Mitigation Ambiguity and Prudence in Climate Pledges

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Abstract

An effective mechanism for states to mutually review each others' mitigation commitments and compliance is widely touted as an indispensable component in international climate cooperation. A precondition for such a review mechanism to work is that states provide sufficiently precise and reliable information. Yet, states' climate pledges under the Paris Agreement (PA) vary substantially in degree of ambiguity, potentially obfuscating reviews of efforts. While previous literature has outlined the reasons why reliable information provision matters for compliance, this paper examines how ambiguity is related to the ambition level of commitments. Does mitigation ambiguity affect the ambition level of climate pledges?

We formulate an original theoretical model that shows how states face a dilemma between ambitious pledging and achievable compliance, and explains why target ambiguity incentivizes states to exercise prudence when setting the ambition level of climate pledges. If states are unable to set precise mitigation targets, the prospect that non-compliance will be revealed in the periodic review process induces states to set less ambitious targets than states that are capable of precise pledging. Fitting a set of regressions, the empirical analysis tests the hypothesis that mitigation ambiguity is negatively associated with ambition on the full set of Nationally Determined Contributions (NDCs) under the PA. Overall, point estimates show that ambiguity leads to lower ambition in NDCs, in line with our theory. However, the analysis also reveals that different kinds of ambiguity have differing effects on the ambition level of pledges. Our findings shed light on exogenous and endogenous sources of ambiguity in climate cooperation under the Paris Agreement, and provides evidence on how plausible it is that ambiguous pledges will be complied with. We conclude by discussing what the relationship between ambiguity and ambition means for the overall effectiveness prospects of the Paris Agreement.

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1 Introduction

The Paris Agreement (PA) established a pledge-and-review system under which Parties to the Agreement are supposed to undertake progressively ambitious climate policies. This system requires the submission of Nationally Determined Contributions (NDCs), in which Parties periodically outline the climate actions they plan to undertake. The implementation of these pledges is subsequently subject to technical expert review under the Agreement's enhanced transparency framework and periodic global stocktakes of aggregate efforts (UNFCCC 2015).

The overarching purpose of the PA's transparency framework is to build 'mutual trust' and promote implementation of the NDCs through a logic of reciprocity (UNFCCC 2015, art.13). Extant literature posits that a crucial condition for this type of reciprocity to obtain is that states can straightforwardly assess the ambition level of other states' pledges and their performance in complying with pledged mitigation targets (Aldy et al. 2016; Keohane and Oppenheimer 2016). One potential obstacle to mutual assessment is that the precision of states' pledged targets under the PA varies considerably: While some NDCs contain detailed information about mitigation targets and their implementation trajectories, many lack essential technical clarifications that leave their mitigation assumptions open to interpretation (Rogelj et al. 2017; Rowan 2019). The ambiguity in NDC mitigation targets comprises both impact precision—the degree to which global warming consequences can readily be derived from the pledges—and information completeness—which is the level of relevant information that the NDCs provide with respect to the implementation trajectories of the stated mitigation targets. Both types of ambiguity render the review of individual efforts more difficult and obfuscate the collective ambition of the Paris Agreement.

The existence of widespread ambiguity in NDC mitigation targets raises questions about how ambiguity is related to both the ambition level and compliance prospects of states' pledges—which are two central tenets of the PA's overall effectiveness (Dimitrov et al. 2019). One principal question is whether the ambition level of ambiguous pledges differs systematically from that of precise pledges: Do states that pledge ambiguous mitigation targets take on imprudently ambitious targets, or is ambiguity associated with prudence in mitigation targets?

This paper presents a theoretical model that delineates the relationship between mitigation ambiguity and ambition, and empirically probes its plausibility by evaluating how target precision and ambition is related in NDCs. Our model shows how states face a dilemma between ambitious pledging and achievable compliance; and explains why states have incentives to pledge prudently in the face of ambiguity. Hence, we hypothesize that increased ambiguity in the mapping from pledges to actual mitigation is associated with less ambitious pledges. Our empirical analysis of 20 target characteristics of all NDCs supports the hypothesis on an aggregate level. However, the analysis also demonstrates that two sub-indicators of mitigation ambiguity lead to imprudence in mitigation ambition. By assessing the relationship between the ambiguity and ambition of mitigation targets under the Paris Agreement this paper contributes to the literatures on international climate cooperation and on the effects of ambiguity in international institutions. Our findings also provide policy-relevant evidence on how plausible the pledges of states with ambiguous mitigation targets are. Since mitigation ambiguity varies substantially across NDCs, this question has implications both for the aggregate ambition and compliance prospects of the Paris Agreement.

2 Theory: Ambiguity and Prudence under Pledge-and-Review

Under the Paris Agreement, Parties self-determine their mitigation targets by submitting NDCs. Article 4.2 of the Agreement asks that 'Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve' (UNFCCC 2015). However, the Agreement sets few requirements for the type of information that NDCs should contain, which has thus far led to substantial variation in the level of precision of NDC targets (Keohane and Oppenheimer 2016; Pauw et al. 2016). For example, extant NDCs are based on different types of mitigation targets: 32 NDCs currently contain absolute emission targets, 78 contain business-as-usual targets, 9 have intensity targets, and 35 only outline 'policies and actions' (Pauw et al. 2016). Of these three target types, only absolute targets have clear global warming impacts absent the reliance on significant socio-economic assumptions and projections. Moreover, the NDCs cover different sets of greenhouse gases; include varying numbers of mitigation sectors in the targets; provide varying precision in mitigation cost estimations (if any); and specify different conditions such as finance or technology transfers for mitigation targets to be met.

Imprecise information provision can undermine reciprocal collective action in an international institution. First, since the precision of each NDC matters for estimating the aggregate mitigation impact of the Paris Agreement, widespread ambiguity in NDC targets can obfuscate the collective ambition of the Paris Agreement. Extant public goods literature has shown that ambiguity in a collective target is detrimental for individuals' willingness to cooperate (Barrett and Dannenberg 2012; Dannenberg et al. 2015; Barrett and Dannenberg 2016). Second, both the enforcement and managerial schools in international negotiations literature argue that the provision of precise information about states' commitments and degree of implementation can facilitate reciprocity and spur increased compliance (Chayes and Chayes 1993; Tallberg 2002; Dai 2005; Breitmeier et al. 2006; Aldy 2014). Crucially, tit-for-tat strategies can generate cooperative equilibria in repeated prisoner's dilemma games if players can perfectly observe each others' behavior, allowing them to reciprocate positively or negatively (Dai 2005). Hence, Keohane and Oppenheimer (2016) propose that pledge-and-review under the PA will 'only work if there is transparency' and Aldy et al. (2016) argue that transparency enhances the credibility of targets and the likelihood that Parties will comply with their NDCs.

However, whether information precision in the pledge phase of a pledge-and-review system can generate enhanced compliance rates presumably depends on the ambition level of mitigation targets. In this paper, we define mitigation ambition as the projected global warming impact of NDCs; and compliance as adequate implementation of the NDCs' mitigation components (Tørstad 2020). Previous literature has argued that a trade-off exists between ambition and compliance: Since unambitious pledges are easier to comply with, lower ambition should generate higher compliance rates (Dimitrov et al. 2019). Hence, mitigation ambition can mediate the relationship between precise pledges and compliance. This paper thus investigates whether states that have ambiguous mitigation targets in their NDCs have pledged less ambitious targets than states with precise NDC targets. Understanding the relationship between ambiguity and ambition is important because it can shed light on the plausibility that states will meet their mitigation targets. If states with high ambiguity in NDC targets are more ambitious than states with low NDC ambiguity, ceteris paribus, we can infer that the targets of ambiguous NDCs are inflated—and compliance will hence likely be lower than for NDCs with precise targets. Conversely, if ambiguous NDCs are less ambitious than NDCs with precise targets, the ambiguous NDCs are likely conservative—and compliance more easily achievable.

When formulating mitigation targets in a climate pledge, states have partly conflicting incentives when deciding on the ambition level of targets. On one hand, states have strategic reasons to pledge ambitious targets. Following a logic of reciprocity, states can signal ambitious mitigation targets with the aim to spur other states to do the same (Tingley and Tomz 2014; Weikmans et al. 2019). Hence, signalling ambition can lead states to obtain specific mitigation benefits from others. The potential benefits of high ambition can also include more diffuse objectives such as enhanced international reputation or willingness by other states to cooperate in other institutions (Keohane and Oppenheimer 2016). Finally, pledging ambitious targets can also be a mechanism to please or attract domestic constituencies such as environmental interest groups or voters more broadly (Keohane and Oppenheimer 2016).

On the other hand, states also have an incentive to pledge unambitious targets in order to easily achieve compliance and hence avoid repercussions internationally or domestically (Dai 2005; Keohane and Oppenheimer 2016). The PA does not set any minimum requirements for the ambition level of pledges, and states have to consider that their implementation achievement will be extensively reviewed. In a public goods laboratory experiment, Barrett and Dannenberg (2016) find that the introduction of a review of efforts decreases individuals' pledges to be more in line with actual contributions. Notably, this finding suggests that states may formulate relatively more prudent mitigation targets in the face of a compliance review mechanism such as the transparency framework under the Paris Agreement. From a compliance perspective, pledging unambitious NDC targets is a particularly appealing strategy for states that have low capacities to formulate precise and detailed targets, in order to maximize the likelihood that the pledged targets will be achieved. Finally, the so-called 'progression principle' of the Paris Agreement binds Parties to adopt increasingly ambitious climate policy targets (UNFCCC 2015, art. 4.3); if states exercise prudence in the formulation of NDC mitigation targets, they can obtain leeway to ensure that they are in a position to further increase ambition in subsequent rounds of pledging.

While ambitious and unambitious pledging each offers appealing benefits, we propose that the two strategies differ in the likelihood that the different sets of benefits will materialize. Importantly, the posited international and domestic benefits of pledging ambitiously depend on other actors perceiving that a pledge is ambitious. However, no ambition level is likely sufficiently high to *guarantee* widespread acclaim. Further, although high ambition may spur reciprocal ambition among other states, this outcome is only likely to ensue if a critical number of states pledge ambitiously (Nyborg 2018). Hence, the likelihood that the benefits of ambitious pledging will materialize is uncertain. In contrast, all states that submit an NDC are aware that their performance in implementing the pledge will be scrutinized by the PA's review mechanism, and that ambition has to be ratcheted up over time. Hence, states face two tangible shadows of the future that give reason to pledge prudently if any doubt prevails on a state's ability to comply or its potential to subsequently increase ambition in future pledging.

To formalize our argument, we consider a utility function of pledges, mitigation, and compliance. Specifically, the utility of a state is:

$$U = -\lambda(p)u(q(X) - p) \tag{1}$$

where p denotes pledge and $q(X) - p$ is the discrepancy between the latent mitigation variable, $q(X)$, reported in the review stage, and the pledge, p. For notational simplicity we simply write q throughout. q is the estimated mitigation conditional on country characteristics, X, including factors such as mitigation capacity, vulnerability to climate change, and fossil fuels endowments (Tørstad et al. 2020). λ is a scalar that potentially depends on p, reflecting that states value discrepancies between q

and p differently depending on the size of p. As described above, pledging ambitiously could be attractive because states hope to incentivize other states to invest in mitigation. However, states have to weigh the benefits of ambitious pledging against the feasibility of compliance. The utility function u in (1) has a symmetric U-shape, where the unique minimum (and maximum of (1)) reflects the optimal pledge, p^*. This bliss point may be bigger or smaller than q depending on the benefits states attach to ambitious pledges relative to compliance.

Since we focus on the determination of pledges, we treat mitigation, q, as a random variable which—conditional on different country characteristics—has the following distribution: $q \sim D(\mu_q, \sigma_q^2)$, where the probability density function is symmetric about μ_q and independent of other country characteristics than X[1]. A state with 'full' control over its own mitigation, $\sigma_q \to 0$, will pledge to mitigate approximately p^* and obtain utility $U = u(q - p^*)$ where $q \approx \mu_q$. As σ_q increases, so does the chances of severe compliance and non-compliance. Hence, the state is compelled to balance these concerns.

In the following we define, for notational simplicity, the variable $C := q - p$ as the discrepancy between q and p. C is then distributed with expectation $\mu_C = \mu_q - p$ and variance σ_q^2, and $C^* = \mu_q - p^*$ is the optimal realization of C. Finally, f(C) is the probability density function of C. To summarize, a given state cannot affect the probability of achieving C^*, but it can determine its pledge to increase the probability of compliance by reducing its pledge and thus increasing μ_C; or accept a higher probability of non-compliance by setting p such that $\mu_C < C^*$.

We now follow Waud (1976) to analyze how states determine C relative to C^* when facing uncertainty about the realization of q. Suppose for simplicity, and without loss of generality, that $C^* = 0$, meaning that the optimal pledge equals the expected mitigation. Since the benefits of ensuring compliance are more tangible than the benefits of pledging ambitiously, states are more worried about undershooting C^*—that is, $C < C^*$—than overshooting. Formally, we assume the following:

$$\begin{aligned} u(C) \qquad & \text{if} \quad C \geq 0 \\ \lambda u(C) \qquad & \text{if} \quad C < 0 \end{aligned} \tag{2}$$

where $\lambda > 1$. Hence, realized discrepancies between $\bar{C}$, the chosen C, and C^* lead to greater loss on the left side of 0 than on the right side. The state then maximizes (1) by choosing the $\bar{C}$ that minimizes the expected loss:

$$\underset{C}{\text{minimize}} \quad -E(U) = \lambda \int_{-\infty}^{0} u(C) f(C; \mu_C) dC + \int_{0}^{\infty} u(C) f(C; \mu_C) dC \tag{3}$$

Result 1: *If $\sigma_q^2 > 0$ the state will choose $\bar{C} > C^*$. $\bar{C}$ is increasing in σ_q^2. Hence, as ambiguity increases, states will decrease the ambition level of pledges.*

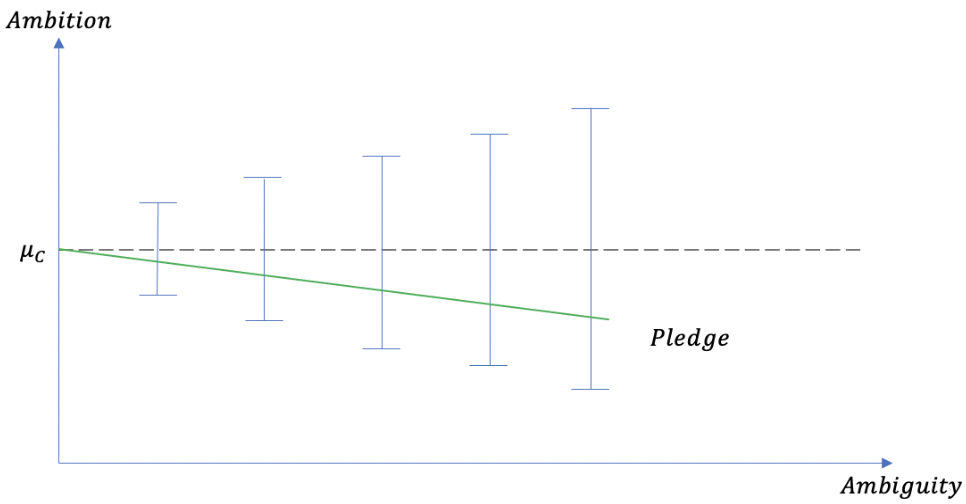
Proof. See the proof of Waud (1976) adapted to our model, in Supplementary Material E ■

It immediately follows from Result 1 that states' pledges will be lower than p^*. Moreover, as the variability of q increases, states decrease the ambition level of their pledges. The intuition is that as the σ_q increases, the loss associated with undershooting relative to overshooting is given more weight. The increased probability of low realizations of q disincentivizes states to pledge ambitiously. We call this

[1]Throughout, we use the term 'ambiguity' to describe epistemic uncertainty in the mapping from pledges to mitigation.

behaviour prudence. While states' actual mitigation may be higher or lower than pledged, they focus on the possible down-side risk—which is more tangible than the upside risk due to the existence of a review system. Prudence implies more conservative pledging relative to the case where mitigation levels are more certain, as illustrated in Figure 1. In contrast, imprudence would imply that states weight the upside risk more heavily. In our model, imprudence would manifest itself as $\lambda < 1$ and imply a positive relationship between ambiguity and ambition.

Figure 1: Exogenous ambiguity and prudence



Notes: This figure illustrates the predicted relationship between exogenous ambiguity and ambition as measured in states' pledges, conditional on $C^* = 0$. The blue, vertical line segments represent exogenous ambiguity. The dashed line shows expected mitigation level conditional on controls. The green line represents ambition as a function of ambiguity.

Until this point, our model has presumed that ambiguity in NDCs is exogenous (represented by σ_q), meaning that ambiguity originates in factors beyond the control of states. Such exogenous factors could, for example, be scientific and technical capacity, bureaucratic capability, and fiscal resources (Chayes and Chayes 1993). Some states may, however, have incentives to also intentionally introduce ambiguity in their targets (Keohane and Oppenheimer 2016; Rowan 2019). We call this endogenous ambiguity and henceforth denote it A_{En}.

Endogenous ambiguity has been shown to feature in a wide range of political institutions. For example, endogenous ambiguity can be winning strategy for candidates and political parties trying to attract voters (Tomz and Van Houweling 2009; Bräuninger and Giger 2018); for a small state engaging in an arms race with a big power (Baliga and Sjöström 2008); and for judges that seek to pre-empt defiance of judicial rulings (Staton and Vanberg 2008). In climate cooperation, a given state may introduce ambiguity in order to obtain a degree of flexibility in the review process, effectively obfuscating whether the state is in compliance with its targets or not (Keohane and Oppenheimer 2016). Second, a state could introduce more ambiguity in order to signal a higher mitigation level than it actually intends to pursue, in order to obtain reciprocity benefits from other states (ibid.). The effect of ambiguity on the relationship between the ambition level of pledges and the actual achieved mitigation level depends on which one of these considerations states weigh more. Hence, we can think of states' decision to decide the optimal relationship between pledges and mitigation as a two-stage process where states initially decide their optimal pledges and next adjust the ambiguity regarding q to signal potential prospects for high or low mitigation levels in the second stage.

Suppose that the endogenous ambiguity of a given state's mitigation, q, is decided by adjusting A^{+}_{En} and A^{-}_{En}. By setting $A^{+}_{En} > 0$, the state gives the impression that higher values of q are achievable than implied by the exogenous ambiguity. Hence, if states' primary concern is to signal their potential to implement large emission cuts, we would expect them to increase A^{+}_{En}. For example, states could introduce conditional statements in their targets that imply higher levels of mitigation if certain conditions, e.g. financial support, are met. Conversely, $A^{-}_{En} > 0$ would portray lower mitigation level as more probable. In our model, states do not have an incentive to do this as a means of achieving greater leeway. The possibility of low realizations of q is captured by the exogenous ambiguity and if states want to hedge against the possibility of not reaching their target, this concern would be captured by their choice of p in expression (1). One could, however, imagine that states wanted to set $A^{-}_{En} > 0$ and exert little effort to reach q, but this would affect the choice of μ_q in the first place since this is considered the optimal mitigation level given country characteristics. Unambitious states would rather adhere to their optimal level of mitigation, set their pledges optimally in the first stage, and increase A^{+}_{En} to reflect potentially large emission reductions. Overall, the introduction of endogenous ambiguity does not alter the directional effect outlined in Result 1 since the level of p relative to μ_q is unresponsive.

We model a state's incentive to signal the potential for high mitigation levels as a concave function of total ambiguity. This choice reflects that too much ambiguity—such as introducing endless numbers of conditional statements—may decrease the credibility of targets. States care about the level of total ambiguity in their NDCs, as this is what is observed by others. Hence, the A^{+}_{En} is a function of σ_q. The degree of endogenous ambiguity also depends on p since prudent states reduce their ambitions as σ_q increases, thus expanding the the room for realization of q above p and ultimately rendering A_{En} less useful. We end up with the following problem:

$$\underset{A^{+}_{En}}{\text{maximize}} \quad G(A^{+}_{En} + \sigma_q - \beta p(q, \mu_q, \sigma_q)) \tag{4}$$

where β represents a state's perception of the optimal degree of A^{+}_{En}, which we assume is independent of σ_q. The first order condition of (4), $G'(A_{Ex}(\sigma_q) + \sigma_q - p(q, \mu_q, \sigma_q))$, pins down the optimal level of endogenous ambiguity as a function of the exogenous ambiguity. Differentiating with respect to σ_q generates the following result:

Result 2: *Endogenous ambiguity is negatively related to exogenous ambiguity.*

$$\frac{\delta A_{En}}{\delta \sigma_q} = \beta \underbrace{\frac{\delta p}{\delta \sigma_q}}_{<0} - 1 \tag{5}$$

We cannot observe each state's optimal pledge in the case of precision or μ_q. Hence, our identification strategy of risk behaviour relies on cross-country observations of how states react to variations in NDC mitigation ambiguity in the mapping from $p \to q$ and control variables that are likely to affect ambition and ambiguity. While the inclusion of endogenous ambiguity does not alter a state's pledge, p, relative to expected mitigation μ_q, it may affect our interpretation of the relationship between ambiguity and ambition. As in Figure 2, we will in our regressions array states based on total ambiguity—which is the sum of exogenous and endogenous ambiguity. Now suppose we were to estimate the following OLS regression to find the linear relationship between *ambition* and *pledge* in Figure 2:

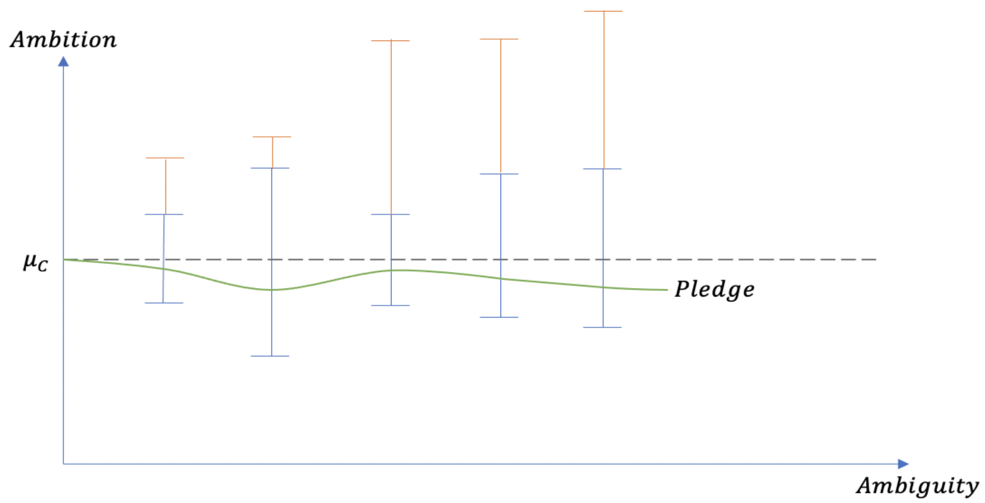
$$p = \gamma + \beta(\sigma_q + A_{En})$$

where γ is the constant term. The slope is denoted β and its sign depends on the following:

$$\beta = \frac{cov(\sigma_q + A^+_{En}, p)}{var(\sigma_q + A_{En})} = \overbrace{\frac{cov(\sigma_q, p)}{var(\sigma_q + A_{En})}}^{<0} + \overbrace{\frac{cov(A_{En}, p)}{var(\sigma_q + A_{En})}}^{>0} \tag{6}$$

Whether the causal exogenous or endogenous ambiguity determine the sign of β depends on the signs and magnitudes of the two rightmost terms in (6). Based on our theoretical considerations—and given that these relationships have linear tendencies—these have opposite signs: $cov(\sigma_q, p) < 0$ and $cov(A^+_{En}, p) > 0$. While we have not formally derived the latter relationship we structurally infer it from Results 1 and 2, which state that both p and A^+_{En} are negatively related to σ_q. A positive β would thus be a sufficient statistic for states strategically varying A^+_{En} to portray themselves as more ambitious, according to our model. However, we can not exclude that states are also prudent with regard to exogenous ambiguity. Likewise, a negative β would reveal the existence of a prudence motive while not excluding strategic determination of A^+_{En}.

Figure 2: Ambition as a function of endogenous and exogenous ambiguity



Note: This figure illustrates the predicted relationship between ambiguity and ambition as measured in states' pledges, conditional on $C^* = 0$. The blue, vertical line segments represent exogenous ambiguity, which is beyond states' control, while the orange line segments portray potential strategic ambiguity. The dashed line shows the expected mitigation level of states conditional on controls. As the combined level of ambiguity increases, the pledges decrease relative to the expected mitigation, which reflects prudent behaviour by states.

In sum, the discussion above showed why states have an incentive to pledge prudently in the face of ambiguity. We hence hypothesize that:

Hypothesis: *Ambiguity and mitigation ambition are negatively related in states' climate pledges.*

To probe the hypothesis, we indirectly infer whether states are prudent by assessing the correlation between ambiguity and ambition in states' climate pledges under the Paris Agreement. A negative correlation between ambiguity and ambition in these pledges indicates that states pledge prudently in the face of ambiguity, and that ambiguous targets are deflated compared to certain targets. No correlation or a positive correlation between the two variables imply weightings of endogenous and exogenous ambiguity that are hard to disentangle based on our theory. In the empirical analysis we include a battery of control variables that have previously been shown to be important in predicting NDC ambition (Tørstad et al. 2020). Our interpretation of the relationship between pledges and ambiguity as states respond to (exogenous and endogenous) ambiguity naturally hinges on the assumption that the controls provide a fairly accurate estimate of the latent variable μ_C.

3 Data and empirical strategy

In the empirical analysis we collect data from a variety of sources. First, our dependent variable *NDC ambition* is based on Robiou du Pont & Meinshausen (2018), who apply a hybrid allocation approach to estimate the global temperature impact (measured in $^\circ$C) consistent with each given state's NDC. Their assessment takes three effort-sharing principles into account—capability to pay (GDP per capita), historical responsibility (convergence to equal cumulative per capita emissions), and equality (convergence to equal per capita emissions)—and the global warming impact of a given NDC is calculated based on the principle most lenient for the given state. In contrast to other ambition assessments, Robiou du Pont & Meinshausen's (2018) variable covers nearly all NDCs, minimizes the normative choices made, has an intuitive interpretation (global warming impact measured in $^\circ$C), and avoids making counterfactual assumptions about business-as-usual emissions (Tørstad et al. 2020). A robustness test reported in Supplementary Material B also demonstrates that our results hold when we use an alternative ambition metric (Burck et al. 2018) as dependent variable.

To measure the ambiguity of NDC mitigation targets, we gather information on the precision of all NDCs from Pauw et al's (2016) *NDC explorer* database. To capture NDC ambiguity, we code the precision of 20 different NDC mitigation characteristics, e.g., which gases the NDCs cover; what types of mitigation targets the NDCs set; and whether targets are conditional on financial or technological support. We measure two main types of ambiguity in these NDC mitigation characteristics. *Impact precision* is the degree to which global warming consequences of mitigation targets can be derived with certainty from the NDCs. For instance, absolute mitigation targets—i.e. emission reductions relative to a specified base year—have clearer global warming implications than emission intensity targets—emission reductions relative to economic indicators such as GDP—as the latter depend on the future socio-economic development trends of a given country (Rogelj et al. 2017). *Information completeness* refers to the breadth of policy sectors and tools included in the formulation of the NDC: For example, whether an NDC covers policy sectors such as transport or agriculture and whether it covers policy tools such as carbon capture and storage or renewable energy generation. Impact precision is closely related to the ambition level of NDC targets, in the sense that higher impact precision renders ambition more straightforward to evaluate. Information completeness, on the other hand, can be understood as the level of details in the implementation trajectory of an NDC—and is hence more related to the credibility that a country will achieve its stated target than the actual ambition of the target. We recode all mitigation-related variables from Pauw et al.'s (2016) database such that higher variable values indicate higher degrees of NDC ambiguity. We also standardize the variables for ease of interpretation. Lastly, to minimize bias in our estimates of the effects of ambiguity, we also include a set of control variables that Tørstad et al. (2020) show can explain variation in our NDC ambition variable. Descriptions of all variables and their coding are provided in Supplementary Material A.

We evaluate the relationship between NDC ambiguity and ambition by means of two different variable selection procedures. First, we include all the ambiguity variables and assess the effect of aggregate NDC ambiguity on ambition. Second, in order to reduce the dimension of our dataset, we trim it using data-driven model selection. The machine learning algorithm we use is the Least Absolute Shrinkage and Selection Operator (Lasso) procedure (Tibshirani 1996). As in a regular OLS model, the Lasso procedure evaluates the following linear model: $Y = \beta X$ where X is a vector of NDC characteristics and control variables, and β a vector of the corresponding coefficients. The lasso automatically introduces one variable at a time in the model and evaluates, at each inclusion, the extra explanatory power of a specific variable. Including more variables in the model, however, comes with a penalty, λ, which is equal for all variables. The lasso includes the variables that provide enough explanatory power to exceed the value of the penalty parameter, λ, and excludes the variables that do not contribute sufficiently relative to the penalty. We conduct the Lasso procedure in order to minimize the risk of overfitting the data due to the high number of variables relative to observations, without having to arbitrarily choose which variables to exclude (Aronow and Miller 2019). [2]

We begin by constructing different types of indices to asses the effect of overall ambiguity on NDC ambition using 1) all ambiguity variables and 2) the ambiguity variables selected using the lasso procedure. Since we do not have any theoretical expectations regarding the importance of each ambiguity dimension, we use three different weighting procedures in constructing the indices.

The first index, *Equality index*, assigns equal weights to all ambiguity variables (see e.g. Ray 2008). In the second, *Correlation index*, ambiguity variables are weighted by the relative magnitude of their bivariate correlations. The third, *Regression index*, assigns weights proportionally to the strength of variable coefficients in explaining variations in the variable 'type of target', which we consider to be a particularly valid proxy for the concept of NDC ambiguity. More detailed explanations of the construction of indices are provided in Supplementary Material C.

To exploit the variation in the ambiguity dimensions, we also assess the individual impact of ambiguity variables selected by the Lasso. We make statistical inference on the selected variables by running the following OLS to obtain confidence intervals on the coefficients:

$$Y = \alpha + \beta U + \gamma X + \epsilon \tag{7}$$

where α is the constant term, U is the vector of variables indicating ambiguity with the parameters in β. X and γ are vectors of control variables and coefficients. Finally, it should be noted that, due to

[2]To determine the optimal value of λ, we use cross validation. The cross validation, first, randomly selects a sample (train) of the data on which it builds a model conditional on a specific value of λ. Subsequently, the model is used to predict the dependent variable in the sample which was not used for model selection (validation). The performance measure of a model with a specific λ is the mean squared error ϕ in the validation sample. This process is repeated multiple times generating a set of pairs (λ, ϕ). In our final model we use the λ leading to the smallest mean squared error

missing data, somewhat different sets of NDCs are included in the various empirical analyses below. [3]

4 Empirical analysis

In this section, we first provide descriptive statistics on the NDC ambiguity variables. We then proceed with the results of the lasso procedure, followed by the analyses of the effects of the ambiguity indices on ambition. Finally, we examine the relationship between each of the ambiguity variables selected by the lasso and NDC ambition.

4.1 Descriptive statistics

Overall, we find substantial cross-country variation in NDC ambiguity. On most ambiguity dimensions, a large number of states display substantial amounts of ambiguity in their NDCs (see Figure A.1 in the Supplementary Material). A correlation matrix [4] also reveals mostly positive relationships between the ambiguity dimensions: Countries with imprecise NDCs along some ambiguity dimensions also tend to be imprecise on other dimensions. This non-random distribution of ambiguity indicates that the variables captures the same underlying concept of ambiguity, hence evincing the internal validity of the 20 selected ambiguity variables. [5]

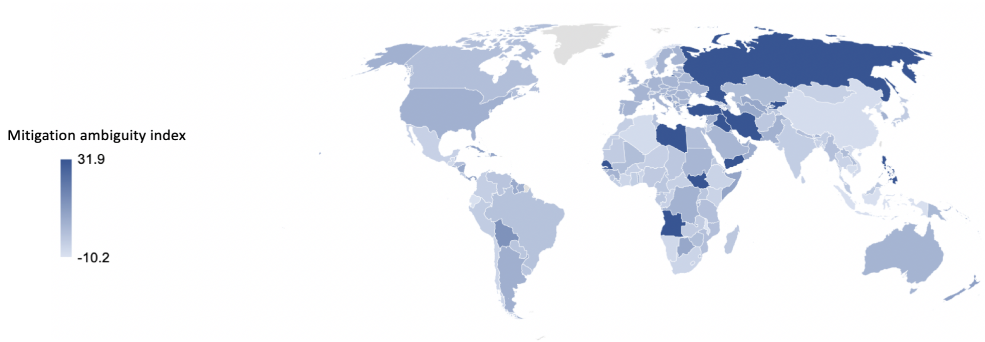
Figure 3 displays country scores on a mitigation ambiguity index with equal weights for all 20 variables. Darker blue indicates more ambiguity in NDCs. The map shows that Angola, Brunei, Iran, Iraq, Kyrgyzstan, Lebanon, Libya, Philippines, Russia have the most ambiguous mitigation targets in NDCs, while Algeria, China, Cambodia, Norway, Indonesia, Ecuador, Armenia, Malawi have the most precise NDCs. On a regional level, the map shows that countries in Western Europe, Asia, and the Americas have more precise NDCs than countries in the Middle East and Africa. However, NDC ambiguity varies substantially between African countries.

[3] Instead of imputing values for these states, we posit that the values are missing randomly with respect to NDC ambiguity.

[4] See Figure A.2 in the Supplementary Material.

[5] Exceptions are *Conditionality of technology transfer*, *Mitigation costs*, and *Type of target*.

Figure 3: Country scores on the mitigation ambiguity index



4.2 NDC ambiguity and ambition

We first evaluate the aggregate effects of ambiguity on NDC ambition, using six ambiguity indices that are weighted differently. Table 1 shows the relationships between the different indices and NDC ambition.

Table 1: The effects of six NDC ambiguity indices on ambition

	Equal weights		Correlation weights		Regression weights	
Dep Var: NDC Ambition	Full (coeff / 95% CI)	Lasso (coeff / 95% CI)	Full (coeff / 95% CI)	Lasso (coeff / 95% CI)	Full (coeff / 95% CI)	Lasso (coeff / 95% CI)
Index	-0.0127 [-0.035, 0.010	-0.022 [-0.062, 0.017]	-0.224 [-0.662, 0.214]	-0.235 [-0.636, 0.165]	-0.0625 [-0.439, 0.313]	-0.048 [-0.364, 0.268]
Controls included	Yes	Yes	Yes	Yes	Yes	Yes
Observations	149	149	149	149	149	149

Notes: This table displays the effects of six indices on countries' NDC ambition. Columns denoted 'Full' include indices in which we include all of the variables in Table 1. Columns named 'Lasso' only include variables selected in the lasso procedure. 95% confidence intervals for the coefficients are included in squared brackets.

Columns 1-6 above respectively show regressions of a summative index using equal weights, correlation weights, and regression weights. All coefficients are negative, pointing to a negative relationship between NDC ambiguity and ambition. The coefficients are statistically insignificant on the standard levels, precluding generalisations of the findings to future rounds of NDC submissions as well as other negotiation settings.

Next, we focus on the effects of the individual ambiguity variables, and run regressions based on the variables that the Lasso procedure selected. To identify the most salient variables in the relationship between NDC ambiguity and ambition, we include all variables, and a set of control variables, in the lasso procedure. We then use cross validation to estimate the value of the strictness parameter that minimizes the mean squared error.

Table 2 displays OLS regressions with the selected ambiguity as independent variables, with and without control variables. As mentioned above, higher values in the variables indicate higher degrees of ambiguity. The regression analysis shows that different types of NDC ambiguity have different effects on NDC ambition. Further, the inclusion of control variables in column 2 shows that the controls are correlated with some of the ambiguity dimensions: Notably, the significance of *Mitigation costs* and mentioning of *Energy efficiency* depend on whether control variables are included or not.

Table 2: Effects of ambiguity on NDC ambition

Dep. Var.	NDC Ambition	
Mitigation costs (ccm)	0.349**	-0.169
	[0.0676,0.630]	[-0.395,0.0559]
Renewable energy	0.254	0.124
	[-0.211,0.719]	[-0.202,0.450]
Agriculture	-0.0481	-0.0518
	[-0.396,0.300]	[-0.309,0.205]
Waste	-0.0180	-0.289**
	[-0.314,0.278]	[-0.552,-0.0269]
Reducing non-co2 gases	0.417**	0.490***
	[0.0762,0.758]	[0.240,0.740]
Land use and forestry	-0.571***	-0.508***
	[-0.930,-0.211]	[-0.765,-0.251]
Mitigation documents	-0.162	-0.0687
	[-0.415,0.0900]	[-0.297,0.160]
Technology needs	-0.0563	0.111
	[-0.337,0.224]	[-0.124,0.347]
Conditionality of technology transfers	-0.154	0.251*
	[-0.461,0.154]	[-0.00329,0.505]
Monitoring and review	0.00530	0.0650
	[-0.293,0.304]	[-0.176,0.306]
Planning of NDC formulation	-0.356**	-0.382***
	[-0.681,-0.0314]	[-0.656,-0.107]
Controls included	No	Yes
Observations	170	149
R^2	0.260	0.630
F Statistic	7.25 (df=11)	33.09 (df = 17)

Notes: The table displays OLS regressions of each Lasso-selected variable's impact on NDC ambition. *,** and *** denote significance at the 0.1, 0.05 and 0.01 level. 95% confidence intervals are displayed in squared brackets below the coefficients.

In the full model with controls (Table 2), we find that ambiguity regarding *Waste* and *Land-use and forestry* substantially reduce NDC ambition—these variables lead to reductions of 0.33°C and 0.51°C in mitigation ambition per one standard deviation increase in ambiguity, respectively. Moreover, increased ambiguity in the *Planning* process of NDCs is associated with a reduction of 0.3°C per standard deviation. While these three factors indicate that NDC ambiguity leads to conservatism in pledging, two dimensions are positively related to ambition. More ambiguity in *Reducing non-*CO_2 *gases* and *Conditionality of technology transfer* are associated with higher ambition. In other words, the fewer greenhouse gases an NDC covers, the more ambitious it is; and countries that have made their targets conditional on technology transfer have more ambitious NDCs, on average. Finally, the combined effect of all ambiguity variables in the second column is negative: a one unit increase in the standard deviation of all variables lead to accumulated changes in NDC ambition of −0.42°C.

4.3 Discussion

First, our analysis shows that higher aggregate NDC ambiguity is associated with lower NDC ambition. This negative effect is robust to different weightings of ambiguity indices. Hence, our analysis of aggregate NDC ambiguity supports the hypothesis that was outlined above: Countries with ambiguous mitigation targets have pledged less ambitious targets than countries with precise targets. In light of our model, we interpret this negative relationship to mean that states are prudent when faced with exogenous factors that increase the opportunity space of realized mitigation. Conditional on the control variables included here, this finding indicates that countries with ambiguous pledges are more likely to overshoot their mitigation targets than underperform. While the findings should be interpreted with caution due to the potential existence of endogenous ambiguity, the confidence intervals at least preclude that ambiguity leads to significant imprudence in their pledges.

That countries with ambiguous mitigation targets have taken on a more prudent ambition level suggests that these are more concerned about target achievement than signalling high ambition through audacious pledges. Hence, if states' willingness to adhere to the Paris Agreement depends on widespread compliance, the negative association between ambiguity and ambition can indicate that ambiguity is unlikely to undermine future cooperation under the Agreement. This finding challenges propositions that ambiguous pledges are unreliable and detrimental to cooperation (Aldy et al. 2016; Keohane and Oppenheimer 2016).

Instead, the prudence of states with ambiguous targets points to an untapped potential for increasing ambition for a set of states. Increased capacity building in low-income countries—through institutions such as the Paris Committee on Capacity-building and the Green Climate Fund—could be one way to decrease exogenous NDC ambiguity and thereby increase ambition (Stender et al. 2019). In this respect, our analysis points to three specific variables that capacity initiatives could address. Decreasing ambiguity in the NDCs also has the added benefit that the collective goal achievement of the Agreement will be easier to assess, which has been shown to have beneficial effects on reciprocal cooperation (Barrett and Dannenberg 2012; Rogelj et al. 2016).

Second, we identify partly conflicting effects of the ambiguity variables on ambition. Of the five ambiguity dimensions that significantly impact NDC ambition, with find that three variables decrease ambition and two increase ambition. The three variables that substantially reduce NDC ambition are ambiguity in *Waste*, *Land-use and forestry*, and in the *Planning* process of NDCs. Of these three, ambiguity in *Waste* and *Planning* fall under the category *Information completeness* while ambiguity in the *Land-use and forestry* variable leads to more imprecise *Global warming impact* of NDCs. Notably, from a state's perspective, estimating the *Waste* and *Land-use and forestry* variables reliably are costly and technically challenging, underscoring the likely importance of increased capacity building for reducing ambiguity (Röser et al. 2020). In particular, quantifying emissions from land-use change and forestry is one of the most contentious issues in carbon budgeting (Rogelj et al. 2016.)[6]. The importance of the third factor, *Planning*, is also notable, as it indicates that more extensive planning in NDC formulation leads states to pledge more ambitiously. This effect corroborates extant literature that finds a positive relationship between NDC planning and ambition (Röser et al. 2020).

The two variables that increase NDC ambition are ambiguity in the *Reduction of non-CO_2 gases* and *Conditionality of technology transfer*. Hence, to the extent that states have made imprudent NDC pledges, these two factors are significant. Notably, both of these variables fall under the ambiguity dimension of global warming impact. The positive effect of *Reduction of non-CO_2 gases* shows that the fewer greenhouse gases an NDC covers, the more ambitious it is. If states have not taken other gases than CO_2 into account, the global warming impact of their NDCs are likely underestimated. Hence, this finding points to the importance of covering as many GHGs as possible when formulating NDCs for setting realistic targets. Like the *Waste*, and *Land-use and forestry* variables, including more GHGs in NDC targets is related to countries' capacities to measure such emissions.

Finally, in contrast to the other ambiguity variables that affect ambition, the positive effect of *Conditionality of technology transfer* is likely related more to states' strategic goals in the Paris Agreement negotiations than domestic capacities, as states have deliberately chosen to make their targets conditional on technology transfer or not, and conditionality is not a variable that directly relates to measurement difficulties. This effect is in line with Result 2 in our theoretical model. To the degree that states have pledged high ambition with an aim to reap reciprocal benefits from others in the negotiations (Keohane and Oppenheimer 2016), therefore, the positive effect of *Conditionality of technology transfer* may indicate such a tendency.

5 Conclusion

This paper analyzes the relationship between ambiguity and ambition in climate pledges both theoretically and empirically. Theoretically, the paper constructs a formal model of ambiguity and risk behaviour in climate pledges. The formal model takes into account both exogenous and endogenous target ambiguity, and demonstrates why—in the face of a review mechanism—states have reason to exercise prudence when determining the ambition level of mitigation targets. Empirically, the paper tests whether ambiguity in the global warming impact and completeness of information in states' climate pledges under the PA are related to the ambition levels of their mitigation targets. Based on our formal model, we indirectly identify whether states that have more ambiguous pledges have set more prudent or imprudent mitigation targets than states with precise targets.

Overall, we see the main contributions of this paper as twofold. First, our formal modelling of the pledge-and-review system contributes to the literature on the determinants of compliance in international institutions. The model, based on a well-known trade-off between ambitious pledging and achievable compliance (Dimitrov et al. 2019), originally shows how ambition can mediate the relation-

[6]Because of uncertainties in estimates of land-use emissions, such emissions are not included in Robiou du Pont and Meinshausen's (2018) ambition variable that we use in this paper.

ship between precise information provision and compliance with targets. While extant literature posits a straightforward relationship between ambiguity and non-compliance (Chayes and Chayes 1993; Keohane and Oppenheimer 2016), we show that ambiguity does not necessarily undermine compliance under a pledge-and-review system. Instead, we argue that ambiguity incentivizes states to pledge prudent targets—which should lead to *higher* compliance rates, ceteris paribus. More generally, our model also highlights that the source of ambiguity (exogenous or endogenous) renders different implications for how ambiguity is related to ambition and compliance, which gives rise to an important distinction that has hitherto not been extensively discussed in the compliance literature.

Second, our empirical analysis contributes to the growing literature on the effectiveness prospects of the pledge-and-review system under the Paris Agreement (Barrett and Dannenberg 2016; Keohane and Oppenheimer 2016; Dimitrov et al. 2019; Tørstad 2020). Overall, we find a negative relationship between ambiguity and ambition in states' climate pledges under the PA, which suggests that countries are prudent when faced with ambiguity regarding their future emission reductions. That finding offers implications for the effectiveness prospects of the Paris Agreement. First, that ambiguity is associated with prudent pledging may imply that ambiguous mitigation targets are unlikely to undermine compliance with pledges. Instead of pledging unrealistically high targets, our analysis suggests that the pledge-and-review system incentivizes states that face ambiguity to formulate targets they can realistically comply with. Second, the ambition level of ambiguous pledges are—on average—deflated compared to precise pledges: hence, states with ambiguous targets have more leeway to further enhance the ambition level of their pledges in the next round of pledging under the PA.

However, the disaggregated analysis of ambiguity on ambition shows that different kinds of ambiguity have differing effects on the ambitiousness of pledges. Our analysis suggests that reducing the three variables that are negatively correlated with ambition—*Waste*, *Land-use and forestry*, and *Planning*—could have positive effects on NDC ambition. Further, reducing ambiguity in the two variables that are positively correlated with ambition—*Reduction of non-CO_2 gases* and *Conditionality of technology transfer*—could help states set more realistic targets, avoiding inflated NDCs. Notably, increased capacity building could likely help reducing several of the exogenous ambiguity dimensions, and hence spur increased ambition and more realistic targets. Finally, however, the target inflation caused by the positive relationship between *Conditionality of technology transfer* and NDC ambition is unlikely to be reduced by enhanced capacity building: instead, this is an example of imprudence generated by endogenous ambiguity.

On a final note, the current exploratory analysis has several limitations. First, the empirical analysis does not offer conclusive evidence on whether the ambiguity of pledges is exogenous or endogenous. Future research could better isolate the two concepts and explore their causal effects more systematically. Relatedly, qualitative research on how state representatives formulate pledges could be helpful for understanding how ambiguity originates in climate pledges. Second, our ambiguity measure includes a wide range of dimensions but does not *theoretically* distinguish the relative importance of these. While the data-driven selection of variables provides an objective weighting scheme, that approach does not necessarily ensure a theoretically valid measurement of ambiguity. Third, our point estimates of the effects of ambiguity may be biased by omitted variables. Hence, future research should further develop theoretically valid measures of mitigation ambiguity, as well as identify other exogenous sources of ambiguity variation. Fourth, the current analysis has relied on the relationship between ambiguity and ambition to discuss the compliance prospects of the pledges: future research should evaluate the direct relationship between ambiguity and compliance, when data become available. Finally, it should be noted that our theoretical model depends on the existence of a review mechanism—which is the main reason why states weigh prudence over imprudence when determining the ambition level of their mitigation targets. The PA has an advanced review mechanism, but the sanctioning of non-compliance is limited to naming and shaming. We would expect the tendency of prudence to be even stronger in settings where strong sanctioning mechanisms render non-compliance even more costly.

References

[1] Aldy, Joseph E. 2014. "The Crucial Role of Policy Surveillance in International Climate Policy." *Climatic Change* 126 (3–4): 279–92. https://doi.org/10.1007/s10584-014-1238-5.

[2] Aldy, Joseph, William Pizer, Massimo Tavoni, Lara Aleluia Reis, Keigo Akimoto, Geoffrey Blanford, Carlo Carraro, et al. (2016). Economic Tools to Promote Transparency and Comparability in the Paris Agreement. *Nature Climate Change 6* (11), 1000–1004.

[3] Aronow, Peter M. and Benjamin T. Miller. 2019. *Foundations of Agnostic Statistics.* Cambridge: Cambridge University Press.

[4] Baliga, Sandeep, and Tomas Sjöström. 2008. "Strategic Ambiguity and Arms Proliferation." *Journal of Political Economy* 116 (6): 1023–57. https://doi.org/10.1086/595016.

[5] Barrett, S., & Dannenberg, A. 2012. Climate negotiations under scientific uncertainty. *Proceedings of the National Academy of Sciences, 109*(43), 17372–17376.

[6] Barrett, Scott, & Dannenberg, A. 2016. An experimental investigation into "pledge and review" in climate negotiations. *Climatic Change, 138*(1-2), 339–351

[7] Bräuninger, Thomas, and Nathalie Giger. 2018. "Strategic Ambiguity of Party Positions in Multi-Party Competition." *Political Science Research and Methods* 6 (3): 527–48. https://doi.org/10.1017/psrm.2016.18.

[8] Breitmeier, H., Young, O. R., & Zürn, Michael. 2006. Analyzing international environmental regimes. From case study to database. London: MIT Press.

[9] Burck J, Hagen U, Franziska M, Niklas H and Christoph B. 2018. The Climate Change Performance Index: Results 2019. Germanwatch, Bonn `https://climate-change-performance-index.org/sites/default/files/documents/ccpi2019_results.pdf`

[10] Chayes, Abram, and Antonia Handler Chayes. 1993. On Compliance. *International Organization 47* (2), 175–205.

[11] Coppedge M., et al. 2017. V-Dem Dataset v7.1. Varieties of Democracy (V-Dem) Project.

[12] Dai, Xinyuan. 2005. Why Comply? The Domestic Constituency Mechanism. *International Organization 59* (2), 363–398.

[13] Dannenberg, Astrid, Andreas Löschel, Gabriele Paolacci, Christiane Reif, and Alessandro Tavoni. 2015. "On the Provision of Public Goods with Probabilistic and Ambiguous Thresholds." *Environmental and Resource Economics 61* (3): 365–83. https://doi.org/10.1007/s10640-014-9796-6.

[14] Dimitrov, Radoslav, Jon Hovi, Detlef Sprinz, Håkon Sælen, and Arild Underdal. 2019. "Institutional and Environmental Effectiveness: Will the Paris Agreement Work?" *Wiley Interdisciplinary Reviews: Climate Change* 10 (4), e583.

[15] Keohane, Robert O., and Michael Oppenheimer. 2016. Paris: Beyond the Climate Dead End through Pledge and Review? *Politics and Governance 4* (3), 142.

[16] ND–GAIN (Notre Dame Global Adaptation Index). 2015. Vulnerability scores ND–GAIN: http://index.gain.org/ranking/vulnerability (Accessed: 9 January 2018)

[17] Nyborg, Karine. 2018. Reciprocal climate negotiators. *Journal of Environmental Economics and Management, 92*, 707-725.

[18] Pauw, W. P., Richard J. T. Klein, Kennedy Mbeva, Adis Dzebo, Davide Cassanmagnago, and Anna Rudloff. 2018. Beyond Headline Mitigation Numbers: We Need More Transparent and Comparable NDCs to Achieve the Paris Agreement on Climate Change. *Climatic Change 147* (1–2), 23–29.

[19] Pauw, W.P, Cassanmagnano, D., Mbeva, K., Hein, J., Guarin, A., Brandi, C., Dzebo, A., Canales, N., Adams, K.M., Atteridge, A., Bock, T., Helms, J., Zalewski, A., Frommé. E., Lindener, A., Muhammad, D. (2016). NDC Explorer. German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE), African Centre for Technology Studies (ACTS), Stockholm Environment Institute (SEI).

[20] Ray, A.K. (2008). Measurement of social development: an international comparison. *Social Indicators Research, 86*, 1–46.

[21] Robiou du Pont, Yann, and Malte Meinshausen. 2018. Warming Assessment of the Bottom-up Paris Agreement Emissions Pledges. *Nature Communications 9* (1).

[22] Rogelj, Joeri, Oliver Fricko, Malte Meinshausen, Volker Krey, Johanna J. J. Zilliacus, and Keywan Riahi. 2017. Understanding the Origin of Paris Agreement Emission Uncertainties. *Nature Communications 8* (1), 1–12.

[23] Röser, Frauke, Oscar Widerberg, Niklas Höhne, and Thomas Day. 2020. Ambition in the Making: Analysing the Preparation and Implementation Process of the Nationally Determined Contributions under the Paris Agreement. *Climate Policy 0* (0), 1–15.

[24] Rowan, Sam S. 2019. "Pitfalls in Comparing Paris Pledges." *Climatic Change* 155 (4): 455–67. https://doi.org/10.1007/s10584-019-02494-7.

[25] Staton, Jeffrey K., and Georg Vanberg. 2008. "The Value of Vagueness: Delegation, Defiance, and Judicial Opinions." *American Journal of Political Science 52* (3): 504–19.

[26] Stender, Frederik, Ulf Moslener, and Willem P. Pauw. 2019. More than Money: Does Climate Finance Support Capacity Building? *Applied Economics Letters 0* (0), 1–5.

[27] Sælen, Håkon, Vegard Tørstad, Christian Holz, and Tobias Dan Nielsen. 2019. Fairness Conceptions and Self-Determined Mitigation Ambition under the Paris Agreement: Is There a Relationship? *Environmental Science & Policy 101* (November), 245–254.

[28] Tallberg, Jonas. 2002. "Paths to Compliance: Enforcement, Management, and the European Union." *International Organization* 56 (3): 609–43. https://doi.org/10.1162/002081802760199908.

[29] Tibshirani, Robert. 1996. Regression shrinkage and selection via the lasso. *Journal of the Royal Statistical Society. Series B (Methodological)* 58(1): 267-88.

[30] Tingley, Dustin, and Michael Tomz. 2014. "Conditional Cooperation and Climate Change." *Comparative Political Studies* 47 (3): 344–68.

[31] Tomz, Michael, and Robert P. Van Houweling. 2009. "The Electoral Implications of Candidate Ambiguity." *American Political Science Review 103* (01): 83–98. https://doi.org/10.1017/S0003055409090066.

[32] Tørstad, Vegard H. 2020. "Participation, Ambition and Compliance: Can the Paris Agreement Solve the Effectiveness Trilemma?" *Environmental Politics* 29(5): 761-80.

[33] Tørstad, Vegard, Håkon Sælen, and Live Standal Bøyum. 2020. The Domestic Politics of International Climate Commitments: Which Factors Explain Cross-Country Variation in NDC Ambition? *Environmental Research Letters 15* (2), 024021.

[34] UNFCCC. 2015. Paris Agreement. Available from: `https://unfccc.int/sites/default/files/english_paris_agreement.pdf`

[35] Waud, Roger N. 1976. Asymmetric policymaker utility functions and optimal policy under uncertainty. *Econometrica, 41* (1), 53-66.

[36] World Bank. 2015a. Coal rents (% of GDP)

[37] World Bank. 2015b. Natural gas rents (% of GDP)

[38] World Bank. 2015c. Oil rents (% of GDP)

[39] World Bank. 2016. GDP per capita http://data.worldbank.org/indicator/NY.GDP.MKTP.CD (Accessed: 9 November 2018)

A Variables included in the analysis

Table A.1: Ambiguity and control variables

Panel A: Ambiguity dimensions

Variables	Description
Type of target	Discrete variable measuring whether a country's target is business as usual-, absolute-, intensity-, peaking- or policy and actions target.
Mitigation costs (ccm)	Dummy variable indicating whether countries include estimation of costs of mitigation contribution.
Renewable energy	Dummy variable indicating whether renewable energy is considered in order to reach mitigation ambitions .
Energy efficiency	Dummy variable indicating whether energy efficiency is considered in order to reach mitigation ambitions.
Transport	Dummy variable indicating whether transport sector is considered in order to reach mitigation ambitions.
Carbon capture and storage	Dummy variable indicating whether carbon capture and storage is considered in order to reach mitigation ambitions.
Agriculture	Dummy variable indicating whether agriculture is considered in order to reach mitigation ambitions.

Land use and forestry	Dummy variable indicating reference to land use and forestry and whether emissions and mitigation potential are quantified.
Mitigation documents	Discrete variable indicating reference to domestic or international (or both) mitigation plans and strategies.
Reducing non-co2 gases	Dummy variable indicating whether a country has considered the reduction of non-Co_2 gases in order to reach ambitions.
Land use change	Discrete variable indicating reference to land use change in order to reach mitigation target.
Conditionality of finance	Dummy variable indicating whether adaption contribution is conditional on international financial support.
Technology needs	Discrete variable indicating reference to (specific) technologies to use for adaption or mitigation.
Conditionality of technology transfers	Discrete variable indicating whether implementation is conditional on technology transfers.
Conditionality of capacity building	Discrete variable indicating whether implementation is conditional on capacity building.
Planning of NDC formulation	Discrete variable different extents of references to the planning process of the INDC.
Stakeholder consultation	Discrete variable indicating whether stakeholders are consulted and who they are.
Planning of NDC implementation	Discrete variable indicating mentioning of how NDC targets are implemented and whether references are made to domestic laws and policies.
Monitoring and review	Discrete variable indicating reference to national or international (or both) assessments and review of NDC.
Waste	Dummy variable indicating whether waste sector is considered in order to reach mitigation ambitions.

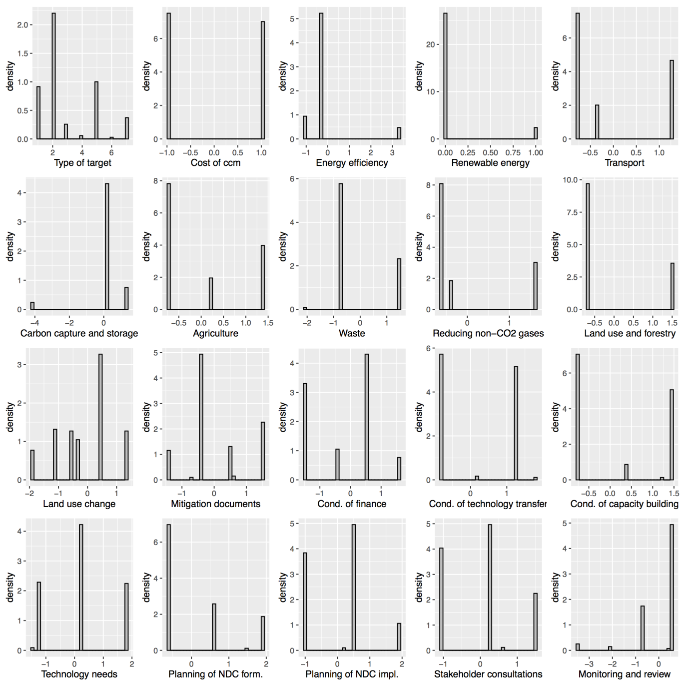
Panel B: Controls included in the empirical analyses	
GDP	Logarithm of PPP-adjusted GDP per capita (internationals dollars, 2015). Higher scores=higher GDP per capita (World Bank 2016).
Democracy index	Country scores on the 2015 V-Dem multiplicative polyarchy index (Coppedge et al. 2017). The index measures a country?s degree of freedom of association, clean elections, freedom of expression, elected executives and suffrage. Higher scores=higher level of democracy.
Vulnerability	ND-GAIN Vulnerability index (ND-GAIN 2015). Higher scores=higher vulnerability to climate change.

Coal rents	The difference between the value of both hard and soft coal production at world prices and their total costs of production (World Bank 2015a). Measured as % of GDP. Higher scores=higher coal rents..
Oil rents	The difference between the value of crude oil production at regional prices and total costs of production (World Bank 2015c). Measured as % of GDP. Higher scores=higher oil rents.
Natural gas rents	The difference between the value of natural gas production at regional prices and total costs of production (World Bank 2015b). Measured as % of GDP. Higher scores=higher natural gas rents.

Notes: Panel A in this table shows a list of all variables regarding uncertainty that are extracted from the NDCs. Panel B lists the variables that are noted as 'control' in our empirical analyses. The second columns provides short descriptions of variables that are adapted from Pauw et. al. (2016).

Notes: Panel A in this table shows a list of all variables regarding uncertainty that are extracted from the NDCs. Panel B lists the variables that are noted as 'control' in the our empirical analyses. The second columns provides short descriptions of variables are adapted from Pauw et. al. (2016).

Figure A.1: Histograms displaying the density of ambiguity variables



Notes: This figure displays the densities of each of the 20 ambiguity variables we consider.

Figure A.2: Bivariate correlations between ambiguity variables

	costs_~z	type_t~z	renewa~z	energy~z	transp~z	carbon~z	agricu~z	land_u..	mitiga~z	reduci~z	land_u..	cond~n_z	techno~z	cond~a_z	cond~d_z	plan~s_z	stakeh~z	plan~n_z	monito~z	market~z	waste_~z
costs_of_c~z	1.0000																				
type_targe~z	-0.3533	1.0000																			
renewable_~z	-0.3816	0.6818	1.0000																		
energy_eff~z	-0.2854	0.6402	0.8513	1.0000																	
transport_~z	-0.0709	0.2783	0.3669	0.3249	1.0000																
carbon_cap~z	0.3093	-0.2674	-0.1107	0.0156	0.0018	1.0000															
agricultur~z	-0.0355	0.3527	0.3504	0.3897	0.1622	0.0827	1.0000														
land_use_a~z	-0.2761	0.4513	0.5316	0.4719	0.1864	-0.1696	0.4315	1.0000													
mitigation~z	-0.0276	0.1808	0.3725	0.4017	0.2152	0.0556	0.1812	0.2555	1.0000												
reducing_n~z	-0.1937	0.6283	0.5105	0.5318	0.2229	-0.1293	0.4349	0.4002	0.2567	1.0000											
land_use_c~z	-0.3702	0.3693	0.4394	0.3946	0.2214	-0.1735	0.3019	0.5046	0.1603	0.3107	1.0000										
conditio~n_z	0.1134	-0.0068	-0.1584	-0.2886	-0.1318	-0.0797	-0.2164	-0.1707	-0.3495	-0.1334	-0.2426	1.0000									
technology~z	0.0298	-0.0834	0.1702	0.3246	0.1678	0.3200	0.2620	0.1291	0.3586	0.1250	0.0979	-0.6375	1.0000								
conditio~a_z	0.1291	-0.1429	0.1064	0.2687	0.2489	0.2162	0.1450	0.0333	0.2911	0.0673	0.0101	-0.5660	0.5713	1.0000							
conditio~d_z	0.0367	-0.0690	0.1294	0.2822	0.1993	0.2392	0.1302	0.0771	0.3969	0.0214	0.1099	-0.7251	0.6330	0.7123	1.0000						
planning~s_z	-0.1476	0.1729	0.3693	0.4455	0.3962	0.1519	0.2549	0.2015	0.4337	0.3042	0.2368	-0.4469	0.4629	0.4185	0.5115	1.0000					
stakeholde~z	-0.1410	0.2366	0.3409	0.3590	0.3465	0.0669	0.1951	0.2411	0.2827	0.2354	0.2392	-0.3736	0.3244	0.3560	0.4782	0.6348	1.0000				
planning~n_z	-0.1521	0.3056	0.4395	0.5160	0.2699	0.1716	0.3249	0.2512	0.3418	0.4058	0.2778	-0.3648	0.4175	0.2467	0.3565	0.5744	0.4175	1.0000			
monitoring~z	-0.0976	0.0055	0.0832	0.1370	0.1103	0.0847	0.0295	0.1781	0.1887	0.1148	0.1270	-0.2614	0.2082	0.2643	0.3103	0.3404	0.2310	0.2152	1.0000		
market_mec~z	-0.1492	0.1017	0.1128	-0.0698	-0.1072	-0.2300	-0.1568	0.0535	-0.2253	-0.0608	0.0248	0.5019	-0.4961	-0.3115	-0.4336	-0.3233	-0.1631	-0.3139	-0.2760	1.0000	
waste_clas~z	-0.1888	0.4438	0.5179	0.3956	0.2499	-0.1014	0.4580	0.3764	0.1653	0.5307	0.3103	-0.0383	0.0872	0.0302	-0.0031	0.1435	0.1974	0.2780	0.1319	0.0499	1.0000

Notes: This figure shows all bivariate correlations between ambiguity variables

B Robustness test

Table B.1: The effects of six NDC ambiguity indices on ambition

	Equal weights		Correlation weights		Regression weights	
	Full	Lasso	Full	Lasso	Full	Lasso
Dep Var: NDC Ambition (CCPI)	(coeff 95% CI)	(coeff 95% CI)	(coeff 95% CI)	(coeff 95% CI)	(coeff 95% CI)	(coeff 95% CI)
Index	-0.375**	-0.608*	-6.587*	-6.277*	-5.739*	-5.039*
	[-0.641, -0.108]	[-1.161, -0.0543]	[-12.05, -1.121]	[-11.67, -0.885]	[-10.63, -0.852]	[-9.188, -0.891]
Controls included	Yes	Yes	Yes	Yes	Yes	Yes
Observations	53	53	53	53	53	53

Notes: This table displays the effects of six indices on countries' NDC ambition as measured by CCPI. Columns denoted 'Full' include indices in which we include all of the variables in Table 1. Columns named 'Lasso' only include variables selected in the lasso procedure. 95% confidence intervals for the coefficients are included in squared brackets. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

C Weights in the composite indices

This section gives detailed information regarding the weighting procedures in the three different types of indices. The resulting weight are displayed in Table C.1. In the two columns names 'Equal', variables are weighted equally. In order to calculate the weights in columns denoted 'Corr', we first compute all bivariate correlations between the variables we are interested in. Next, we assign each variable a value, C, equal to the sum of the absolute value of its bivariate correlation with the other variables. The weight of a variable is the size of C relative to the sum of Cs across all variables. Finally, to construct the reg-index we compute weights based on the relative explanatory power of variables in predicting the variable 'type_target'. First, we run an OLS regression on 'type_target'. The weight of a variable is the size of the absolute value of the regression coefficient relative to the sum of the absolute values of all coefficients. These weights can be found in the two rightmost columns in Table C.1. Columns named 'Full' include all ambiguity dimensions, while columns named 'Lasso' includes variables selected by the lasso procedure.

Table C.1: Weights of variables for different indices

	Equal		Corr		Reg	
Variables	Full	Lasso	Full	Lasso	Full	Lasso
Mitigation costs (ccm)	1	1	0.039	0.062	0.0417	0.058
Type of target	1		0.049		0	
Renewable energy	1	1	0.072	0.135	0.105	0.313
Energy efficiency	1		0.069		0.145	
Transport	1		0.045		0.046	
Carbon capture and storage	1		0.013		0.045	
Agriculture	1	1	0.041	0.089	0.029	0.043
Land use and forestry	1	1	0.048	0.098	0.022	0.043
Mitigation documents	1	1	0.042	0.084	0.017	0.017
Reducing non-co2 gases	1	1	0.049	0.098	0.150	0.251
Land use change	1		0.051		0.016	
Conditionality of finance	1		0.057		0.031	
Technology needs	1	1	0.057	0.086	0.086	0.134
Conditionality of technology transfer	1	1	0.050	0.074	0.089	0.072
Conditionality of capacity building	1		0.058		0.041	
Planning of NDC formulation	1	1	0.067	0.115	0.056	0.017
Stakeholder consultation			0.056		0.050	
Planning of NDC implementation	1		0.062		0.004	
Monitoring and review	1	1	0.034	0.065	0.019	0.029
Waste	1	1	0.041	0.092	0.007	0.024

Notes: This table shows the weights that we use in different indices for various variable selections. While weights are displayed with three decimales, we used nine decimal in the analysis. Hence, the weights in each of the four rightmost columns do not exactly add to one. See the details in the text above.

D Predicting NDC ambiguity with control variables

Table D.1: OLS regression: The effects of control variables on the six NDC ambiguity indices

	Equal		Corr		Reg	
	Full	Lasso	Full	Lasso	Full	Lasso
Dep Var: Ambiguity indices	c/se	c/se	c/se	c/se	c/se	c/se
GDP	-0.179	0.345	-0.0229	0.0123	-0.0401	-0.0346
	(1.333)	(0.769)	(0.0677)	(0.0752)	(0.0751)	(0.0870)
Democracy	-3.646	-2.647	-0.171	-0.280	-0.146	-0.279
	(3.220)	(1.857)	(0.164)	(0.182)	(0.181)	(0.210)
Vulnerability	-24.20	-8.581	-1.594	-1.088	-1.954*	-1.567
	(16.06)	(9.266)	(0.816)	(0.906)	(0.904)	(1.049)
Coal rents	-4.153	-2.336	-0.194	-0.209	-0.276	-0.302
	(2.890)	(1.667)	(0.147)	(0.163)	(0.163)	(0.189)
Oil rents	0.272	0.139	0.0125	0.0151	0.0121	0.0176
	(0.163)	(0.0938)	(0.00826)	(0.00917)	(0.00915)	(0.0106)
Natural gas rents	-0.0933	-0.245	-0.00148	-0.0204	-0.0213	-0.0332
	(0.424)	(0.245)	(0.0215)	(0.0239)	(0.0239)	(0.0277)
Observations	157	157	157	157	157	157

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

E Proof of Result 1

Waud's (1976) proof of Proposition 1 and Proposition 2 using the notation in the model in section 2.

Proof.

$$\underset{C}{\text{minimize}} \quad -E[U] = \lambda \int_{-\infty}^{0} u(C)f(C;\mu_C)dC + \int_{0}^{\infty} u(C)f(C;\mu_C)dC$$

First define $\Phi(\mu_C;\lambda,\sigma_q) = -E[U]$. Suppose first that $\lambda = 1$ and that $C^* = 0$. Then we have:

$$-E(U) = \int_{-\infty}^{\mu_C} u(C)f(C,\mu_C)dC + \int_{\mu_C}^{\infty} u(C)f(C;\mu_C)dC$$

Since u and f are symmetric, we can write the three following equivalences:

$$\int_{-\infty}^{\mu_C} u(C)f(C,\mu_C)dC = \int_{0}^{\infty} u(C+\mu_C)f(C;0)dC$$

$$\int_{\mu_C}^{\infty} u(C)f(C,\mu_C)dC = \int_{-\infty}^{0} u(C+\mu_C)f(C;0)dC$$

$$\int_{0}^{\infty} u(C+\mu_C)f(C,0)dC = \int_{-\infty}^{0} u(C-\mu_C)f(C;0)dC$$

We then have that

$$-E(U) = \int_{0}^{\infty} u(C+\mu_C)f(C,0)dC + \int_{-\infty}^{0} u(C-\mu_C)f(C;0)dC$$

$$= \int_{0}^{\infty} u(C+\mu_C) + u(C-\mu_C)f(C;0)dC$$

$$> 2 * \int_{0}^{\infty} u(C)f(C,0)dC = \Phi(0;1,\sigma_q)$$

Hence, $\mu_C = 0$ minimizes $-E[U]$ for $\lambda = 1$. Now, suppose $\lambda > 1$ and that $-E[U]$ is differentiable at $C = 0$. We know have that

$$-E(U) = \lambda \int_{-\infty}^{0} u(C)f(C,\mu_C)dC + \int_{0}^{\infty} u(C)f(C;\mu_C)dC$$

$$= (\lambda - 1) \int_{-\infty}^{0} u(C)f(C,\mu_C)dC + \Phi(\mu_C;1,\sigma_q)$$

By evaluating the last expression we see that integral term is decreasing μ_C and it goes towards 0 in the limit. Conversely, as showed above $\Phi(\mu_C;1,\sigma_q)$ goes to infinity as $|\mu_C|$ is increasing—that is, increasing its distance to C^*. At $\mu_C = 0$ this expression is not changing as it is at its minimum. Hence, at $\mu_C = 0$, $\int_{-\infty}^{0} u(C)f(C,\mu_C)dC$ is decreasing and $\Phi(\mu_C;1,\sigma_q)$ is constant. As μ_C increases the former decreases while the latter increases, meaning that there exists a minimum at $\mu_C > 0$.

We refer to Waud (1976) pages 56-58 for discussion and comparative statics.