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What makes them believe in the low-carbon energy transition? Exploring corporate perceptions of the credibility of climate policy mixes

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ABSTRACT

The credibility of climate policy has been identified as paramount factor for low-carbon investment and innovation and is thus key to achieving the decarbonization objectives set out in the Paris Agreement. Yet, despite its importance, we have only limited insights at present into how such policy credibility is formed. To address this gap, we explore whether and to what extent corporate perceptions of policy credibility depend on the current policy mix. We draw on the case of the German *Energiewende* and rely on data collected in 2014 in a survey of German manufacturers of renewable power generation technologies. We analyzed the answers of 390 companies using a linear regression model and found that corporate perceptions of policy credibility are mainly shaped by two characteristics of the policy mix: the coherence of policymaking and implementation, and the consistency of the policy mix. Changes in the design of the core demand-pull instrument (in Germany, the Renewable Energy Sources Act, EEG) and the nuclear phase-out policy are also important as are Germany's targets for the expansion of renewable energies. These insights enable us to derive broader policy and research implications concerning climate policy credibility.

1. Introduction

Policy credibility has been identified to be of paramount importance for the low-carbon innovation and long-term investments needed to decarbonize the economy, and achieve the climate targets set out in the Paris Agreement (Bosetti and Victor, 2011; Nemet et al., 2017). Correspondingly, there is an emerging body of literature discussing options for how to strengthen and assess such climate policy credibility (Brunner et al., 2012). However, so far, this literature has mainly focused on institutional design as a determinant of credibility (McGregor et al., 2012; Grosjean et al., 2014), with only limited attention paid to the role of concrete policy action (Nemet et al., 2014; Jakob, 2017).

Credibility has also started to receive greater attention in the context of governing fundamental transformations towards more sustainable modes of production and consumption (Markard et al., 2012; Rogge et al., 2017). In particular, it has been proposed as a key characteristic of policy mixes for sustainability transitions, capturing how believable and reliable a policy mix is (Rogge and Reichardt, 2016). Early empirical work confirms that policy mix credibility is important for low-carbon innovation, but that other aspects also play a key role such as consistency and stability (Reichardt and Rogge, 2016; Uyarra et al., 2016).

However, we have limited empirical insights into how such credibility is related to the policy mix governing the decarbonization of the energy system (Nemet et al., 2014; Nemet et al., 2017). Therefore, in this paper, we take a first step towards closing this research gap by investigating whether and to what extent various aspects of the policy mix are related to corporate perceptions of its overall credibility. Building on Rogge and Reichardt (2016), we develop an analytical framework which differentiates between the *elements* - policy targets, instruments and their design features - and *characteristics* of policy mixes - comprehensiveness, consistency and coherence - as key determinants of credibility.

As a research case, we chose the transition of the German electricity system to renewable energies, the so-called *Energiewende*, as this is ideally suited to provide exploratory insights into a globally relevant phenomenon given Germany's pioneering role in low-carbon energy transitions (Strunz, 2014; Quitzow et al., 2016). Drawing on company survey data, we psychometrically explore the perceptions of German

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manufacturers of renewable power generation technologies regarding the credibility of the corresponding policy mix. We discuss the implications of our findings for the policy design categories developed by Nemet et al. (2017).

The remainder of the paper is structured as follows. In Section 2, we review the literatures on climate policy credibility and on policy mixes for sustainability transitions. Based on this, we develop our analytical framework in Section 3. We then present the research case of the German Energiewende in Section 4 and our methodology in Section 5. Our findings are presented in Section 6, followed by their discussion in Section 7. We close by providing conclusions in Section 8.

2. Literature review

2.1. Climate policy credibility

The notion of policy credibility can be traced back to a seminal article by Kydland and Prescott (1977) and has been applied in various policy fields, such as monetary and fiscal policy (Persson and Tabellini, 1990; Drazen and Masson, 1994) and antitrust policy (Gheventer, 2004). Climate economists have also identified policy credibility as a key area of research (Toman, 1998). For example, Brunner et al. (2012) argue that governments – when faced with a lack of reputation – can deliberately engineer institutional commitment devices to enhance the level of policy commitment. Most recently, Nemet et al. (2017) proposed the following four categories to assess the credibility of the climate targets pledged under the Paris Agreement: institutional, procedural, political and instrumental determinants of credibility.

The increased attention to climate policy credibility is justified by the modeling results that highlight the outstanding relevance of credibility for low-carbon innovation and investment. As shown by Bosetti and Victor (2011), a lack of regulatory credibility significantly increases the costs of climate mitigation, as actors behave in a short-sighted way and make suboptimal investments in R&D and long-lived technologies. This finding is supported by Cian et al. (2012) with regard to the 2020 climate target and by Faehn and Isaksen (2016) for the example of Norway.

However, the definitions of credibility vary across studies, even within the subset dealing with climate policy credibility (Helm, 2003; Brunner et al., 2012; Jakob, 2017; Nemet et al., 2017).[1] Some studies have not explicitly defined policy credibility (Boehmer-Christiansen, 1990; Jacobs, 2016), whereas others use the term fairly loosely, often overlapping it with other concepts (Brunetti et al., 1998; van der Ven, 2015; Faehn and Isaksen, 2016), such as regulatory uncertainty (Engau and Hoffmann, 2009) or predictability (Kemp and Pontoglio, 2011).

More importantly - and despite the recognition of the paramount relevance of climate policy credibility for low-carbon transitions - we know little about how investors form their beliefs concerning the credibility of future policy, leading to calls for empirical research (Nemet et al., 2014; Nemet et al., 2017). In particular, Nemet et al. (2017, p. 55) stress that “understanding interactions among policies and considering policy mixes will be crucial” to future research on climate policy credibility.

2.2. Policy mix research

Policy mixes have been called for to address the multiple market as well as structural and transformational system failures associated with sustainability transitions (Weber and Rohracher, 2012; Rogge and Reichardt, 2016). Therefore, an increasing number of studies have investigated the combination of multiple policies, building on seminal work on smart regulation in environmental policy (Gunningham and Grabosky, 1998; Gunningham and Sinclair, 1999).

This 'first generation' of such policy mix studies focuses on the interaction of policy instruments (Spyridaki and Flamos, 2014) with applications in several environmental policy fields. Examples include climate policy (Sorrell and Sijm, 2003; del Río, 2009), energy efficiency policy (del Río, 2010; Rosenow et al., 2016), renewables policy (Fischer, 2010; Cantner et al., 2016), biodiversity policy (Gunningham and Young, 1997; Ring and Schröter-Schlaack, 2011) and resource efficiency policy (Numata, 2016; Wilts et al., 2016).

The emerging ‘second generation’ of policy mix studies pays greater attention to policy strategies, policy processes and policy mix characteristics (Rogge et al., 2017). First, policy strategies with long-term targets and principal plans for their implementation, such as those laid out in the Nationally Determined Contributions (NDCs) under the Paris Agreement, can play an important role in providing direction to transformative change processes (Schmidt et al., 2012; Jakob, 2017). Second, greater attention to politics, learning and the co-evolution of policy mixes and socio-technical systems is seen as an important research avenue (Reichardt et al., 2016; Kern and Rogge, 2017; Edmondson et al., 2018). Finally, it has been argued that policy mix characteristics, such as consistency, coherence, comprehensiveness and credibility, are key to explaining the effectiveness and efficiency of policy mixes (Reichardt and Rogge, 2016; Costantini et al., 2017).

The first insights of these 'second generation' policy mix studies investigating credibility as one driver of low-carbon energy transitions are in line with the model results summarized in Section 2.1 (Bosetti and Victor, 2011; Cian et al., 2012). However, it remains to be investigated what makes a policy mix credible in the first place. This indicates an overlapping research interest in the literatures on climate policy credibility and policy mixes for sustainability transitions.

3. Analytical framework to explore the policy mix determinants of policy credibility

In this paper, we aim to address the identified gap in the literature by exploring whether and to what extent companies’ perceptions of policy credibility depend on specific aspects of the policy mix relevant for the decarbonization of the energy system. We follow Rogge and Reichardt, 2016, who define credibility as “the extent to which the policy mix is believable and reliable” (p. 1627). Based on their extended policy mix concept, we construct an analytical framework that combines policy mix elements and characteristics as determinants of policy credibility (see Fig. 1 and Table 1). In doing so, we focus on the role of credibility as one of multiple policy mix characteristics, and investigate its interrelatedness with other policy mix characteristics and policy mix elements.

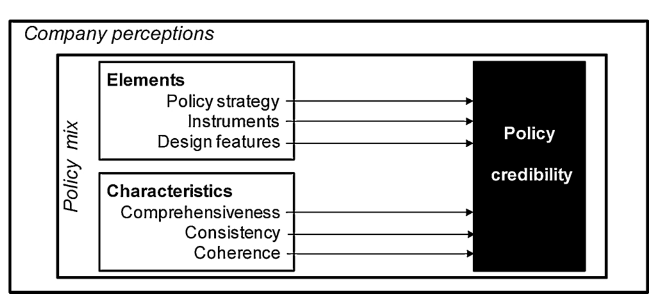

Fig. 1. Analytical framework to explore policy mix determinants of policy credibility.

[1] A compilation of various definitions of credibility (policy, source, institutional and corporate credibility) can be found in Table 2 in Rogge and Dütschke (2017).

Table 1
Definitions of analyzed determinants of the credibility of policy mixes.
Source: Rogge and Reichardt (2016).

	Definitions
Policy mix elements	*Policy strategy* means the "combination of policy objectives and the principal plans for achieving them. That is, the definition puts an emphasis on the output – the ends and means – of the strategy process [..]." (p. 1623) *Instruments* "constitute the concrete tools to achieve overarching objectives. [..] A number of alternative terms are used, such as implementing measures [..], programs [..], policies [..], or policies and measures [..] We propose a [..] typology that combines three instrument types (economic instruments, regulation and information) with three instrument purposes (technology push, demand pull and systemic concerns)." (p. 1623) *Design features* "can be differentiated by abstract and descriptive features. Descriptive design features, such as an instrument's legal form, its target actors, and its duration, summarize the content of a policy instrument [..]. A number of abstract design features [..] may be important to consider: stringency, level of support, predictability, flexibility, differentiation and depth." (p. 1624)
Policy mix characteristics	*Comprehensiveness* "captures how extensive and exhaustive its elements are [of the policy mix] and the degree to which its processes are based on extensive decision-making" (p. 1627) *Consistency* "captures how well the elements of the policy mix are aligned with each over, thereby contributing to the achievement of policy objectives. It may range from the absence of contradictions [weak consistency] to the existence of synergies [strong consistency] within and between the elements of the policy mix." (p. 1626) *Coherence* refers "to synergistic and systematic policymaking and implementation processes contributing – either directly or indirectly – towards the achievement of policy objective." (p. 1626)

3.1. Elements of policy mixes as determinants of policy credibility

In terms of policy mix elements, we consider three aspects to be relevant for policy credibility: the policy strategy, multiple instruments and their design features.

First, regarding the *policy strategy*, we focus on how the ambition of long-term targets and recent changes in ambition levels influence policy credibility. As shown by Nemet et al. (2014), meeting policy objectives in the past positively influences the policy credibility of future targets. In addition, while the ambition of policy targets seems to play a key role for predicting success in meeting targets, even - with hindsight - overly ambitious targets may have a positive influence on perceived credibility, for example, by surviving multiple electoral cycles (Reichardt et al., 2016).

Second, drawing on Nemet et al. (2017), we argue that the adoption of *multiple policy instruments* can positively influence policy credibility. Our focus on low-carbon energy transitions implies including instruments aimed at supporting green niches, for example, by addressing technology-push (e.g. through R&D funding), demand-pull (e.g. through feed-in tariffs) and systemic concerns (e.g. ensuring grid expansion) (Taylor, 2008; Cantner et al., 2016). However, it also necessitates paying specific attention to instruments that destabilize the carbon-intensive energy system, for example, through carbon pricing and phasing-out fossil fuel subsidies (Kivimaa and Kern, 2016; David, 2017).[2] Such 'destruction policies' signal strong political commitment as they are likely to be more difficult to adopt given the resistance of powerful incumbents with vested interests in the status quo (Geels, 2014; Smink et al., 2015), and therefore require greater efforts by policy makers in coalition building and compensating losers (Markard et al., 2016; Nemet et al., 2017). Finally, in recognition of different and potentially conflicting policy objectives (Flanagan et al., 2011), we not only consider climate policy instruments but also those from other policy fields, such as innovation, education or biodiversity, as their alignment can also signal the determination of governments to pursue a given sustainability target (OECD/IEA/NEA/ITF, 2015).

Third, regarding *instrument design features,* we focus on recent changes in the design of the core instrument(s) in the policy mix (Kemp and Pontoglio, 2011; Rogge and Reichardt, 2016). We thereby acknowledge that some instruments may be more important for influencing policy credibility, and that what matters the most for them is their actual design. A well known example for such a core instrument is the German Renewable Energy Sources Act (EEG), which promotes the expansion of renewable energies in Germany (Hoppmann et al., 2014; Lauber and Jacobsson, 2016).

3.2. Characteristics of policy mixes as determinants of policy credibility

Policy mix characteristics can act as a determinant of policy credibility, and we consider three of them here: comprehensiveness, consistency and coherence (Rogge and Reichardt, 2016).

First, regarding *comprehensiveness,* we argue that the extent to which the instrument mix addresses all relevant market and system failures may influence companies' perceptions of policy credibility. As such, comprehensiveness complements Nemet et al.'s (2017) idea of the robustness of instrument mixes influencing policy credibility, but goes beyond counting the number of policy instruments (Costantini et al., 2017).

Second, we include *consistency* as an influencing factor of policy credibility. This captures to what extent policy objectives and the instrument mix are mutually supportive or at least free from contradictions (Rogge and Reichardt, 2016). While there may be thresholds, limits and trade-offs in achieving such consistency (McLean Hilker, 2004; Quitzow, 2015a), policy makers who strive to improve consistency may seem more committed to achieving climate policy targets.

Third, we include the *coherence* of policy processes as a potential determinant of policy credibility. Although transparency and trust may result from monitoring and verification, independent authorities and reputation effects of past compliance (Nemet et al., 2017), we argue that additional policy process determinants of credibility exist which seem to have received limited attention in past monetary, fiscal and trade policy. In particular, a participatory policy style based on dialog with stakeholders can inform policy makers early on of problems and bring about a joining of forces in finding solutions, thereby also actively signaling to actors the willingness, competence but also potential restrictions to getting things done (Reichardt et al., 2017).[3] In addition, we acknowledge the need for policy flexibility despite long-term commitments (Brunner et al., 2012; Nair and Howlett, 2016), and include policy amendment processes to capture adaptive policymaking and governance in the context of deep uncertainty (Marchau et al., 2008; Haasnoot et al., 2013; DeCaro et al., 2017). Finally, since decentralized policymaking may play a role for credibility (Nemet et al., 2017), we argue that the operationalization of coherence should capture the

[2] Research on phasing-out policies supporting carbon-intensive technologies and practices can be informed by the literatures on policy dismantling (Jordan et al., 2013; Bauer and Knill, 2014) and policy termination (deLeon, 1978; Geva-May, 2004).

[3] Clearly, the design of such participatory processes should avoid regulatory capture (Thaw, 2014). For example, diverse participating stakeholders - rather than focusing on government-industry policy learning alone - can be seen as an important aspect for creating procedural legitimacy in the context of governing low-carbon energy transitions (Stigson et al., 2009; Ricard, 2016). Therefore, we suggest that future work could further explore the role of procedural legitimacy, building on work in other areas, such as EU policymaking (Engelen et al., 2008; Schmidt, 2012).

distribution of policymaking across different vertical and horizontal levels of governance (Howlett et al., 2015; Howlett et al., 2017).

3.3. Limitations of the framework

The analytical framework developed here is intended to shed more light on whether and to what extent companies' perceptions of policy credibility are related to the policy mix for the low-carbon energy transition. We recognize two key limitations:

First, the framework represents only a first step in opening the black box of perceptions of policy credibility. Indeed, given the exploratory nature of our research, we have restrained from postulating hypotheses.

Second, we limit the scope of our framework to enable an in-depth analysis of the relevance of policy action for companies' perceptions of policy credibility. This implies an - at least implicit - exclusion of other determinants of policy credibility, such as institutional, distributional and reputational ones, as well as the respondents' attributes, such as climate change awareness.

4. Research case

As a research case, we chose the German energy transition towards renewable energies and the perceived credibility of the corresponding policy mix for three main reasons.

First, we use the case of the *Energiewende* as Germany has been implementing a rich policy mix aiming to achieve an ambitious 80% share of electricity generated from renewable energies by 2050 (BMWi and BMU, 2010; BMWi, 2015). By the end of 2014, the expansion of renewables in Germany's electricity generation had reached a share of 27.4% and the country was on track to meet its interim target of 40–45% by 2025 (BMWi, 2014). Arguably, the core policy instrument is the Renewable Energy Sources Act (EEG), introduced in 2000 (Jacobsson and Lauber, 2006) and regularly amended since then (Hoppmann et al., 2014; Lauber and Jacobsson, 2016). Many other additional instruments are in place as well. For example, by 2014, federal public R&D support for low-carbon innovation had risen to more than 800 million euros per year, with a good third of this going to renewable energy (BMWi, 2016).

Second, in the past few years, Germany has experienced a dynamic policymaking process. After the Fukushima accident, the previously abandoned nuclear phase-out until 2022 was reinstated in 2011 (Hermwille, 2016; Quitzow et al., 2016). Globally declining technology costs and increased international competition for solar PV accelerated the expansion of renewable energies in 2012 (BMWi, 2015), leading to unscheduled reductions in feed-in tariffs and industry consolidation (Hoppmann et al., 2014; Quitzow, 2015b). In addition, the increase in the EEG surcharge led to fierce political debates about the retrospective adjustment of previously guaranteed feed-in tariffs (set for 20 years) which had been unthinkable prior to that (Bröcker, 2013). This left scars on the perceived predictability and associated investment security of the EEG (Reichardt et al., 2016). In addition, due to the federal elections in 2013, the EEG's next regular reform was postponed, leading to considerable regulatory uncertainty. At the beginning of 2014, the new Federal Ministry of Economics and Energy published the first pillars of a revised EEG. However, the uncertainty about its design features remained high until its adoption by the Federal Cabinet on April 8, 2014.[4]

Finally, since the energy sector is supplier dominated (Pavitt, 1984), we chose to study the perceptions of manufacturers of renewable power generation technologies. Germany is particularly suitable because it has a prominent manufacturing industry for renewable energies (Bruns et al., 2011; Doblinger et al., 2015).

5. Research design and methodology

In our study, we aim at exploring corporate actors' subjective perceptions of policy credibility rather than objective facts or expert opinions, as it is these perceptions which influence companies' decision-making (Kaplan and Tripsas, 2008; Nooteboom, 2009), and are key for low-carbon innovation (Schmidt et al., 2012). We therefore rely on company survey data, building on the seminal study by Brunetti et al. (Brunetti et al., 1998; Borner et al., 1999) and other related credibility survey analysis (Newell and Goldsmith, 2001; Ho, 2014; van der Ven, 2015; Kril et al., 2016).

As abstract concepts such as credibility are difficult to measure, they require proxies (Ho, 2014). For example, Brunetti et al. (1998) construct a credibility indicator based on the average answers to multiple questions for five sub-indicators using a 6-point answer scale. Their first sub-indicator on the predictability of changes in laws and policies is the one most closely related to our definition of policy credibility, as it covers, for example, unexpected policy changes, information provided in the policymaking process or the consideration of concerns by parties affected by policy change. Similarly, Newell and Goldsmith (2001) develop and test proxies for perceived corporate credibility using an 8-point Likert-like scale including the two dimensions of expertise and trustworthiness.

However, there is no existing standardized set of survey questions to capture the credibility of policy mixes. We therefore design and conduct a survey of companies involved in the low-carbon energy transition. More specifically, we integrate questions on companies' perceptions of policy credibility and key aspects of the policy mix into an otherwise fairly standardized innovation survey, which is based on the Community Innovation Survey (CIS) conducted regularly in EU Member States (Horbach, 2016).

5.1. Data collection

For our explorative study, we employ data from a sample of German manufacturers of renewable power generation technologies.[5] Three steps were involved in collecting this company-specific data:

In a first step, we compiled a database of all German companies producing components, final products and production equipment for electricity generation based on renewable energies, including on- and offshore wind power, solar PV, hydro, bioenergy, wave and tidal energy, geothermal energy and concentrated solar power. This resulted in a sample population of 1092 manufacturers active in renewable energies in Germany in 2014.

In a second step, we designed a set of questions aimed at elucidating companies' perceptions of credibility and other policy mix characteristics and elements. While concepts such as consistency and comprehensiveness seemed fairly straightforward to operationalize, we developed eight items for the broad concept of the coherence of policy processes and seven items for our dependent variable of credibility. In addition, we included questions about companies' perceptions of political targets and their consistency, the consistency and comprehensiveness of the instrument mix and perceived support by various policy instruments, and an assessment of selected design features of the core policy instrument in Germany, the EEG (the Renewable Energy Sources Act). Companies were asked to provide technology-specific perceptions of the policy mix based on their main renewable power generation technology.

In a third step, we collected company responses in a computer-assisted telephone survey (CATI). After a day-long pre-test, the survey was conducted in the field from April 9, 2014 until July 22, 2014. Interviews were conducted with the CEO or a top-level manager

[4] The regulatory uncertainty was fully resolved with the decision of the Federal Parliament (Bundestag) on July 4, 2014.

[5] For further details on data collection see Rogge and Schleich (2018), who utilize this survey data to investigate the impact of policy mix characteristics on green innovation.

responsible for the company's strategy, R&D or sales and who had an overview of products, innovation and corporate policy.

In total, the survey was completed by 390 German manufacturers of renewable power generation technologies (response rate 35.7%), with approx. 70% small and medium-sized enterprises (SMEs). The majority of responses concerned solar PV (37.2%), followed by biogas (22.3%) and onshore wind (17.4%). Regarding the competitive environment, respondents stressed the dependence on the political framework conditions.

5.2. Data analysis

5.2.1. Data preparation

Prior to the linear regression model (ordinary least square OLS), we applied the Expectation Maximization (EM) imputation approach (Allison, 2002) in SPSS (drawing on Z-standardized values) to replace missing data (6.5% overall). This ensures a higher level of data quality than simply excluding all the cases with missing values (Roth, 1994), as this would unnecessarily reduce our sample size and thereby its statistical power. For this we included all the variables that were part of our multivariate analyses. When presenting descriptive statistics, we use the original values from the questionnaire, e.g. to calculate the mean and standard deviation (SD) (see Tables 2–4). In the regression analysis, we draw on the scales based on the Z-standardized values calculated with imputed missing values.

In addition, because we draw on newly developed items to measure policy credibility and the elements and characteristics of the policy mix, we apply explorative factor analysis to check whether the items intended to measure a certain construct converge on the same factor. This was done for constructs measured by several items, i.e. our dependent variable credibility as well as the independent variables operationalizing coherence, consistency and comprehensiveness. As a confirmatory factor analysis did not result in a statistically satisfactory model, the final model was constructed building on modification indices yielding an acceptable fit (CMIN = 92.3, DF = 49, CMIN/DF = 1.86, p = 0.00, RMSEA = .048, PCLOSE = .581, HI90 = 0.062).[6]

5.2.2. Dependent variable: credibility

To measure the dependent variable *policy credibility,* the questionnaire included seven items which covered two aspects: On the one hand, we asked for the perceived support for the Energiewende from different societal actors (political parties, federal states, municipalities, national government). On the other hand, we asked for companies' assessments of synonyms often utilized when referring to the credibility of Germany's Energiewende policy (political will, vision, signals, etc.).

Table 2
Measurement of policy credibility.

Please say how much you agree with the following statements about the policy framework conditions for supporting renewable energies in Germany at the present time for the renewable branch [you have chosen as your main one].		Mean	SD
Concerning the increase of electricity generation from renewable energies in Germany, there is …[a]	…a clear political vision	2.57	1.33
	…a firm political will	2.61	1.26
	…unambiguous political signals	2.57	1.27
	…strong support from the German government	2.53	1.27
	Credibility indicator	*2.57*	*1.07*

[a] Respondents answered on a scale from 1 = do not agree at all to 6 = fully agree.

The initial factor analysis indicated that the items referring to the subnational level form a consistent factor. Such a differentiation of state levels appears plausible from a conceptual point of view, and given our focus on national level energy policy, we excluded those subnational items. The remaining four national credibility items (see Table 2) were aggregated into a scale by using the mean value across items.[7]

5.2.3. Independent variables: policy mix elements and characteristics

5.2.3.1. Policy mix elements. Regarding the *elements* of the policy mix, we investigate the role played by the policy strategy, different policy instruments and design features of the core policy instrument, the EEG (see Table 3).

Table 3
Measurement of the elements of the policy mix.

	Mean	SD
Policy strategy[a]		
The planned expansion target for renewable energies in Germany up to 2025 is very ambitious. *[Ambitiousness]*	4.10	1.80
The planned expansion target for renewable energies in Germany up to 2025 is lower than the expansion target of the previous legislative period. *[Reduction in ambitiousness]*	4.11	1.66
Policy instruments[b]		
Renewable Energy Sources Act (EEG)	3.26	1.31
Public R&D / innovation funding	3.38	1.33
Energy Industry Act (EnWG) and other policy initiatives to expand the grid	2.92	1.11
Promoting the training of skilled workers for the renewable branch	3.34	1.43
Federal Nature Conservation Act and its implementation	2.49	1.09
EU Emission Trading System for the reduction of greenhouse gas emissions	2.33	1.34
Policy framework conditions for fossil electricity generation	2.32	1.28
Phase-out of nuclear energy by 2022	4.17	1.55
Design features of the core policy instrument EEG[c]**- scale**	3.89	1.24

[a] The following questions refer to the policy conditions for renewable energies in Germany. To start with, we consider Germany's target for expanding the share of renewable energies in the electricity supply up to 2025, i.e. the targeted share of 40–45 percent in the power supply until 2025 that is cited in the current EEG draft. Please evaluate the following statements from today's perspective using a scale from 1 (do not agree at all) to 6 (agree completely).

[b] I will now name different policy instruments and measures that could be relevant for the expansion of renewable energies. Please say how much you think these support the expansion of renewable electricity generation in their current form. Please answer using a scale from 1 to 6. 1 means "no support at all" and 6 "fully supports".

[c] The German cabinet passed draft legislation to reform the EEG {EEG 2.0} at the beginning of April. Please say how much you think the following changes in the EEG will negatively affect sales of your products on the German market in your branch? Please answer using a scale from 1 to 6, where 1 means probably "no negative effect at all" and 6 means probably "a very negative effect".

First, for the *policy strategy,* we included two items capturing the ambition level of the 2025 expansion target for renewable energies in Germany - looking at the absolute ambition level and its recent downward adjustment. It can be seen that, on average, respondents thought the target was fairly ambitious, but that its ambition level had been reduced.

Second, for *policy instruments,* we asked the respondents' opinion on how much the current form of eight different instruments supports the expansion of renewable electricity generation. It is noteworthy that, on average, respondents thought the nuclear phase-out would support the further expansion of renewable energies the most, despite this policy instrument being listed last. Furthermore, on average, respondents saw

[6] All values are in the ranges given e.g. by Kline (2011) and Hair et al. (2010) indicating an acceptable model fit.

[7] This scale showed high internal consistency (α = .858, where values above .7 are regarded as acceptable by e.g. Nunnally and Bernstein (2008)).

Table 4
Measurement of three characteristics of the policy mix.

	Mean	SD
Comprehensiveness[a,b] **- item**		
Important flanking policy regulations are missing that push the expansion of renewables (e.g. on power market design or for grid expansion).	4.69	1.50
Consistency[a]**- items**		
The planned expansion target for renewable energies in Germany up to 2025 is a good match with other energy and climate policy targets of the German government. *[Consistency of the policy strategy, 1st level consistency] 'Consistency1_PS'* [c]	3.58	1.64
The existing policy instruments reinforce each other in their positive effect on supporting renewables' expansion. *[Consistency of the instrument mix, 2nd level consistency] 'Consistency2_IM'* [b]	2.38	1.26
The planned expansion target for renewable energies in Germany up to 2025 can be achieved with the help of existing policy instruments and measures. *[Consistency of the policy strategy with the instrument mix, 3rd level consistency of the policy mix] 'Consistency3_PM'* [c]	2.37	1.38
Coherence informational[a,d] **- scale**	2.27	0.87
There is a continuous exchange of information between policymakers and manufacturers.	2.57	1.21
Policymakers are well informed about developments in the branch.	2.53	1.34
Emerging problems are spotted early on by policymakers.	1.85	1.00
Coherence procedural[a,d] **- scale**	2.41	1.14
The responsibilities for the branch are clearly defined for the relevant Federal ministries.	2.83	1.36
National and regional governments are pulling in the same direction.	2.07	1.16

[a] Please evaluate the following statements from today's perspective using a scale from 1 (do not agree at all) to 6 (fully agree).
[b] The following questions refer to the policy instruments to promote renewable electricity generation in Germany and are always with regard to your branch [for your main renewable power generation technology].
[c] To start with, we consider Germany's target for expanding the share of renewable energies in the electricity supply up to 2025, i.e. the targeted share of 40–45 per-cent in the power supply until 2025 that is cited in the current EEG draft.
[d] Please say how much you agree with the following statements for the renewable branch [of your main renewable power generation technology] at the present time. Please answer using a scale from 1 to 6, where 1 is "do not agree at all" and 6 means "fully agree".

public R&D support (technology push), skills training (systemic) and the EEG (demand pull) as more or less equally important for the further expansion of renewable energies in the German electricity system.

Third, for the *design features,* we focused on the EEG as the core demand-pull instrument, asking for respondents' assessments of some of the key planned and previously heavily contested changes to its design.[8] An exploratory factor analysis led to a one-factor solution (with an internal consistency of the design scale of $\alpha = .80$), suggesting the aggregation of items to prevent multicollinearity. It is important to note that the items concerning the EEG design asked about the extent to which negative consequences are expected from the EEG amendment, i.e. high values on this scale mirror a negative evaluation of the changes. On average, companies' anticipated some negative consequences for their domestic sales from the EEG amendments.

5.2.3.2. Policy mix characteristics. The second set of determinants of policy mix credibility concern three selected characteristics of the policy mix: comprehensiveness, consistency and coherence (see Table 4).

First, regarding *comprehensiveness,* we asked respondents if they thought important instruments to support the expansion of renewable energies were missing. On average, companies felt that some flanking measures were missing.

Second, concerning *consistency,* we followed Rogge and Reichardt (2016) in differentiating three levels. The survey included a statement for each of these – one for the consistency of the policy strategy, one for the consistency of the instrument mix, and one for the overarching policy mix consistency, i.e. the consistency of the policy strategy with the instrument mix. On average, respondents thought that the target for renewable energies was a good match with other climate and energy policy targets. In contrast, the instrument mix and broader policy mix were viewed as only somewhat consistent. In the factor analysis, consistency did not converge into a single factor, confirming that these three different items apparently measure related facets of consistency, but not the same construct. Therefore, in line with conceptual considerations, we did not aggregate the items measuring consistency into a scale.

Finally, to operationalize the *coherence* of policy processes, we developed eight items ranging from information exchange through problem awareness and solving to more formalized stakeholder engagement procedures and cooperation among ministries and multiple governance levels (see Table 4). On average, respondents provided lower scores here than for the other policy mix characteristics, suggesting a degree of discontent with policymaking and implementation processes at the time of the survey. The factor analysis resulted in splitting up the items on coherence into two dimensions that can be characterized as informational and procedural coherence, with their scales showing acceptable values of internal consistency (α. = 75 for informational coherence and 0.74 for procedural coherence).[9]

5.2.4. Potential control variables

We also looked at firm characteristics as possible control variables that might influence the perceived credibility beyond the perception of the policy mix elements and characteristics. The relevant firm characteristics include the share of a company's turnover with renewables, change in turnover with renewables compared to the year before, number of business units with a focus on renewables, number of employees in the renewables branch, or whether wind or solar is part of the company's portfolio. However, if credibility is regressed on these variables, we do not find a significant relationship with the credibility scale, apart from the change in turnover with renewables compared to the year before. However, if combined with policy mix elements and characteristics in the same regression model, this variable also becomes

[8] The design features included the declining level of feed-in tariffs, the introduction of tenders to determine the support level, the introduction of technology-specific expansion corridors, the stepwise introduction of mandatory direct marketing, and disadvantages for those supplying their own power.

[9] From the items originally included in the questionnaire to measure coherence, three were deleted as they did not clearly converge with either of the two factors. The deleted items referred to "Policymakers always strive to remove obstacles", "The search for solutions to problems takes place in a constructive exchange between policymakers and representatives of the RE branch" and "The last amendments of the EEG (2012 and today) were made in a transparent procedure."

insignificant. Therefore, to limit the number of predictors, we omit these potential control variables in our final model.

6. Results

Our analysis explores to what extent credibility can be regressed on the measured policy mix elements and characteristics. We conducted OLS regression analysis, which leads to a highly significant model that explains 46.9% of the variance of credibility (corrected $R^2 = .445$, see Table 5).

We find that three policy mix elements turn out to be significant predictors of credibility: For the policy strategy, those who agree more strongly that the ambition of the mid-term renewables expansion target has been reduced show lower levels of credibility. In addition, the only policy instrument related to higher levels of credibility is the phase-out of nuclear energy. Finally, the evaluation of changes in the design features of the EEG is negatively related to credibility.

Regarding policy mix characteristics, we find that all three items capturing facets of consistency and both coherences scales turn out to be significant. Informational coherence shows the highest β-value of all variables included in the model, i.e. is the strongest predictor in our analysis.

7.1. The coherence of policy processes may be the most influential factor for perceptions of policy credibility

We find that the coherence of policy processes, in particular the informational type, has outstanding relevance for shaping companies' perceptions of the credibility of the policy mix.

It could be argued that such *informational coherence* is captured by Nemet et al.'s (2017) category of transparency and trust. However, this category largely refers to the government providing information about its climate performance (through monitoring, verification, reporting, etc.). In contrast, informational coherence in our sense goes beyond this and covers how well the government is informed about what is going on in a certain sector, how actively it pursues a two-way exchange of information, and how quickly it recognizes emerging challenges. As already alluded to by Nemet et al. (2017), the government's experience paired with its capacity for an informed and participatory policymaking style may be key for such informational coherence (Quitzow, 2015a; Howlett and Ramesh, 2016; Reichardt et al., 2017).

In addition, *procedural coherence*, measured here as the horizontal and vertical coherence of policymaking and implementation, also seems to shape companies' perceptions of policy credibility. This adds to Nemet et al.'s (2017) insight on the decentralization of policymaking safeguarding credibility by providing robustness. More specifically, our

Table 5
Linear regression model with policy mix elements and characteristics as determinants of policy credibility.

	β	S.E.	p
Policy mix elements			
Policy strategy			
Ambitiousness level of mid-term renewables expansion target	0.075	0.035	.072
Reduction in ambitiousness of mid-term renewables expansion target	−0.084*	0.036	.038
Policy instruments			
Renewable Energy Sources Act (EEG)	0.060	0.167	.037
Public R&D / innovation funding	0.010	0.822	.039
Energy Industry Act (EnWG) and other policy initiatives to expand the grid	0.018	0.728	.046
Promoting the training of skilled workers for the renewable branch	−0.088	0.062	.041
Federal Nature Conservation Act and its implementation	−0.022	0.615	.040
EU Emission Trading System for the reduction of greenhouse gas emissions	0.086	0.058	.038
Policy framework conditions for fossil electricity generation	0.030	0.470	.036
Phase-out of nuclear energy by 2022	0.113**	0.008	.035
Design features			
Design features of EEG - scale	−0.188**	0.049	.000
Policy mix characteristics			
Comprehensiveness of the instrument mix	−0.046	0.033	.221
Consistency1_PS	0.103*	0.036	.018
Consistency2_IM	0.107*	0.039	.023
Consistency3_PM	0.090*	0.036	.038
Informational coherence of policy processes - scale	0.251**	0.046	.000
Procedural coherence of policy processes - scale	0.169**	0.041	.000

Cells give βs, i.e. standardized regression weights, S.E., p-values from final equation. Levels of significance are indicated as follows: ** - $p < .001$, * - $p < .050$.
To check for multicollinearity, VIF was calculated and was < 2 for all variables.

7. Discussion

Our regression analysis indicates that companies' perceptions of policy credibility are mainly shaped by two characteristics of the policy mix, namely the coherence of policymaking and implementation, followed by the consistency of the policy mix. Elements of the policy mix matter as well, in particular changes in the design of the core demand-pull instrument EEG, the nuclear phase-out policy, and the expansion targets for renewable energies. In the following sections, we discuss three main implications of our exploratory findings.

findings indicate the importance of all governance levels working towards the low-carbon energy transition, and of responsibilities being clearly laid out between different ministries. We argue that these are important additional aspects which deserve further attention as determinants of policy credibility, drawing inspiration from the policy mix literature as well as the literatures on (environmental) policy integration and coordination (Bouckaert et al., 2010; Magro et al., 2014; Howlett et al., 2017).

7.2. Credibility may be lost through adjusting institutionalized elements of the policy mix

Another implication of our findings concerns the loss of credibility indicated by two determinants, thereby confirming that "credibility is fragile" (Nemet et al., 2014, p. 531).

First, our research indicates the negative effect caused by the *reduction of the ambition of the medium-term expansion target for 2025*. This complements insights from Nemet et al. (2014) into enhancing credibility by sequentially increasing the ambition levels of policy targets once less ambitious targets have been achieved. In our particular case, Germany had built a strong reputation for achieving its targets set for the expansion of renewable energies. It had a pattern of target overachievement and, until 2012, it had reacted to this by upping the ambition of its targets for the share of renewable energies in the electricity system. In this context of institutionalized expectations of an increase in ambition, it can be argued that breaking this pattern may have triggered serious doubts about the government's continued commitment to renewables.

At first glance, this may appear surprising given that the long-term target for 2050 was left unchanged, and that only the path taken towards the target was adjusted in order to shift the further expansion of renewable energies into the future. While cost minimization was provided as an obvious reason, at a deeper level, this policy change may have revealed delays in grid expansion and limited progress with wider changes in the network and consumption regime needed to accommodate the increasing share of renewable energies (Rogge et al., 2018). Arguably, these bottlenecks occurred because of insufficient policy attention (Kuzemko et al., 2017), thereby raising doubts about the strength of the government's commitment to the *Energiewende*.

Second, our results suggest that the adoption of *less favorable design features of the core demand-pull instrument EEG* may have undermined belief in the credibility of the policy mix. As policy makers have followed the amendment procedures laid out in the EEG (Hoppmann et al., 2014), the negative impact on credibility can only be understood when considering the broader context. In this case, the policy change was embedded into heightened concerns regarding costs, consolidations in the domestic PV industry and a resurge in the attention paid to the interests of incumbents (Quitzow, 2015b; Geels et al., 2016; Lauber and Jacobsson, 2016). In this context, the EEG design changes pointed to a pending policy regime shift towards tendering (instead of institutionalized feed-in tariffs). In addition, the introduction of growth limits to the expansion of renewable energies indicated a shift in priorities towards controlling the cost and speed of expansion. The resulting anticipation of negative consequences for domestic sales may thus have arisen from the government sending – knowingly or unknowingly - multiple signals of wanting to slow down the energy transition, which seems to have had negative repercussions on the perception of policy credibility.

Our findings underline that target *ambition* and instrument *design* – and *changes therein* – may be more important for credibility than the existence of specific targets and multiple instruments. Our findings also highlight the limits to safeguarding policy credibility by clearly defining the flexibility of how rules can be (re)designed (Nemet et al., 2017), particularly when such changes conflict with institutionalized expectations about future policy changes in core elements of the policy mix.

7.3. 'Destruction policies' and policy mix consistency seem to be key for policy credibility

Our findings also provide two new insights regarding the relevance of multiple instruments for credibility, thereby complementing Nemet et al.'s (2017) focus on their role in generating robustness.

Our first insight concerns the *outstanding relevance of 'destruction policies'*, because, of all the eight policy instruments included in our regression, only one – Germany's nuclear phase-out policy (Hermwille, 2016) – proved to be unambiguously related to policy credibility. This goes to show the important, albeit in many sectors and countries so far neglected, role of destruction policies (Kivimaa and Kern, 2016) – in Germany also referred to as exnovation policies (David, 2017; Heyen et al., 2017). Such policies develop their clout not only by freeing up space for green technologies in future markets by helping to destabilize existing unsustainable regimes, but also by showcasing the credible commitment of governments to the low-carbon energy transition. They represent a strong form of market intervention that is likely to be heavily politically contested, with policy makers having to overcome strong resistance from powerful incumbents with vested interests in the existing regime (Geels, 2014). Finally, another example for a 'destruction instrument', the EU emissions trading system (EU ETS), which was found to have some relevance, indicates the importance of the stringency of such instruments, because they can only truly support policy credibility with the proper design.

Our second insight concerns the *key role played by the consistency of the policy mix*. The alignment of policy instruments with each other seems to be what matters for credibility, rather than simply having multiple overlapping instruments in place. This highlights the importance of policy design (Howlett and Rayner, 2013; Kern et al., 2017) to enhance synergies and avoid negative instrument interactions (Gunningham and Sinclair, 1999; Antonioli et al., 2014). Another aspect concerns the relevance of having policy instruments stringent enough to achieve long-term targets. This is clearly not yet the case for the EU ETS due to the surplus of allowances (Grosjean et al., 2014; Koch et al., 2014), which has resulted in limited incentives for low-carbon innovation (Rogge, 2016). A final consideration concerns the importance of aligning not only instruments but also targets and thus different policy objectives with each other.

7.4. Overarching reflections on analyzing policy credibility

We offer three overarching reflections for future research on climate policy credibility.

First, while much can be learned about policy credibility from the policy fields that have traditionally dealt with it, such as monetary policy, research in *transition studies* (Markard et al., 2012; Weber and Rohracher, 2012) investigating directed, long-term transformative change processes offers additional insights which can enrich our understanding of policy credibility.

Second, our findings support the *second generation of policy mix research* with the three building blocks of elements, processes and characteristics, thereby going beyond a pure focus on instruments and their interactions (Rogge and Reichardt, 2016). Indeed, in our case, policy mix characteristics had a much greater explanatory value for perceived credibility than concrete policy instruments. In particular, the coherence of policy processes proved important, pointing to the need to pay closer attention to procedural policy instruments rather than only substantive ones (Gunningham and Grabosky, 1998; Howlett and Rayner, 2007).

Finally, we argue that *interdisciplinary research* combining economics and political science (Kern and Rogge, 2017; Schmidt and Sewerin, 2017) is required to shed more light onto the coherence of policy processes as an influential determinant of policy credibility.

8. Conclusions

This paper presented a first step in exploring whether and to what extent the existing policy mix helps to explain companies' perceptions of policy credibility. In the context of the German energy transition, we find that credibility is shaped by a number of policy mix elements including changes in expansion targets, design changes in the EEG as the core demand-pull instrument, and the nuclear phase-out policy. However, we also find that the informational and procedural coherence of policy processes and the consistency of the policy mix constitute even more influential determinants of manufacturers' perceptions of policy credibility.

Our paper makes two main contributions to the literature. First, its theoretical contribution is to combine the literatures on climate policy credibility and policy mixes for sustainability transition, and to propose considering policy mix elements and characteristics as explicit determinants of policy credibility. Second, its empirical contribution is to be the first study employing survey data to investigate which aspects of the policy mix make companies believe in the commitment of the government to a low-carbon energy transition.

While our detailed findings for Germany are specific to this country, we argue that they still provide four general insights to any policy maker interested in increasing – or avoiding the loss of – policy credibility as means to support low-carbon energy (or other sustainability) transitions. First, policy makers are well advised to *stick to their targets or gradually increase target ambition* over time (Nemet et al., 2014), but not to reduce their ambitiousness - particularly if they comply with achieving a target.

Second, given the aspirations of the Paris Agreement concerning the decarbonization of the economy, policy makers are advised to demonstrate their commitment by *devising or strengthening 'destruction policies'* for fossil energies (Kivimaa and Kern, 2016), for example by reducing subsidies (Schwanitz et al., 2014) or adopting phase-out strategies for coal (Johnstone and Hielscher, 2017). In a similar vein, policy makers need to continue their efforts to overcome political resistance to increasing carbon prices. An example for this concerns the problem of surplus allowances in the EU ETS (Grosjean et al., 2014; Koch et al., 2016). This needs to be tackled in order to turn the trading scheme into a stringent control policy signaling strong commitment to decarbonization and providing adequate low-carbon incentives. If there is no European majority for a sufficiently ambitious policy change, national policy makers should aim to further strengthen carbon price signals, for example by introducing supplementary carbon taxes.

Third, policy makers are advised to *pay greater attention to the nature of policymaking and implementation processes*, rather than just policy outputs. For example, they should enhance the systematic nature of policymaking procedures, improve multi-directional information exchanges with green innovators and avoid destructive discussions about the future of the policy mix (Reichardt et al., 2016). This also means taking great care when redesigning core policy instruments, because the process followed, such as a participatory policy style, may matter more for perceptions of credibility than the actual policy changes (White et al., 2013; Reichardt et al., 2017). This may require strengthening the procedural and informational capacities of the state and enhancing the capabilities of policy makers to steer system innovation (Bradshaw, 2003; OECD, 2015; Quitzow, 2015a; Howlett and Ramesh, 2016).

Finally, since we surveyed manufacturers of low-carbon technologies, our findings can also be interpreted as a call for *greater attention to green industrial policy* (Pegels and Lütkenhorst, 2014; Kemp and Never, 2017). This includes better anticipation of industry localization effects and international competitiveness (Quitzow, 2015b; Schmidt and Huenteler, 2016).

Our study is not free of limitations. First, since we measured many items for the first time in a survey, it is not surprising that our data is not perfect psychometrically speaking. Second, our sample only includes manufacturers and therefore does not capture differences in the perceptions of policy credibility among other actor groups. Finally, our study is based on a cross-sectional design and is thus purely correlational.

Despite these limitations, we argue that our study provides valuable new insights into a neglected but important area of climate and transition policy, for which we see at least three promising avenues for future research. First, we recommend conducting similar empirical studies in different countries and with additional actors, as well as over time. Second, future studies should investigate more complex models that can capture potential interdependencies between policy mix elements and characteristics. Finally, future research should investigate how companies form such credibility perceptions, for example through interviews or experiments.

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