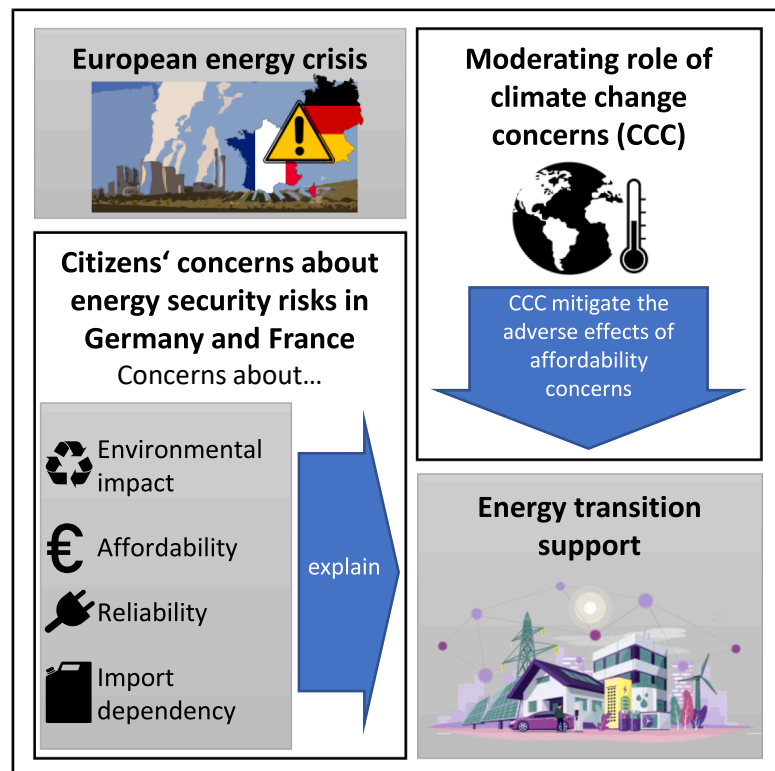


# Public perceptions of energy security risks and energy transition support in France and Germany

## Graphical abstract



## Authors

Daniel Sloot, Kristin Limbach, Corinne Faure, Marie-Charlotte Guetlein, Wolf Fichtner, Frank Schultmann

## Correspondence

daniel.sloot@kit.edu

## In brief

The recent European energy crisis has influenced public debate over the course of the sustainable energy transition, but research has not explored the role of public concerns over energy security risks in energy transition support. Using representative survey data from Germany and France, this study shows that although affordability of energy is the main concern in both countries, concerns about the environmental impacts of the energy system are more consistently related to support for renewable energy and energy transition policies.

## Highlights

- Investigates the role of energy security concerns in energy transition support
- Affordability concerns rated as more important than environmental impact concerns
- Yet, environmental impact concerns are consistently related to transition support
- Climate change concerns can mitigate the negative impacts of affordability concerns



## Article

# Public perceptions of energy security risks and energy transition support in France and Germany

Daniel Sloot,<sup>1,4,\*</sup> Kristin Limbach,<sup>1</sup> Corinne Faure,<sup>2</sup> Marie-Charlotte Guetlein,<sup>3</sup> Wolf Fichtner,<sup>1</sup> and Frank Schultmann<sup>1</sup>

<sup>1</sup>French-German Institute for Environmental Research, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

<sup>2</sup>Department of Marketing, Grenoble Ecole de Management, Grenoble, France

<sup>3</sup>Department of Management & Technology, Grenoble Ecole de Management, Grenoble, France

<sup>4</sup>Lead contact

\*Correspondence: [daniel.sloot@kit.edu](mailto:daniel.sloot@kit.edu)

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**SCIENCE FOR SOCIETY** The recent energy crisis following the Russia-Ukraine war of 2022 has led to concerns about energy security among European citizens, especially about energy costs and being dependent on energy imports. One can wonder whether these concerns about energy security risks make citizens more or less supportive of the energy transition. Our research in Germany and France shows that although citizens worry most about energy costs, it is their concerns about the environmental impacts of the energy system that are most consistently related to their support for the energy transition. In addition, we find that concerns about climate change in general help reduce the negative effects of being worried about energy costs on support for the energy transition. These insights can help policymakers maintain support for the energy transition even in times of energy crises.

## SUMMARY

The recent European energy crisis following the Russia-Ukraine war of 2022 has highlighted energy security risks and influenced public debates over the course of the sustainable energy transition. We investigate how public concerns over four dimensions of energy security risks (reliability of supply, import dependency, affordability, and environmental impact) are related to support for the energy transition in Germany and France. Our survey data ( $n = 2,010$  participants) show that citizens in both countries are most concerned about the affordability of energy. However, multiple regression analysis shows that concerns about the environmental impact of the energy system are most consistently related to general support as well as specific supply-side energy technologies and demand-side energy policies. Moreover, climate change concerns mitigate the adverse effects of affordability concerns, and perceptions of the energy crisis as an opportunity can partially explain why perceived energy security risks can translate into energy transition support.

## INTRODUCTION

European energy policy aims to transform the energy system to achieve carbon neutrality and, at the same time, strives to maintain a secure energy supply. However, the recent energy crisis following the Russia-Ukraine war of 2022 has led to uncertainty among policy makers and the public about the future path of the energy transition.<sup>1,2</sup> On the one hand, the energy crisis has led to concerns over import dependencies, reliability of energy supply, and high energy prices.<sup>3</sup> On the other hand, this crisis has highlighted both the short-term necessity and the negative environmental impact of fossil fuels (especially natural gas) for domestic electricity production and, more generally, the urgent need for a sustainable energy transition.<sup>4</sup> It is not well under-

stood how citizens perceive different energy security risks in the context of the energy crisis and how public concerns shape support (or lack thereof) for a sustainable energy transition. More specifically, are energy security risks in the context of the recent energy crisis a barrier or an opportunity for the energy transition, and in what way?

Energy crises mark phases when energy security risks materialize in high prices or shortages of energy supply.<sup>5</sup> In the past, such crises have had strong impacts on energy policy, such as France's focus on nuclear energy following the energy crisis of the 1970s.<sup>6</sup> By revealing vulnerabilities of an energy system, energy crises often trigger an increased focus on energy security risks, specifically concerns that maintaining a reliable, affordable, and sustainable energy supply chain is at risk.<sup>7-9</sup> Energy



security is a multi-dimensional concept that has evolved from a focus on national security against outside threats to a broader view encompassing vulnerabilities of citizens and environmental sustainability.<sup>10</sup> As a consequence of this widened definition, research on energy security no longer only concentrates on national states but relates more widely to social groups or individual citizens, thus associating it with feelings of safety and stability.<sup>11</sup> Recent research has distinguished between positive and negative energy security, finding that positive security can be enabled by improving the security of supply, whereas negative security relates to the availability of renewable energy technologies.<sup>12</sup>

Research commonly conceptualizes energy security risks through several dimensions, representing different risks on the demand or supply side, although there is no consensus on a definitive set of dimensions.<sup>13,14</sup> Narrow conceptualizations typically focus on the availability, accessibility, or affordability of energy, whereas broader conceptualizations have identified up to 20 dimensions of energy security that include environmental sustainability and governance.<sup>10,15</sup> It has also been noted that energy security is highly contextual with respect to geographic or temporal circumstances as well as energy sources or systems.<sup>16</sup> For the recent European context (the European energy crisis following the beginning of the Russia-Ukraine war in 2022), concerns about supply reliability, import dependency, affordability, and environmental impact have been particularly highlighted in the public discourse,<sup>2,6</sup> and we thus focus on these dimensions in the current research. Although this is generally in line with recent empirical analyses of energy security risks, other studies have not always distinguished between these dimensions (instead measuring them on one aggregate scale) or have considered other dimensions, such as terrorist attacks on the energy system, which we deemed less relevant for the context in focus.<sup>17–19</sup> Analogous to previous empirical studies, we conceptualize perceived energy security risks as the extent of concern that an individual feels regarding each of the dimensions.<sup>19,20</sup>

Although national strategies to tackle the recent European energy crisis have differed, they have been linked to long-term efforts for a sustainable energy transition. Germany and France, the EU's two largest economies, have both set national targets to reach net-zero emissions by 2050; however, their strategies to reach this target, as well as how they were affected by the energy crisis, differ due to their vastly different energy systems.<sup>21,22</sup> France generates the majority of its electricity from nuclear energy, with a relatively small share of solar and wind energy, and plans to substantially rely on nuclear energy as part of its energy transition. In contrast, Germany has completely phased out nuclear energy after decades-long public protests and relies mainly on wind and solar energy generation, while also being dependent on natural gas and coal. Due to its heavy reliance on Russian gas imports prior to the start of the Russia-Ukraine war in 2022, Germany was affected more severely by the sudden decreases in Russian gas imports, followed by price spikes and concerns about the reliability of supply and dependence on fuel imports.<sup>23,24</sup> Despite these cross-national differences, however, both countries' energy transition emphasizes market mechanisms and economic incentives and thus relies on the support of consumers and businesses for demand-side or supply-side

policy reforms.<sup>25–27</sup> This highlights the importance of analyzing public opinions and concerns and how they are related to preferences for energy transition policies.<sup>28,29</sup> Notably, high levels of heterogeneity (both within and across countries) of public acceptability of energy policies have been found in previous research.<sup>30–32</sup> In light of the recent European energy crisis, this study thus examines how public concerns about energy security risks are related to support for the energy transition based on survey data from Germany and France.

## RESULTS

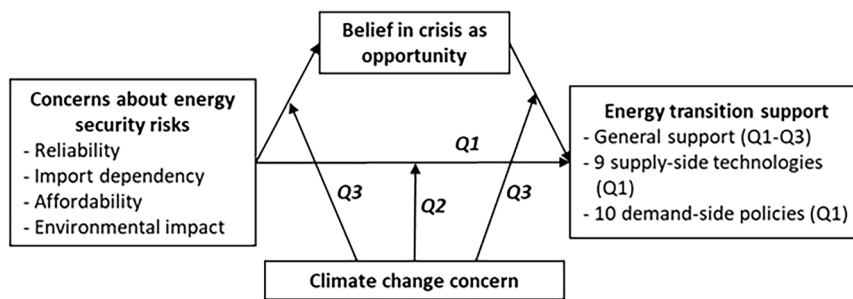
### Concerns about energy security risks and energy transition support

The majority of the existing empirical research treats concerns about energy security risks as the outcome of interest.<sup>19,20,33,34</sup> A few studies have empirically linked concerns about energy security risks to public support for the energy transition. For example, research conducted in the UK prior to the Russia-Ukraine war of 2022 found that public attitudes toward nuclear energy were less positive when concerns about energy security and general concerns about climate change were higher.<sup>18</sup> Other research examined support for different energy sources in multiple European countries and found that concerns about import dependencies and technical disruptions of the energy supply decrease support for electricity generated from renewable energy sources and increase support for electricity from coal, natural gas, and nuclear energy.<sup>17</sup> Recent research that examined support for different clean energy policy mixes in the wake of the Russia-Ukraine war of 2022 found that public support for policies to reduce fossil fuels and increase renewables may have risen as a result of the war in Ukraine.<sup>35</sup> These studies suggest that the relationships between perceived energy security risks and energy transition support may be heterogeneous, highlighting the need to study distinct dimensions of perceived risks and energy transition support and also consider possible processes and boundary conditions.

Importantly, some of the aforementioned studies have captured dimensions of energy security risks related to environmental impacts through individuals' climate change concerns.<sup>17,18</sup> Building on this research, we conceptualize climate and environmental impacts of the energy system as a specific dimension of energy security risks. In contrast, climate change concerns reflect a more general state of worry about the severity of global climate change that could explain *when* perceptions of specific risks translate into energy transition support.<sup>36,37</sup> In line with recent studies on public support for direct air capture<sup>38</sup> and support for sustainable energy policies,<sup>39</sup> we examine the role of climate change concerns as a potential moderating factor that determines to what extent specific concerns about energy security risks translate into energy transition support.

### Current research

This study investigates public concerns about energy security risks across four dimensions, specifically supply reliability, import dependencies, affordability, and environmental and climate impacts of the energy system. We analyze binational data from a representative survey conducted in parallel in



**Figure 1. Theoretical model depicting the relationship between concerns about energy security risks and energy transition support**

Note: reliability reflects concerns about power blackouts and the rationing of electricity. Import dependency reflects concerns about the country's dependence on energy imports from other countries within or outside the EU. Energy affordability reflects concerns about electricity and fuel price surges. Environmental impact reflects concerns that the current energy system produces negative environmental or climate impacts.

Germany ( $N = 1,004$ ) and France ( $N = 1,006$ ). Through a series of multiple regressions, we estimate the effects of the four risk dimensions on public support for the sustainable energy transition in general, as well as on nine supply-side electricity generation technologies and ten demand-side energy transition policies (see Figure 1, Q1). Moreover, we investigate the role of individual climate change concerns in moderating how concerns about energy security risks affect energy transition support (Q2). Finally, our context of focus, the European energy crisis of 2022, might be perceived by the public as either a trigger (for instance, because it may force countries to accelerate the switch to renewable energies) or a hindrance (for instance, because it may imply longer reliance on outdated technologies such as coal) for the energy transition. Therefore, we directly examine whether viewing the energy crisis as an opportunity for the energy transition could explain (i.e., mediate) the process of how perceived energy security risks are related to energy transition support, depending on the level of climate change concern (i.e., a moderated mediation, Q3).

Our focus is on explaining support for the energy transition, which we capture with three distinct outcomes: general support, supply-side technology support, and demand-side policy support. The primary outcome variable in this study is citizens' general support for the sustainable energy transition, and we expected energy security risks with immediate consequences for individuals (i.e., reliability, dependency, and affordability concerns) to be negatively related to general support, whereas we expected concerns about environmental impacts of the energy system to be positively related to general support. In addition, we aimed at capturing energy transition support in a comprehensive way, thus covering support for a range of specific supply-side technologies and demand-side energy policies. These analyses were more exploratory in nature, as we did not have specific expectations about the role of energy security concerns for each technology and policy.

Supply-side technologies cover both renewable and non-renewable ways to generate electricity and can be conceptually classified into distinct categories. First, hydropower, solar, and onshore and offshore wind are renewable energies that the public is relatively familiar with, as they have been a central part of the energy landscape in Germany and France. Second, biomass from biogas and geothermal energy are more novel renewable energy generation technologies that the public is generally not yet familiar with, and attitudes toward these

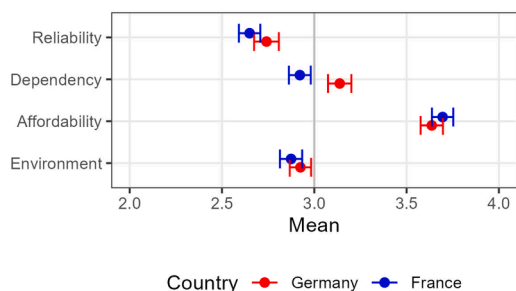
technologies might thus be relatively unstable. Third, natural gas and coal are fossil energy technologies, and attitudes toward these technologies are thus likely to be inverted compared with those toward renewable energy technologies. Lastly, nuclear energy is a particularly controversial technology in the given context, as it was phased out after decades-long protests in Germany but remains a cornerstone of the French energy system.<sup>40</sup> Thus, it is likely that the support for these different technologies depends on how they are perceived to perform in terms of facilitating (short-term or long-term) energy security: for example, citizens concerned about the reliability of supply might reject intermittent renewable energies in favor of nuclear energy or natural gas, whereas those concerned about environmental impacts are likely to support renewable energies over coal or natural gas.

Demand-side energy transition policies relate to governmental interventions in both mobility and domestic energy efficiency. These policies can broadly be divided into push policies in the form of regulations, bans, and taxes (e.g., limiting oil and gas heating systems in buildings) and pull policies in the form of structural incentives (e.g., free public transportation).<sup>41,42</sup> Concern about environmental impacts of the energy system is likely to increase support for all policies, whereas affordability and reliability concerns might be associated with reduced support for push policies that are costly or restrictive (e.g., a carbon tax) but with increased support for pull policies providing structural incentives (e.g., free public transport).

Regarding between-country differences, we generally expected that concerns about reliability and dependency on fuel imports would show a stronger (negative) association with support for the sustainable energy transition in Germany compared with France, as these concerns were very salient due to the country's strong reliance on Russian gas prior to the crisis.<sup>24</sup> In contrast, we expected that the role of affordability, and especially environmental impact concerns, would be similar across both countries, as these concerns might generalize more strongly to the different energy systems and energy transition strategies in Germany and France.

### Concerns about affordability dominate energy security perceptions in France and Germany

In the following, we present the results of our analyses, starting with descriptive statistics before moving on to testing the different components of our theoretical model. Figure 2 shows the levels of concern for the four energy security risks. In both



**Figure 2. Level of concern across the four dimensions in Germany and France**

Note: error bars indicate 95% confidence intervals around the mean. The x axis is truncated by one scale point at each end. Independent-sample *t* tests indicate that the means of reliability concerns ( $p = 0.043$ ) and dependency concerns ( $p < 0.001$ ) significantly differ between countries.

countries, energy affordability was seen as the most concerning risk. Even though electricity prices for private consumers in France were (in absolute terms) about 14 ct/kWh lower than in Germany at the time of the survey,<sup>43</sup> concerns about affordability were at a very similar level in both countries. Participants were relatively less concerned about the other three risk dimensions. Dependency on energy imports from other countries was the second-highest concern and was closely followed by concerns about the negative impacts of electricity production on the climate and the environment. Respondents in Germany expressed greater concern about dependency on energy imports than those in France, possibly due to Germany's historically high reliance on Russian natural gas. Participants in both countries were concerned about environmental impact to a very similar extent, even though Germany's electricity generation from coal and gas produces substantially higher CO<sub>2</sub> emissions than the electricity sector in France.<sup>44</sup> Concerns about reliability were rated as the lowest concerns in both countries.

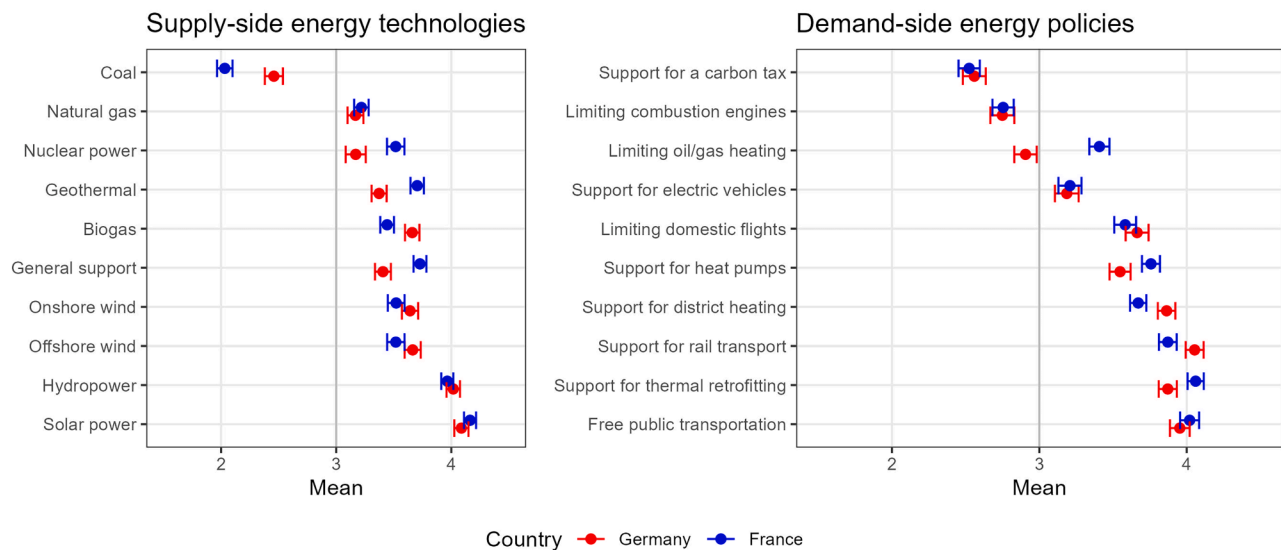
### Concerns about energy security risks explain energy transition support

Descriptive analysis of the different outcome variables showed great variance in the level of agreement with different supply-side technologies and demand-side policies, both within and across countries (see Figure 3). A series of regression analyses showed that concerns about energy security risks were significantly associated with support for the energy transition, including support for specific supply-side energy technologies and demand-side policies (Figures 4 and 5; see Methods S4 for detailed descriptive statistics of all outcome variables as well as socio-demographic control variables). In Germany, where effects were generally stronger than in France, concerns about all four energy security risk dimensions were significantly related to general support for the energy transition. In France, only concerns about climate and environmental impacts were significantly associated with general support (Figure 3, top left; see Methods S4 for detailed model results). Specifically, individuals in Germany who were more concerned about reliability, dependency, and affordability were on average less supportive of the energy transition. Conversely, individuals in France and Ger-

many who were more concerned about the negative climate and environmental impacts of the energy system were on average more supportive of the energy transition. These results indicate that concerns about environmental and climate impacts of the energy system continue to play a crucial role even in the presence of more immediate risks, such as reliability, dependency, and affordability.

Regarding support for specific supply-side energy technologies, we find strong variation both between countries and across the different technologies (Figure 4). For the familiar renewable energy technologies (e.g., solar and wind), concerns about environmental impacts were consistently related to stronger public support in both countries (with the exception of hydropower in France). In Germany (but not in France), concerns about reliability were mostly negatively related to support, whereas dependency concerns showed no clear pattern with renewable energy technologies. The most ambiguous relationships emerged for affordability concerns, which were related to higher support for some renewable energy technologies (solar and hydro in France) but to lower support for others (onshore and offshore wind, for which the results were consistent across both countries). For unfamiliar technologies (biogas and geothermal energy), almost no significant relationships between energy security risks and public support were found, which might indicate that the public would need more information to be able to confidently evaluate these technologies. In particular, public support for biogas and geothermal energy was not consistently higher for those concerned about environmental impacts, suggesting that the public might not generally perceive these technologies to be renewable. In Germany, where fossil fuels (natural gas and coal) still play a dominant role in the energy mix, support was associated with higher reliability and affordability concerns, suggesting that the public might indeed support fossil energy more in the face of perceived immediate energy security risks. At the same time, concerns about environmental impacts remained negatively related to public support for fossil sources. In contrast, in France, where fossil fuels constitute a small share of the energy mix, energy security risks were mostly unrelated to public support, although coal was more supported when reliability was a concern. Support for nuclear energy was negatively related to environmental impact concerns and positively related to affordability concerns in both countries. In sum, these findings demonstrate a strong and consistent role of environmental impact concerns, which increase support for renewable energy generation and decrease support for fossil and nuclear energy generation in both countries. Moreover, we find evidence that more immediate energy security concerns (especially affordability) increase fossil and nuclear energy support, thus posing a potential risk for the energy transition.

Regarding support for demand-side energy transition policies, concerns about environmental impacts generally had the strongest effects on policy support compared with the other risk dimensions (Figure 5). These relationships appeared relatively stronger for push policies (e.g., limiting oil and gas heating or a carbon tax) than for pull policies (e.g., free public transportation and subsidized district heating). Affordability concerns also played a substantial role, mostly lowering policy support for push policies and sometimes increasing support for pull



**Figure 3. Mean support for the supply-side energy technologies (left) and demand-side policies (right) in Germany and France, ordered from lowest to highest support**

Note: error bars indicate 95% confidence intervals around the mean.

policies. Support for thermal retrofits represented an interesting outlier, which was found to closely mirror the pattern of a push policy. Although this item was worded as a pull policy, it is possible that the respondents instead associated retrofits with direct financial obligations (more similar to a push policy), as only a part of the retrofit costs would be covered by subsidies. Concerns about reliability also inhibited support for most of the demand-side policies in Germany but played no role in policy support in France. Concerns about import dependencies played a small role in both countries.

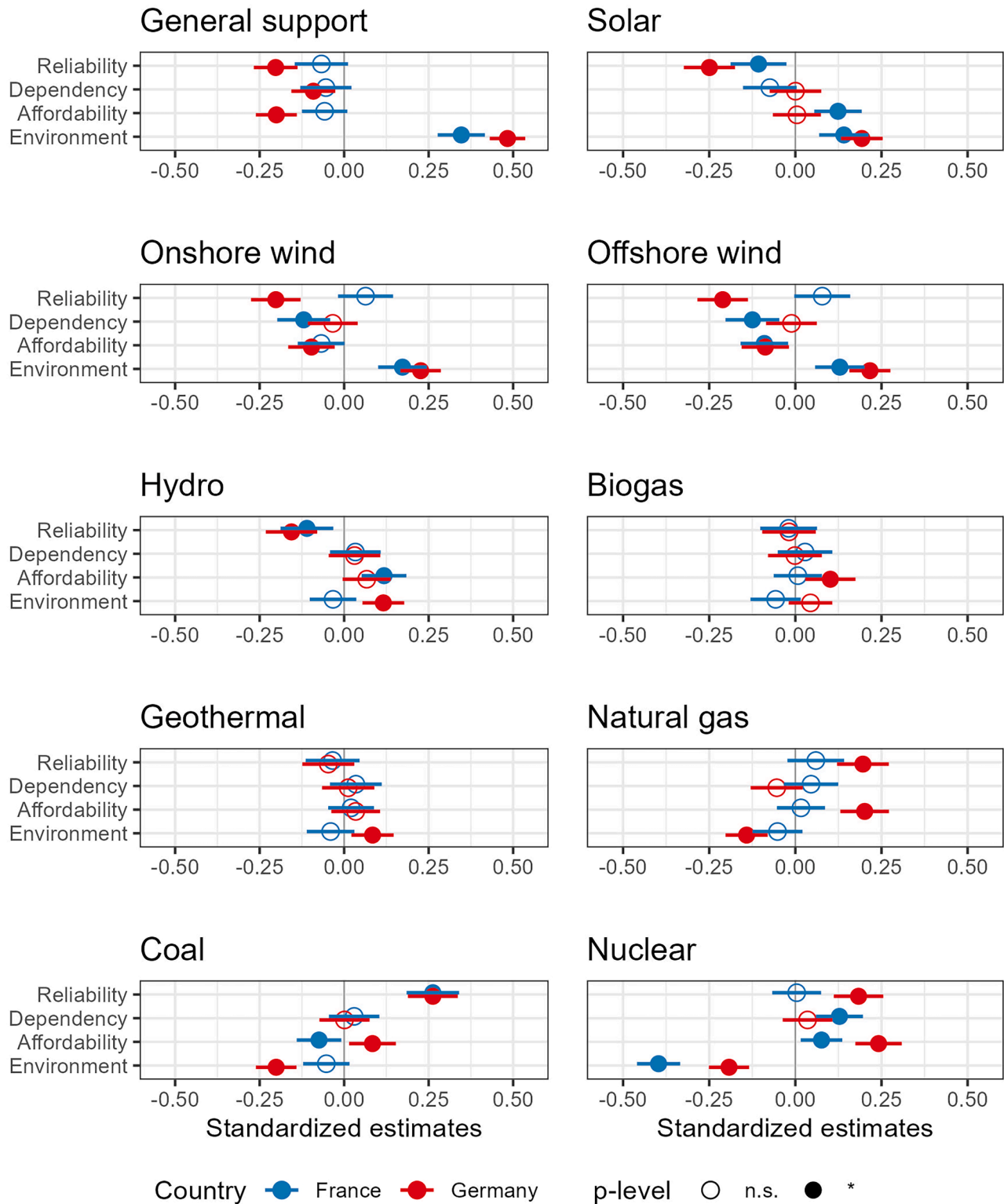
Lastly, socio-demographic control variables were partly associated with energy transition support, but the relationships were not consistent across technologies, policies, or countries. For example, men generally showed more support for renewable energy technologies than women, but not for energy policies (with few exceptions). Similarly, older and more educated people tended to support renewable energy and some policies more than younger and less educated people, but these effects were not consistent and mostly small in size. Income was mostly unrelated to the different outcomes, with a few exceptions. Notably, people with a higher income supported nuclear energy more, both in Germany and in France. These results indicate that, although it is important to statistically control for socio-demographic variables, interpreting their effects appears less interesting compared with the focal role of energy security concerns.

#### Climate change concerns mitigate the adverse effects of affordability concerns

Unsurprisingly, climate change concerns were positively associated with energy transition support in both countries. Consistent with our theoretical model, climate change concerns also moderated some of the effects of perceived energy security risks on energy transition support (see [Methods S5](#) for full regression results). In both countries, climate change concerns reduced the

negative effects of affordability concerns on energy transition support (Figure 6, left and middle). In France (but not in Germany), climate change concerns moderated the relationship between perceived environmental impacts of the energy system and energy transition support: those high in climate change concern supported the energy transition regardless of their level of concern about the environmental impact of the energy system (Figure 6, right).

Participants' level of climate change concern also moderated the link between concerns about reliability risks and perceptions of the energy crisis as an opportunity (see Figure 7A). Individuals in France who were concerned about reliability increasingly saw the energy crisis as an opportunity when climate change concerns were high (and a similar trend was marginally significant in Germany). In contrast, higher concerns about reliability were linked to a decreased perception of the crisis as an opportunity when climate change concerns were low. In Germany, lower affordability concerns led to a lesser belief in the crisis as an opportunity when climate change concern was low. In both countries, climate change concerns also moderated the extent to which concerns about environmental impacts of the energy system were linked to perceptions of the crisis as an opportunity. Specifically, increasing concerns about negative environmental consequences of the energy system were more strongly related to perceptions of the crisis as an opportunity when climate change concern was low, as opposed to high, and this effect appeared stronger in France than in Germany. Lastly, climate change concerns moderated the relationship between perceptions of the crisis as an opportunity and energy transition support, such that those higher in climate change concern showed a weaker relationship between belief in crisis as an opportunity and energy transition support (Figure 7B). However, this interaction effect appeared rather weak in both countries.



(legend on next page)

**Perceiving the crisis as an opportunity as a potential process to understand the effects of risk concerns**

In the last step, we examined, through an integrated moderated mediation model, whether there were conditional indirect effects of perceived energy security risks on general energy transition support via the perception that the energy crisis presents an opportunity for accelerating the energy transition (see Figure 1). As the results of this integrated model closely correspond to the results of the individual model components presented above, we focus on the indirect effects, some of which were conditional on the level of climate change concern (see Methods S6 for an overview of all model results and indirect effects). Results showed that participants' perceptions of the crisis as an opportunity emerged as a potential mechanism for the effects of risk perceptions on energy transition support, especially explaining why concerns about affordability and environmental impacts can translate into higher energy transition support. Concerns about reliability or import dependencies did not have an indirect effect on general energy transition support in either of the two countries.

Affordability concerns showed an indirect effect on energy transition support that was conditional on the level of climate change concern in both countries. Specifically, affordability concerns were indirectly associated with support via a decreased perception of the crisis as an opportunity only among those with a low level of climate change concern (Germany:  $b = -0.06$ , 95% CI =  $[-0.10; -0.03]$ ; France:  $b = -0.02$ , 95% CI =  $[-0.05; -0.004]$ ), whereas there was no significant indirect effect for those high in climate change concern (Germany:  $b = 0.02$ , 95% CI =  $[-0.01; 0.05]$ ; France:  $b = -0.003$ , 95% CI =  $[-0.02; 0.01]$ ).

Concerns about environmental impacts of the energy system were also indirectly associated with stronger energy transition support. In Germany, this indirect effect was significant across low ( $b = 0.06$ , 95% CI =  $[0.03; 0.09]$ ) and medium ( $b = 0.04$ , 95% CI =  $[0.02; 0.07]$ ) levels of climate change concern. In France, the effect was significant for those with a low level of climate change concern ( $b = 0.03$ , 95% CI =  $[0.01; 0.06]$ ) but not for those high in climate change concern ( $b = -0.003$ , 95% CI =  $[-0.02; 0.01]$ ), suggesting a ceiling effect, such that people who are particularly concerned about climate change always show high energy transition support.

**DISCUSSION**

This study analyzed how the German and French public's concerns about energy security risks in the context of the European energy crisis following the Russia-Ukraine war of 2022 are related to their degree of support for the energy transition. Based on a quantitative survey conducted in parallel in Germany and France, we find that citizens in both countries rate concerns about energy affordability as most important,

over concerns about reliability, import dependencies, or environmental impacts. Yet, regression modeling showed that all four risk dimensions are differentially related to energy transition support in both countries (Table 1). In line with expectations, the more individuals were concerned about negative environmental impacts from the energy system, the more they supported the energy transition, renewable energies, and demand-side policies to advance the energy transition, and the less they supported fossil fuel technologies and nuclear power. In contrast, concerns about import dependencies played a small role in both countries; the instability of the fossil fuel supply chains, therefore, does not appear to lower support for the energy transition. Moreover, in Germany, those with stronger affordability and reliability concerns showed less general support for the energy transition and renewables, more support for fossil fuels and nuclear power, and less support for most of the demand-side policies. This was in line with expectations that more immediate concerns in the context of the energy crisis (e.g., about the affordability of energy) may inhibit energy transition efforts and instead allow the prolonged use of energy generation based on fossil fuels. In France, patterns were less consistent. Stronger affordability concerns were, for instance, associated with higher support for solar and nuclear power, but with lower support for offshore wind power and coal, whereas reliability concerns showed very little association with energy transition support.

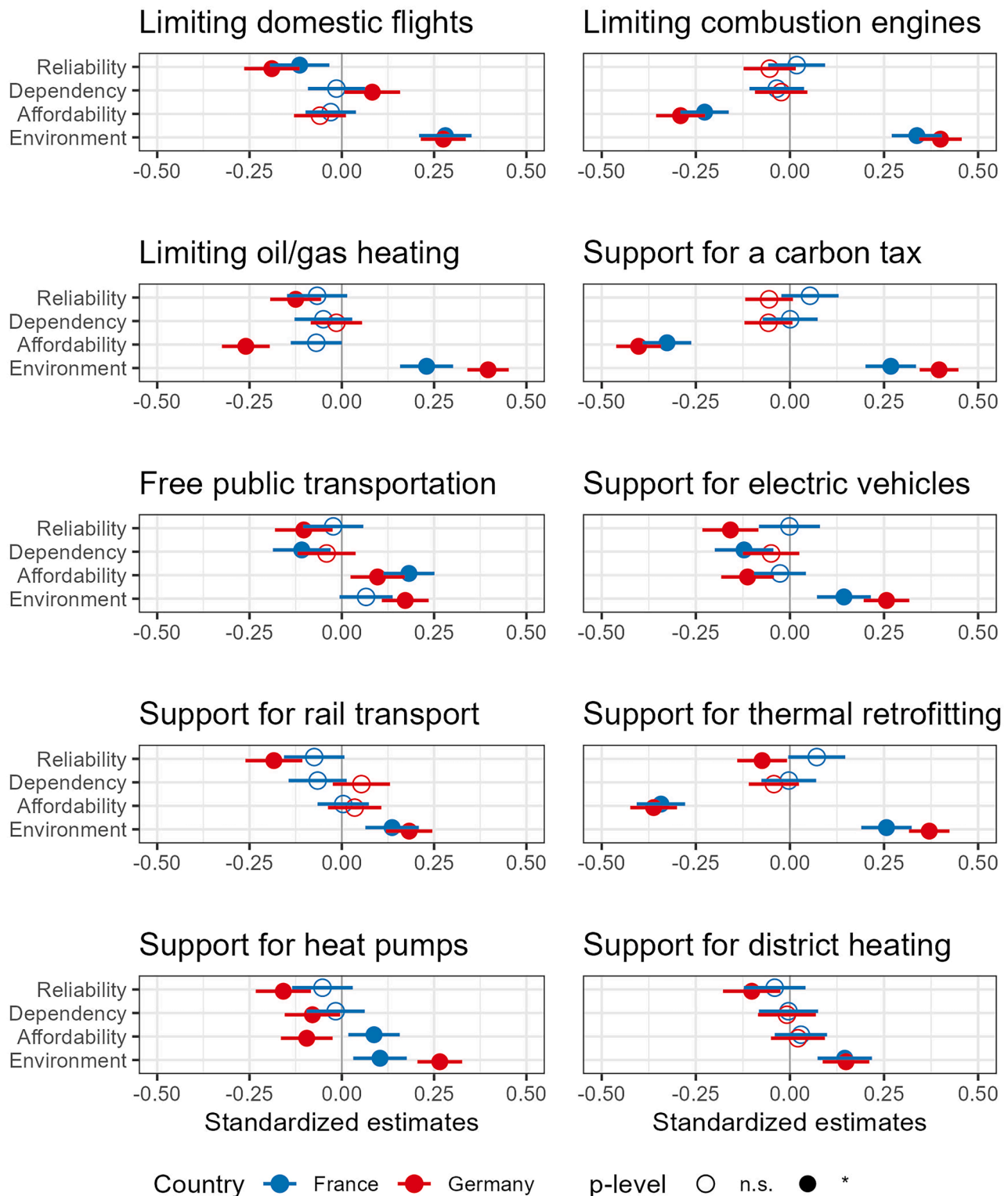
Our analysis further highlights the important role of climate change concern. In particular, higher climate change concerns seem to reduce the negative effects of affordability concerns. Climate change concerns also moderated the relationship between concerns about reliability and perceptions that the energy crisis provides an opportunity for the energy transition in both countries. More specifically, in France, the relationship between reliability concerns and belief in the crisis as an opportunity was negative when climate change concerns were low but positive when they were high. Moreover, the effects of affordability concerns (in Germany) and environmental impact concerns on beliefs in the crisis as an opportunity were stronger when climate change concerns were low (versus high). Perceptions of the crisis as an opportunity could partially explain the relationship between risk perceptions and energy transition support, but our analysis shows that these indirect effects are also conditional on the level of climate change concerns.

**Theoretical implications**

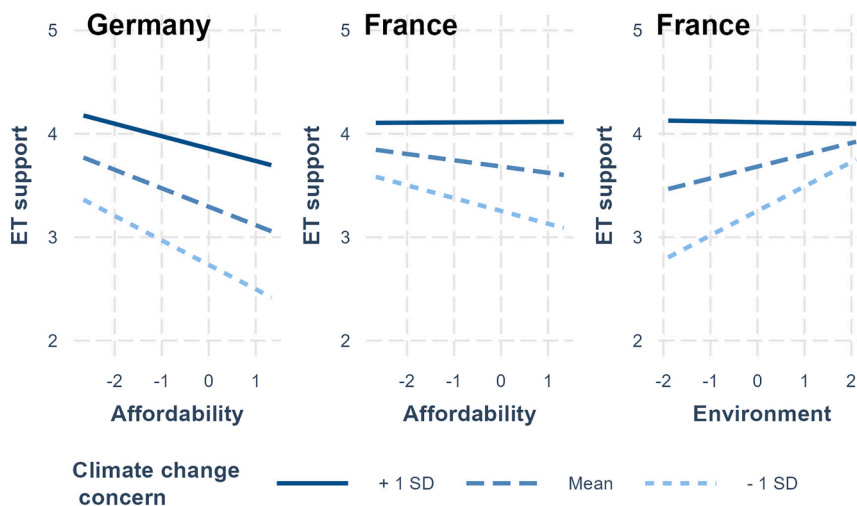
Our findings have important theoretical implications. First and foremost, the consistent positive relationship we find between environmental impact concerns and energy transition support is in line with a large body of literature highlighting the important role of environmental concerns in sustainable behavior.<sup>45–47</sup> Yet, theoretical frameworks on the acceptability of energy technologies have suggested that individual cost-benefit trade-offs also

**Figure 4. Standardized effect size estimates for the relationship between risk dimensions and general energy transition support as well as supply-side energy technologies**

Note: dots represent standardized regression coefficients, and whiskers represent 95% confidence intervals for the estimates. Each technology was analyzed in a separate regression with the four risk dimensions as the focal predictors. Gender, age, education, and income were included as covariates but are not included in the display.



**Figure 5. Standardized effect size estimates for the relationship between risk dimensions and demand-side energy policies**  
 Note: dots represent standardized regression coefficients, and whiskers represent 95% confidence intervals for the estimates. Each technology was analyzed in a separate regression with the four risk dimensions as the focal predictors. Gender, age, education, and income were included as covariates but are not included in the display.



**Figure 6. Simple slopes plots showing the relationship between risk perceptions and energy transition support for low and high values of climate change concern**

Note: only significant interaction terms from the overall regression model are plotted. The y axis is truncated by one scale point.

play a role next to intrinsic environmental motivations.<sup>48,49</sup> In the context of the European energy crisis, we show that concerns about environmental impacts remain the most consistent driver of energy transition support across a range of specific outcomes, even when accounting for more immediate risks, such as affordability concerns. Moreover, general climate change concern emerged as an important moderator by reducing the negative relationship between affordability concerns and energy transition support. This suggests that climate change concerns can provide a lens through which perceived energy security risks are interpreted,<sup>39,50</sup> as well as provide a potential point for interventions communicating climate risks more broadly. Future research could experimentally examine whether highlighting or strengthening climate change concerns could serve as a useful intervention in cases where concerns about energy security risks (in particular, concerns about affordability) reduce support for the energy transition.

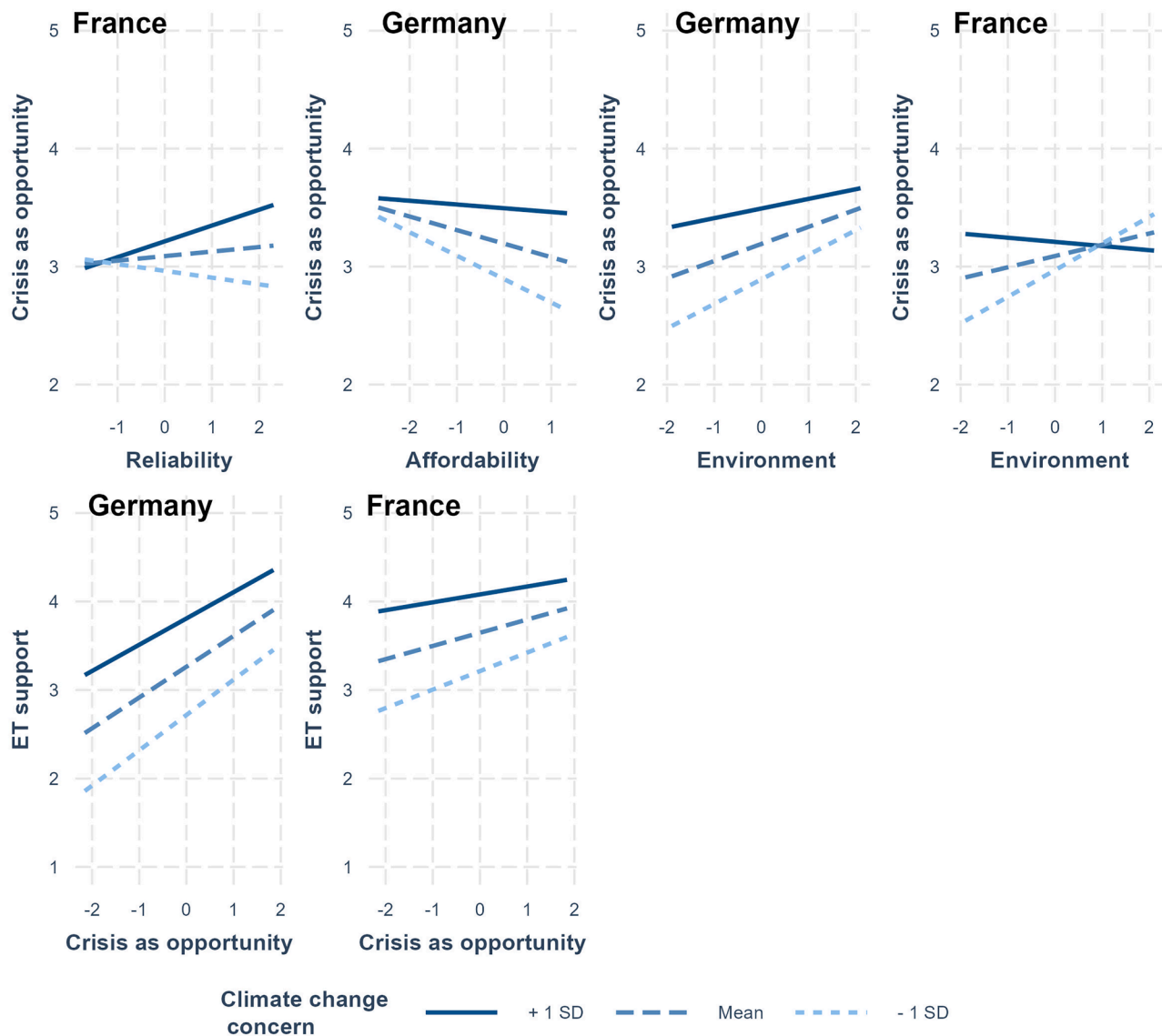
Second, we add to the literature on energy security risk perceptions, which has largely focused on energy security concerns as an outcome<sup>19,20,34</sup> and typically has not linked it to energy transition support. Past studies were also limited in scope, capturing energy security in a highly aggregated way or neglecting important dimensions such as affordability concerns.<sup>17,18</sup> Our approach, focusing on the link between specific dimensions of energy security and energy transition support, is novel and yields valuable insights; all four of our measured energy security dimensions show distinct relationships with energy transition support outcomes. Affordability concerns, in particular, emerge as an important factor (generally more important than reliability or dependency concerns), next to environmental impact concerns. Regarding affordability concerns, our findings somewhat differ from a recent study finding that affordability risks increase the acceptability of policies targeted at renewable adoption.<sup>39</sup> However, this study used a framing manipulation instead of measuring affordability concern and included a positive appeal that specifically related renewable energy to mitigated affordability risks. This suggests that affordability concerns are somewhat malleable and may be influenced by framing.

Third, differences between our findings and related studies (in the UK and across European countries) may also emphasize that the role of energy security risks is highly contextual across countries and likely also across time.<sup>17,18</sup> Our study addresses some of these context effects by studying two large European countries at the same time and with the same methodology, thus facilitating cross-country

comparison. For both Germany and France, we find some consistency across the different outcomes. For some demand-side energy policies, in particular, the role of energy security risks is highly similar (for instance, for limiting domestic flights or combustion-engine vehicles). This might be explained by the fact that these policies are not very sensitive to variations in national energy systems and would affect citizens in both countries similarly. For supply-side energy technologies, we find larger differences between the two countries. These differences are likely attributable to the vastly different energy systems in Germany and France, which led to Germany being relatively more affected by the sudden drop in Russian natural gas imports.<sup>51</sup> Correspondingly, we observe generally stronger negative effects of reliability and affordability concerns on energy transition support in Germany compared with France.

One particularly interesting case is nuclear energy, which constitutes a central pillar of the French energy system but has been phased out after a decades-long debate in Germany.<sup>52</sup> In the wake of the recent energy crisis, some groups in Germany have pushed for a possible revival of nuclear energy for the sake of strengthening energy security.<sup>53,54</sup> These developments are somewhat reflected by our data: although public support for nuclear energy is comparatively higher in France, it is still on average positive in Germany. Moreover, among the German public, support for nuclear energy is associated with concerns about dependency on fossil fuel imports and the affordability of energy prices, two key impacts of the energy crisis that affected Germany in particular.<sup>55</sup> We note that our survey referred to conventional nuclear power plants, although countries such as France are planning the use of small modular reactors (SMRs) in the future, which might elicit different degrees of public support and is an important future research question.<sup>56</sup>

Another interesting case of divergence was found in the support for heat pumps, where we find a significant positive association between affordability concerns and policy support in France but a negative one in Germany, likely due to a polarized public debate on heat pumps in Germany that took place in 2023.<sup>57</sup> In general, these variations signify that some findings on the role of energy security risks are more context dependent



**Figure 7. Simple slope plots showing the relationship between risk concerns and perceptions of the crisis as an opportunity or between crisis as an opportunity and energy transition support for low and high values of climate change concern**

(A and B) Simple slopes plots showing the relationship between risk concerns and perceptions of the crisis as an opportunity (top) or between crisis as an opportunity and energy transition support (bottom) for low and high values of climate change concern. Note: only significant interaction terms from the overall regression model are plotted. The y axis is truncated by one scale point in the top row.

than others, stressing the importance of taking national variations in energy systems, economics, and policy-making into account.<sup>20</sup> Beyond these national variations, within-country variation might also exist, although some preliminary analyses suggest that different regions within Germany and France produce mostly similar results (see [Methods S7](#)).

### Policy implications and conclusion

The results from this study have implications for climate and energy policy. Our results not only suggest that various perceived energy security risks influence public support for the energy transition in different ways but also that the impact

of energy security risk perception varies depending on the specific energy technology, policy measure, and country. Consequently, policymakers could frame messages in ways that resonate with public concerns in a given context.<sup>39,50</sup> For example, even though many German and French citizens appear at least somewhat concerned about their country being dependent on fossil fuel imports, these concerns show little relationship with their energy transition support. Thus, putting more emphasis on this risk may not impact support. In contrast, addressing immediate and personal concerns, such as the affordability of energy prices, may be especially important to garner support for specific

**Table 1. Overview of results**

|                         |                | Germany     |            |               |                      | France      |            |               |                      |
|-------------------------|----------------|-------------|------------|---------------|----------------------|-------------|------------|---------------|----------------------|
|                         |                | Reliability | Dependency | Affordability | Environmental impact | Reliability | Dependency | Affordability | Environmental impact |
| General support         |                | –           | –          | –             | +                    | ns          | ns         | ns            | +                    |
| Renewable energy        | solar          | –           | ns         | ns            | +                    | –           | ns         | +             | +                    |
|                         | onshore        | –           | ns         | –             | +                    | ns          | –          | ns            | +                    |
|                         | offshore       | –           | ns         | –             | +                    | ns          | –          | –             | +                    |
|                         | hydro          | –           | ns         | ns            | +                    | –           | ns         | +             | ns                   |
| Unfamiliar technologies | biogas         | ns          | ns         | +             | ns                   | ns          | ns         | ns            | ns                   |
|                         | geothermal     | ns          | ns         | ns            | +                    | ns          | ns         | ns            | ns                   |
| Fossil fuels            | natural gas    | +           | ns         | +             | –                    | ns          | ns         | ns            | ns                   |
|                         | coal           | +           | ns         | +             | –                    | +           | ns         | –             | ns                   |
| Nuclear energy          |                | +           | ns         | +             | –                    | ns          | +          | +             | –                    |
| Push policies           | flying         | –           | +          | ns            | +                    | –           | ns         | ns            | +                    |
|                         | combustion     | ns          | ns         | –             | +                    | ns          | ns         | –             | +                    |
|                         | gas heating    | –           | ns         | –             | +                    | ns          | ns         | ns            | +                    |
|                         | carbon tax     | ns          | ns         | –             | +                    | ns          | ns         | –             | +                    |
| Pull policies           | public trans   | –           | ns         | +             | +                    | ns          | –          | +             | ns                   |
|                         | EVs            | –           | ns         | –             | +                    | ns          | –          | ns            | +                    |
|                         | rail transport | –           | ns         | ns            | +                    | ns          | ns         | ns            | +                    |
|                         | retrofitting   | –           | ns         | –             | +                    | ns          | ns         | –             | +                    |
|                         | heat pumps     | –           | –          | –             | +                    | ns          | ns         | +             | +                    |
|                         | district heat  | –           | ns         | ns            | +                    | ns          | ns         | ns            | +                    |

Note: The table provides an overview of the relationships between energy crisis perceptions and public support. Signs indicate a significant positive (+) or negative (–) relationship, and (ns) indicates no statistically significant relationship. EVs, electric vehicles.

technologies or policies, such as offshore wind power or a ban on combustion engines. Among all risk dimensions, concerns about environmental impacts were most consistently related to support for the energy transition. This suggests that highlighting the environmental consequences of the energy system, particularly in terms of greenhouse gas emissions, could foster public support for the energy transition. It also indicates that long-term environmental concerns remain highly relevant, even amid the more recent energy crisis.<sup>58</sup>

Though not directly a focus of our study, it is important to note that a lack of energy security might especially affect more vulnerable groups such as low-income households.<sup>59</sup> These groups feel the consequences of instability or rising energy costs to a greater extent and also cannot easily adapt to higher prices or otherwise compensate by switching technologies or fuel sources.<sup>60</sup> Future research could thus investigate the consequences of energy security risks among vulnerable groups in particular and examine how energy security risks and the sustainable energy transition can be addressed simultaneously for these groups. A related question is to what extent these issues can (and should be) be addressed in a top-down way by state actors (e.g., through national energy policies) or how they can be complemented by bottom-up change. For

example, individual households and local communities already facilitate the energy transition through the adoption of sustainable energy technologies and behavioral change.<sup>61,62</sup> They could thus help mitigate energy security risks (such as dependency on fossil fuel imports and associated price spikes) by switching from gasoline cars to electric vehicles or adopting solar panels to produce their own electricity.<sup>63</sup> However, individual technology adoption by wealthier households does not address inequalities in energy security. Communities can facilitate local energy autonomy more widely, for example, by establishing district heating systems with local renewable energy sources (such as community wind power or geothermal energy) that benefit all citizens.

In conclusion, our study on the role of energy security risks in explaining energy transition support in Germany and France shows that different risk dimensions are differentially related to energy transition support. Concerns about the environmental impacts of the energy system are consistently related to higher energy transition support, even when accounting for more immediate concerns about the affordability of energy, reliability of supply, or dependence on energy imports. Affordability concerns tend to be related to lower energy transition support, but the role of affordability, reliability, and dependence concerns generally varies substantially across support

for different energy technologies and policies, as well as countries.

## METHODS

### Procedure and sample

We conducted a survey online through a commercial panel company in December 2023. The data were collected simultaneously in Germany and France and, in each country, quota sampling was used to obtain nationally representative samples for gender, age, education, net household income, and geographic region. All outcome variables were assessed at the beginning of the survey. Perceptions of the risks associated with the energy crisis were assessed toward the end of the survey (after additional survey sections not relevant to this paper). Individual motivations and socio-demographic characteristics were measured last, unless they were part of the quotas, in which case they were measured at the beginning. The median duration of the survey was approximately 14 min. All questions were identical in both countries, and were translated into German and French, respectively, by native speakers. Informed consent was obtained at the beginning of the survey, and the study was approved by the GEM Research Ethics Committee of Grenoble Ecole de Management.

In total, 2,010 participants completed the survey (1,004 from Germany and 1,006 from France). These participants had passed at least two of three attention checks. In Germany, 50.4% of the participants were women (49.6% men) and the mean age was 52.5 years (SD = 15.7 years). In France, 55.5% were women (44.5% men) and the mean age was 51.5 years (SD = 15.9 years).

### Measures

An overview of all items, scales, and detailed descriptive statistics, as well as (if applicable) scale reliabilities, is available in the [Methods S1](#) and [S2](#). Unless stated otherwise, items were measured on 5-point Likert scales anchored by “totally disagree” and “totally agree.”

#### Energy transition support

Public support for the energy transition was captured broadly with three distinct types of measures. First, a three-item scale assessed general support for the energy transition. Second, support for supply-side energy technologies was measured for nine specific electricity generation technologies. These included renewable energies as well as nuclear energy and electricity generation from fossil fuels. Third, support for demand-side energy policies was assessed for ten energy policies that would directly affect private households, such as limiting new registrations of vehicles with a combustion engine, support for free access to local public transportation, or levying a CO<sub>2</sub> tax that gradually increases the price of oil and gas to heat homes. We kept all policy items separate in the analysis with the exception of two items that both tapped CO<sub>2</sub> tax support, which were aggregated via a mean score.

#### Concerns about energy security risks

The survey assessed the extent to which participants were concerned about different dimensions of risks for the energy system. All items were measured on a 5-point Likert scale,

anchored by “not at all concerned” and “extremely concerned.” Multiple items tapping into one dimension were aggregated via mean scores given acceptable scale reliability (see [Methods S1](#) and [S2](#)). Two items measured concerns that the reliability of electricity supply would be threatened by rationing or blackouts in the participant’s country. Concerns about the country’s dependency on energy imports from other countries was captured by three items and captured dependency from countries both inside and outside the European Union. Concerns about the affordability of energy were assessed through three items and captured concerns that energy prices were too high, as well as that electricity or petrol and diesel prices would be unaffordable in the future. Lastly, four items captured concerns that the production of electricity in one’s country produces negative environmental impacts by accelerating climate change and harming the environment. All four items were highly correlated in both countries and were thus treated as a single factor (see the [Methods S3](#) for more details).

#### Perceptions of the crisis as an opportunity

Two items captured the extent to which participants thought that the energy crisis in the preceding 2 years was a big opportunity or helped to push forward the energy transition in their country

#### Climate change concern

One item measured general concern about climate change on a 5-point Likert scale anchored by not at all concerned and extremely concerned.

#### Socio-demographic characteristics

To confirm eligibility to take part in the survey in accordance with the statistical quotas, participants indicated their gender, age (numerical), education (in three categories), and income (below or above the national median household income).

### Data analysis

Prior to the analysis, we created statistical weights to restore any imbalances in the population characteristics during the data collection phase. Weights were based on participants’ gender, age, education, and geographic region and computed separately for each country. With the exception of the moderated mediation model, which used a bootstrapping procedure for the indirect effect estimates, all regression analyses were conducted by taking the sample weights into account. For the main analysis, we conducted a series of weighted least squares regressions with the four energy risk dimensions as predictor variables and the energy transition and policy support variables as separate outcomes. Socio-demographic characteristics were included in all models (in the form of dummy variables for categorical predictors).

For better interpretability, we first conducted the moderation analysis separately for the three moderated paths of the integrated model via regression analysis and subsequently probed and plotted the simple slopes for significant interaction effects. For the final moderated mediation model, we used Hayes’ PROCESS macro (model 59) with 10,000 bootstrap draws.<sup>64</sup>

### Methodological justifications, reflections, and limitations

We reflect on three methodological aspects of our study that could introduce certain limitations to the conclusions that can

be drawn from the analysis. First, our sample consists of an online panel, which means that any participants who took part in our survey study were already pre-selected. Panel companies generally aim for diverse panels that reflect national populations, and from this panel, we selected participants based on certain socio-demographic quotas. To further facilitate national representativeness of our data, we weighted the data in most of the statistical analyses so that national socio-demographic and geographic population characteristics were reflected. Nevertheless, we cannot exclude the possibility of a certain degree of selection bias due to how participants were recruited.

Second, our theoretical model predicts that public concerns about energy security risks determine support for the energy transition. However, our data are correlational and do not allow any firm causal conclusions. It is possible that a reverse causal link exists wherein stronger support for the energy transition produces certain concerns about energy security risks. Here, we assume energy transition support to be an outcome of risk perceptions, which is conceptually in line with a large body of literature on the relationship between risk perceptions or psychological beliefs on the one hand and sustainable attitudes and technology acceptance on the other hand.<sup>17,48,65</sup>

Third, as a related point, we use socio-demographic variables as basic control variables to exclude possible confounding effects of variables such as household income on affordability concerns. We note that our measurement and treatment of socio-demographic variables follows relatively broad categories (e.g., a median split on income and only three levels of education). This was done to keep the statistical models from being overly complex (e.g., by introducing many dummy variables) and to keep consistency between countries (e.g., due to different educational levels in Germany and France). Nevertheless, it is a potential limitation, and future research could include and model socio-demographic and other control variables in a more fine-grained way and potentially further segment the analysis of relationships based on these characteristics.

### RESOURCE AVAILABILITY

#### Lead contact

The lead contact for this project is Daniel Sloom, [daniel.sloom@kit.edu](mailto:daniel.sloom@kit.edu).

#### Materials availability

The data and statistical code for this analysis are available on Open Science Framework (OSF) via <https://osf.io/bfpjg/overview>.

#### Data and code availability

Data and analysis files are publicly available on OSF: <https://osf.io/bfpjg/overview>.

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### AUTHOR CONTRIBUTIONS

Conceptualization, D.S., C.F., M.-C.G., and W.F.; data curation and formal analysis, D.S. and C.F.; investigation and methodology, D.S., C.F., and M.-C.G.; project administration, D.S., K.L., W.F., and F.S.; writing – original draft, D.S.; and writing – review and editing, K.L., C.F., M.-C.G., W.F., and F.S.

### DECLARATION OF INTERESTS

The authors declare no competing interests.

### SUPPLEMENTAL INFORMATION

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