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Dead End Ahead – How Phase-out Policies Affect Incumbent Adaptation to Technological Change in the Automotive Industry

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Abstract

In recent years, there has been a growing interest among academics and practitioners in policies that aim to phase out unsustainable technologies. While there are normative calls for the introduction of such policies, and their use in real-world policymaking is increasing, their implementation remains controversial because it is less understood how they affect key actors for technological change, such as incumbents. To shed more light on this highly relevant question, we conducted a qualitative case study to analyze how the recent EU-level decision to effectively forbid new registrations of internal combustion engine vehicles as of 2035 affects incumbent car makers in their adaptation to technological change. We offer original insights into the channels through which phase-out policies affect incumbents' adaptation and show how firm-level factors shape policy effectiveness. By highlighting that phase-out policies drive and facilitate incumbent adaptation, we propose that these policies are highly effective in accelerating transitions and are not as incumbent-unfriendly as one might assume. Instead, the policy is an effective means of overcoming multiple internal and external sources of inertia that increase the likelihood that incumbents will well survive technological change. However, great care should be taken in designing a phase-out policy and complementary policies for alternative technologies to ensure policy credibility.

Keywords: Phase-out policy, technology ban, destructive policy, sustainability transition, incumbent adaptation, technological change, electric vehicles

1 Introduction

In the face of the climate crisis, carbon-intensive technologies must be replaced with climate-friendly alternatives. To this end, innovation in climate-friendly technologies, such as photovoltaic, wind power, and electric vehicles, has been fostered by innovation policies (Hoppmann et al., 2013; Luetkehaus, 2024; Peters et al., 2012). Yet, while viable mitigation technologies are now available for many sectors, a key problem in reaching the 1.5°C target is that incumbent firms continue to use established fossil-based technologies based on coal, oil, or gas (IPCC, 2023). A reason for this is that incumbents often still economically benefit from producing and selling established products, are unwilling to cannibalize their own sales (Chandy and Tellis, 1998), or face inertia rooted in managerial cognition, existing capabilities, or organizational incentives (Eggers and Park, 2018; Kaplan, 2008; Sull et al., 1997; Tripsas and Gavetti, 2000).

As a result of these observations, scholars in the field of sustainability transitions and innovation policy have argued that innovation policies are not sufficient and should be complemented by policies that destabilize incumbency, which then can accelerate transitions and lead incumbents to engage more actively in sustainability transitions (Kivimaa and Kern, 2016; Turnheim and Geels, 2012). More concretely, there has been a growing scholarly interest in and normative calls for phase-out policies that gradually terminate unsustainable technologies, substances, or processes (Trencher et al., 2022). This scholarly interest is mirrored by a growing number of real-world examples of stringent phase-out policies that introduce stepwise bans for certain technologies. Recent examples include the stepwise ban of incandescent light bulbs, inter alia in the US and the EU (Howarth and Rosenow, 2014), the phase-out of coal-fired electricity generation in Germany and UK (Bang et al., 2022), the phase-out of nuclear power in Germany (Rogge and Johnstone, 2017), and a zero-CO2-emission regulation for passenger vehicles in the EU from 2035 (European Parliament, 2023).

Prior literature has ascribed various functions to phase-out policies, such as signaling, delegitimizing, or promoting alternatives. Still, there is a lack of empirical evidence on how phase-out policies affect technological change (Trencher et al., 2022). While first studies, such as the one by Rogge and Johnstone (2017), show that announcing the phase-out of technologies is positively associated with innovation activities of firms developing and producing alternatives, we still lack detailed insights into how these policies affect incumbents' adaptation, e.g., strategic reconfiguration of their business activities, thereby accelerating

transitions. A comprehensive understanding of how phase-out policies affect the technology choices of incumbents is, however, important since the use of phase-out policies remains controversial in the policy field. In fact, it has been claimed that excluding technology options is economically inefficient and unnecessary, given that firms could decide to phase out technologies on their own if they are no longer valued by the market (Schnellenbach, 2023; Winton, 2022).

To contribute to a more nuanced and empirically grounded understanding of the role of phase-out policies in the adaptation of incumbents to technological change and, thus, in the sustainability transition from a broader perspective, we address the question of *how phase-out policies affect incumbents' adaptation to technological change*. To this end, we conducted a qualitative case study analyzing how the recent EU-level decision to effectively prohibit new registration of internal combustion engine vehicles from 2035 affects automotive incumbents. The research setting is well suited for our research question because the industry is characterized by large incumbents whose successful adaptation is relevant to national economies, and governments worldwide are promoting the transition to more climate-friendly technologies with growing attention to phase-out policies. In-depth interviews with 12 company representatives from 9 incumbent car makers, complemented by interviews with 16 industry experts, allow us to uncover the detailed theoretical mechanisms through which phase-out policies shape incumbents' adaptation to technological change and the firm-level factors that moderate impacts.

2 Theoretical Background

As the basis for our study, we discuss the relevant theory pertaining to our research question in the following. To this end, we provide a more in-depth account of the literature on (1) incumbents and phase-out policies in sustainability transitions and (2) incumbent adaptation to technological change rooted in organization studies.

2.1 Incumbents' Role in Sustainability Transitions

Incumbent firms are key actors in sustainability transitions (Geels et al., 2016). As those firms that develop, produce, and diffuse established technologies, they possess considerable resources and power in socio-technical regimes. They usually possess long experience

developing specific technologies and, hence, important capabilities in technological innovation. Moreover, due to their market power, they often have considerable financial resources and complementary assets that they can deploy. These features make incumbents important actors in the socio-technical regime, implying that they could become enablers of faster sustainability transitions if they adapt and deploy resources to drive technological transitions (Frei et al., 2018; Turnheim and Sovacool, 2020). In fact, recent literature has argued that incumbents play a key role, particularly in the later stages of transitions, in driving the mass market transitions through economies of scale (Berggren et al., 2015; Frei et al., 2018; Geels, 2021; Turnheim & Sovacool, 2020). At the same time, incumbents can also (proactively) engage in niche development (Berggren et al., 2015; Bulah et al., 2023; Penna and Geels, 2015; Weigelt et al., 2021), enable niche projects (Ampe et al., 2021), become challengers by diversifying in adjacent industries (Turnheim and Geels, 2019), or act as transition agents (Trencher et al., 2021).

Despite the important and potentially helpful role incumbents play in transitions, the extant literature stresses that incumbents have often slowed down rather than accelerated sustainability transitions. For example, previous studies show that incumbents use framing to delegitimize emerging niche technologies (Lee and Hess, 2019; Rosenbloom et al., 2016) or to legitimize their established technologies (Trencher et al., 2019), finance political resistance (Hess, 2014), or impede niche emergence by investing in incremental innovation (Bergek et al., 2013). The reason for taking this destructive role is that transitions challenge incumbents' power position and, thus, their source of income and resources. More specifically, as transitions progress, new technologies, policies, and norms emerge, which challenge the status quo, thereby putting established firms' business models at risk. In the worst case, therefore, transitions may threaten incumbents' survival, which explains why transitions are usually not directly in the interest of incumbent firms (Geels et al., 2016; Geels and Schot, 2007).

2.2 The Role of Phase-Out Policies for Sustainability Transitions

Given the limited interest incumbents have in supporting sustainability transitions, it is not surprising that scholars have shown that external pressure (e.g., from public policies) is usually required for incumbent firms to change and become drivers of sustainability transitions. For example, Penna and Geels (2015) show that incumbents in the automotive industry engaged early in new technologies but did not transform their businesses. The authors argue that environmental pressure and clear direction, e.g., from policy, are needed to incentivize or force

incumbents to reorient. In line with this observation, there is a rising call for policies that not only support niche innovation but also address incumbent technology lock-ins (Kivimaa and Kern, 2016; Turnheim and Geels, 2012), with an increasing scholarly emphasis on phase-out policies (Trencher et al., 2022).

Phase-outs are political measures aimed at the gradual or incremental elimination of one or more technologies, substances, processes, or practices from use to prevent adverse impacts on third parties (Rinscheid et al., 2022; Rosenbloom and Rinscheid, 2020). Phase-outs might entail one or multiple policies, ranging from market-based approaches, such as taxation or the removal of subsidies, to command-and-control policies, such as regulation or performance standards culminating in technology bans (Rinscheid et al., 2021; Trencher et al., 2022). Nevertheless, real-world policymaking has so far relied primarily on command-and-control approaches (Trencher et al., 2022).

The literature on phase-outs and related phase-out policies is growing rapidly, approaching the topic from a variety of disciplines and perspectives (for a recent review, see Rinscheid et al., 2022; Rosenbloom and Rinscheid, 2020; Trencher et al., 2022). Yet, current studies provide limited insights into how phase-out policies affect incumbents or other actors in sustainability transitions (Trencher et al., 2022). To our knowledge, the studies by Rogge and Johnstone (2017) and Rogge and Dütschke (2018) are the only ones so far to provide empirical evidence on how phase-out policies affect firms in the sustainability transitions. Analyzing the case of Germany's nuclear phase-out policy as part of the German energy transition, the former study finds that the policy is one of the most influential factors on manufacturers' expectations of future market size and is associated with an increase in innovation activity (Rogge and Johnstone, 2017). Later work shows that the policy is an influential factor in firms' perceptions of the credibility of the overall policy mix (Rogge and Dütschke, 2018).

Despite these valuable insights, however, it remains unclear how, i.e., through which mechanisms, phase-out policies shape incumbent actors' decision to adopt new technologies and support sustainability transitions. In fact, the effectiveness and efficiency of phase-out policies remain controversially debated in both academia and policymaking practice. While some see such policies as necessary tools to steer incumbents on sustainable pathways (Kivimaa and Kern, 2016; Rosenbloom et al., 2020), others argue that they are both inefficient and unnecessary, as they limit the technological options firms have at stake, and firms could decide to phase out specific technologies themselves if market conditions required them to do so (Schnellenbach, 2023; Winton, 2022). Given these differing views on phase-out policies and

their impact on incumbent adaptation, it seems essential to better understand the detailed mechanisms through which such policies shape incumbents and their technological choices. In the following, we review the literature on incumbent adaptation to technological change, which is rooted in the literature on organization theory and has long been interested in understanding the detailed mechanisms driving and hindering incumbent adaptation at the firm level.

2.3 Incumbents' Adaptation to Technological Change

Adaptation to new technology is a process in which incumbents either already possess or acquire and then integrate relevant (new) resources and subsequently reconfigure their business. The literature on incumbent adaptation stresses that inertia mechanisms may impede the adaptation process at each stage (Eggers and Park, 2018).

There are multiple sources of inertia that arise from within an established organization as well as its external environment. Given that top managers make strategic decisions and shape the organization (Hambrick and Mason, 1984), their cognition and where they direct their attention is an important determinant of firm adaptation and biases therein (Cho and Hambrick, 2006; Eggers and Kaplan, 2009; Kaplan, 2008; Tripsas and Gavetti, 2000). Beyond managerial attention, commitment to technology and managers' inclination to make commitment-maintaining decisions can be barriers to adaptation (Eggers and Park, 2018; Sull et al., 1997; Tang, 1988). Even corporate boards, as a control mechanism, can become a source of inertia when environmental change creates conflicts of interest for board members (Hoppmann et al., 2019). While managers and board members are influential individuals in an organization, inertia can also be rooted in the broader organization, stemming from established routines (Gilbert, 2005) or organizational identity, which includes shared beliefs about the legitimate scope of action (Tripsas, 2009). Moreover, in technological change, new products replace old ones, leading to the devaluation of incumbents' prior investments and specialized assets, as such adaptation entails cannibalization of one's own products and (further) devaluation of one's own resources, which reduces incentives to adapt (Chandy and Tellis, 1998; Conner, 1988; Eggers and Park, 2018; Nijssen et al., 2005).

However, even when an incumbent is willing to cannibalize its products and overcome other internal barriers to adaptation, external sources of inertia may persist. For example, the success of innovators and technologies often depends on complementary innovations in the ecosystem (Adner and Kapoor, 2010; Afuah, 2000; Eggers and Park, 2018). Thus, the pace of

technological change depends not only on the progress of the focal technology but also on overcoming challenges in the technology ecosystem, e.g., in the form of necessary complements or new supplier competencies (Adner and Kapoor, 2010, 2016). In this way, a lag in ecosystem development can become a source of inertia for firms' adaptation. Moreover, institutional pressure from financial markets is shown to be a source of inertia as financial markets might react negatively to an incumbent's efforts to adapt to uncertain technological change (Benner, 2007; Eklund and Kapoor, 2019).

The previous paragraphs indicate that incumbents face a variety of sources of inertia. However, importantly, overcoming inertia for one step of adaptation does not ensure successful adaptation (Eggers and Park, 2018). For example, in a case study of the photography incumbent Polaroid Corporation, Tripsas and Gavetti (2000) find that managerial cognitions enabled the acquisition of new relevant technological knowledge but later became a powerful source of inertia for business reconfiguration. Another example relates to overcoming the inertia of routines and identities, where firms may use separate business units to pursue more radical innovation (e.g., Burgers et al., 2009; Ossenbrink et al., 2019), while the holistic transformation of the entire business remains challenging. Also, some inertial factors can become more powerful for later adaptation stages. For example, incumbents might engage in new technology as a hedge against the threat of substitution (Cooper and Smith, 1992), which resonates with engagement in niches from a sustainability transition perspective, but might refrain from driving technological substitution given that firms typically take product cannibalization into account (van Heerde et al., 2010).

2.4 Research Gap: Mechanisms Driving the Impact of Phase-Out Policies in Incumbent Adaptation

In sum, previous research on sustainability transition stresses the important role of incumbents in transitions and indicates that phase-out policies are important when trying to motivate incumbents to leave old technologies behind and adopt new ones. Thus far, however, this literature provides limited insights into the firm-level mechanisms through which phase-out policies shape incumbent firms. In contrast, the organizational literature on incumbent adaptation to technological change provides detailed insights into firm-level antecedents of firm-level changes. This literature, however, primarily focuses on identifying sources of inertia and change but has not explicitly linked them to policy measures thus far. As a result, neither the literature on sustainability transitions nor the one on incumbent adaptation to technological

change provide detailed insights into how phase-out policies affect the different inertias that exist at all stages of the adaptation process, particularly during business reconfiguration, to become accelerators of transitions. A better understanding of these mechanisms is critical when trying to understand the impact of phase-out policies and making targeted recommendations for how to maximize their efficiency and effectiveness in practical policymaking.

3 Method and Sampling

To analyze *how phase-out policies affect incumbents' adaptation to technological change*, we employ qualitative case study research because it is well-suited to study the mechanisms of a contemporary phenomenon that has not yet been fully captured and theorized in literature (Eisenhardt, 1989; Yin, 2017).

3.1 Research Setting

To study how phase-out policies affect the adaptation of incumbents to technological change, we focus on incumbent car makers and the contemporary EU-level decisions to phase out market introductions of conventional internal combustion engine cars by 2035. This research case is well-suited for three reasons. First, the automotive industry is characterized by large incumbents with a long history of manufacturing internal combustion engine vehicles and owning relevant resources such as production facilities, human capital, or distribution channels. Second, in many countries, the automotive sector is an important provider of jobs and economic income. Hence, the adaptation of incumbents to new technologies is important not only for companies but also for the broader economy and society (Pichler et al., 2021). Third, given the climate impact of the transportation sector, various governments are implementing policies to promote a transition to more sustainable technologies (IPCC, 2023), among which the EU regulation to phase out internal combustion engine vehicles is one of the most ambitious. The EU was the first of the three largest automotive markets to implement a rigorous phase-out policy, allowing us to gain detailed insights into how such a policy affects incumbents' adaptation to technological change. As such, this case study can provide lessons for other automotive markets, as well as for other industries.

3.1.1 The Policy-Driven Technological Change from Internal Combustion to Electrified Vehicles

From the outset, policy and incumbents have played a significant role in the technological transition from internal combustion engine vehicles to electrified vehicles. As early as 1990, California mandated a zero-emission vehicle sales target for major incumbent automakers, prompting the affected incumbents to introduce the first electrified vehicles of the new era, such as GM's EV1 (Pilkington and Dyerson, 2006). However, the technology did not become competitive, and the policy was amended several times to allow more time for large-scale electric vehicle deployment and alternative technology pathways (Bedsworth and Taylor, 2007; Wesseling et al., 2015a). Eventually, all incumbents temporarily withdrew from battery electric vehicles in the 2000s (Sierzchula et al., 2012).

Nevertheless, the idea of zero-emission vehicles remained, and strong deployment policies spurred rapid market growth for electrified vehicles, from global annual sales of a few thousand in 2010 to more than 10 million in 2022 (IEA, 2023). During this time, new entrants such as Tesla Motors, which has since become a mass-market car manufacturer, and other startups such as Rivian, Lucid Motors, and Nio have emerged. But even in the early years, some incumbents diversified and introduced mass-market electric vehicles such as the Nissan Leaf (launched in 2010), the Renault ZOE (launched in 2012), or the BMW i3 (launched in 2013). Nowadays, most incumbents engage in electrified vehicles. One favorable factor is that while electric vehicles require different knowledge and assets for propulsion technology, complementary assets such as safety technologies, distribution channels, or brand recognition remain relevant resources (Eggers and Park, 2018; Helfat and Lieberman, 2002). Despite these advantages that incumbents had, the pace at which incumbents switched from combustion to electric vehicles remained slow, so regulators introduced additional measures to push companies toward zero-emission vehicles.

3.1.2 EU's Internal Combustion Engine Vehicle Phase-Out Policy

In the EU, an important policy to foster the transition from combustion engines to electric vehicles is the fleet emission standard, which requires carmakers to continually reduce the CO2 emissions of the cars they produce (European Parliament, 2019). Manufacturers that do not meet the emission target mandated by the EU face considerable penalties, implying that there is a strong incentive for car makers to comply with the legislation. Early standards were set

such that car makers could reach them by reducing the emissions of combustion engine cars or raising the share of electric vehicles in the portfolio. In contrast, regulation (EU) 2023/851 of the European Parliament and of the Council of 19 April 2023 amended the fleet-wide average CO_2 emission performance standards for new passenger cars and light commercial vehicles to a reduction target of 100% of average emissions from 2035 (European Parliament, 2023). This 100% reduction represents a de facto technology ban on the market introduction of new conventional internal combustion engine vehicles, enforced through a command-and-control approach. The regulation includes interim targets and allows time for industry and society to adapt, intended to facilitate a gradual transition culminating in a ban from 2035. The EU regulation's policy design is exemplary for a standard policy approach to phase-outs (Trencher et al., 2022), and therefore, understanding this specific policy's impact provides valuable insights beyond the single case.

3.2 Data Collection and Analysis

To collect our data, we drew on two main sources: Industry experts and company representatives. The first source, industry experts, comprised consultants, policymakers, trade unions, think tanks, capital market analysts, and automotive suppliers. Experts were identified by drawing on web research and screening industry reports on the automotive industry's transformation. To collect data on our research question, we then used semi-structured interviews during which we asked respondents to describe the role of the EU phase-out policy: (a) for the automotive industry, (b) for OEMs' corporate strategy, and (c) for business transformation. We also asked about: (d) the reasons for the different attitudes of OEMs towards the policy decision to phase out, (e) the role of geographically heterogeneous policies, and (f) how the policy affects various stakeholders, i.e., capital markets, trade unions, politics, suppliers, or customers. We used the insights from the interviews with industry experts to generate a broad understanding of the impact of the EU phase-out policy on the automotive industry and have an outsider's perspective on the different strategies of incumbent car manufacturers.

The second data source, company representatives, was sampled using theoretical sampling (Eisenhardt and Graebner, 2007). Specifically, to distill the mechanisms connecting phase-out policies and incumbent technology adaptation, we purposefully sampled interviewees from incumbent car manufacturers that differed in their exposure to the policy because (a) the companies differed in the extent to which they had already invested in the electrification of

vehicles and (b) were active in different geographic markets, leading to differences in the importance of EU policy. We interviewed representatives of nine large incumbent car manufacturers listed in ACEA's ranking of new passenger car registrations in the EU in 2022 (ACEA, 2023).

Typically, the company representatives interviewed were part of the senior management responsible for their company's strategy or long-term planning. We discussed how the phase-out policy affected their strategy, underlying processes, and business transformation. In general, we asked respondents how the EU phase-out policy affects: (a) their corporate strategy, including R&D investment, portfolio decisions, production planning, and asset management or workforce planning; (b) underlying strategy processes; (c) business transformation, including change management or employees; (d) external stakeholders, such as capital markets or suppliers, and their interaction with them. In addition, we asked them to describe: (e) how they deal with different regulations in their non-European markets and (f) why their publicly stated policy assessment differs from that of some competitors. In preparation for the interviews, we screened archival data for each company from annual reports, strategy documents, and newspaper articles. We then used the insights to include specific questions about the phase-out policy related to, for example, the companies' public statements, the fit with their stated strategy, the latest strategic decisions, or the importance of the EU market to the company.

In order to triangulate the findings and deepen insights into internal coordination processes and business transformation, we conducted additional interviews with internal stakeholders, i.e., employee representatives. In these interviews, we typically asked about the role of the policy: (a) for employees and them as their representatives, (b) for debates within the workforce and with the general management, and (c) we asked them to describe their role in the transformation process. Similar to the interviews with managers, we screened archival data in the form of press articles, position papers, or strategy documents to tailor questions to the specific interviewee. We usually interviewed one person per organization, as they were very knowledgeable and capable representatives concerning our research question. In sum, we conducted 27 interviews with 28 respondents that lasted between 18 and 83 minutes, with an average duration of 49 minutes[1]. All of the online interviews were audio-recorded and then transcribed.

[1] The interview with Employee Representative B took the form of a written interview. Included in number of interviews but not in calculation of average time.

Table 1: Overview of interviewee sample[2]

Category		No of interviewees	Interviewee codes
Expert interviewees	Consultant	9	Consultant A - Consultant I
	Policy maker	1	Politics A
	Trade union	2	Trade Union A - Trade Union B
	Thinktank	2	Thinktank A - Thinktank B
	Capital market analyst	1	Analyst A
	Automotive supplier	1	Supplier A
	Sum	**16**	
Company interviewees	General management & strategy	9	OEM A – OEM I
	Employee representative	3	Employee Representative A – Employee Representative C
	Sum	**12**	

To derive theoretical insights, we followed an iterative process that alternated between data collection and theory development, and theory development and data coding (Yin, 2017). We initially followed an inductive analysis strategy that increasingly included deductive elements in later stages (Yin, 2017). Specifically, initial interviews were inductively coded regarding the impact of the policy on incumbents using the qualitative data analysis software MaxQDA. Then, the resulting granular coding categories were transferred to an Excel spreadsheet to identify and cluster mechanisms to outline a preliminary framework. The framework was used to refine interview questions to gain more detailed insights into specific mechanisms and challenge emerging propositions. As new evidence emerged, we continually revised and refined the framework and the interview guidelines. Once it became apparent that the impact of mechanisms varied across incumbents, we started to use cross-case pattern comparisons to identify similarities and differences across incumbents (Eisenhardt, 1989). For example, we compared cases of incumbents with a reported high and low impact of the policy to identify differences or cases with a similar impact to identify similarities. This enabled the refinement of firm-level factors in the coding scheme, framework, and interview guidelines. When little additional insight was gained from interviews, the end of the iterative process was reached (Eisenhardt, 1989). In the final stage, the interview transcripts were recoded using closed

[2] An anonymization of the organizations and interviewees was agreed upon with the interviewees, so that no information can be given that could lead to an identification of the interviewees. For this reason, some passages in the quotations that could lead to identification, such as certain years or the naming of countries, had to be edited.

coding categories based on the emerging framework to challenge and strengthen the internal validity of the findings.

4 Findings

In the following, we present our findings on how phase-out policies affect the adaptation of incumbents to technological change. First, we present and describe four impact channels, which we identified, through which phase-out policies affect the adaptation process of incumbents. Second, we account for incumbent heterogeneity and show that the channels are not equally effective for each incumbent but are moderated by firm-level factors.

4.1 Mechanisms of the Phase-Out Policy that Affect Incumbents' Adaptation

Our analysis yielded four impact channels through which phase-out policies affect incumbents' adaptation processes at different stages. The channels are (1) attention, (2) exclusion, (3) forecast, and (4) coordination. In the following sections, we elaborate on the channels in greater detail.

4.1.1 Attention

The first channel through which phase-out policies affect incumbents' adaptation process is attention, i.e., an increased cognitive focus of decision-makers on technology change. Concretely, by implementing a phase-out policy, policymakers draw the attention of incumbent managers and employees to the technology alternatives, which streamlines decision-making processes and increases the willingness to allocate resources to adaptation. In this context, impacts unfold at both the individual and organizational levels.

At the individual level, in the firms we investigated, the phase-out policy highlighted the need for technological change and led to a focus on adaptation measures, even among skeptics within organizations. As OEM G stressed, the phase-out policy "makes it absolutely clear to everyone that the transformation is going to happen, regardless of whether one believes in it or not." This effect goes beyond the EU, as OEM D explained: "Because our headquarters is in [non-EU country], you can talk as much as you want about what we forecast [...], that will not be understood. But if there is a regulation and it says black on white: over. Then the [non-EU

citizen] also accepts that." This individual-level attention is important because, according to several consultants and company representatives, the discussions surrounding the decision processes to adapt and phase out legacy technology were often not purely rational but had a significant emotional component. For example, OEM I expressed: "Well, I think that this decision at one point in time had become or became kind of dogmatic. Well, lots of debates. Should we, should we not, etcetera." This is where the policy "rationalized the discussion very much because it is no longer a question of 'whether,' it is now only a question of 'how' best to do it" (Consultant A).

At the organizational level, the policy then led to a sharp increase in strategic attention to technological change and adaptation measures, going beyond knowledge acquisition to focus on a holistic business transformation for adaptation. Several interviewees emphasized that most incumbent automakers were aware of the technological change and invested in electrification prior to the policy decision. Nonetheless, the phase-out policy "sets completely new priorities in strategic planning, a very clear focus in terms of the business area, meaning the business strategy or the functional or divisional strategies" and for "the allocation of resources" (OEM A). The shift in strategic focus translated into a willingness to devote resources, both financial and time, as expressed by OEM I, "our responsibility is to prepare the company to be at the highest level of competitiveness, being compliant, but of course protecting also our business and our employees' jobs." Importantly, as such, the phase-out policy draws attention to a holistic business transformation, including reconfigurations in "product strategy," "development and investments, [...] supply chain, manufacturing, [...] workforce planning" and "supplier ecosystem" (OEM B, OEM H, OEM I).

In this context, it is noteworthy that some strategic decisions preceded the policy implementation since the incumbent automakers were part of the political process and, as such, were able to anticipate the policy. For instance, OEM I pointed out:" This decision [to pursue battery electric vehicles and phase-out internal combustion engine vehicles] was even taken earlier [before the final vote]."

Table 2: Exemplary quotes – Attention impact channel

Mechanism	Exemplary quote	Source
Individual focus on adaptation	And this is not just changing my process. It starts in the mind because we still have people in the company [...] who think, well, somehow, we are still going to sell the internal combustion engine vehicle. [...] Here, of course, it helps when somebody says very clearly, 2035, whether you like it or not, over and done with. That helps.	OEM D
	It shifted the lines of discussion, of course, so that later on, it was also a question, yes, in part less of a factual discussion and more of an emotional discussion.	Consultant H
	This is also a pretty emotional exit. [...] It is actually not purely rationally driven, also what I experience with my customers. It is not, it is like 50% rational.	Consultant C
	But of course, it did, of course it accelerated the decision-making process that led to the transformation. And, of course, it also silenced the doubters.	OEM G
	Yes, clearly, this is a kind of threshold, so kind of deadline. So, yes, it focuses the company on this target. As said. It is also in a kind of way from a global strategic perspective.	OEM I
Shift in strategic focus	This is a planning premise for us, which means it is quite clear that currently, in the planning itself, there is no doubt left that this exit will happen.	OEM G
	Of course, the legislation affects our market forecasts. And then, of course, the market segments in the area of combustion engines will become smaller. And then, of course, you react to that with a product strategy. You reduce complexity here. And then, of course, that has a corresponding impact on capacities.	OEM B
	Well, um, the phase-out, the ICE [internal combustion engine] phase-out policy obviously plays a significant role within our overall strategy and process developments, right? So, it requires us to shift the focus of both our development and investment into alternative fuel-powered vehicles, but also electric-powered vehicles.	OEM H
	In which technologies do I want to invest? Where do I want to establish myself, in which value chain, where do I want to build up my own competencies? Or where will I outsource these competencies? What business model changes do I need to prepare for?	OEM A
	In a kind way, this phase-out led from an internal perspective to a decision to accelerate potential deadlines and to anticipate them. And at the same time, also, because we are talking about technologies, we are talking about all suppliers, ecosystem also to settle these new ecosystems and of course, you're perfectly aware that one of the key challenges is the battery supply.	OEM I

4.1.2 Exclusion

The second channel through which phase-out policies shape incumbents' technology adaptation is exclusion, i.e., the reduction of viable technological options. Specifically, we find that by setting a phase-out goal for a specific technology, policymakers altered the relative attractiveness of different technological options and, hence, altered firms' investment decisions. It is important to note that while phase-out policies most directly shape the

attractiveness of incumbent technology, they also shape the relative attractiveness of novel technologies since by setting the goal to phase out one technology at a specific point in time, policymakers create a gap, which is usually filled by the technology that is most advanced at that point in time. For example, in the context of the automotive industry, battery electric vehicles benefited most from the phase-out of combustion engines since fuel cell vehicles and e-fuels were not considered mature enough or cost-competitive. In this sense, phase-out policies do not only exclude incumbent technologies but also select novel ones. In the following, we explain in more detail how phase-out policies shape the attractiveness of both incumbent and novel technologies.

Pertaining to incumbent technologies, the exclusion of technologies via phase-out policies diminishes their long-term revenue potential. Since the internal combustion engine vehicles are still "the cash cow" whereas "e-mobility does not yet generate the same high margins as a combustion engine today." (OEM A, Employee Representative A), incentives to allocate resources to the conventional technologies remained high. However, with the policy limiting potential long-term revenues, the incentives for further investment in conventional vehicle products and technology development are significantly reduced. For example, OEM A explained that "certain technologies you just administer. [...] You no longer put all your engineering skills [...] into that." To reduce investments, the incumbents, e.g., narrow their "engine-transmission portfolios" or "utilize existing platforms" for new models (OEM H). In addition, specialized assets for the technology to be phased out are devalued because they are given an expiry date in the asset valuation, which, in this case, "can be cut off in 2035" (Consultant F). Accordingly, the incentives for incumbents to (re)invest in new, long-lived specialized assets are also reduced. In this way, the phase-out policy avoids incumbents' investments in unsustainable technologies and potential stranded assets.

Table 3: Exemplary quotes – Exclusion impact channel

Impact	Exemplary quote	Source
Limited revenues from incumbent technology	It does help our long-term portfolio planning in terms of just reducing the amount of ICE investments that we do, optimization of our body types, of engines, transmissions, technologies that are being used.	OEM H
	Of course, you can also focus your limited resources, one's development budget in order to offer relevant products, relevant services accordingly.	OEM A
	As we are seeing right now, they are pushing it to the point where they are saying that this fully autonomous driving or these advanced features are only going to be available in electric cars, or preferably in electric cars, because it does not pay to build this whole platform on the combustion engine side.	Consultant D
	The clear requirements of the CO2 limit, of course, define the implementation period so clearly that you simply have a regulatory end date in your planning. Otherwise, you could always leave a back door, so to speak, and say, okay, if the customers are still there and I can sell it, then I will also offer it.	OEM C
	We have our own forge [...], engine factories, etc. That is, of course, you can write it off to a large extent.	OEM A
	We are in a phase right now where every player is thinking, okay, where do I actually reinvest, or where do I start phasing out or selling? Because to seriously invest in production now would also mean: Okay, then I have to see it through to the end, or I need a buyer [...] who offers me a very fair price for it. [...]. That is a risky strategy because [...] the assets do not go away easily.	Consultant F
Reduced uncertainty in the era of ferment	I believe that the legislator is the right and probably the only means to say that we simply have to create a stronger movement here, which at the same time will lead to an equal situation in competition so that everyone is affected or has to act accordingly.	Consultant I
	This framework, at one point in time, I think, should maybe have […] given the opportunity to different OEMs to take strategic decisions. But okay, that's it. So now, as I said, we will be compliant. We will have the right technologies to fulfill.	OEM I
	But it does help overall planning in a sense that, yeah, okay, we're going to move towards fully electric vehicles, even though they're currently, what we're missing is a relatively strong infrastructure that would support that development going forward.	OEM H
	I think the technology as such would also drive the transition. But then, of course, the whole environmental aspect and sort of the regulatory part, of course, helps de-risk it.	OEM E
	We are shifting completely to a different technology, and if I did not have this planning security, but if I always had to reckon [...] with the possibility that in the future there might be a different regulation that might push something more in the direction of combustion engines. [...] Then I would have to invest in both technology paths today because I have to remain competitive everywhere. And the companies simply cannot afford to do that.	Consultant F

Pertaining to novel technologies, the exclusion of potential future technology trajectories provides certainty in the era of ferment, which reduces the risk of focusing resources on the most mature technology alternative to internal combustion engines, i.e., battery electric

vehicles. Exclusion affects every player, thus "leveling the field," which leads to convergence of incumbents' strategies, i.e., an incumbent "is not facing someone in the competition who might have a different line-up" (OEM H, Consultant I). This "gives companies the comfort that, […] the whole market is now really moving in this direction. And it minimizes the risk of having to go in two or more directions for powertrain technologies in the long run" (Consultant F). In this way, the policy "helps de-risk" a progressive adaptation strategy (OEM E). Thus, firms can "channel financial flows differently" and "focus on a successive ramp-up of the EV [electric vehicle] share to 100% in Europe by 2035" (Consultant C, OEM G). As a result, the policy allows for faster scaling of the focal technology, enabling companies to achieve economies of scale and benefit from learning effects. In this regard, OEM I explained: "This transition is, of course, spreading, and of course, all the current programs are tackling this EV transition. But in fact, this scale-up effect is not starting in 2030. It is starting already right now by all the launches we are providing."

4.1.3 Forecast

The third channel through which phase-out policies shape incumbents' technology adaptation is forecast, i.e., a better possibility to predict technological change. Specifically, we find that by defining a clear phase-out date for a technology, policymakers facilitate decision-making and adaptation-planning in firms. The impact is achieved through two mechanisms: (1) the fixed point allows backward calculation, and (2) uncertainty is reduced to the medium term.

First, the policy provides a regulatory end date for conventional internal combustion engine vehicles, allowing incumbents to "calculate backward. Now [they] can calculate all of [their] product lines, everything [they] have in development, back to this date and say by when [they] need to be ready to have [their] entire portfolio converted" (Consultant G). For instance, OEM F explained: "2035 is far enough away. There are two model cycles in between. [...] We have very consciously said which car can go fully electric when it is also a question of cost." With typical model lifecycles of around 6-8 years, working backward means that a new internal combustion engine model should be launched no later than 2027 to 2029 to commercialize the full cycle or, as Consultant D put it: "I do not need to set up a completely new platform three years before the 'end' [...] but I can calculate backward so that investments can amortize over the corresponding period." Thus, the end date informs product development, and incumbents can decide not to invest in a new platform but rather to extend the life cycle of their last platform or even to extend the lifecycle of the current platform. Eventually, this means budget allocation

“can be shifted to earlier points in time in the direction of battery electric vehicles, as if one did not know that this date of phase-out already stands” (Consultant D).

Second, the fixed endpoint narrows the possible scenarios to a “temporal slider logic” (Consultant A), which reduces uncertainty about technology shares to the medium term, making it easier for incumbents to plan the reconfiguration of their business. For example, OEM G explained: “There are always some setbacks, there are subsidies that come or go, etc., but these are just statistical fluctuations in the short or medium term. In the long term, the planning must always be that we have exactly 0% internal combustion engines.” So, in strategic planning, “you no longer have to consider so many scenarios, at least for the European market. […] Of course, you can then proceed in a completely different way there” (OEM A). Among other things, knowing the “end goal with a good lead time allows [an incumbent] to develop technologies, negotiate and partner with suppliers. [An incumbent] can make good assumptions about how volumes will evolve, and [an incumbent] can make localization strategies accordingly to get to a competitive, reasonable cost base. Also, to decide the investment in this technology [internal combustion engine vehicles] is no longer profitable, we are pooling our resources in this direction [electric vehicles]” (OEM D). Reduced uncertainty in volume projections then also facilitates workforce transformation, which “is also absolutely key and needs to be settled at the right pace” (OEM I), by making it easier to assess needs at any given time, enabling a “process that can take place over those 15 years without significant social hardship” (OEM A). In sum, the fixed point in forecasts facilitates strategic planning and allows incumbents to make adaptation decisions under less uncertainty, which can then facilitate the incumbent’s adaptation process and avoid potentially stranded assets.

Table 4: Exemplary quotes – Forecast impact channel

Mechanism	Exemplary quote	Source
Possibility to calculate backward	I at least have a clear framework. I can say: 2035, no more selling combustion engines at least not in Europe.	Consultant H
	And, of course, it just makes strategic frameworks and decisions easier. Why is that? Because in the automotive industry, you do not decide every three years what to do with your product portfolio, you have to have extremely long-term planning security. An investment in a plant footprint or a platform goes well beyond seven years.	OEM A
	There might be some impact which affects us and others. And I mean, having a specific end date for combustion engines, of course, makes it easier to have discussions around, well, how much investments are actually reasonable in the old technology given that we're all transitioning to BEV [battery electric vehicles?	OEM E
	The discussion we have then is, [e.g.,] do we rock the party for Euro 7 [...] or leave it alone? [...] That is a switch, on off. And before that, it was a lot more diffuse because you didn't really know, well, maybe the Euro 7 will run for another ten years. And then the question didn't come up about a switch-off. It was always on, and so the question was, how much money do I put into this?	Consultant A
	And in that respect, I think this is an opportunity in this case to create planning certainty, which will, of course, also allow manufacturers to decide not to develop certain model variants anymore.	Consultant D
Reduction of uncertainty to medium-term	The big advantage is that when I have a fixed date, the scenarios no longer fluctuate so much. I always have different scenarios [...], and the initial hypotheses were, before 2015, [...] electromobility, so to speak, 0 to 100.	Consultant A
	[The phase-out policy] helped us with the strategy and provided more clarity, as it had a sufficient lead time.	OEM C
	The question is, of course, how much of each model will I sell? In 2026, 27, 28, 29? [...] So, of course, planning certainty plays a big role when we go into this calculation: When will the customer switch? Of course, we take into account various resources when we plan for the coming years, how much the customer will demand, regulation is one of them. The end goal is clear: 2035, all-electric cars.	OEM D
	This also means that I have planning security. What happens to my plants? What happens to my footprint? Do I have to design a plant to be doubly flexible for a very, very long time? What about my tools? [...] Can I put them in an end-of-life at some point? What about purchase contracts? [...] What about employees? When do I need to retrain them? [...] Or I also mentioned the supplier network. Which suppliers should I still support in the long term?	OEM A
	You save countless hours of internal scenario calculations on what one would mean and what the other would mean. Because when you start to translate that into production planning, and production planning is a very complex thing for an OEM, [...] simply the number of hours and employment potential that can be saved is enormous.	Consultant C
	At the end of the day, of course, the date is also important because it is clear how many electric vehicles I will produce in principle by when, for example, 80 percent electric vehicles by 2030 or so, and then I also know how many employees I will have in principle in these areas.	Employee Representative A

4.1.4 Coordination

The fourth channel through which phase-out policies shape incumbents' technology adaptation is coordination, i.e., the possibility to synchronize activities across different firms and other societal actors. By providing an externally mandated target, the phase-out policy "creates a clear orientation for the industry, for the adjacent suppliers, for the stakeholders, be it society, be it customers" (OEM C), which facilitates an incumbent's adaptation since it helps overcome firm-internal barriers to business transformation and avoid firm-external bottlenecks during the build-up of technology ecosystems.

Internally, the phase-out policy can help align employees behind the decision to adapt the business and foster collaboration with employee representatives, organized internally in work councils or externally in trade unions. In a large company, "the workforce is a reflection of society. The opinions about the exit from the combustion engine are thus as diverse as those of the general population" (Employee Representative B). Therefore, "there has to be a date so that these thousands of people, who may have their own personal doubts as to whether this is the right thing to do, can be moved in the right direction." (Consultant B). However, it is not that employees and their representatives should be seen as primarily opposing business transformation. Rather, some unions "have been pushing for a while now to engage more intensively with other forms of propulsion, to invest more and to pick up the pace" (Trade Union A). The discussions with employee representatives are "now a matter of finding a way that is compatible with the company on the one hand, but also with the employees on the other. [...]" (Consultant A). In this context, phase-out policies create a "level of clarity [which] really helps to kind of structure the discussion" and is "incredibly helpful" (Trade Union B, Consultant A). In addition, depending on the level of organization, works councils can even act as change agents, with the phase-out policy being an important guideline. In this respect, Employee Representative B explained: "As a works council, clear and long-term guidelines help us. This is the only way we can decide which job profiles we need, how we can help our colleagues get the qualifications they need, and with what value-added we can keep employment attractive and stable. Clarity and transparency create trust and also help us in communicating to the workforce." In short, the policy can help coordinate with employees in several ways: as an argument for the need for transformation, in discussions with employee representatives, and as a guide for their role as a change agent.

Externally, the phase-out policy can facilitate the adaptation of the incumbents by helping to coordinate with external stakeholders on the uptake of the ecosystem, such as complementary infrastructure, new supplier competencies, or capital provision, which are (partly) beyond the direct influence of the individual automaker. This is highly relevant because "it is not only a tech transition […], a whole ecosystem needs to be embraced, needs to be implemented" (OEM I). Consultant I emphasized in this regard: "But it certainly needs this phase-out situation so that this is really done by all those involved in the ecosystem." Similarly, OEM C explained: "If we as a large manufacturer fix a specific year, some other OEMs also do this, and policymakers also agree, then I think it is clear for everyone: In this corridor, there will be a complete shift to sustainable mobility." This then provides a degree of certainty also for infrastructure investments, as OEM E explained: "over a five-year cycle, the fleet will grow significantly. So, I think you can always discuss when the time is right to invest. But if you take a five-year perspective, then I think there should be a comfort around it."

With respect to (large) suppliers, who are external providers of value to the automaker, many of the functions that drive adaptation discussed earlier can be transferred to some extent. For instance, even though suppliers are indirectly affected by the regulation, the forecast impact channel is still relevant, as explained by Supplier A: "If we know concrete phase-out dates, that, of course, makes it much easier to model the situation and to deal with the transformation, with the transition, than if it were some kind of relatively wild transitional phase arising from market dynamics." One peculiarity, however, is that the internal combustion engine technology could be a profit pool for suppliers for a longer time because the adaptation of the established car manufacturers to new technologies is accompanied by "outsourcing of technologies, investments to suppliers. [...] This is a massive change [...] also driven by policy and its framework" (Consultant H).

Table 5: Exemplary quotes – Coordination impact channel

Mechanism	Exemplary quote	Source
Alignment of employees (representatives) with business transformation	Well, we need to sell electric vehicles. So yeah, in terms of internal development, everybody is aware and, you know, our strategy takes that into account. We make sure to communicate and we are communicating our long-term strategy to our all of our internal personnel, including our subsidiaries and distributors.	OEM H
	It is definitely a very good argument to say, guys, there is no other way. You have to adjust to it.	OEM A
	It wouldn't make any sense for us as trade unions to oppose decarbonization policies, to oppose electrification. It's happening anyway. Investments are taking place. And instead of just trying to stop something which is unstoppable […], we have been trying for years to have what we call a just transition.	Trade Union B
	A definite end date for all manufacturers under the same conditions helps us - provided it is reliable and thus predictable. As a works council, we can then concentrate fully on new technologies and set the course for electric drive trains, digital manufacturing processes, software and hardware requirements, and additional value-creation potential.	Employee Representative B
	This is the process that we actively influence, i.e., from technology to personnel, from qualification to the target function. And in between, we move both in terms of content with our tasks as a works council, but also as a training consultant and situation counselor.	Employee Representative C
Facilitating coordination of technology ecosystem uptake	And then one does a little bit of hydrogen, another does a little bit of E-fuels, another does a little bit of hybrids, nobody builds enough charging stations, and in the end, you have a system that is not moving forward. So, I think I have to send out a relatively clear signal that, of course, Fit for 55 has accelerated a lot.	Analyst A
	Our suppliers also have to change over a long period of time, and you must not forget what is involved, [which] is a lot of external value added. They also need a clear direction.	OEM C
	Of course, with this hard line 2035, you have a very, very much more concrete starting point to talk to customers and to get a practical idea of what they want.	Supplier A
	You will certainly get closer to the goal step by step, and then you will probably see over time how well the manufacturers get there. And there, they are actually relatively strong when they set a goal that they then also implement it because there is also a financial market behind it, which, of course, also analyses it and looks at it.	Consultant I
	What the capital markets want: I want subsidies, and I want clear rules. I want my companies not to waste money in the wrong direction. That is why good regulation is important.	Analyst A

In terms of coordination with the capital market, the policy increases the credibility of the transition for investors, which in turn emphasizes the need for incumbents to adapt. For example, Analyst A explained: "When we consider charging infrastructure or grid expansion or so, it is, of course, much easier to imagine [...] that there is [...] a large pot of money that is

thrown at the problem when the regulator has clearly said that this is what is happening." Therefore, with the phase-out policy, "it is even clearer for all capital market players that the transition to electric mobility will take place," which also means that incumbents need an "equity story" that explains "how do I manage this transition" (Consultant D). In this way, the capital market becomes the supervisor of incumbents' adaptation and thus "helps policymakers to enforce the regulation" (Consultant B).

In sum, the phase-out policy can help incumbents coordinate internally and externally to facilitate a smooth ramp-up of the technology ecosystem, thereby avoiding some bottlenecks that might slow the transition. However, it is not a silver bullet in this regard. Despite the phase-out policy, incumbents have repeatedly expressed concerns that access to raw materials, charging infrastructure, and customer acceptance are or might become bottlenecks.

4.2 Firm-Level Moderators

In the first section, we have outlined the general impact channels and their mechanisms. However, these channels do not have the same relevance and influence for all incumbents. We found three internal factors, namely the firm's (1) progress in adaptation, (2) coverage of heterogeneous markets, and (3) lack of perceived policy credibility, as moderators that reduce the relevance or magnitude of specific impacts on the firm's adaptation to technological change. We discuss each of them in more detail below.

4.2.1 The Impact of Firms' Progress in Adaption on the Role of Impact Channels

First and foremost, the impact of phase-out policies on incumbent adaptation decisively depends on the extent to which firms had adapted to the technology prior to the implementation of the policy. Most importantly, if firms have previously adjusted, the attention channel becomes less important.

As outlined in the research setting, technological change was already underway, and partly, incumbents were strongly engaged when the EU policy was enforced. So "a lot of companies [...] have already anticipated this ahead of time," which is why "they do not have the pressure now" (Consultant G). Others "have relied primarily on combustion technology. And, of course, those have to make considerable efforts to manage this transformation." (OEM A). For those firms that had previously adapted, discussions and strategic attention to electromobility often have passed a stage where the attention impact channel played a significant role. The other

impact channels and their mechanisms remain relevant. However, in the cases of exclusion and forecasts, the impact can be seen as a validation of strategic decisions and adaptation measures rather than a driving force. In this respect, Consultant A explained that some incumbents are dependent on the upcoming phase-out because they "have already stopped investing in the development of combustion engines in 2016 [...]". Or as OEM C puts it: "[The phase-out policy] has not altered our strategy, but it has reinforced or underpinned it."

4.2.2 The Impact of Firms' Coverage of Heterogeneous Markets on the Role of Impact Channels

Second, the coverage of heterogeneous markets is a relevant moderator of the impact of the phase-out policy. The policy is tied to the EU market, and even though other markets are also making the transition, they are changing at a slower pace and mainly without a phase-out target. For Eurocentric firms, the four impact channels unfold their full potential, such that the "phase-out decision can also lead to a competitive advantage" (OEM A). However, incumbents serving slower-transitioning markets have to cope with different regulatory frameworks, which reduces the magnitude of the effects of the attention and exclusion impact channels. The impacts of the forecasting and coordination channels remain. Still, as they are subject to the European market, their relevance for the incumbent apparently depends on the respective importance of the European market.

In terms of the attention impact channel, heterogeneous markets lead many multinational incumbents to maintain some strategic focus on internal combustion engine technology. For example, OEM B emphasized: "As a global company, you have to have a global product strategy. [...] Ultimately, the overlap of all these regulations [in different markets] is the decisive influence on the product strategy. Similarly, OEM C stated: "There are different estimates of the pace of transformation from region to region. We then incorporate these into a strategic ten-year plan and adjust plants, products, and models in the markets accordingly. So, it is not easy for us to give an end-end date. Nevertheless, the push for attention to electromobility remains strong because, as OEM D underscores: "Of course, it remains a strategically important market. It is not a market we can ignore. We need it, and we also see it as a forerunner of what will happen in other regions sooner or later."

In terms of the exclusion impact channel, the coverage of heterogeneous markets leads to a lower constraint on the potential revenue from internal combustion engines. At the same time,

the reduced uncertainty in the era of ferment remains and might have a spillover effect on other markets. If an incumbent operates in markets transforming at a slower pace, then "combustion engines are also a cash cow for them for a long time" (OEM G). Thus, a complete phase-out of internal combustion engines is often not perceived as feasible. For example, OEM A stressed: "That is not possible. Otherwise, we will lose entire markets, and losing entire markets means losing contribution margin volume [which] means that we are not in a position to fully manage the transformation." Thus, this exclusion mechanism on the combustion engine vehicle side is partially offset by other markets, and incumbents might continue to invest in this technology or choose to build on flexible platforms to cater to different markets. At the same time, on the future technology side of the exclusion channel, the European phase-out policy favoring battery electric vehicles is unaffected by slower transforming markets but rather is likely to have a spillover effect on the incumbents' other markets if scaling and learning effects strengthen the competitive position of the technologies relative to potential alternatives.

4.2.3 The Impact of a Firm's Perceived Lack of Policy Credibility on the Role of Impact Channels

Finally, beyond the incumbent's progress in adaptation and coverage of heterogeneous markets, we find that a perceived lack of policy credibility is a relevant moderating factor. We deliberately refer to this as a *perceived* lack of credibility to emphasize that it is a subjective assessment based on individual or organizationally shared perceptions. To illustrate, roll-out infrastructure, access to raw materials, geopolitical struggles, and the 2026 policy revision are among the most frequently named uncertainties. While OEM G stated: "this does not lead to anyone seriously questioning the fact that no cars with CO_2 emissions can be sold in Europe after 2035," OEM B reached a different conclusion: "From our point of view, these are not necessarily solved issues from today's perspective. It can work, but it does not have to work." We then find that a perceived lack of credibility has less of an effect on attention to adaptation but a strong effect on the effectiveness of the exclusion and forecast channels, which leads to the retention of strategic flexibility. In short, it does not affect whether incumbents adapt but how they adapt.

Table 6: Exemplary quotes – Firm-level moderators

Moderator	Exemplary quote	Source
Progress in adaption	The more in this direction has been thought, or the strategy has been laid out, the more positively it will be received. A pure electric car player will naturally only welcome this in case of doubt. Someone who has been particularly strong in the internal combustion area will have a harder time.	Consultant D
	How do I prepare myself for this competition, which is being fueled to the maximum, in which capacities simply become obsolete but are still there? Machines that can only produce, but for which there is no more demand [...]. Some companies, I think, have made very smart decisions. And others have waited. And those are the ones that are now being driven, so to speak.	Consultant A
	Many OEMs had already set their own goals to get out ahead of time. Others, I would say, may have to be forced into their luck. That means that it has to be 35 or that they have to convert virtually their entire fleet or their entire portfolio by 35, which is quite a challenge.	Consultant G
	It doesn't play any role because we already set our ambition […]. So that means that by 35, we will for sure be fully electric and have been so for a number of years.	OEM E
	We committed to Paris relatively early on, so if you do the math, we always end up at a point like this. Nevertheless, it was an important milestone that this is also being supported and implemented politically. Because I think what everyone needs, customers as well as industry, is clarity.	OEM C
Coverage of heterogenous markets	First of all, Europe is not the world. We are a global player. If I look at markets like Korea, India, Japan, I do not know whether I will be 100% BEV in 2035. So, I need a product strategy that can deal with different regions and different pace of transformation	OEM B
	Well, of course. I mean, going forward in Europe, we will become fully electric by the period, even earlier, depends on the legislation in certain markets. But so globally, it doesn't make any sense to do that because, you know, how do you cater to the needs of markets that are not electrified?	OEM H
	And we are bundling all our activities for internal-combustion engines because it is clear that if internal-combustion engines are phased out in Europe, their volume will have to be withdrawn from the international markets. We still expect that up to the year 2050, quite essential shares of internal combustion engines will be sold.	OEM G
	We are a global player, and all the regions are not going at the same pace to this electrification. And so, we are not aiming to develop specific platforms, specific technologies for specific regions, because if we do that, we just multiply the overall R&D and Capex spending. So, this is why keeping these capabilities is also a way to have shared platforms, but which are able to support products which will be sold, for example, in [Region], as we will only sell those platforms and those vehicles with the BEV versions in Europe.	OEM I
	The difficulty that we actually have is that we talk about double investments all the time, while we have overcapacities in some cases, and we have to be very careful about what we produce where for which market over the next four years.	OEM D

Table 6: Exemplary quotes – Firm-level moderators (ctd.)

Moderator	Exemplary quote	Source
Perceived lack of credibility	I think the target will remain. I don't see any reason why it should be abolished. I mean, if you look at all the communications from the various OEMs, they're all sort of aligning with the targets. So, I'm not concerned about that.	OEM E
	A year ago, it would have been almost irrelevant, but now, where a little bit of skepticism comes up, like: Is this really happening so fast with the electric transformation? [...] But [with the phase-out policy] it was always clear [...] this is not a reversal of the trend, and that is exactly how it is being treated.	OEM G
	It would be great if there was a sense of unity also among the European countries. But, you know, obviously, this is a matter of cost […] I'm sure that countries will find ways which either delays or some loopholes to prolong the phase-out	OEM H
	So even if [incumbent's platforms] are, of course, supporting best-in-class competition in terms of EV design architectures, we still have this ICE compatibility, which means that at one point in time, we within our [...] platform tech portfolio, we will have the ability to adapt. So, right now, the decision has been taken. Company has taken the strong commitment [to battery electric vehicles]. No, no deviation. And after that, let's see.	OEM I
	I have a benefit side that is opposite to the cost side, and especially in a scenario where electric mobility grows more slowly, this benefit side is even greater. In other words, it is basically a bit of an insurance premium that is included for a potential market that could still be there in a certain scenario.	OEM B

On the one hand, with high perceived credibility, recent setbacks in the transformation do not lead to uncertainty about the long-term development and more extensive strategic adjustments but can be seen as "just a dent" (OEM G). On the other hand, if an incumbent does not perceive the policy as reliable and expects it to change depending on environmental conditions, then the exclusion and forecast impact channels are way less effective. This is because these companies perceive the end of the internal combustion engine in the EU to be somewhat uncertain and are considering scenarios where 2035 is not the end date. Companies are therefore incentivized to adopt a more flexible product strategy, e.g., hybrid platforms, and to hold on to certain assets, e.g., (flexible) production capacity, to "keep the ability to operate depending on the external constraints" (OEM I). This gives companies a prospective advantage if market uptake is slower than predicted. Still, it also comes at the cost of an "insurance premium," e.g., in the form of "more complexity and also more tension in the whole system. On the development side itself, but also to some extent on the production side" (OEM B).

4.3 Emerging Theoretical Framework

Summarizing our findings, the emerging theoretical framework in Figure 1 illustrates how phase-out policies affect incumbents' adaptation to technological change. Our results provide evidence that the phase-out policy (1) fosters incumbents' adaptation to technological change (4), i.e., acquisition and integration of new resources or business reconfiguration, through four impact channels (2) – attention, forecast, exclusion, coordination – and that three firm-level factors (3) can reduce the magnitude of specific channels.

First, we find that the phase-out policy (1) can focus the attention of individuals and, at a higher level, firms on adaptation to alternative technologies (2a), leading to more efficient decision-making and increased willingness to allocate resources to adaptation also at the expense of conventional technology (4). The magnitude of the impact depends on two firm-level moderators. On the one hand, the more progressive firms are in adaptation (3a), the less they are affected, as they may have settled discussions and adaptation strategies. On the other hand, the extent of an incumbent's coverage of heterogeneous markets (3b) reduces the impact because overall strategies then take into account slower-transitioning markets. Interestingly, our results suggest that perceived credibility (3c) is not a moderator of the attention impact channel, as it affects how incumbents adapt rather than whether they adapt.

Second, the phase-out policy (1) unfolds an impact through the exclusion of potential future technology trajectories, providing certainty in the era of ferment (2b). This reduces incentives to invest in conventional technologies and encourages more progressive adaptation strategies by favoring the most mature technology, leading to a convergence of incumbents' strategies that reduces the risk of focusing on a single technology trajectory (4). The impact is somewhat reduced by the coverage of heterogeneous markets (3b), as conventional vehicles may generate a relevant profit stream for incumbents established in slower transitioning markets beyond 2035. Moreover, a perceived lack of credibility of the policy (3c) changes the impact in that incumbents may pursue more flexible strategies that maintain the capability to continue the internal combustion engine trajectory at the cost of inefficiencies, e.g., in production or platform design.

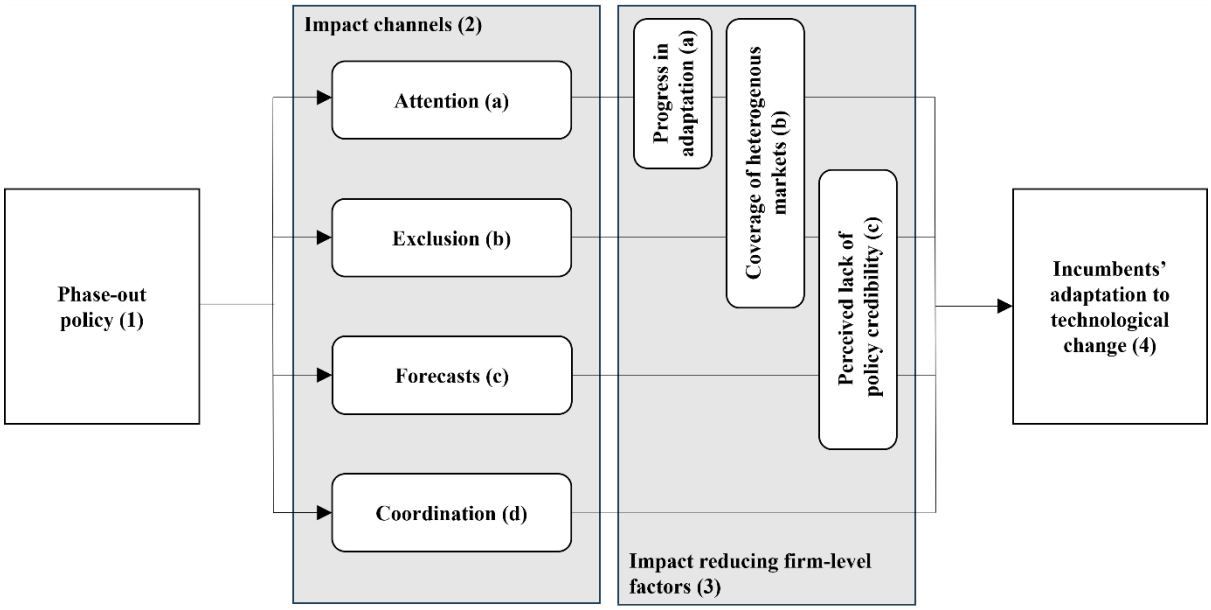

Figure 1: Emerging framework describing how phase-out policies impact incumbents' adaptation to technological change

Third, the end date of the phase-out policy (1) provides a reference point for forecasting that reduces uncertainty about the transition timeline (2c), in addition to the increased certainty about technology trajectories provided by the exclusion. This allows incumbents to make well-informed investment decisions, e.g., by back-calculating investments, and reduces the volatility of the technological substitution to the medium term, allowing incumbents to plan their business transformation, e.g., in terms of production facilities, workforce or supplier networks, with less uncertainty (4). The impact is counteracted when there is a perceived lack of credibility in the phase-out policy (3c). In this case, the end date stated by the policy does not (fully) function as a fixed reference point.

Fourth, the phase-out policy (1) facilitates coordination of incumbents with their internal, e.g., employees, and external stakeholders, e.g., complementors, suppliers, or capital markets, by providing an externally mandated target (2d). This can reduce internal barriers to adaptation measures and allow for a smoother ramp-up of the technology ecosystem (4). Here, capital markets play a unique role in both enabling and monitoring the transformation of the business at the same time.

5 Discussion

In the following sections, we discuss the implications of our findings for the existing literature and provide suggestions for future policymaking.

5.1 Implications for the Literature

Our study makes at least three contributions to the literature on sustainability transitions, incumbents' adaptation to technological change, and phase-out policies.

5.1.1 Implications for Sustainability Transitions

First, we show that phase-out policies, in the form of command-and-control regulation, stimulate and facilitate incumbents' reorientation towards more sustainable technologies. In this way, incumbents can become accelerators of sustainability transitions (e.g., Turnheim and Sovacool, 2020). Previous studies have shown that innovation policies, such as demand-pull and technology-push policies, can drive firms' innovation activities (Beck et al., 2016; Hoppmann et al., 2013) but that incumbents respond heterogeneously depending on firm-level incentives to exploit market opportunities and due to prior commitments (Luetkehaus, 2024; Wesseling et al., 2015b). In our case study, we find that despite the implementation of such innovation policies and the fact that most incumbents are already engaged in the electric vehicle niche, the phase-out policy has a significant impact on the firms.

On the one hand, we show that a phase-out policy leads to strong adjustments in the strategic attention of incumbents, with the effect being strongest for firms that are less advanced in their adaptation. As a result, a momentum for transitions is created that goes beyond the engagement of early movers in new technologies, which is argued to be highly relevant for socio-technological transitions (Geels, 2021). On the other hand, we find that the policy facilitates incumbents' adaptation not only in terms of innovation activities but also in terms of a more holistic transformation of their business activities, including portfolios, production, workforce, and the broader ecosystem. By providing greater certainty to incumbents and stakeholders about the future technology trajectory and timing of the transition, the phase-out policy makes the transition more predictable, which may also help mitigate some of the negative societal impacts of the transition, e.g., by transforming the incumbent's workforce with less social hardship. However, we also find that the phase-out policy is not a silver bullet for the transition

to more sustainable vehicle technology, as incumbents' responses also depend on their assessment of the reliability of the policy and bottlenecks in the technology ecosystem, such as access to raw materials, lack of complementarities, or low consumer acceptance, may still hinder the uptake of new technologies (e.g., Adner and Kapoor, 2016; Singh et al., 2020).

Moreover, previous literature has argued that "destructive" policies, such as command and control phase-out policies, are important building blocks of a broader policy mix that drives the transition to more sustainable technology (Kivimaa and Kern, 2016). Our results provide empirical support for this argument. However, our results also show that the phase-out policy is only destabilizing in this sense of technology substitution, while it may help incumbents renew their position as dominant actors. Thus, phase-out policies may be particularly beneficial with respect to a transformation pathway of transitions that builds on the reorientation of incumbents, while they may be less effective if a substitution pathway that replaces incumbents with new entrants is preferred (see Geels et al., 2016). For example, in the case of this study, the policy does not promote the replacement of individual mobility by other forms of mobility. Yet, it has certainly pushed incumbents to be more proactive in the transition to electric vehicles.

5.1.2 Implications for Incumbents' Adaptation to Technological Change

Second, we provide empirical evidence that phase-out policies can address several inertial mechanisms and thus facilitate incumbents' adaptation to technological change. So far, the previous literature has examined how demand-pull or technology-push policies affect firm adaptation, for example, with respect to innovation activities (Beck et al., 2016; Hoppmann et al., 2013; Luetkehaus, 2024; Nemet, 2009) or knowledge search behavior (Hoppmann et al., 2021). We contribute to this literature by extending the scope to include phase-out policies.

To begin with, our results show that the phase-out policy can focus managers' attention on the pursuit of technology alternatives, for which previous work has shown that it has a relevant influence on the incumbent's adaptation (Kaplan, 2008). In addition, institutional exclusion of the incumbent technology as a future technology trajectory (for a large market) reduces the longer-term potential revenues from the established technology and devalues corresponding specialized assets and resources. In this way, the disincentives stemming from cannibalization of one's own products and resources by adaptation (e.g., Chandy and Tellis, 1998; Eggers and Park, 2018) are significantly reduced as this is increasingly (with decreasing time to technology

ban) preempted by the policy. This can be particularly important in cases such as the shift to electrified vehicles, where incumbents' profit margins for new products have been lower than the margins of legacy products. Furthermore, coordination of the technology ecosystem can enable a more even ramp-up, which reduces the propensity of bottlenecks impeding incumbents' possibility of capturing value from the new technology. Moreover, inertia from (intertwined) routines and organizational identity (Gilbert, 2005; Tripsas, 2009) may be easier to overcome when managerial endeavors for adaptation align with internal and external stakeholders, e.g., employee representatives acting as change agents or capital markets demanding adaptation strategies.

While phase-out policies can address several inertial mechanisms and thereby increase the likelihood of incumbents' survival and success in the face of technological change, they do not affect all firms equally. Our results suggest that early-moving incumbents may be less affected in terms of shifting attention and strategy but may benefit from the other impact channels – exclusion, forecasting, and coordination. Since policies are typically tied to specific jurisdictions, the magnitude of some policy effects is reduced for incumbents serving different markets with heterogeneous regulations. Finally, we find that managers' cognition of policy credibility is a mechanism that leads to less efficient adaptation measures, such as flexible production facilities or platforms, which, in turn, may pay off when policies are revised.

5.1.3 Implications for Phase-Out Policy Literature

Third, we contribute to the emerging literature on phase-out policies with an in-depth case study of the impact of a command-and-control phase-out policy on incumbent manufacturers and our emerging theoretical framework of impact channels and firm-level moderators. Besides our theoretical framework, we complement the insights of previous work in two important ways. First, contrasting our results with previous work highlights that the relevance of phase-out policy mechanisms depends on firms' technology portfolios, which may result in new challenges in ecosystem uptake. In the German nuclear phase-out context, Rogge and Johnstone (2017) find that the phase-out policy affects manufacturers of technology alternatives via demand-pull mechanisms, i.e., by increasing firms' market expectations for renewable energy technologies. Our case study shows that phase-out policies have yet another similarity to demand-pull policies in favoring more mature technologies (Hoppmann et al., 2013; Nemet, 2009). However, while we find similar demand-pull mechanisms for incumbents, the "destructive" mechanism, i.e., the exclusion of legacy technology options, is shown to be

highly important. That is, while incumbents need to transform their entire business, successively replacing the legacy product with technology alternatives to stay in the market, new actors in the automotive ecosystem, such as charging infrastructure providers and battery technology suppliers, move due to market opportunities. This divergence in the nature of policy mechanisms could have important consequences. For example, we could imagine complementary infrastructure providers cherry-picking locations, given the abundance of market opportunities. At the same time, incumbent firms and the large-scale transition depend on the ubiquitous provision of infrastructure.

Second, we find that a phase-out policy may suffer from a perceived lack of credibility, e.g., due to concerns about ecosystem uptake, i.e., insufficient infrastructure, and enabling conditions, i.e., access to raw materials. Policymakers can address this by adding policy strategies and instruments to the policy mix that address such bottlenecks to the production and adaptation of new technology. This extends previous findings that phase-out policies are highly beneficial for the credibility of the policy mix (Rogge and Dütschke, 2018) by showing that the relationship between phase-out policies and the overall policy mix (credibility) is not unidirectional but interdependent.

5.2 Implications for Future Policymaking

Our study has several important implications for policymakers regarding the use and design of phase-out policies. Most strikingly, the preceding discussion of our findings shows that phase-out policies, in the form of command-and-control type policies, can be very effective in accelerating the transition to more sustainable technologies. At the same time, phase-out policies address inertia mechanisms that limit the ability of incumbents to adapt to new technologies, even when it may be economically beneficial to do so. This increases the likelihood that incumbent firms will survive or even thrive in the transition, which may, to some extent, mitigate potential negative societal consequences of the transitions, e.g., job losses or structural breaks in economies with strong domestic car industries. Thus, phase-out policies can also be regarded as a form of industrial policy that helps car-producing countries to renew or upgrade their incumbent industry (Meckling and Nahm, 2019). This also challenges claims that phase-out policies are inefficient or unnecessary, based on the notion that firms are capable of finding the most efficient way to reduce emissions, as we find that the policy not only pushes incumbents to adapt but also facilitates their adaptation.

Despite these benefits, policymakers should consider the potential for technology lock-in, as phase-out policies, like demand-pull policies, favor more mature technologies (see also Hoppmann et al., 2013; Schmidt et al., 2016). As argued in previous work, convergence to a dominant technology design may actually be a prerequisite for incumbents to reorient and should not be considered detrimental in all cases (Penna and Geels, 2015). Our analysis supports this notion by showing that the exclusion of technology trajectories is an important channel for incumbents to adapt. Nevertheless, the timing of phase-out policies can serve as a selection criterion for technology trajectories. This should be kept in mind, especially when technology requires infrastructure investments that can lead to strong lock-ins.

Moreover, in an industry with multinational firms, the impact of a phase-out policy in one market is somewhat reduced by heterogeneous regulation in other markets. Therefore, implementing (equal) phase-out targets in other jurisdictions may benefit the transition beyond the single markets.

In addition, in our case study, some incumbents' perceived lack of credibility emerged as a relevant factor in the impact of policy, leading respective incumbents to hedge or even bet on policy adjustments. This suggests to policymakers that policy design, e.g., planned revision, should be carefully considered concerning potential impacts on policy credibility and that continued efforts to secure enabling conditions for transitions, e.g., in the case of electric vehicles, access to raw materials, or complementary infrastructure, are essential. Finally, once incumbents have started to plan and implement their business transformations with phase-out dates as a reference point, reversing or prolonging implemented policies could be very detrimental to them, as some adaptation measures may be difficult to reverse, e.g., platform development decisions or reconfiguration of production facilities. This is very much in line with the public protest by many incumbent carmakers against the announced changes to the UK phase-out policy (Winton, 2023).

6 Limitations and Future Research

Our study has at least three limitations that provide promising avenues for future research. First, we chose to study the European phase-out policy in the automotive market, which is highly relevant from a climate change perspective and provides important insights for the ongoing transition in this sector, providing relevant policy implications. However, the

automotive market is a complex product market where suppliers and complements are highly important. Thus, due to the focus on a single industry, it remains uncertain to what extent the findings are transferable to distinct industries, e.g., the energy market as a commodity market or the lighting market as a less complex product market. Therefore, future research should examine how phase-out policies in different industries affect incumbents' adaptation to technological change to replicate or contrast our findings and deepen our understanding of policy impacts.

Second, contrasting our results with previous work revealed that phase-out policies show structural differences in the nature of impacts for different (firm) actors. Additional research is needed to shed light on the consequences of these differences, if any, for example, with respect to the uptake of the technology ecosystem, which cannot be demonstrated in our work due to the focus on incumbent automakers in our sample.

Third, focusing on the impact of phase-out policies on incumbents' adaptation allowed us to elaborate on granular mechanisms but also raised new questions that our research design could not address. For example, we found that the perceived credibility of the phase-out policy differed significantly between incumbents despite similar institutional contexts. This suggests that the credibility of a policy mix may be shaped not only by the elements and characteristics of the policy mix (Rogge and Dütschke, 2018) but also by the characteristics of policy recipients. Promising starting points could be exploring the relationships with top management characteristics (Hambrick and Mason, 1984) or organizational routines and identity (Gilbert, 2005; Tripsas, 2009).

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