect on the R&D employment and spending of those firms leading the project compared to collaborators. In terms of R&D employment, lead firms saw a 15% increase compared to 5% for collaborators whilst R&D spending impacts were only present for lead firms implying an 11% increase for leads. An increase in R&D employment but not R&D expenditure for collaborators may suggest that these firms were more likely to bring in R&D activity that would otherwise be externalised. These firms were also often SMEs and supply chain companies which may count income received from grants or from lead applicants as turnover.

- **Impact on total R&D spending:** The preferred approach to aggregating these findings to the population of firms awarded APC funding resulted in a central estimate that the programme led to a total increase in R&D spending of £1bn by the end of 2022[14]. This estimate does not account for the possibility that the programme placed pressure on prices, leading to reductions in R&D activity elsewhere in the economy.

- **Leverage of private R&D spending:** Monitoring data indicated that the total project costs at the end of 2022 were £750m, of which £327m was funded by the public sector. Over the lifetime of APC projects (assuming an average length of three years), estimated total impacts on R&D spending totalled £500m which implies that 67% of spending would not have occurred in the absence of the programme (implying deadweight of 33%). However, this was clearly more than offset by additional R&D activity leveraged following project completion. Using the estimated impact of the programme on R&D spending suggested that the programme leveraged £2.20 of private R&D spend per £1 of public sector spending by 2022/23. This finding suggests that the APC programme was a highly economical use of public funding with a relatively low degree of deadweight and significant amounts of additional R&D investment crowded in. This also implies that APC competition funding has been more effective at leveraging private R&D activity than R&D tax credits[15], however this may be expected given the targeted nature of grant funding.

- **R&D jobs:** The findings imply that the programme has supported the creation or safeguarding of around 8,300 R&D job years (which compares with a gross figure of 14,800 expected at the application stage in VfM forms). This was calculated using estimates of impacts on leads and collaborators separately.

**Table 4.2: Estimated impact on R&D spending by 2022/23 and associated leverage ratio**

| Timeframe | Estimated impact on total R&D spending (£m) | Expenditure of APC grant awards (£m) | Implied increase in private R&D spending (£m) | £s of additional private R&D spend per £1 of APC grant spending |
|---|---|---|---|---|
| Total impacts to 2022/23 | 1,048 | 327 | 721 | 2.20 |

Source: Business Expenditure on R&D survey, ONS, Ipsos analysis. Estimate generated using a staggered difference-in-difference model with grant recipients receiving grants later as the counterfactual for those receiving grants earlier.

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14 The technical annex and Economic evaluation section outline the process taken to generate this figure.
15 See Do Tax Incentives for Research Increase Firm Innovation? An RD Design for R&D. Dechezlepretre, Einio, Martin, Nyugen and Van Reenan. Centre for Economic Performance Discussion Paper No 1413. London School of Economics. 2016

# 5 Direct outcomes and impacts

This section presents an analysis of how far APC funding has led to the integration of low carbon vehicle technology in vehicle platforms, and associated effects on the growth, employment levels, and productivity of firms awarded funding. Evidence for this section is taken from the programme of data-linking and econometric analysis, available evidence for the organisation and project level case studies, analysis of monitoring records and views provided by key stakeholders.

## Key findings

- 10.5m vehicles integrating technologies developed with APC funding had been sold by the end of 2022/23 (slightly less than 13.9m anticipated at the application stage). Project partners also projected sales of 98m vehicle sales by 2037/38 (relative to 180m projected at the application stage).
- Econometric analysis found that the programme had a significant effect on net capital expenditures of around 25% per annum (emerging around four years APC grants were awarded). This suggests that firms began to expand or repurpose facilities in anticipation of production as projects were completed, with the total impact on net capital investment estimated at £88m by 2022.
- APC competition funding was also shown to have significant impacts on wider firm outcomes including overall employment and GVA:
    - **Employment**: Each APC grant was estimated to have led to an expansion in the employment of applicants by 5% (an effect persisting for eight years). It was estimated that 35,000 job years were safeguarded or created by the programme by 2022.
    - **GVA**: Each grant awarded led to an increase firm level GVA by 10% (an effect emerging three years post grant award and persisting for at least four years).
    - **Productivity:** APC grants had a temporary effect on GVA per worker of 3.6% to 4% that emerged in the third and fourth year following the award of grant funding. The programme also led to positive impacts on the wages of workers (a 1.6% uplift in hourly earnings), though these impacts were limited to workers in higher skill occupations.

## 5.1 Integration of technologies into new vehicles

The key commercial objective for projects and the principal mechanism through which the programme will realise its expected economic and environmental benefits is through the integration of APC funded technologies into vehicle programmes. This subsection provides an analysis of the extent to which projects achieved, or are on track to achieve, their commercial objectives, including the extent of any commercial exploitation activities.

### 5.1.1 Achievement of core commercial objectives

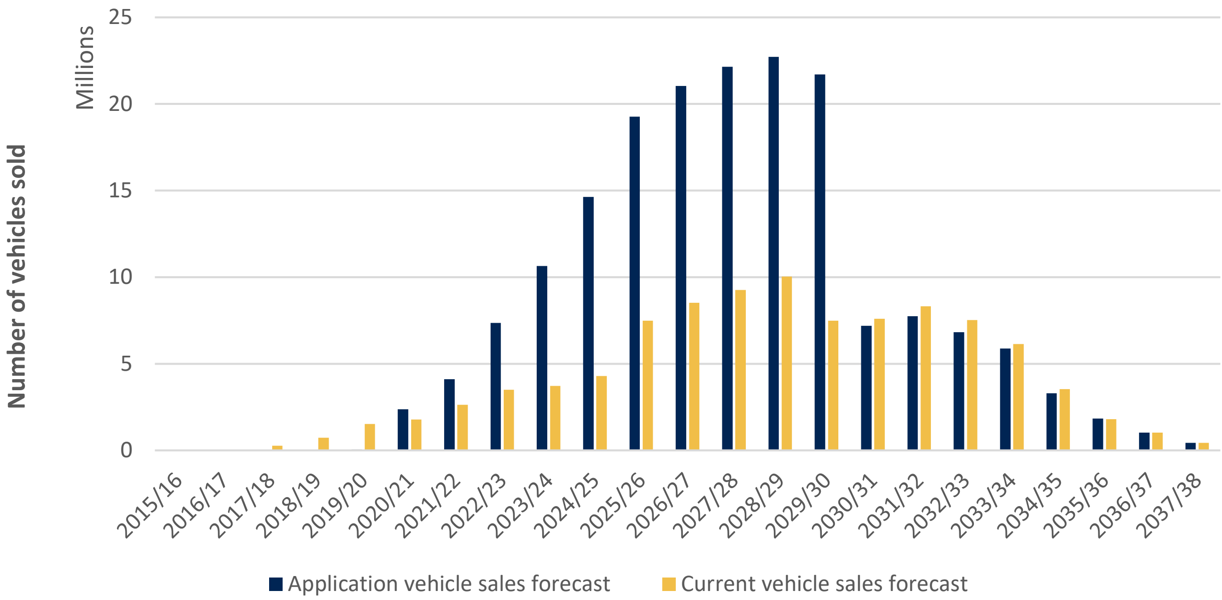
Data on the number of vehicles expected to be sold by year at the application stage was obtained from the APC and compared to those sold and forecast to be sold in most recent VfM returns. Based on this data, expected levels of commercialisation (in terms of vehicle sales) have fallen since the application stage:

- By the end of 2022/23, most recent VfM returns suggested that 10.5m vehicles integrating APC technologies had been sold. At the application stage this was expected to be 13.9m (3.4m more).

- At the application stage, project partners expected to sell a total of 180m vehicles integrating technologies developed with APC funding by 2037/38. This compares to more recent forecasts which put this total at 98m (a 46% reduction).

The figure below illustrates the changes to forecast sales since project applications were approved.

**Figure 5.1: Forecast vehicle sales at application and most recent assessment**




Source: APC monitoring data, Ipsos analysis. Base: 90 projects

The fall in forecast vehicle sales primarily resulted from the early closure of one project that aimed to develop a new lightweighting technology for forming aluminium components. This project was not successful but the components that would have been developed were expected to be integrated into large volumes of vehicles at the application stage. Whilst this accounted for a considerable reduction in forecast vehicle sales, $CO_2$ savings were less affected given the marginal $CO_2$ savings associated with the small change in weight anticipated to be brought about in vehicles using this technology.

Of the 24 projects sampled in the case studies, 15 achieved some form of commercialisation through the integration of components into vehicle models. Evidence from these on the number of vehicles sold was mixed, however comparisons to most recent VfM forms indicated that these projects were roughly on track to meet revised projections from the close-out stage. Of the remaining nine projects sampled, commercial objectives were not met due to weakened opportunities for exploitation opportunities (primarily as a result of the changing market context), insurmountable technical issues, or delays with technical development. For example, cash flow constraints in two cases meant that the introduction of new vehicle programmes were cancelled.

Evidence from the case studies also suggested that projects completed prior to the COVID-19 pandemic were also more likely to be on track to achieve commercial targets whilst five of the nine not on track were completed after March 2020.

### 5.1.2 Product launches

Evidence from the PPM survey indicated that 17 of the 27 businesses had integrated APC technologies into vehicles, with seven of these reporting a total of 145,569 vehicle sales in 2022/23. APC projects had led to the launch of several products through the case studies and monitoring information. These included:

- UK-REEV: This project involved the development of a new range extended hybrid electric drive-train light commercial vehicle. The vehicle went on sale in 2021, however sales numbers are not known for this vehicle.
- HEDB: The HEDB project included the integration of a BEV battery into a mass-produced vehicle for the lead partner. Over 46,000 units had been sold by 2018, however updated figures were not yet available at the time of writing.
- $CO_2$ divided by 2: This project involved the integration of an enhanced ICE into two models of niche vehicles with over 400 vehicle sales in 2018.
- Active: An engine was reported to have been integrated into a range of passenger vehicle platforms manufactured in Europe and China.
- ALIVE6: This project led to the integration of the technology on a large SUV. Data on the volume of vehicle sales has not been provided.

There were also some notable anticipated product launches that did not transpire. In particular the HIPERAT project consortia had successfully developed a high-performance battery for installation in a demonstrator vehicle with APC funding. Since project completion, production of the vehicle was cancelled as the lead partner sought to focus more on core offerings in response to a declining cash flow position in 2022.

## 5.2 Capital investment

A key objective of the APC funding competition is to stimulate additional investment in the UK automotive supply chain. The econometric evidence provided a strong signal that the delivery of the APC funding competition has resulted in increased levels of investment that appear to be driven by firms gearing up to produce products and technologies developed through APC projects. Firms amongst those sampled in case studies also reported current and future investments in existing facilities and planned new facilities.

**Examples of capital investments**

**HEDB:** The project sought to develop enhanced BEV propulsion battery and manufacturing facilities. Its results prompted further investment to convert other production lines to be compatible with the newly developed technology. Following on in part from the success of the HEDB project, the lead partner also plans to invest £1.12 billion to produce two new electric vehicle models in Sunderland. The investment will allow the production of two new models and enable wider investment in infrastructure projects and the supply chain, including a new gigafactory. The upgraded site will produce all-electric replacements for two models in addition to the all-electric replacement.

**UK REEV:** This project aimed to develop a range extended large plug-in EV for light commercial use. This required further investment into the production line to enable new manufacturing processes to be implemented.

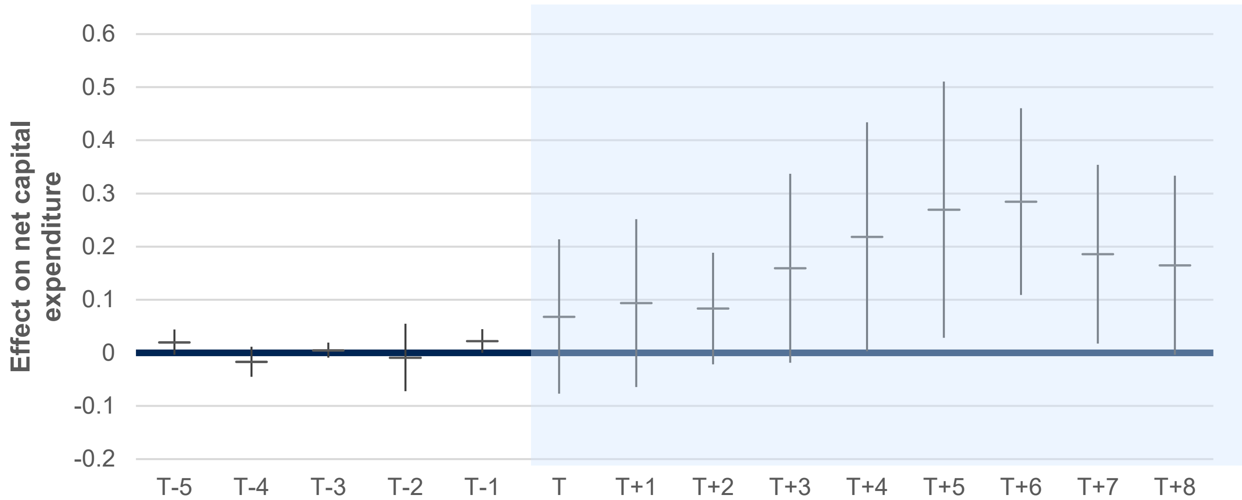
**DDISPLACE:** The APC funding secured a corporate commitment from the lead partner to a long-term programme of investment in the UK. It gave them the confidence to scale up their team and choose the UK as a focus point for investment and support for complex field test issues. APC allowed these investments to be grounded in the UK and the outcome meant that the UK now has the world’s only factory for the hydraulic pumps developed.

Econometric analysis was used to examine the effect of the programme on net capital investment drawing on data gathered from the ONS Annual Business Survey, an annual survey capturing information on firm capital expenditure and output[16] (comparing those awarded funding to a variety of comparison groups). This suggested that the magnitude of the effects of the programme on capital investment could be substantial:

- **Estimated effects:** The findings indicate that each APC grant led to an expansion in net capital investment of 25% per annum when compared to the comparators used. Models separating effects between leads and collaborators found that estimated effects on leads were consistent but estimated effects amongst collaborators were mixed and not statistically significant in the most robust specification.

- **Persistence of effects:** The impacts on net capital spending were not persistent and did not take hold until four years after an APC grant was awarded. This suggests that firms began to expand facilities in anticipation of production towards the end of projects or just after they had completed (given an average length of project of 3.3 years). There is a wide variance in the estimated impacts of the programme on capital expenditure that likely reflects the fact that not all projects will be commercialised, leading to greater levels of underlying variance across projects and companies.

**Figure 5.2: Persistence of effects on net capital expenditure**




Source: Annual Business Survey, ONS, Ipsos analysis. Post grant effect period shaded light blue. Error bars indicate 95% confidence intervals.

- **Total impact on net capital investment:** Analysis of the ABS suggested that the average net capital spending of firms supported by the APC in 2013 was £3.5m. However, this average is biased upwards by large firms, and was adjusted downwards based on the ratio of employment across all firms awarded grants (71 employees, based on the BSD) and those appearing in the ABS (522 employees). This gave an adjusted estimate of net capital investment spending of £474,000. Applying this to the estimated effects of the programme over the four years in which statistically significant effects were observed gives a total estimated impact on net capital investment of £88m based on the most robust estimates of impact.

[16] The ABS is a census survey of large firms in the UK but only samples a subset of SMEs in each year. As such, estimates of impact based upon ABS analysis are less generalisable to the population of firms receiving APC grants.

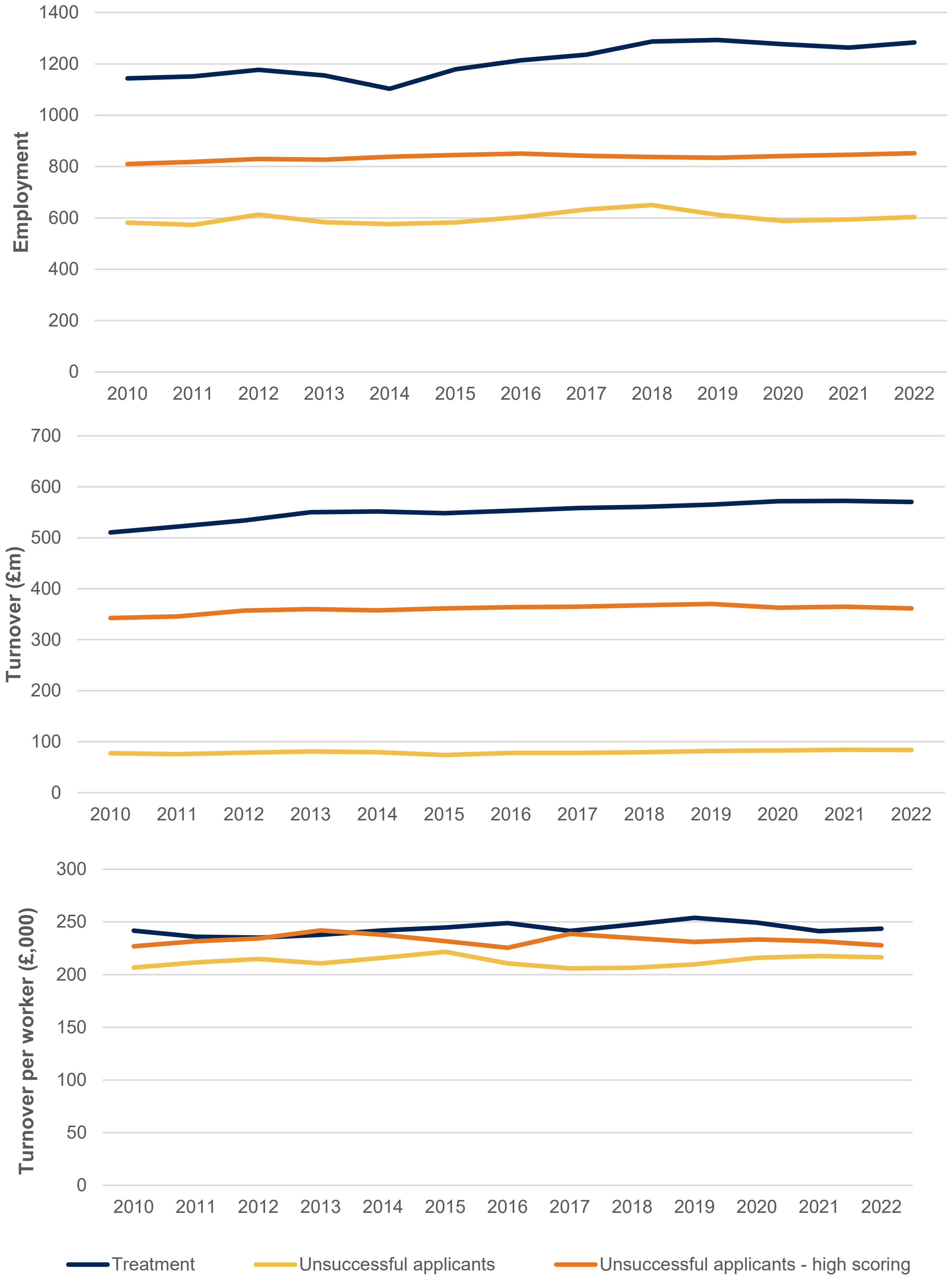
## 5.3 Employment, turnover and GVA

The econometric analysis provides the primary source of evidence of the impacts of the programme on the expansion of firms (as visible in employment, turnover or GVA). Impacts on employment, turnover and turnover per worker were all explored using the Business Structure Database (BSD), an annual snapshot of the Interdepartmental Business Register that provides yearly observations of employment and turnover of all firms registered for PAYE or VAT. GVA was explored using the Annual Business Survey (ABS). Analysis of recent trends across these variables amongst the firms receiving APC grants and those applying but not receiving grants showed:

- **Employment and turnover:** Firms that were awarded grants grew on average, both in terms of employment and turnover. Employment and turnover for successful applicants both rose by 12% between 2010 and 2022, whilst unsuccessful firms grew at a slower rate of 4% and 8% for employment and turnover respectively. High scoring applicants not receiving funding saw a greater increase in employment on average than all unsuccessful applicants at 5% but only saw average growth of 5% in turnover.

- **Productivity**: Between 2010 and 2022, productivity (as measured by turnover per worker) for all groups of firms varied from year to year but remained somewhat stable over the whole period.

**Figure 5.4: Employment, turnover and turnover per worker between 2010 and 2022**



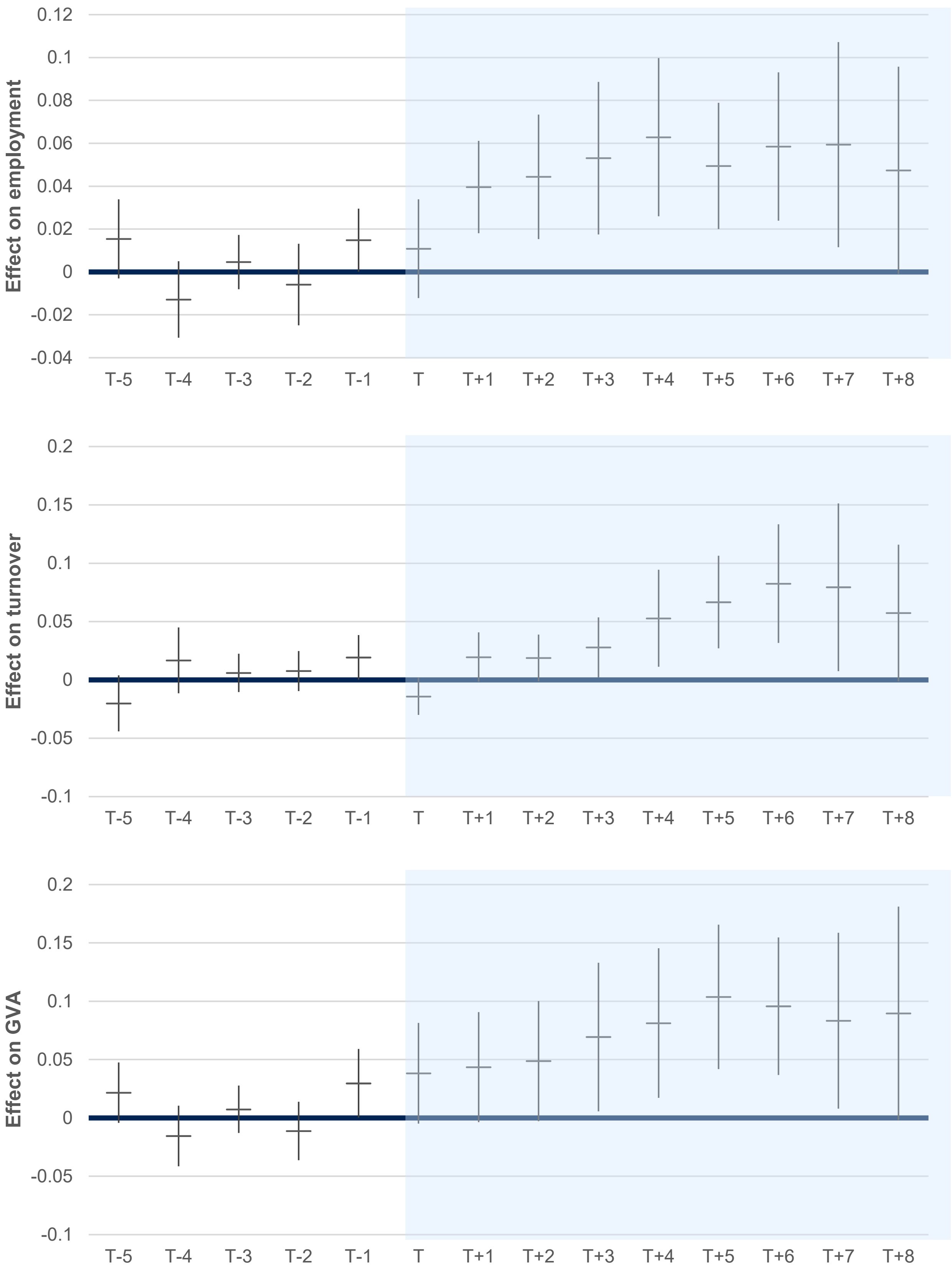

Source: Business Structure Database, ONS, Ipsos analysis.

The findings of the econometric analysis indicate that the programme led to substantial impacts on the growth of lead applicants, though effects on collaborators were more mixed:

- **Employment impacts:** Each APC grant is estimated to have led to an expansion in the employment of applicants of 5%. Impacts on employment appeared one year after grants were awarded with the estimated impact peaking after seven years at around 6%. Using the same method as for R&D jobs, this results in an estimated 35,000 job years safeguarded or created by 2022. When compared to the effect of the programme on R&D jobs, this indicates that most of these positions are likely to be non-R&D roles. It should be noted that these are gross rather than net additional effects and have not been adjusted for either displacement or crowding out.
- **Turnover:** The findings also suggested that each APC grant led to an increase in the turnover of lead applicants of around 8%. No statistically significant impact was found for collaborators. This may indicate that the programme has encouraged 'in-housing' of activities amongst lead applicants and a transfer of output from collaborators to leads. Turnover impacts begin to appear after three years and persisted for the next five years.
- **GVA:** The analysis suggested that each grant awarded led to an increase of around 10% in total firm output. GVA impacts were consistently estimated at around 10% for leads and 8% for collaborators. GVA impacts also begin to appear after three years and persist until around least seven years past project award. Based on an analysis of the ABS, firms awarded grants produced an average of £36.3m in GVA in 2013. However, this figure will be biased upwards due to the relative coverage of large firms and SMEs in the ABS. This average was again adjusted downwards using the ratio of average employment across all firms awarded grants to the average employment of firms appearing in the ABS. This gave an adjusted estimate of the average GVA of firms awarded grants of £4.9m. Applied to the time profile of grants and estimated effects, this results in an estimated increase in GVA of £1.1bn by 2022. This does not allow for displacement effects or crowding out.
- **Import dependency:** Econometric analysis was also completed using the amount of spending placed by firms in business within the UK and outside of the UK to explore impacts on imports in the production process. The analysis indicated that spending on goods and services by firms delivering APC project had risen overall with an 11% rise in pending to UK based firms and 5% in non-UK based firms. This implies a reduction in the import dependency of firms as a result of APC funding.

The figures below illustrate the estimated persistence of impacts on employment, turnover and GVA described above, with the error bars indicating the 95% confidence intervals.

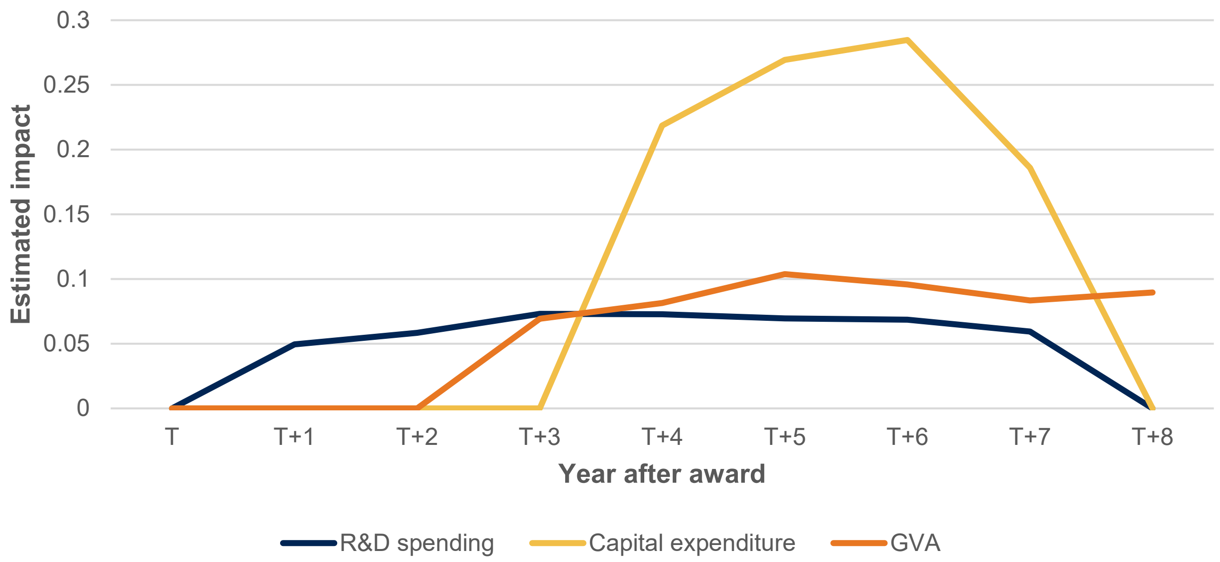
**Figure 5.5: Persistence of effects on employment, turnover and GVA**




Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. Post grant effect period shaded light blue. Error bars indicate 95% confidence intervals.

The figure below combines the time profile of estimated impacts on R&D spending, capital expenditure and GVA. Impacts on R&D spending occur before investments in capital expenditure and increases in GVA occur suggesting that impacts on capital expenditure are a result of investments ready for production of APC technologies.

**Figure 5.6 Distribution of R&D spend, capital spending and GVA impacts**




Source: Annual Business Survey, Business Expenditure on R&D survey, ONS, Ipsos analysis.

### 5.3.1 Plant closures

The Business Structure Database (BSD) data also provides information on company structure including details of the number and locations of 'local units', that was used to explore the effectiveness of the programme in safeguarding economic activity in more detail. Analysis sought to examine the outcomes below:

- Number of new plants established by firms receiving APC funding.
- Number of plant closures by firms receiving APC funding

The results of the analysis indicated that APC funding had led to an increase in the number of plants operated by successful applicants when compared to unsuccessful applicants (of around 2.1%) but that this was accounted for, at least in part, by a reduction in the number of plants closed (relative to the counterfactual). The analysis found that firms receiving APC funding closed 0.6% to 0.8% fewer plants within three years of receiving APC funding and 1.3% to 1.5% fewer within five years. This was corroborated in the case study research with four organisations highlighting the APC as a factor in them not shutting down some UK facilities.

Whilst this would suggest that the APC has safeguarded some UK jobs and output, the evidence for an increased number of plants operated by APC funded firms is less clear. These models implied that APC funded firms opened 0.6% to 0.7% more plants within five years of receiving funding compared to unsuccessful applicants.

### 5.3.2 Productivity

The econometric analysis also explored the impact of the programme on a range of indicators of productivity – including the wages of the workers employed by those receiving grants, turnover per worker (which approximates changes in productivity provided the firms' relative consumption of goods and services is not altered by the programme), and GVA per worker. These findings indicated:

- **Wage effects:** The results of the analysis showed that APC grants had a positive effect on hourly earnings for workers at lead applicants of 1.6%, though there were no significant effects on hours worked. This could be interpreted as a signal of productivity gains (as in competitive labour markets, a marginal increase in labour productivity should be reflected in a marginal increase in the wage). However, it may be that additional demand for workers has leaked into wage inflation (which is more difficult to interpret as a productivity effect). However, it is also possible that this may reflect a 'grant-sharing' effect (in which the firm rewards its employees for securing a grant) or that the programme pushed up equilibrium wage levels.

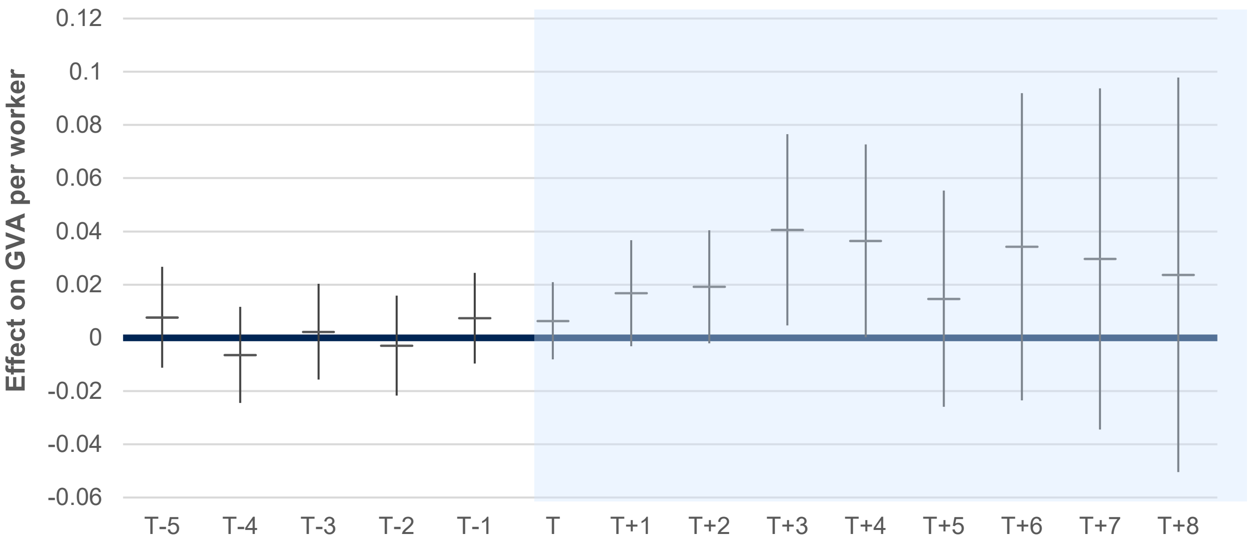
  Analysis of the wage impacts over time indicated that wage effects coincide with employment impacts. Thereafter consistent effects ranging from 1.3% to 2.1% are present until impacts disappear six years after award. This implies that any potential productivity effect brought about through APC funded projects may be temporary. Those in higher skill occupations tended to see stronger growth in earnings than those in lower skill occupations. Those in managerial, professional and technical and in skilled trade occupations saw their earnings rise by between 2.6% and 3.2% in response to the grant whilst no effects were identified for those in lower-level service sector roles or those in the lowest skilled elementary occupations.

  These results were used to estimate the overall impact of the programme on GVA arising from productivity gains using the wage-based estimates of impact, under the assumption that wage gains can be treated as a productivity gain. This was generated by applying the profile of annual estimated effects on hourly earnings to the number of workers employed by firms before the programme was launched. An assumption was made that changes in wages will be broadly reflected in changes in GVA per worker. On this basis, the additional GVA arising from productivity gains was estimated at between £33.4m by 2022.

- **Turnover per worker**: The econometric analysis did not find evidence that the programme led to increases in turnover per worker.

- **GVA per worker:** There was some evidence of an effect on GVA per worker three to four years after funding was approved. This lines up with the timing of capital expenditure and GVA impacts observed above and implies that productivity rose as technologies began to be exploited. As with the capital expenditure and GVA estimates, there is a large degree of variance in these estimates likely reflecting the varying technical outcomes of projects.

**Figure 5.7: Persistence of GVA per worker impacts**




Source: Annual Business Survey, ONS, Ipsos analysis. Post grant effect period shaded light blue. Error bars indicate 95% confidence intervals.

# 6 Indirect outcomes and impacts

This section outlines the evidence of indirect outcomes and spillover effects arising from APC projects – including spillover impacts on local economies and knowledge spillovers. The findings are based upon econometric analysis, case study research and stakeholder consultations.

## Key findings

The key findings on indirect outcomes and spillovers are summarised below:

- APC grants had positive net economic impacts on local economic growth and productivity. Grants appeared to encourage an increase in the number of firms located in the immediate vicinity of firms receiving grants by 7% - indicative of local clustering effects (though there was less evidence of these types of outcomes from the case studies). There were also significant ongoing effects on total employment (12%) and turnover (15%) in these areas (with smaller positive impacts on areas further away).

- The case studies found limited evidence of overseas firms establishing new production locations or R&D facilities in the UK as a direct consequence of APC funding. However, there were examples of expansions of existing production lines as a direct result of APC funding and other support provided to the sector – though the main effect of the programme appears to have been in terms of safeguarding existing facilities rather than attract new manufacturing operations to the UK.

- Knowledge spillovers were most commonly internal where knowledge developed through the project was applied to adjacent or unrelated areas of the applicants' operations. There were no clear examples of external spillovers where technologies developed through the programme found alternative application in related industries (though potential applications were identified in the aerospace and marine industries).

## 6.1 Spatial economic growth impacts

Econometric analyses were completed to explore the indirect effects of APC grants at the local level. This was achieved by refocusing the analysis on Output Areas (a small geographical unit used for the reporting of Census statistics) within a predefined distance of firms benefitting from the grants. The analysis is predicated on the assumptions that the strength of the effects of the grants on economic activity within an area will depend on the number of firms located nearby receiving a grant (a dose-response relationship), and that the strength of these effects will vary by distance (a distance-decay relationship).

Using this approach, the local economic effects (employment, turnover, productivity, and wages) of APC grant activity and how these vary with distance, were explored. The results of the econometric analysis suggested that:

- **Clustering**: The results show that the grant awards had a positive effect on the number of firms located in areas proximate to those awarded grants. These effects were largest in the output area in which the firms' receiving grants were located (7%) but were positive though smaller at greater distances. This indicates that APC grants have worked to produce clustering effects at the local level, with no evidence of net displacement effects within 10km.

- **Local economic performance:** The evidence indicated that APC grants had a positive net economic impact on local economic growth and productivity. The impacts included:

    - **Increased activity proximate to successful firms:** Each grant led to a 12% increase in the number of jobs in the Output Area (approx. 0.81 $km^2$) in which the applicant was located, and a 15% increase in the turnover of firms based in the same area. No significant impacts were identified for turnover per worker. These area level impacts are broadly comparable to those observed amongst the firms receiving funding, suggesting that any displacement or crowding out effects at the very local level were negligible.

- **Increased activity within proximate areas:** There were also positive economic impacts at distances of 1km to 10km from those awarded funding. Larger effects were observed at distances of 5km to 10km than between 1km and 5km, and there was no evidence of net displacement or crowding-out effects locally.

These findings indicate that the APC has produced positive spillover effects for local economies. Given the evidence on firm relocations, it is assumed that some of this effect has come from the attraction of higher value activities to the area as well as the increase in output for existing firms. It should be noted that there will likely be corresponding negative effects on some local economies from which activities were relocated.

## 6.2 Clustering effects

The R&D grants awarded through the APC were expected to result in clustering effects in which the skills, capabilities, and 'first mover' advantages developed by those awarded grants produce incentives for third parties to locate related economic activities in proximity. These incentives could stem from the exploitation of the technologies funded through the programme, where the resultant expansion in demand encourages suppliers (or potential suppliers) to locate new production facilities in proximity to those awarded grants. Several studies have also shown that knowledge spillovers are often spatially concentrated, potentially creating further incentives to locate in proximity to hubs of expertise.

### 6.2.1 Local clustering effects

Evidence from the case studies provided few examples of local clustering. Only one of the 24 projects explored provided clear evidence of local clustering - driven by a desire to locate near to the lead applicant to benefit from future collaborations. Locating near to lead applicants was viewed as desirable because it reduced the cost of current and future R&D and maintaining commercial relationships, both related and unrelated to the APC project being delivered. In two cases, project partners and other firms had secured contracts with an OEM or Tier One and co-located to establish the partnership and capitalise on potential future opportunities.

**Example of local clustering**

**H1PERBAT:** As a result of a joint investment in a new manufacturing facility, a collaborating partner has since moved some of its operation to this new facility to continue further R&D and exploitation of the battery technology under development. In the absence of funding, the opportunity to secure an OEM contract and develop a new manufacturing facility as a result would not have arisen.

### 6.2.2 Foreign direct investment

The case studies found limited evidence of overseas firms establishing new production locations or R&D facilities in the UK as a direct consequence of APC funding, however the organisational level case studies suggested that the availability of APC funding had played a role in one firm's decision to further invest in a UK plant to produce all-electric models. Wider government support was the main driver for this investment, but the funding environment provided by interventions such as the APC in the UK was mentioned.

The evaluation also found evidence of firms linked to domestic based OEMs expanding their presence in the UK with Agratas (part of Tata Group) announcing in 2023 a gigafactory to be built in Somerset. As with the Nissan investment, direct government support was reportedly vital for this investment, the APC was reported to have had an impact on the confidence in the public support for development of technologies that would make use of batteries manufactured at the new site.

However, the evaluation found some examples of expansion in existing premises within the UK as a direct result of the APC projects sampled.

**Example of expansion**

**HEDB:** As a result of the development of manufacturing facilities that have successfully enabled the integration of battery technology into a vehicle platform, the lead OEM has invested in upgrading other production lines in the UK, drawing on the insights into manufacturing processes gained through the APC funded project.

## 6.3 Knowledge spillovers

As highlighted in Section 2, grant recipients may create new skills, knowledge or intellectual property that could be adapted and/or applied in other projects, define new programmes of R&D, or make use of other commercial activities. Case study evidence was used to identify knowledge spillover effects of the following types:

- **Internal spillovers** in which the knowledge developed through the project is applied to adjacent or unrelated areas of the applicants' operations. Spillovers of this type were primarily technical in nature and were identified in three of the five organisation level case studies and five of the nine project level case studies. These were the most common spillovers identified. For example, three projects had resulted in testing processes being developed through the APC project and subsequently built into other projects, including further APC projects.

- **Within consortia spillovers** in which knowledge exchange between partners facilitates exploitation in adjacent or unrelated operational areas. Knowledge gained from collaborations was evident in the case study projects. Nine of the 24 projects in total provide evidence of technical knowledge and learning being applied to other projects. In terms of economic spillovers, four projects sampled had also led to commercial partnerships, with two cases of SMEs becoming part of the lead OEMs supply chain.

- **External spillovers** where third parties external to the consortia receiving funding have exploited the knowledge and skills developed through the project. No examples of this type of spillover were established in the research.

Overall, the evidence identified technical and economic knowledge spillovers that were realised within collaborating organisations of projects. The most commonly cited spillovers were the application of learning from APC projects to other R&D projects within and across consortia partners. Learning came in two main forms, learning related to testing and validation procedures that could be general in nature to R&D programmes and technical knowledge developed specific to the innovation that could be applied to adjacent technologies. There is more limited evidence of economic spillovers with some consortia partners reporting the acquisition of commercial contracts and opportunities by demonstrating capabilities working alongside Tier One and OEM firms.

**Examples of knowledge spillovers**

**ALIVE6:** Testing of controls was completed using a prototype engine and reliability proved a constraint. Going forward the lead partner has set out to use a production engine for testing of controls to improve consistency in testing.

**HIPERCAR II:** Lessons learned from the OEM and motorsport activities were transferred to the Tier One partner and used to update the test base for the cell. This enabled more effective testing and sped up the validation process.

Evidence from the case studies suggested that knowledge spillovers arose through a variety of mechanisms:

- **Industry to academia:** Academic partners in two sampled case study projects reported that the project allowed them to develop an understanding of the research needs of industry. This was something they had and were planning to incorporate into applied research programmes. In this vein, a network of APC grant recipient universities was launched in collaboration with the APC to share knowledge on best practice for working with industry, which included information on academic requirements for working with industry and an overview of processes and tools used to deliver industrial R&D projects. Evidence for university REF criteria were also a benefit noted by academics in the case studies.

- **Academia to industry:** Industry also generated an understanding of the latest modelling, testing and validation approaches developed by university research groups and implemented these across their R&D portfolios. For example, the Virbius project involved the knowledge transfer of a variety of modelling methods from Warwick Manufacturing Group (WMG), including iron loss characterisation, cost modelling and oil cooling modelling to a project partner.

- **OEMs to suppliers:** Evidence from the case studies SMEs and Tier One suppliers to a lesser extent appear to benefit from knowledge shared by OEMs, particularly related to the use of OEM tools, techniques and software.

### 6.3.1 Cross sector spillovers

Innovation activity through APC funded projects has the potential to generate new R&D and/or commercial opportunities outside of the automotive sector. Evidence from the case studies and review of closeout reports suggested that the aerospace sector could benefit from APC projects.

**Aerospace**

The case studies suggested the aerospace sector has particularly benefited from the APC funded projects, which in turn has enabled APC funded projects to further exploit the technologies and capacities developed:

- Some battery pack technologies have the potential to be exploited in the electrification of light aircraft, however these are in their infancy and commercialisation of these benefits is not expected in the short term. The ALIVE6 project is one such example in which the battery pack was considered for use in light aircraft electrification.
- Component parts for motors and other similar items are often transferable between sectors. For example, one project partner for a case study project were in discussions with an aerospace consultancy company regarding the supply of magnet wire coatings for motors with applications across sectors.
- Organisations that specialise in the development of tools, equipment and manufacturing processes tend to work across sectors, transferring knowledge, skills and feeding learnings into a range of projects across sectors.

**Other sectors**

Evidence from the case studies highlighted potential applications in the marine and shipping sectors. Examples included battery pack and catalytic generators with applications on light leisure craft in particular. One project partner reported discussions with a marine OEM in the sector and had explored the possibility of integration onto sailing yachts.

# 7 Economic evaluation

This section presents the findings of the economic evaluation of the APC Programme. The assessment of the economic costs and benefits draw on the findings from the econometric analysis presented in sections five and six above. This explores the relationship between the net costs of the programme (in terms of both R&D and capital investment stimulated) and its economic benefits (in terms of productivity gains) over the ten-year period since its launch.

## Key findings

The key findings from the economic evaluation are summarised below:

- The lifetime resource cost of grants awarded through the APC – covering the costs of administering the programme and past and future R&D and capital investments – were estimated at £1.8bn between 2013 and 2029 (in present value terms). Most of these costs were expected to be incurred by the private sector, highlighting the role of the programme in leveraging private investments in R&D and capital.

- The principal benefits of the programme, related to the productivity gains associated with APC grants, were estimated:

    - **Short-term improvements in productivity/profitability**: The programme was projected to result in productivity gains of £885m in present value terms between 2013 and 2029 arising from its direct effects in raising GVA per worker.

    - **Output safeguarded by protecting high productivity jobs:** The programme was also effective in protecting high productivity employment in automotive firms and the supply chain (with modelling indicated the programme would be expected to safeguard 62,000 employment years between 2013 and 2029). Evidence from historic automotive plant closures indicates that workers displaced are likely to find alternative employment rapidly, albeit in lower productivity occupations. However, there is some uncertainty in relation to the magnitude of the productivity effect arising from safeguarding jobs in the sector. Modelling based on a plausible range for the size of these productivity gains indicated that the value of output safeguarded between 2013 and 2029 could range from £1.6bn to £3.1bn (in present value terms).

- The implied lifetime return on public sector investment (treating additional costs incurred by the private sector as a disbenefit) was estimated at £2.12 to £5.17 per £1 of public sector spending. A full social welfare analysis relating the total social costs of the programme to the resultant productivity gains produced a Benefit-Cost Ratio of £1.31 to £2.15 – reflecting that a high share of the programme's costs was driven by additional investment spending by the private sector.

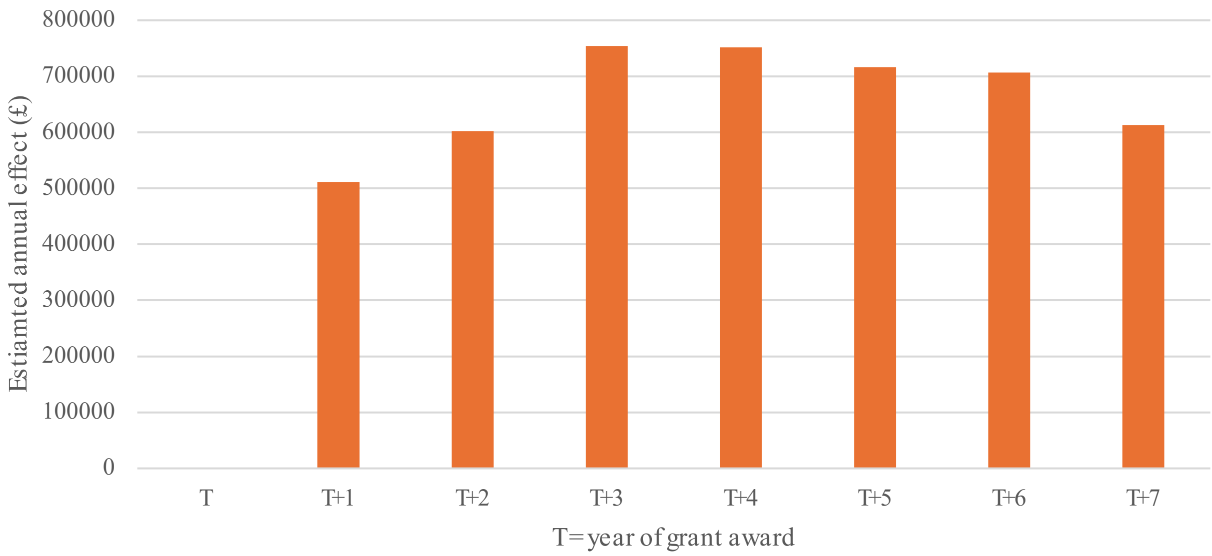
- These results do not account for the leakage of profits overseas (a potential issue given the number of overseas owned companies benefitting from the programme) or the positive environmental benefits of the programme. There is a significant degree of uncertainty associated with each of these factors – though it is likely that any repatriation of profits overseas will be at least offset by the positive environmental benefits of the programme.

## 7.1 Costs

The net social/resource cost of the programme largely relates to the net increases in investment induced in terms of (a) research and development expenditures and (b) follow-on capital investment (years four to seven post award). These costs were estimated based on the econometric findings to provide an estimate of the lifetime social cost of the programme between 2013 and 2029:

- **Value of additional R&D spending:** Estimates of the average effects on R&D spending were aggregated across leads and collaborators participating in APC funded projects to provide an estimate of the impact of the programme on R&D spending:
    - **Average impact on R&D spending per grant:** The evidence from the analysis indicated that grants awarded through the programme led to an increase on R&D expenditure that persisted for seven years (with the effects ranging from 5% to 7%). Estimates of the annual effect were multiplied by average R&D expenditure at the point at which grants were awarded (£10.3m) to estimate the total effect on R&D spending per grant awarded over the seven-year period. Each grant was estimated to have led to £4.7m in R&D spending.
    - **Total effect on R&D spending:** These estimates were then applied to each cohort of grants awarded between 2013 and 2022, to reach an estimate of the total additional R&D spending (and discounted in line with the recommended rate of social time preference of 3.5%). The sum of these values suggested that the programme led to a total increase in R&D spending of £1.3bn by the end of 2023 (£1.2bn in present value). Extending the horizon to beyond 2024 and using the time profile of estimated expected impacts for in flight projects, results in an estimated total cost in additional R&D spending of £2.3bn (£1.7bn in present value).

**Figure 7.1: Effects on R&D expenditure per grant**

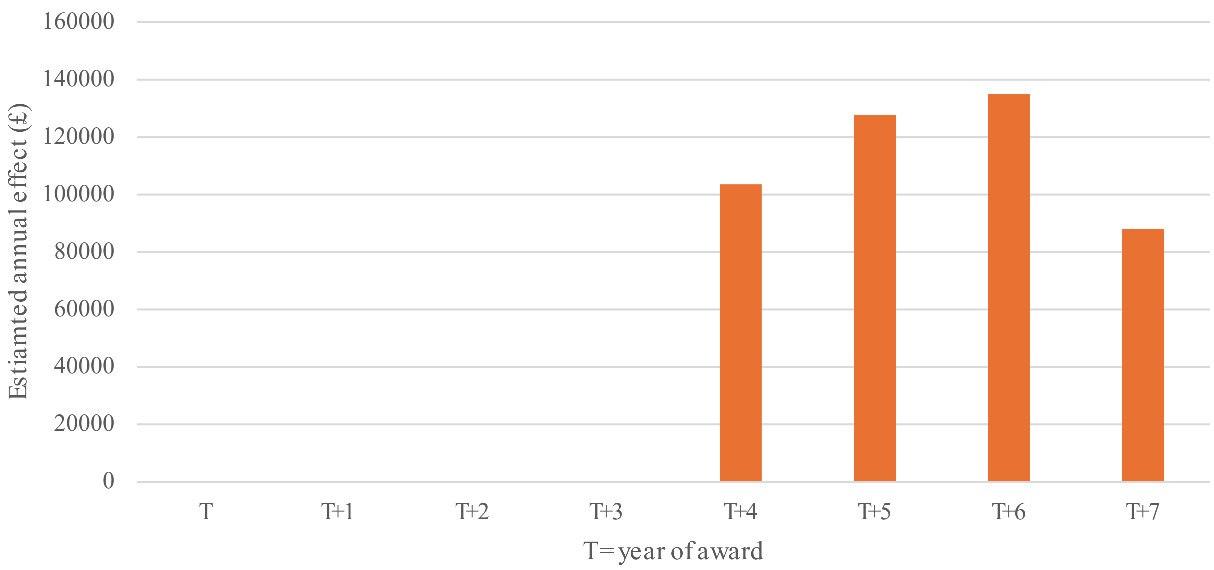



Source: Ipsos analysis.

- **Value of additional capital investment:** Estimates of the average effects of the programme on capital investment were also aggregated across participating firms in a similar manner:
    - **Average impact on capital investment per grant:** The evidence from the analysis indicated that grants awarded through the programme led to an increase on capital investment that persisted for four years (with the effects ranging from 19% to 28%). Estimates of the annual effect were multiplied by average capital investment at the point at which grants were awarded (£474,000) to estimate the total effect on capital investment per grant awarded over the seven-year period. Each grant was estimated to have led to £454,000 in capital expenditure.

- **Total effect on capital investment:** These estimates were then applied to each cohort of grants awarded between 2013 and 2022, to reach an estimate of the total additional capital investment (and discounted in line with the recommended rate of social time preference of 3.5%). This gave a total impact on net capital investment of £117m (£89m in present value) by 2024 and £223m (£156m in present value by 2029).

**Figure 7.2: Effects on capital expenditure per grant**




Source: Ipsos analysis.

- **Administrative costs:** Data on the administrative costs for DBT and Innovate UK were provided for the period from 2014/15 to 2023/24. These were discounted using a 3.5% discount rate with 2013/14 as the base year and summed with total DBT costs of £3.1m and total Innovate UK costs to date of £3.7m by the end of 2023/24.

  In terms of APC administrative costs, these are funded by a levy on total project costs (and are shared between the public and private sector). Public sector contributions to these costs were estimated based on levies on grants awarded as 3.5% of grant spending by year with these values discounted appropriately. This resulted in a total APC administrative cost of £13.7m by 2022/23 and a total forecast cost of £17.1m by 2026/27 for grants awarded by the end of 2022. Private sector contributions are factored into estimates of the GVA impacts of the programme (as these expenditures will be counted as spending on intermediate goods and services) and are implicitly accounted for in estimates of the productivity gains associated with the programme.

**Table 7.1 Total costs**

| | Total 2013/14 to 2022/23 | | Total 2023/24 to 2028/29 | | Lifetime total | |
|---|---|---|---|---|---|---|
| | Value (£m) | PV (£m) | Value (£m) | PV (£m) | Value (£m) | PV (£m) |
| R&D spending | 1,589 | 1,235 | 697 | 448 | 2,286 | 1,683 |
| Capital investment | 117 | 89 | 106 | 67 | 223 | 156 |
| Admin costs | 24 | 20 | 6 | 4 | 29 | 25 |
| **Total** | 1,730 | 1,344 | 809 | 519 | 2,538 | 1,864 |

Source: Ipsos analysis. Base year = 2013. 3.5% discount rate.

## 7.2 Benefits

The potential benefits of APC grant funding are comprised of productivity improvements, spill overs and environmental benefits.

### 7.2.1 Productivity gains

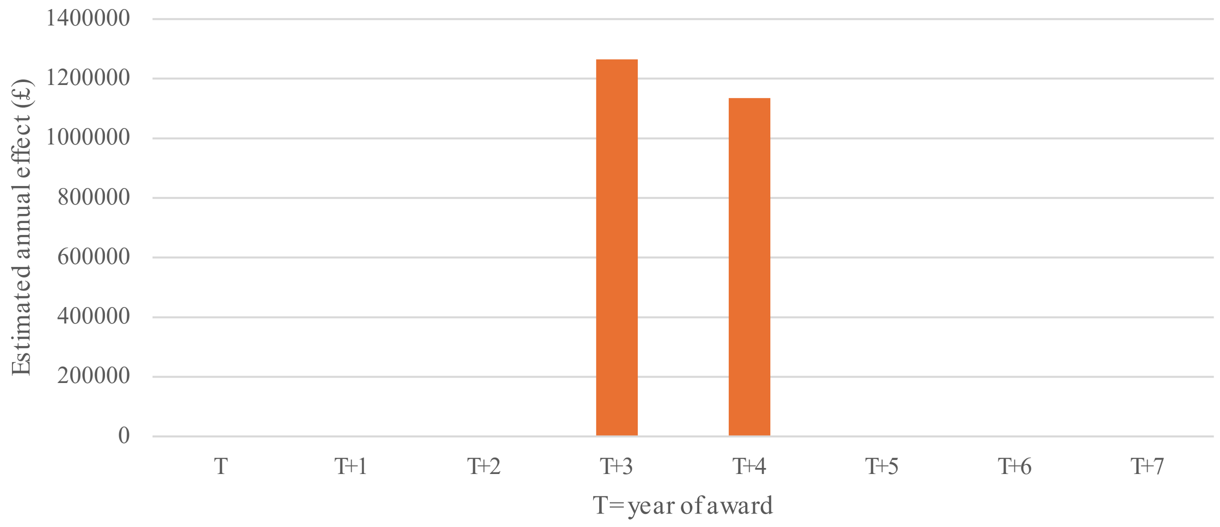
The principal benefits of the programme related to the productivity gains associated with the APC grants:

- **Short-term improvements in productivity/profitability:** The econometric findings indicate that APC grants have a direct statistically and temporary effect on GVA per worker of 4% that emerges three years post award and endures for two years (falling to 3.6% four years post award). The value of these productivity gains was estimated based on average employment at the point at which APC funding was awarded[17] (to avoid double counting any productivity gains associated with the item below) x average GVA per worker across the pool of firms receiving funding (£122,843) x estimated effect on GVA per worker (4% for year T+3 and 3.6% for T+4). This gives an impact per grant of £2.4m.

  These estimates were then applied to each cohort of grants awarded between 2013 and 2022, to reach an estimate of the total additional productivity gains (and discounted in line with the recommended rate of social time preference of 3.5%). By 2024, short term productivity improvements associated with APC grants were estimated at £937m (£725m in present value). The lifetime value of these benefits (up to 2026 for currently funded projects) was estimated at £1.2bn (£885m in present value).

[17] The average employment value used for this calculation has a significant bearing on the estimated value of productivity benefits and the variation in baseline employment levels was significant and highly skewed upwards. Consequently, using the raw mean may be misleading and so robustness checks were conducted using the GVA per worker model by restricting analysis to SMEs and large firms in turn with the impacts found to be slightly smaller for large firms. Based upon this, a 50% trimmed mean was used with the 25% highest and lowest values removed. This left an average baseline value of 234.

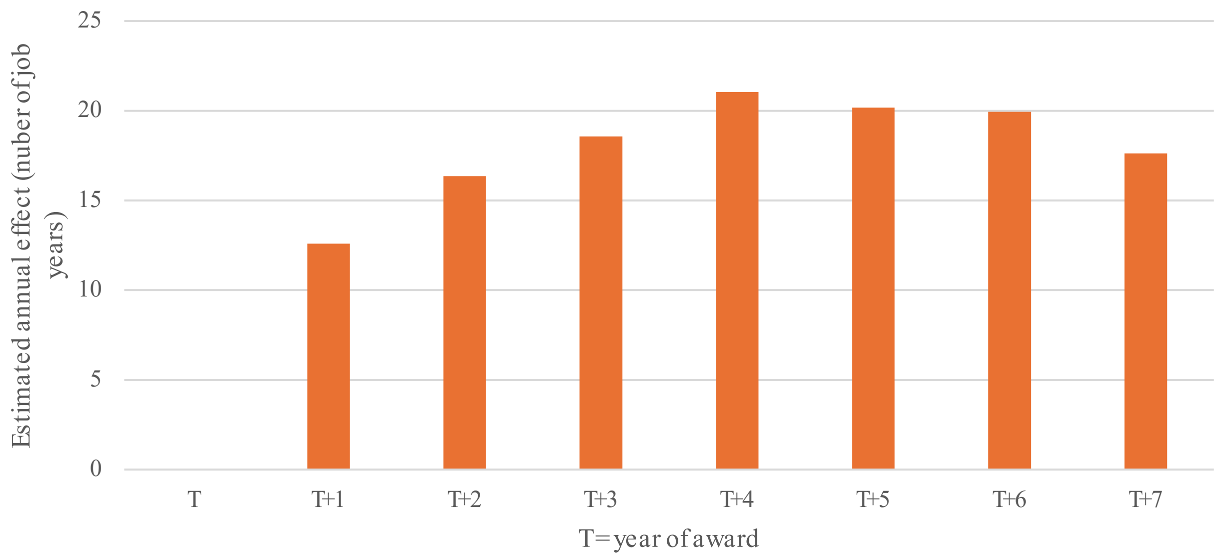
**Figure 7.3: Effects on GVA per worker per grant**




Source: Ipsos analysis.

- **Output safeguarded by protecting high productivity jobs:** The programme has also been effective in protecting employment in automotive firms and the supply chain:
    - **Average impact per grant:** The effect per grant was estimated at between 4% and 6% enduring for six years post grant award. The total value of output safeguarded by the project was generated by first calculating the number of job years safeguarded per grant implied by the econometric results. This was achieved by multiplying the baseline number of employees (254) by the estimated effect for each year post award. This led to an estimated total of 126 job years safeguarded/created per grant This led to an estimate of 62,000 job years safeguarded in supported firms.

**Figure 7.3: Effects on employment per grant**




Source: Ipsos analysis.

- **Total impact on job years safeguarded/created:** These estimates were then applied to each cohort of grants awarded between 2013 and 2022, to reach an estimate of the total additional number of job years safeguarded by the programme of 62,000 job years.

As the automotive sector is characterised by high levels of productivity, and while many of these workers are likely to have found alternative employment in the absence of the programme, it is likely that those occupations would have been associated with lower levels of productivity. However, we do not have evidence on the likely industry of employment in the counterfactual scenario to allow us to directly estimate the productivity gain. As a result, a range for this benefit was estimated based on:

a) The difference between GVA per worker in the sample of firms and GVA per worker in manufacturing sector generally. This assumes that all workers would have otherwise found employment in the manufacturing sector – which we understand is consistent with the economic appraisal model used in the assessment of applications. The average GVA per worker in the manufacturing sector between 2013 and 2022 was £72,532 compared to the average across the same period for firms awarded APC grants of £122,843, resulting in an uplift of £50,312 per worker per year.

   The total value of safeguarded output was then calculated for each cohort of grants by multiplying the number of jobs years safeguarded by the estimated uplift (£50,312 in this case) and the discount factor. Using this method, the total value of safeguarded output by 2024 was estimated at £2.8bn (£2.1bn in present value) with lifetime benefit estimated at £4.3bn (£3.1bn in present value).

b) The difference in GVA per worker implied by falls in the wages of former MG employees following the closure of MG Rover at Longbridge[18]. That study implied a 20% fall in the wages of former MG workers that were surveyed after finding employment following the closure of the car plant. Applying a 20% cut to average GVA per worker for firms receiving APC grants resulted in an estimate for the GVA uplift of £25,081 per worker per year.

   This method led to an estimated benefit of £1.4bn (£1.1bn in present value) by 2024 and £2.1bn (£1.6bn in present value) over the lifetime of estimated impacts.

   The literature available on worker displacement provides a range of potential effects on workers earnings as a result of displacement, either from firm closures, redundancies or dismissal. For example, Hijzen et al. (2010) suggested that incomes fell most for workers displaced due to firm closures (between 18% and 35%) compared to those displaced by mass layoffs (14% to 25% reduction)[19]. Another study by Upward et al. (2019) suggested that workers made redundant saw wages fall around 10%[20]. These would place the 20% fall in the MG study around the middle of these and is based upon workers employed directly in the automotive manufacturing sector.

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[18] The impact of factory closure on local communities and economies: the case of the MG Rover Longbridge closure in Birmingham. 2008. Centre for Urban and Regional Studies, University of Birmingham, UK. Available at: https://www.researchgate.net/publication/238073656_The_Impact_of_Factory_Closure_on_Local_Communities_and_Economies_The_Case_of_the_MG_Rover_Longbridge_Closure_in_Birmingham

[19] Hijzen, A., Upward, R. and Wright, P. (2010), “The income losses of displaced workers”, Journal of Human Resources 45(1), 243–269.

[20] Upward, R., & Wright, P. W. (2019). Don't look down: the consequences of job loss in a flexible labour market. Economica, 86(341), 166-200.

**Table 7.2 Total benefits**

| | | Total 2013/14 to 2022/23 | | Total 2023/24 to 2028/29 | | Lifetime total | |
|---|---|---|---|---|---|---|---|
| | | Value (£m) | PV (£m) | Value (£m) | PV (£m) | Value (£m) | PV (£m) |
| Productivity | - | 937 | 725 | 241 | 160 | 1,178 | 885 |
| Protected output | High | 2,764 | 2,133 | 1,532 | 982 | 4,296 | 3,115 |
| | Low | 1,378 | 1,063 | 764 | 490 | 2,142 | 1,553 |
| **Total** | High | 3,701 | 2,858 | 1,773 | 1,142 | 5,474 | 4,000 |
| | Low | 2,315 | 1,788 | 1,005 | 650 | 3,320 | 2,438 |

Source: Ipsos analysis. Base year = 2013. 3.5% discount rate.

### 8.2 Spillovers

There are two main pathways through which spill over benefits can be observed:

- **Spillovers into supply chains** – Productivity spillovers into supply chains will be captured in the above to the degree that the relevant suppliers participated in APC funded projects as collaborators. This may omit productivity gains arising from spillovers to other suppliers that did not participate in APC funded projects. The evidence from the spatial analysis indicated that the APC has stimulated clustering of firms and greater levels of economic activity within 10km of the firms receiving support from the programme – though there was less evidence that this increase in activity was associated with increases in productivity levels. As such, the extent of any economic benefits omitted are likely to be associated with productivity gains realised by non-participating suppliers located at longer distances. There is no way of assessing the likely significance of this omission - though given findings that APC has reduced import dependency it will be important to acknowledge that the estimated productivity gains are understated.

- **Spillovers into adjacent industries –** The additional R&D stimulated by APC may have further productivity spillovers into adjacent sectors (such as aerospace) that will not be captured by the econometric evidence. There is some uncertainty around the significance of these types of spillovers in the literature – while the ATI has undertaken some research to show aerospace spillovers are some four times the size of the private return, a meta-review appears to indicate that spillovers on typically appear to be positive but highly variable and usually smaller than the private return[21].

  Evidence from the case studies suggested that the aerospace sector in particular has benefited from APC funded projects, which in turn has enabled APC funded projects to further exploit the technologies and capacities developed. These spill overs included the exploitation of some battery technologies and transferable motor components as well as the development of tools for testing that could be applied to components for the aerospace sector. Potential applications in the marine sector were also identified but limited to applications on/in small leisure craft.

## 7.3 Benefit-cost ratio

The table below presents the estimated benefit-cost ratios with the social costs and productivity impacts included (both direct productivity gains and gains from safeguarded high productivity employment). High estimates include the value of safeguarded output calculated by assuming jobs would otherwise be average manufacturing ones. Low estimates include the value of safeguarded output as estimated assuming a 20% decrease in productivity.

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[21] What do we know about R&D spillovers and productivity? Meta-analysis evidence on heterogeneity and statistical power. 2020. Mehmet Ugur, Sefa Awaworyi Churchill, Hoang M. Luong. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0048733319301854

### 7.3.1 Return on public sector investment

The return on public sector investment was estimated by relating the net private benefits of the programme (the total value of productivity gains net of additional private investments in R&D and capital) to total costs of the programme to the public sector. This is consistent with the appraisal method used by DBT and provides a measure of the overall efficiency associated with the use of public sector funds.

The table below sets out these results and suggests that APC grant funding was estimated to have led to between £1.86 and £3.95 in net economic benefits per £1 of public sector cost by 2024, and was expected to rise to between £2.12 and £5.17 per £1 of public sector cost by 2029.

**Table 7.2 Estimated public sector benefit-cost ratios**

| Timeframe | Range for benefits | Total benefits (£m) | Total costs (£m) | Public sector costs (£m) | Private costs (£m) | Benefits less private costs (£m) | BCR |
|---|---|---|---|---|---|---|---|
| | | **A** | **B** | **C** | **D=B-C** | **E=A-D** | **F=E/C** |
| Total impacts to 2024 | High | 2,858 | 1,344 | 512 | 833 | 2,024 | 3.95 |
| | Low | 1,788 | 1,344 | 512 | 833 | 955 | 1.86 |
| Total impacts to 2029 | High | 4,000 | 1,864 | 512 | 1,351 | 2,649 | 5.17 |
| | Low | 2,438 | 1,864 | 512 | 1,351 | 1,087 | 2.12 |

Source: Ipsos analysis. Base year = 2013. 3.5% discount rate.

The econometric results presented in earlier chapters and the estimated BCRs presented above suggest that APC funding of collaborative projects has achieved many of its stated objectives and, in doing so, has achieved a sufficient level of value for money. In the most conservative case, the programme is estimated to result in £1.31 of benefit per £1 in total societal cost by 2029 and £2.12 of benefit per £1 of public spending. In the alternative and less conservative case (assuming jobs safeguarded would otherwise be average manufacturing jobs) these estimates rise to £2.15 of total benefit per £1 of societal cost by 2029 and £5.17 per £1 of public spending over the same period.

### 7.3.2 Overall social welfare analysis

An overall social welfare analysis was also completed by relating the productivity gains associated with APC grants to the social cost of the programme (including public and private sector costs).

Overall, APC grant funding was estimated to have led to between £1.33 and £2.12 benefit per £1 of social cost by 2024. This was calculated by taking the sum of the benefits from short term GVA gains and safeguarded output divided by the sum of the social costs, being R&D and capital expenditure and administrative costs in the running of the APC programme.

By 2029 (the furthest that estimated impacts are expected to last), APC grant funding to date is expected to lead to between £1.31 and £2.15 benefit per £1 of social cost. Whilst these may appear low, a high share of the programme's costs was related to spending by private companies (and therefore lower BCRs might be expected given prevailing rates of return in the automotive industry). Higher BCRs would therefore imply very high rates of return on the investments made and call into the question the need for public sector support.

**Table 7.3 Estimated social benefit-cost ratios**

| Timeframe | Range for benefits | Total cost (£m) | Total benefit (£m) | BCR (£) |
|---|---|---|---|---|
| Total impacts to 2024 | Medium | 1,344 | 2,858 | 2.12 |
| | Low | 1,344 | 1,788 | 1.33 |
| Total impacts to 2029 | Medium | 1,864 | 4,000 | 2.15 |
| | Low | 1,864 | 2,438 | 1.31 |

Source: Ipsos analysis. Base year = 2013. 3.5% discount rate.

## 7.4 Additional adjustments

The above exclude environmental benefits given the uncertainty with what would have happened in the absence of the APC projects. The above also excludes any leakage of GVA gains in the form of profits transferred to overseas firms. Adjustments were therefore applied with forecasted $CO_2$ emissions savings valued and an estimate of leakage generated.

### 7.4.1 Environmental benefits

A comprehensive assessment of the emissions impacts of the Advanced Propulsion Centre would ideally cover direct and indirect emissions impacts (Scope 1, Scope 2, and Scope 3 emissions as defined in the Greenhouse Gas Protocol), covering the total emissions impacts of APC funding across both manufacturing and the downstream use of vehicles sold.

In principle, estimates of the causal effects of the programme on these outcomes (to date) could be derived if it were possible to obtain longitudinal/annual data on the direct and indirect emissions of each firm associated with successful and unsuccessful applications for funding. This information is not compiled in any publicly owned dataset. However, some companies do provide annual reporting of their Scope 1, 2 and 3 emissions in their annual reports. Nevertheless, there would be challenges in compiling this information for the purposes of the econometric evaluation in so far as coverage would be limited to certain firms and certain years with issues such as double counting and projection-based estimates also complicating matters.

Therefore, a partial assessment of the emissions impacts arising from the use of vehicles sold (scope 3 emissions) was completed using the modelling from the VfM toolkits which assess the expected emissions impacts as a function of (a) reduction in emissions at the tailpipe associated with the technologies and (b) projected volumes of vehicle sales. These models were updated in light of:

- Revised projections prepared at project completion (held by APC).
- Subsequent updates to the VfM application form obtained as part of the PPM survey.

- Details obtained in case study research in terms of (a) the technical performance of the technologies developed relative to expectations and (b) sales achieved to date.

Updated VfM records for ongoing and completed projects implied a total of 10m tonnes of UK $CO_2$ emissions savings by the end of the FY 2023/24. Using carbon values from the 2021 policy paper on the valuation of greenhouse gas emissions[22] and discounting future values at the standard rate results in an estimated saving of £1.8bn. Over the expected lifetimes of vehicles incorporating technologies developed through APC projects the estimated benefit increases to £24.8bn from 156.1m tonnes of $CO_2$ emissions savings. Applying an additionality factor derived from estimates of the effect of the programme on R&D spending relative to the total cost of APC projects over the lifetime of projects[23] reduced the estimated benefit to £963m by 2024 and £13bn by 2037.

However, it should be noted that this approach will only yield estimates of the gross emissions savings associated with the programme. While the findings can be adjusted to account for deadweight, the counterfactual scenario in this case is complex as in the absence of public funding, competitors may have arrived with competing vehicle models with a similar emissions profile. It was not possible to quantify these types of displacement effects, so findings will need to be treated with some caution.

### 7.4.2 Leakage of GVA gains overseas

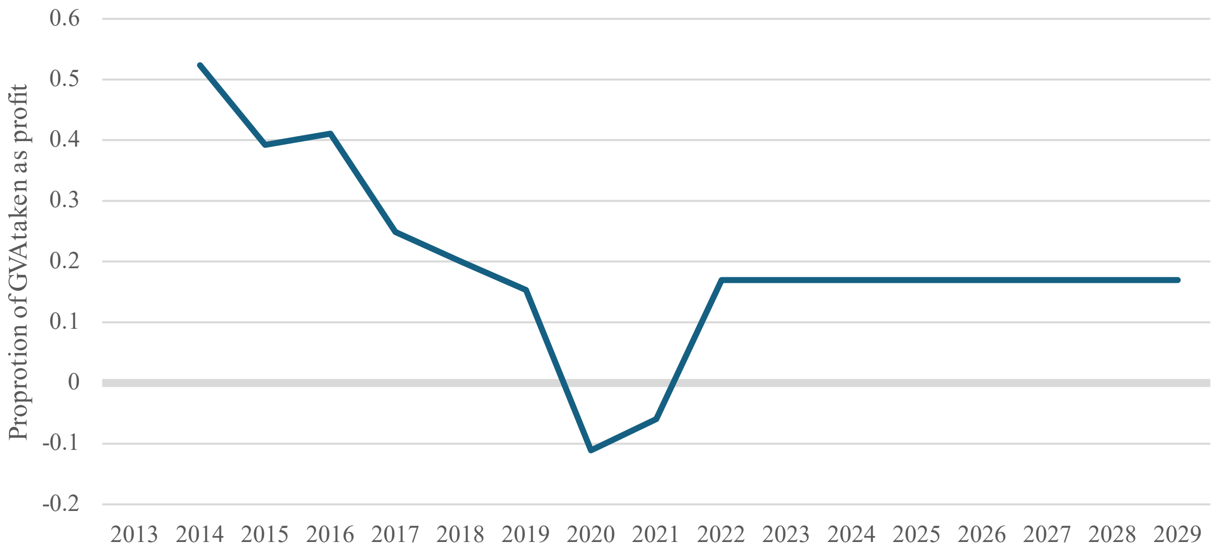
The majority of UK based automotive manufacturers are ultimately owned by overseas owners. As a consequence, there is likely to be some leakage of GVA gain overseas as a result of profits that may be offshored. In principle, these should be excluded from the benefits and a proportion of profits should be included representing the amount reinvested or spent in the UK economy. The approach taken was as follows:

- The percentage of GVA earned as profit in the automotive sector between 2013 and 2022 was calculated using ONS ABS data for the automotive manufacturing sector (SIC 29.1). This was calculated by taking the approximate GVA in each year minus total employment costs and net capital expenditure. This was then weighted by years of jobs safeguarded, and an assumption was made that the level of profit as a proportion of GVA would remain at 2022 levels from 2023 onwards. This led to an estimate of 13.1% of GVA taken as profit across the period on average.

[22] https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation#annex-1-carbon-values-in-2020-prices-per-tonne-of-co2

[23] Total project costs were £1.4bn whilst the total amount of estimated additional R&D spend over the first 3.5 years following award was £732m. The additionality factor was therefore derived as 0.732/1.4 and was equal to 0.52.

**Figure 7.4 Proportion of GVA taken as profit by year for automotive manufacturing sector (SIC 29.1)**




Source: Ipsos analysis. ONS Annual Business Survey data

- It was assumed that average corporation tax rate of 20% would be removed before any profits could be sent overseas.
- The ownership of companies receiving APC competition funding was then explored using companies house data to ascertain the likely location of parent companies and beneficial owners. Two approaches were required depending upon whether a firm was publicly listed or not:
  - **Publicly listed:** Companies listed on exchanges were assumed to have a proportion of earnings redistributed back to the UK through shareholdings. Aside from ONS data on the proportion of UK exchange shareholding held by foreign companies (57%)[24], there was no data readily available to estimate what proportion would be returned to the UK. A flat rate of 43% was therefore applied.
  - **Private ownership:** Companies that were not listed were assumed to have all profits distributed to the country of the ultimate parent company/persons.
- These assumptions culminated in an estimate that 70% of profits were retained or redistributed to the UK. Applying this proportion to the estimated profile of GVA gains (both from short term productivity gains and gains from safeguarding of high productivity jobs) and the proportion of GVA taken as profit (13.1%) resulted in a reduction in the value of total benefits of 4%.

## Adjusted BCRs

Including adjustment for leakage of GVA gains overseas results in small reductions in the estimated BCRs. The benefit-cost ratio to 2024 was £1.26 and £2.02 per £1 of social cost and between £1.68 and £3.77 per £1 of public sector cost.

[24] Ownership of UK quoted shares. ONS. 2022. Available at: https://www.ons.gov.uk/economy/investmentspensionsandtrusts/bulletins/ownershipofukquotedshares/2022

The estimate in terms of social cost rises to between £1.26 to £2.09 by 2029 with the public sector BCR rising to between £1.93 and £4.98.

The above still assumes no environmental benefits associated with APC competition funding and implies that there need be only marginal benefits from emission savings for the adjusted BCR, in terms of public sector cost, to rise above £2 per £1 of public sector cost.

Including the environmental benefits in the calculation results in an increased benefit-cost ratio by 2024 at between £2.04 and £2.84 per £1 of social cost and between £3.74 and £5.83 per £1 public sector cost.

By 2038, the estimated BCRs increase significantly to between £8.29 and £9.12 of benefit per £1 in total societal costs and between £27.50 and £30.54 per £1 of public sector costs.

These long term BCR estimates are significantly larger than those without $CO_2$ emission savings included, however the cost benefit analysis of the programme is not reliant upon these to demonstrate value for money.

**Table 7.3 Estimated societal benefit-cost ratios including leakage of GVA gains through profit and environmental benefits**

| Timeframe | Range for benefits | Total cost (£m) | Total benefit (£m) | BCR |
|---|---|---|---|---|
| **Leakage removed** | | | | |
| Total impacts to 2024 | High | 1,344 | 2,761 | 2.05 |
| | Low | 1,344 | 1,691 | 1.26 |
| Total impacts to 2029 | High | 1,864 | 3,903 | 2.09 |
| | Low | 1,864 | 2,341 | 1.26 |
| **Environmental benefits included** | | | | |
| Total impacts to 2024 | High | 1,344 | 3,821 | 2.84 |
| | Low | 1,344 | 2,751 | 2.04 |
| Total impacts to 2038 | High | 1,863 | 17,004 | 9.12 |
| | Low | 1,863 | 15,442 | 8.29 |

Source: Ipsos analysis. Base year = 2013. 3.5% discount rate.

**Table 7.4 Estimated public sector benefit-cost ratios including environmental benefits**

| Timeframe | Range for benefits | Total benefits (£m) | Total costs (£m) | Public sector costs (£m) | Private costs (£m) | Benefits less private costs (£m) | BCR |
|---|---|---|---|---|---|---|---|
| | | **A** | **B** | **C** | **D=B-C** | **E=A-D** | **F=E/C** |
| **Leakage removed** | | | | | | | |
| Total impacts to 2024 | High | 2,761 | 1,344 | 512 | 832 | 1,929 | 3.77 |
| | Low | 1,691 | 1,344 | 512 | 832 | 859 | 1.68 |
| Total impacts to 2029 | High | 3,903 | 1,864 | 512 | 1,351 | 2,552 | 4.98 |
| | Low | 2,341 | 1,864 | 512 | 1,351 | 990 | 1.93 |
| **Environmental benefits included** | | | | | | | |
| Total impacts to 2024 | High | 3,821 | 1,344 | 512 | 833 | 2,987 | 5.83 |
| | Low | 2,751 | 1,344 | 512 | 833 | 1,918 | 3.74 |
| Total impacts to 2038 | High | 17,004 | 1,864 | 512 | 1,351 | 15,652 | 30.54 |
| | Low | 15,442 | 1,864 | 512 | 1,351 | 14,090 | 27.50 |

Source: Ipsos analysis. Base year = 2013. 3.5% discount rate.

# 8 Conclusions

This section presents the conclusions of the APC Impact Evaluation and links back to the key evaluation questions set out in the introduction.

## Summary

The key findings of the evaluation can be summarised as below:

- The econometric and case study evidence indicates that the APC has proven a highly successful programme and has largely delivered against all of its intended objectives.
- Grants awarded through APC competitions have crowded in significant levels of additional private R&D investment into developing low and zero carbon propulsion systems for passenger and other types of vehicles. The evaluation found that the programme leveraged £2.20 of private R&D spend per £1 of public sector spending by 2022/23.
- The programme has successfully supported the commercialisation of APC technologies. Of the 24 projects sampled in the case studies, 15 achieved some form of commercialisation through the integration of components into vehicle models. Comparisons to most recent VfM forms indicated that these projects were roughly on track to meet revised targets from the close-out stage.
- The APC grant funding was shown to have supported the creation or safeguarding of significant numbers of R&D and production jobs. The study estimates a total of 68,000 job years safeguarded or created by 2022.It has also reduced UK firms import dependency whilst prevented some plant closures.
- In achieving the objectives set out above, the programme was found to have delivered value for money with a low level of deadweight (33%) and a high leverage ratio of R&D spending (£2.20 per £1 of public spend). Under the most conservative assumptions, the programme has delivered a return on public investment of £2.12 per £1 of public spending and £5.17 per £1 under less restrictive assumptions.

Despite the success of the programme, the industry continues to face a number of external threats. While the programme has proven effective in safeguarding UK based activity, it has not attracted new manufacturing to the UK in significant volumes and was potentially insufficient on its own to reverse declining levels of employment in the industry. More recent initiatives in conjunction such as the ATF could be expected to tackle some of these issues.

## Economic benefits

### How far has the availability of APC funding led to – or encouraged – the initiation of new R&D projects in new vehicle technologies and manufacturing process innovations?

The APC has successfully supported technological development since inception. Across the 26 rounds of the APC (22 standard competition rounds and four exceptional - eAPC rounds) a total of 182 applications were submitted with 91 successful applications. There was an initial emphasis in early competition rounds on improving the efficiency of thermal propulsions systems and lightweighting technologies which has moved on to fuel cells. This and the growing importance of electrification appears to have driven changes over time, as might be expected with the growing prominence of electric vehicles as the principal route to achieving net zero in passenger vehicles. Most projects (55%) were developing technologies for passenger cars, with heavy duty vehicles and light commercial vehicles accounting for 26% and 12% of the portfolio respectively. Based on comparisons between completed and live projects – there are some signals that the emphasis of the programme has shifted from passenger cars to commercial vehicles over time (although these changes were predominantly at the margin).

Case study research indicated that 15 of the 24 APC funded projects sampled had their origins in programmes of earlier-stage R&D. This was more likely to be the case for projects sampled as part of the organisation level case studies with a number of these also building upon each other. Where prior research had previously been completed, funding was sourced internally or through programmes such as the APC and other public support programmes. Case studies of projects also highlighted several instances where project consortia developed new programmes of R&D that were linked to the results of an APC project. Technical outputs were also shown to spill-over into adjacent R&D programmes mainly within project consortia.

### How far has APC funding leveraged additional (direct) expenditure on new automotive technologies, both amongst beneficiaries of APC funded R&D projects and their suppliers? How much of this would not have taken place at all/at a slower rate/at higher risk/outside the UK?

APC funding has successfully leveraged R&D spending to develop relevant technologies that would not otherwise have happened. The evidence also suggested that in the absence of funding projects would not have been taken forward or would have been developed at a slower pace. Evidence on the location of R&D activity in the absence of APC funding is mixed with some indications that some activity may otherwise have been taken offshore.

The findings imply that programme led to a total increase in R&D spending of £1.2bn by the end of 2023. Extending the horizon to beyond 2024 and using the time profile of estimated expected impacts for in flight projects, results in an estimated total cost in additional R&D spending of £1.7bn. The central results imply that 67% of spending on projects by 2022 would not have happened in the absence of the APC. Using the estimated impact of the programme on R&D spending suggested that the programme leveraged £2.20 of private R&D spend per £1 of public sector spending by 2022/23.

Case study research indicated that claims made by applicants as to why projects would not have moved forward without APC funding were centred around the high levels of technical risk associated with APC technologies. Survey evidence from unsuccessful applicants suggested that projects were not generally progressed without public support due to excess commercial and technical risk and where they were they were significantly scaled back. Project proposals appeared genuinely marginal in the case of large firms (though it was not always clear why large OEMs would not fund the necessary development work, given the need to meet legislated emissions targets to maintain competitiveness).

### How far has APC funding created or safeguarded high value jobs in R&D and longer-term manufacturing jobs in the UK which otherwise might have been lost or moved overseas?

The funding made available through APC funding competitions successfully supported the creation/safeguarding of high-value R&D and manufacturing jobs in the UK. The study found some evidence that may support the view that some jobs may otherwise have been taken overseas.

Econometric evidence found significant impacts on both R&D employment and overall employment for firms receiving APC grant funding:

- **Effects on R&D employment:** The results suggested that the APC grants had an impact on R&D employment. APC grants appeared to have led to an increase of 12% overall. These results imply a degree of additionality associated with the APC funding and capture the direct and indirect impacts of the APC grants (for example, if the awards enabled firms to attract follow-on grants for related avenues of inquiry). These effects were persistent from one year after award to seven years post. This is substantially longer than the typical duration of an APC project (3.3 years), suggesting that the funding had led to a significant amount of additional R&D activity beyond the initial APC project. This could be associated with the same technology developed through the APC project, but it may also be in part explained by additional projects and/or technologies developed off the back of the initial APC funded project.

The findings exploring the impact on R&D spending by location highlighted an estimated 6% impact on R&D spending in the UK with no impacts identified on non-UK based R&D. This provides clear evidence of APC funding being spent in the UK within UK based firms and suggest that the programme anchored R&D within the UK.

- **Effects on overall employment:** The analysis identified a significant and positive effect on overall employment for firms receiving APC grants. This effect was estimated at around 5% to 6% from one year after APC award and up to seven years. The study estimates a total of 35,000 job years safeguarded or created by 2022. When compared to the effect of the programme on R&D jobs, this indicates that most of these positions are likely to be non-R&D roles.

Industry employment in the UK has, however, continued to fall in recent years and the study found little evidence of impacts on new high volume manufacturing plants. The programme appears to have prevented closures more than encouraged the opening of new facilities.

### How far has APC funding started to influence the plans of automotive companies to locate production in the UK resulting in commitments for manufacturing jobs?

Funding made available by the APC has played a role in influencing firm decisions on location of production facilities. Whilst the evidence suggests that drivers such as cost and access to materials are the most significant drivers of such decisions, the availability and support for UK industry has made the UK more attractive.

Case study research identified the long-term availability of APC funding as a key factor in influencing decisions on the location of both R&D and manufacturing activity. The close relationship and ongoing, continuous cross collaboration between industry and the APC sets the APC apart from other forms of industry support and was viewed positively by case study participants and stakeholders.

The econometric evidence provided a strong signal that the delivery of the APC funding competition has resulted in increased levels of investment that appear to be driven by firms gearing up to produce products and technologies developed through APC projects. Firms amongst those sampled in case studies also reported current and future investments in existing facilities and planned new facilities.

Econometric analysis indicated that that each APC grant led to an expansion in net capital investment of 25% per annum when compared to the comparators used. However, the impacts on net capital spending were not persistent and did not take hold until four years after an APC grant was awarded. This suggests that firms began to expand facilities in anticipation of production towards the end projects or just after projects had completed given an average length of project of 3.3 years. Overall, the study finds an estimated total impact on net capital investment of £89m by 2024 and £156m by 2029.

## Technology benefits

### How far has APC funding accelerated the development of new vehicle technologies and manufacturing readiness levels?

APC funding has accelerated the technological and manufacturing process development of many supported project. Projects surveyed progressed significantly along the TRL and MRL scales, and more than half were on track to reach their emissions saving forecasts. However, 41% of projects were expecting to deliver less than 50% of the anticipated $CO_2$ savings.

Projects funded through the APC have moved through the development pathway (as measured through the TRL and MRL scales). Evidence from the PPM survey and close out VfM forms indicated significant progress and, of the 25 projects with updated VfM forms collected in the survey, 33% had reached TRL 9 by 2023.

Evidence on expected $CO_2$ savings associated with APC technologies indicated significant variations between the expected performance of technologies in delivering $CO_2$ savings and those achieved in practice. Across the whole portfolio, 38% of projects are expected to see either no change or a less than 10% decrease on the level expected at application stage. However, amongst closed projects emissions reductions were forecast to be 84% larger than at application stage.

### How far has there been commercial impacts because of APC funding, for example, taking products to market?

The key commercial objective for projects and the principal mechanism through which the programme will realise its expected economic and environmental benefits is through the integration of APC funded technologies into vehicle programmes. By the end of 2022/23, most recent VfM returns suggested that 10.5m vehicles integrating APC technologies had been sold and current expectations are that a total of 98m will be sold by 2037/38. This is down on application forecasts, largely driven by a single project which was not a technical success. Of the 24 projects sampled in the case studies, 15 had achieved some form of commercialisation through the integration of components into vehicle models. Evidence from these on the number of vehicles sold was mixed, however comparisons to most recent VfM forms indicated that these projects were roughly on track to meet revised targets from the close-out stage, however these remain lower than application forecasts.

Evidence from the PPM survey indicated that 17 of the 27 businesses had integrated APC technologies into vehicles, with seven of these reporting vehicle sales in 2022/23. These amounted to a total of 145,569 vehicles sold in 2022/23. Most recent VfM forms indicated a total of 10.5m sales with APC technologies integrated and so there are substantial numbers sold from outside of these 17 projects.

Case study research suggested that projects completed prior to the COVID-19 pandemic were more likely to be on track to achieve commercial targets. This appears to highlight the external context as a key factor determining the success of APC projects in meeting commercial and consequently carbon targets.

## Environmental benefits

### Did APC funding contribute to reducing scope 1, scope 2, and scope 3 emissions? Has APC funding led to increased resource efficiency?

A comprehensive assessment of the emissions impacts of the Advanced Propulsion Centre would ideally cover direct and indirect emissions impacts (Scope 1, Scope 2, and Scope 3 emissions as defined in the Greenhouse Gas Protocol), covering the total emissions impacts of APC funding across both manufacturing and the downstream use of vehicles sold. Limitations on the availability of data for scope 1 and 2 emissions meant these were not explored in this study. However, a partial assessment of the emissions impacts arising from the use of vehicles sold (scope 3 emissions) was completed. The results implied a total of 10m tonnes of UK $CO_2$ emissions savings by the end of the FY 2023/24. This results in an estimated saving of £1.8bn. Over the expected lifetimes of vehicles incorporating technologies developed through APC projects the estimated benefit increases to £24.8bn from 156.1m tonnes of $CO_2$ emissions savings. Applying an additionality factor derived from estimates of the effect of the programme on R&D spending relative to the total cost of APC projects over the lifetime of projects reduced the estimated benefit to £963m by 2024 and £13bn by 2037.

## Collaboration

### How far has APC funding influenced the development of partnerships and patterns of collaboration across UK firms, universities, and research organisations, or introduced new ones? What additional benefits are realised by beneficiaries who have formed APC consortiums?

All APC projects required some form of collaboration. The APC specify the involvement of at least one SME and encourage the involvement of firms outside the traditional UK automotive supply chain. The results found that most collaborations were between existing partners but here were some instances of the APC influencing new collaborations. Spill over benefits for firms were largely technical in nature and knowledge gained form APC projects was able to be used in other projects (including later APC projects). Econometric findings implied that impacts on R&D activity and firm output were mixed with limited impacts on R&D expenditure and turnover.

A total of 428 partners (of which 262 were distinct businesses) had been involved across successful projects. Survey evidence and case study research suggested that projects often had more than one reason for establishing partnerships. Collaborations were mainly sought to gain access to specialist skills and capabilities and access specialist facilities whilst attempting to increase the likelihood of future R&D and/or commercial opportunities.

Evidence from case studies on the technical and economic knowledge spillovers found that benefits were realised within collaborating organisations of projects. The most commonly cited spillovers were the application of learning from APC projects to other R&D projects within and across consortia partners.

### How far does the involvement of firms across different tiers of the supply chain in APC consortiums bring additional benefits?

Evidence from the case studies suggested that projects with more partners offered some additional benefits in terms of technical spillovers. The collaboration between SMEs with niche and specialist skills in particular allowed for knowledge spillovers to occur. However, those projects with more partners were also more likely to have issues with project management and required flexible and competent project management to organise.

### How far have APC funded projects helped to deliver spillover benefits, such as agglomeration and local clustering, as well as knowledge spillovers outside of project consortia?

The evaluation found some evidence for local clustering effects and positive spillover effects for local economies. Given the evidence on firm relocations, it is assumed that some of this effect has come from the attraction of higher value activities to the area as well as the increase in output for existing firms. Each grant led to a 12% increase in the number of jobs in the Output Area in which the applicant was located, and a 15% increase in the turnover of firms based in the same area. These area level impacts are broadly comparable to those observed amongst the firms receiving funding, suggesting that any displacement or crowding out effects at the very local level were negligible. There were also positive economic impacts at distances of 1km to 10km from those awarded funding. Larger effects were observed at distances of 5km to 10km than between 1km and 5km, and there was no evidence of net displacement or crowding-out effects locally.

As highlighted above, the case study research also highlighted a degree of knowledge spill over, primarily within project consortia. There was limited evidence of knowledge spill overs occurring outside of project consortia. Spillovers were identified from industry to academia, from academia to industry and from OEMs to suppliers across the case studies.

## International comparisons

### How do any impacts arising from the APC compare against similar international automotive business support schemes?

The evaluation sought to identify similar initiatives in place internationally that aim to achieve similar objectives to the APC competition funding. The most analogous scheme was identified in Germany that provided EUR 1 billion in 2021 to support the development and production of climate-friendly vehicles, partly in response to the COVID-19 pandemic. This scheme was also for collaborative projects with two funds: batter cell production and green battery. However, no evaluations or estimates of impacts brought about by this scheme were found, and so comparisons were not possible between this and the APC programme.

Other support provided to the automotive sector varies with the majority of support in the form of subsidies to manufactures or consumers. For example, the U.S. Inflation Reduction Act (IRA) includes tax subsidies to cut emissions and boost domestic manufacturing in certain industries whilst France has provided support through the COVID-19 pandemic as well as other subsidy support for a gigafactory in Northern France, announced in summer 2023. The EU has and continues to provide substantial support to the automotive industry, especially with respect to promoting innovation and sustainability. No evaluations and/or value for money assessments were available for comparison.

# Annex 1: Cost benefit analysis tables

### Table 7.1 Discounted cash flow of R&D expenditure impacts

| Year funded | Baseline R&D spend (£m) | Grants by year | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 10.3 | 25 | 0 | 12 | 14 | 17 | 16 | 15 | 14 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 101 |
| 2014 | 10.3 | 46 | 0 | 0 | 22 | 25 | 30 | 29 | 27 | 25 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 179 |
| 2015 | 10.3 | 29 | 0 | 0 | 0 | 13 | 15 | 18 | 18 | 16 | 15 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 109 |
| 2016 | 10.3 | 95 | 0 | 0 | 0 | 0 | 42 | 48 | 58 | 56 | 51 | 49 | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 344 |
| 2017 | 10.3 | 28 | 0 | 0 | 0 | 0 | 0 | 12 | 14 | 16 | 16 | 15 | 14 | 12 | 0 | 0 | 0 | 0 | 0 | 98 |
| 2018 | 10.3 | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 22 | 27 | 26 | 24 | 22 | 19 | 0 | 0 | 0 | 0 | 159 |
| 2019 | 10.3 | 74 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 34 | 40 | 39 | 36 | 34 | 29 | 0 | 0 | 0 | 241 |
| 2020 | 10.3 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 38 | 46 | 45 | 41 | 39 | 33 | 0 | 0 | 276 |
| 2021 | 10.3 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 16 | 19 | 19 | 17 | 16 | 14 | 0 | 115 |
| 2022 | 10.3 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 9 | 10 | 10 | 9 | 9 | 7 | 61 |
| Discount factor | | | 1.00 | 0.97 | 0.93 | 0.90 | 0.87 | 0.84 | 0.81 | 0.78 | 0.75 | 0.73 | 0.70 | 0.68 | 0.65 | 0.63 | 0.61 | 0.59 | 0.57 | |
| Total | | | 0 | 12 | 36 | 55 | 104 | 122 | 149 | 177 | 198 | 195 | 187 | 142 | 123 | 95 | 58 | 22 | 7 | 1683 |

Source: Ipsos analysis.

### Table 7.2 Discounted cash flow of capital expenditure impacts

| Year funded | Baseline capex (£,000) | Grants by year | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 474 | 25 | 0 | 0 | 0 | 0 | 2 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| 2014 | 474 | 46 | 0 | 0 | 0 | 0 | 0 | 4 | 5 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 |
| 2015 | 474 | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 2016 | 474 | 95 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 9 | 9 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 32 |
| 2017 | 474 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 9 |
| 2018 | 474 | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 4 | 3 | 0 | 0 | 0 | 0 | 15 |
| 2019 | 474 | 74 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 6 | 7 | 4 | 0 | 0 | 0 | 22 |
| 2020 | 474 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 7 | 7 | 5 | 0 | 0 | 26 |
| 2021 | 474 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 2 | 0 | 11 |
| 2022 | 474 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 1 | 6 |
| Discount factor | | | 1.00 | 0.97 | 0.93 | 0.90 | 0.87 | 0.84 | 0.81 | 0.78 | 0.75 | 0.73 | 0.70 | 0.68 | 0.65 | 0.63 | 0.61 | 0.59 | 0.57 | |
| Total | | | 0 | 0 | 0 | 0 | 2 | 7 | 10 | 17 | 17 | 17 | 18 | 19 | 19 | 16 | 9 | 4 | 1 | 156 |

Source: Ipsos analysis.

### Table 7.3 Discounted cash flow of short term GVA gains

| Year funded | Baseline employment | Baseline GVA per worker at award | Grants by year | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 254 | 122,843 | 25 | 0.0 | 0.0 | 0.0 | 28.4 | 24.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 53.0 |
| 2014 | 254 | 122,843 | 46 | 0.0 | 0.0 | 0.0 | 0.0 | 50.5 | 43.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 94.1 |
| 2015 | 254 | 122,843 | 29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 30.7 | 26.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 57.3 |
| 2016 | 254 | 122,843 | 95 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 97.0 | 84.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 181.0 |
| 2017 | 254 | 122,843 | 28 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 27.6 | 23.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 51.5 |
| 2018 | 254 | 122,843 | 47 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 44.7 | 38.7 | 0.0 | 0.0 | 0.0 | 0.0 | 83.4 |
| 2019 | 254 | 122,843 | 74 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 67.9 | 58.8 | 0.0 | 0.0 | 0.0 | 126.7 |
| 2020 | 254 | 122,843 | 88 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 77.9 | 67.5 | 0.0 | 0.0 | 145.4 |
| 2021 | 254 | 122,843 | 38 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 32.5 | 28.1 | 0.0 | 60.6 |
| 2022 | 254 | 122,843 | 21 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 17.3 | 15.0 | 32.3 |
| Discount factor | | | | 1.00 | 0.97 | 0.93 | 0.90 | 0.87 | 0.84 | 0.81 | 0.78 | 0.75 | 0.73 | 0.70 | 0.68 | 0.65 | 0.63 | |
| **Total** | | | | 0.0 | 0.0 | 0.0 | 28.4 | 75.1 | 74.4 | 123.6 | 111.6 | 68.6 | 106.6 | 136.7 | 99.9 | 45.4 | 15.0 | 885.4 |

Source: Ipsos analysis.

## Table 7.4 Job years safeguarded/created

| Year funded | Baseline employment | Grants by year | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 474 | 25 | 0 | 314 | 408 | 463 | 525 | 504 | 498 | 440 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3152 |
| 2014 | 474 | 46 | 0 | 0 | 578 | 751 | 853 | 966 | 927 | 916 | 809 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5800 |
| 2015 | 474 | 29 | 0 | 0 | 0 | 365 | 473 | 537 | 609 | 584 | 577 | 510 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3656 |
| 2016 | 474 | 95 | 0 | 0 | 0 | 0 | 1195 | 1551 | 1761 | 1996 | 1914 | 1891 | 1672 | 0 | 0 | 0 | 0 | 0 | 0 | 11978 |
| 2017 | 474 | 28 | 0 | 0 | 0 | 0 | 0 | 352 | 457 | 519 | 588 | 564 | 557 | 493 | 0 | 0 | 0 | 0 | 0 | 3530 |
| 2018 | 474 | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 591 | 767 | 871 | 987 | 947 | 936 | 827 | 0 | 0 | 0 | 0 | 5926 |
| 2019 | 474 | 74 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 930 | 1208 | 1371 | 1555 | 1491 | 1473 | 1302 | 0 | 0 | 0 | 9330 |
| 2020 | 474 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1107 | 1437 | 1631 | 1849 | 1773 | 1752 | 1548 | 0 | 0 | 11096 |
| 2021 | 474 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 478 | 620 | 704 | 798 | 766 | 756 | 669 | 0 | 4791 |
| 2022 | 474 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 264 | 343 | 389 | 441 | 423 | 418 | 370 | 2648 |
| **Total** | | | 0 | 314 | 987 | 1579 | 3046 | 3910 | 4842 | 6152 | 7074 | 7239 | 7246 | 5815 | 5260 | 4260 | 2728 | 1087 | 370 | 61908 |

Source: Ipsos analysis.

## Table 7.5 Discounted cash flow of safeguarded GVA gains (Manufacturing jobs)

| Year funded | Baseline GVA per worker (awarded) | GVA per worker (manuf.) | GVA uplift | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | Total (£m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 122,843 | 72,532 | 50,312 | 0 | 16 | 21 | 23 | 26 | 25 | 25 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 159 |
| 2014 | 122,843 | 72,532 | 50,312 | 0 | 0 | 29 | 38 | 43 | 49 | 47 | 46 | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 292 |
| 2015 | 122,843 | 72,532 | 50,312 | 0 | 0 | 0 | 18 | 24 | 27 | 31 | 29 | 29 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 184 |
| 2016 | 122,843 | 72,532 | 50,312 | 0 | 0 | 0 | 0 | 60 | 78 | 89 | 100 | 96 | 95 | 84 | 0 | 0 | 0 | 0 | 0 | 0 | 603 |
| 2017 | 122,843 | 72,532 | 50,312 | 0 | 0 | 0 | 0 | 0 | 18 | 23 | 26 | 30 | 28 | 28 | 25 | 0 | 0 | 0 | 0 | 0 | 178 |
| 2018 | 122,843 | 72,532 | 50,312 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 39 | 44 | 50 | 48 | 47 | 42 | 0 | 0 | 0 | 0 | 298 |
| 2019 | 122,843 | 72,532 | 50,312 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 47 | 61 | 69 | 78 | 75 | 74 | 66 | 0 | 0 | 0 | 469 |
| 2020 | 122,843 | 72,532 | 50,312 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 56 | 72 | 82 | 93 | 89 | 88 | 78 | 0 | 0 | 558 |
| 2021 | 122,843 | 72,532 | 50,312 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 31 | 35 | 40 | 39 | 38 | 34 | 0 | 241 |
| 2022 | 122,843 | 72,532 | 50,312 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 17 | 20 | 22 | 21 | 21 | 19 | 133 |
| Discount factor | | | | 1.00 | 0.97 | 0.93 | 0.90 | 0.87 | 0.84 | 0.81 | 0.78 | 0.75 | 0.73 | 0.70 | 0.68 | 0.65 | 0.63 | 0.61 | 0.59 | 0.57 | |
| **Total** | | | | 0 | 16 | 50 | 79 | 153 | 197 | 244 | 310 | 356 | 364 | 365 | 293 | 265 | 214 | 137 | 55 | 19 | 3,115 |

Source: Ipsos analysis.

### Table 7.5 Discounted cash flow of safeguarded GVA gains (20% decrease)

| Year funded | Baseline GVA per worker (awarded) | GVA per worker (20% fall) | GVA uplift | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | Total (£m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 122,843 | 97,762 | 25,081 | 0 | 8 | 10 | 12 | 13 | 13 | 12 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 79 |
| 2014 | 122,843 | 97,762 | 25,081 | 0 | 0 | 15 | 19 | 21 | 24 | 23 | 23 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 145 |
| 2015 | 122,843 | 97,762 | 25,081 | 0 | 0 | 0 | 9 | 12 | 13 | 15 | 15 | 14 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 92 |
| 2016 | 122,843 | 97,762 | 25,081 | 0 | 0 | 0 | 0 | 30 | 39 | 44 | 50 | 48 | 47 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 300 |
| 2017 | 122,843 | 97,762 | 25,081 | 0 | 0 | 0 | 0 | 0 | 9 | 11 | 13 | 15 | 14 | 14 | 12 | 0 | 0 | 0 | 0 | 0 | 89 |
| 2018 | 122,843 | 97,762 | 25,081 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 19 | 22 | 25 | 24 | 23 | 21 | 0 | 0 | 0 | 0 | 149 |
| 2019 | 122,843 | 97,762 | 25,081 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 | 30 | 34 | 39 | 37 | 37 | 33 | 0 | 0 | 0 | 234 |
| 2020 | 122,843 | 97,762 | 25,081 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 36 | 41 | 46 | 44 | 44 | 39 | 0 | 0 | 278 |
| 2021 | 122,843 | 97,762 | 25,081 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 16 | 18 | 20 | 19 | 19 | 17 | 0 | 120 |
| 2022 | 122,843 | 97,762 | 25,081 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 9 | 10 | 11 | 11 | 10 | 9 | 66 |
| Discount factor | | | | 1.00 | 0.97 | 0.93 | 0.90 | 0.87 | 0.84 | 0.81 | 0.78 | 0.75 | 0.73 | 0.70 | 0.68 | 0.65 | 0.63 | 0.61 | 0.59 | 0.57 | |
| **Total** | | | | 0 | 8 | 25 | 40 | 76 | 98 | 121 | 154 | 177 | 182 | 182 | 146 | 132 | 107 | 68 | 27 | 9 | 553 |

Source: Ipsos analysis.

**Department for Business and Trade**

We are the UK's department for economic growth. We support businesses to invest, grow and export, creating jobs and opportunities across the country.

We are responsible for:

- Redrawing our rules to ensure businesses thrive, markets are competitive and consumers are protected.
- Securing investment from UK and international businesses.
- Advising, supporting, and promoting British businesses to grow and export.
- Opening up new markets for businesses by removing barriers and striking trade deals.
- Promoting free trade, economic security and resilient supply chains.

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