Credible commitment in carbon policy

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Abstract

This paper discusses the internal commitment problem in carbon policy. Investors favour long-term predictability of the policy but absent external enforcement mechanisms governments find it difficult to credibly commit, resulting in increased market risks and investment hold-up. Regulatory uncertainty stems from (i) strategic interactions between government and firms, (ii) potential learning about climate damage and abatement cost, and (iii) political volatility. While commitment to future policy encourages private investment, it also imposes costs in the form of reduced flexibility to accommodate new information or preferences. The paper reviews devices that may help policymakers to raise the level of commitment while also leaving some room for flexible adjustments. In particular, legislation of a long-term governance framework, delegation to an independent carbon agency, and securitization of investors' stakes in emission markets offer palliative approaches.

Key words: carbon price, incentives, investment hold-up, credibility, commitment devices

1 Introduction

If there is one lesson to be drawn from the 2010 UN Climate Change Conference in Cancun, it is that achieving global cooperation for stabilizing the climate system remains devastatingly difficult. Although the 2°C stabilization target has been adopted by a formal UN decision for the first time, major actors such as the USA and China continue to oppose discussions, let alone the adoption, of legally-binding carbon constraints. The hitherto followed top-down vision of global carbon policy might increasingly give way to a bottom-up reality where individual nations and regions commit unilaterally to carbon constraints (Ostrom, 2010). One (by far not the only) problem with this approach, however, is credibility because in absence of a global treaty that provides external enforcement mechanisms, governments easily can and often do break with their past commitments.

Assume a government unilaterally introduces a carbon price and commits to up-hold this policy for the foreseeable future. Firms react to this announcement by incorporating the expected price in their investment decisions. Polluting capital stocks fare relatively worse while the profitability of cleaner technologies improves. Yet, rational actors will discount the expected carbon price and they will do so even more when they feel that the government might not stick to its commitment. Uncertain carbon policy will pressure firms to either postpone investments until uncertainty is resolved or require higher rates of return, both reducing the total level of emissions abatement (IEA, 2007). The question of how to strengthen commitment internally seems therefore vital for effective climate change mitigation.

This paper discusses credible commitment in carbon policy. Carbon policy primarily (but not exclusively) comprises measures that put an explicit price on carbon emissions in order to incentivise abatement, including price-based (e.g. carbon tax) or quantity-based instruments (e.g. cap-and-trade system). Note that technology subsidies may substitute for carbon pricing if credible commitment is infeasible (Abrego and Perroni 2002; Ulph and Ulph, 2009; Golombek et al., 2010).

The commitment problem in carbon policy has been discussed before. Helm et al. (2003), for example, highlight time inconsistency as a problem source and propose delegation to an independent carbon agency as a remedy. Ismer and Neuhoff (2009) suggest the use of financial options as a means to secure government commitment. There are many more proposals, each with differing views on the problem's origin and potential approaches. The contribution of our paper is hence twofold: First, it differentiates three distinct sources of regulatory uncertainty in carbon policy and discusses the benefit of commitment vis-à-vis each uncertainty source. And second, it reviews proposals aimed at alleviating the commitment problem. The angle of proposals is very diverse, and it is the purpose of this paper to synthesize commitment strategies which may serve as an orientation for subsequent analyses of individual devices.

The remainder of the paper is structured as follows: Section 2 defines credibility. Section 3 examines the three different sources of carbon policy uncertainty and their distinct implications for the benefit of commitment. Section 4 reviews the literature on commitment devices. Section 5 concludes.

2 Defining credibility

What is credibility? An individual or a set of individuals enjoys credibility if others believe that it will do what it commits to do. Credibility is hence a subjective belief rather than an objectively measurable quality. Since a commitment refers to one's *future* actions and is usually given in order to motivate others to do something *now*, credibility is a vital element of intertemporal transactions where actors move in sequence.[1]

A common scenario in carbon policy is a government that announces to price carbon (by means of taxation or emissions trading) over a future period in order to encourage abatement. The regulated firm may believe or disbelieve the announcement when planning its investments. Its assessment, however, is not a binary choice but rather extends along a continuum between perfectly credible and perfectly incredible. The level of perceived credibility depends on the government's observable incentives. The more the observable gains from compliance outweigh the observable gains from deviation, the more credible a policy appears to be. Following Forder (2001), there are two factors which predominantly determine the level of incentives and perceived credibility: (1) reputation, and (2) commitment devices.

2.1 Repetition and reputation

Through a history of compliance in repeated political transactions, a government can build up the reputation of being credible. This reputation can be seen like a capital asset

[1] A government that could move first by, for example, paying the firm a subsidy for emissions abatement upfront would need to worry less about credibility (Golombek et al., 2010). As Schelling (1956, p. 283) puts it: what is the best way to persuade someone of his/her intention? "Make it true".

that needs investment (refraining from opportunism) but also pays a yield (Dixit, 1996). The yield materializes in the government's ability to secure better outcomes for the economy because credibility leads to lower risk, higher private investments and growth (North, 1993). If the incentives of repetition and reputation are strong enough, no additional measures will be needed (Persson and Tabellini, 1994). However, the transience of governments in democracies may inhibit reputation building as there is less incentive for an incumbent to accept short-term losses to build up reputation that will be beneficial to its successors.

2.2 Making binding commitments

Where reputation is lacking or low, credibility can be deliberately engineered or improved through various ties and bonds, so-called commitment devices. Kydland and Prescott describe them as "institutional arrangements that make it a difficult and time-consuming process to change the policy rules in all but emergency situations" (ibid., 1977, p. 487).[2] Below, we discuss these institutional arrangements in detail but before it is important to differentiate three principle dimensions of commitment:

First, the institutional arrangement can be either external or internal to the jurisdiction undertaking the commitment (Ismer and Neuhoff, 2009). Internal commitment primarily aims at binding government vis-à-vis its regulated subjects (vertical hierarchy). External

[2] Bryan et al. (2010) point out that these arrangements do not serve a strategic purpose with respect to others but rather help the agent to fulfill plans for his/her own future behaviour. Schelling (1954), in contrast, discusses commitment in an explicit strategic context where "the power to constrain an adversary may depend on the power to bind oneself" (ibid., 282). Though both strands of literature partly overlap in regard to their recommended design of commitment devices, it is important to differentiate between their motivations. Strategic commitment (à la Schelling) may help opponents in distributional conflicts to win a bigger slice of the cake. Efficiency-enhancing commitment (à la Kydland and Prescott) may help to make the cake bigger.

commitment primarily binds a government vis-à-vis other governments (horizontal hierarchy). Our analysis focuses on internal commitment because external commitment, such as through multilateral environmental agreements (MEAs), depends on the feasibility of international cooperation, moving this device beyond any single government's control. But it is nevertheless important to understand that external commitment could considerably improve the credibility of internal commitment (Conconi and Perroni, 2009). For the case of non-compliance, the MEA might foresee certain penalties, externally providing government with an incentive to honour its obligation. However, as the example of the Kyoto process demonstrates, devising a self-enforcing international climate treaty is a challenging statecraft (Barrett, 2003).[3] And even if sustained global cooperation might eventually be achieved, agreeing internationally on carbon constraints will still require their transcription into national policies. Hence, the question of how to strengthen commitment internally, i.e. via means that bind policymakers within their own jurisdiction gains relevance.

Second, commitment can be credible in the motivational or imperative sense (Shepsle, 1991). As was mentioned above, the level of perceived credibility depends on observable incentives. Commitment is motivationally credible if the observable gain from deviation is below the observable gain from compliance. Motivational commitment devices do not rule out deviation *per se*. They only introduce additional costs for potential defectors,

[3] Note that the quality of enforcement mechanisms varies over issue areas. The Montreal Protocol on ozone depleting gases is widely considered as a successful MEA with good enforcement mechanisms. However, designing a self-enforcing global climate change treaty seems more challenging for a number of reasons (for a detailed analysis see Barrett, 2003). Note that linking regional emissions trading systems could provide an alternative source of external commitment because linking agreements can curtail the flexibility for unilateral adjustments to carbon pricing (Flachsland et al., 2009).

making deviation less profitable and hence less likely. In contrast, commitment is credible in the imperative sense if actors cannot act otherwise because compliance is coerced. A popular illustration of imperative commitment is Ulysses who bound himself to a mast in order to resist the Sirens' lures (Elster, 1977). Resisting their temptations was his commitment, and the fetters around his wrists enforced his compliance. But unlike Ulysses, a sovereign state, that is a state who owns the monopoly for using ultimate force, cannot be coerced to honour its obligations.

Ulysses also illustrates the third commitment dimension: autonomous or heteronomous commitment. We speak of autonomous commitment when the obliger and the obliged are identical individuals or sets of individuals. Ulysses clearly had to deal with the problem of autonomous or self-binding commitment (Schelling, 1984). Commitment in public policy, however, also needs to be able to bind others (Alesina and Tabellini, 1988). For example, constitutions are deliberately structured so as to be difficult to change by successive majorities (Holmes, 1988). Carbon policy needs to provide for heteronomous commitment because climate change is a long-term issue and the obliger and the obliged will be different sets of individuals at the time of performance.[4] Commitment devices hence provide successive majorities with an incentive to honour their predecessors' policies. While they foster trust in the regulatory regime, investment, and growth, they also carry costs. It is this trade-off we now turn to before discussing individual commitment devices.

[4] If one views 'government' as a unitary ever-lasting entity, commitment in public policy will appear autonomously. Through commitment, the institution 'government' binds its own hands. This is usually the perspective chosen by analyses of time-inconsistency problems (see below). However, we regard government as a set of different individuals whose composition and motives may change.

3 Sources of carbon policy uncertainty

The benefit of commitment is not unequivocally positive but rather depends on what source of regulatory uncertainty one looks at. Rodrik and Zeckhauser (1988) highlight that public policy in general suffers from a fundamental trade-off between valuable commitment and valuable flexibility (or 'responsiveness' as they call it). Hovi et al. (2009) identify time inconsistency, international anarchy and domestic politics as uncertainty sources in climate change policy but ignore the distinct trade-offs between flexibility and commitment. In our view, there are three main sources of carbon policy uncertainty and each of them implies different net-benefits of commitment. First, in a deterministic setting where government and firms interact strategically, government's ability to make binding commitments improves outcomes whenever firms' anticipation of government's reaction may have adverse incentive effects. Second, with potential learning about climate change damages, abatement technologies, and international politics, commitment can impose costs as it reduces valuable flexibility to respond to new circumstances. Third, political volatility may be used as an argument for commitment but it raises questions of democratic legitimacy. We discuss each of these issues in detail below.

3.1 Strategic interaction between government and firms

Time inconsistent optimality

Analyses of the problem of time inconsistency began with the seminal article by Kydland and Prescott (1977) in the arena of macroeconomic policy. They demonstrate under which conditions policymakers may have an *ex-post* incentive to renege on a policy that may have been optimal *ex-ante*. Time inconsistency now is a widely discussed issue in the literature on optimal pollution control, though there is still no consistent opinion on its origin and direction.[5]

Consider a benevolent and omniscient government whose sole objective lies in the maximization of social welfare. The government commits *ex-ante* to tax carbon emissions. Based on this announcement, firms invest in low-carbon technologies. These investments generate sunk costs on the private sector side. Firms are committed by investments in factories, power plants, etc. while the government is only committed by laws (many of which it can change). In pursuance of other goals, the government is eventually tempted to exploit this asymmetry by adjusting the policy *ex-post*. For instance, it might reduce the carbon tax to a level which permits low-carbon energy providers to only cover their variable costs (Blackmon and Zeckhauser, 1992). The appropriated quasi-rent of sunk investments is then redistributed to consumers in form of lower energy prices. Utilities in general and the energy sector in particular are vulnerable

[5] While some authors identify redistribution as the source of the problem (Marsiliani and Renström 2000; Helm et al. 2003; Baldursson and von der Fehr 2008), others emphasize changes in marginal abatement cost curves (Biglaiser et al. 1995; Gersbach and Glazer 1999). Some predict higher *ex-post* levels of the optimal carbon price (e.g. Marsiliani and Renström 2000), others demonstrate the opposite (e.g. Abrego and Perroni 2002).

to *ex-post* appropriation because plant value is highly dependent on location and use (Spiller, 1996).[6] Note that the reason for policy change does not stem from resolved uncertainty or shifts in political preferences (these issues are discussed below). The impartial and benevolent government redistributes because this action maximizes social welfare once investments are made. In this setting, policy can be either optimal or time consistent but not both.

Investment hold-up

In order to achieve the optimal outcome, the government might try to 'fool' firms by first promising the *ex-ante* policy before opportunistically adjusting the policy *ex-post*. Of course, this strategy only works with naïve agents. Rational agents who anticipate the government's incentive to renege might respond in several ways (Spiller, 1996): They either postpone investment, or require a higher rate of return to compensate for higher risk, or invest in areas where the payback period is relatively short. Moreover, firms may reduce maintenance expenditures, or choose technologies that have a lower degree of specificity. These reactions reduce firms' exposure to governmental opportunism but they also reduce social welfare.

The risk premium firms demand in presence of regulatory risk reflects the loss of the option value of being able to decide whether the investment should be undertaken or not at a later stage when additional information is available (Dixit and Pindyck, 1994). The value of that option increases with risk. For example, consider the investment case for Carbon Capture and Sequestration (CCS): Blyth et al. (2007) find that uncertain policy

[6] The incentive to appropriate is greater when the interval between investments is longer because the penalty for appropriation (higher future capital cost) has a lower present value (Blackmon and Zeckhauser, 1992).

increases the carbon price required to stimulate investment in CCS by 16-37% compared to a situation of perfect policy certainty.

Ratchet effects

Flexible policy might allow governments to pursue time inconsistent strategies against firms. But firms may also try to exploit regulatory discretion to their own advantage. So-called ratchet effects can occur if current performance is used as a criterion for setting future policy targets (Weitzman 1980). For example, consider the periodic update of emission caps in the EU emissions trading scheme (EU ETS). Flexible caps may provide firms with an incentive to distort investment decisions in order to signal high compliance costs and prepare the ground for a more lenient cap in subsequent trading periods (Harstad and Eskeland, 2010). Their chance of winning with this strategy increases with their market power. Moreover, the use of grandfathering will further aggravate dynamic incentive problems if allowance allocation is based on historical emissions (Hepburn, 2006). Here, regulated entities may seek to delay abatement or even exacerbate carbon lock-in in order to maximize the number of allowances received.

Regardless of whether firms or governments peruse opportunistic strategies, flexible policy carries the risk to distort the incentives for emissions abatement. The mere potential for strategic interactions between government and firms, with firms having incomplete knowledge about the direction and extent of policy change, generates risks and reduces investments below socially optimal levels.

3.2 Uncertain damage and abatement costs

Given the potential costs of strategic interactions, the ability to commit is clearly valuable in a deterministic setting. Carbon pricing, however, has to deal with many unknowns. Today's best available estimates of benefits and costs of emissions abatement are likely to change over time. There are three main areas of positive (as opposed to normative) uncertainty: damage costs, technological development, and international climate policy.

First, the benefits of emissions abatement (mainly avoided climate change damages) depend on multiple variables and links in the Earth system none of which are perfectly understood today (IPCC, 2007 a,b). Second, the costs of emissions abatement are determined by the development and deployment of low-carbon or carbon-free technologies (IPCC, 2007c). For example, consider the unexpected arrival of a backstop technology which provides low-carbon energy in abundance and at low costs. The ex-ante carbon price would need to be lowered to reflect cheaper abatement costs (in case of emissions trading, the cap would have to be tightened to achieve the new socially higher level of abatement). If the policymaker was strictly committed, significant economic inefficiencies could arise.

Third, the scientific uncertainty over climate damage and abatement costs is exacerbated by uncertainty over international climate policy. Emissions abatement is a global public good and the net-benefits of national carbon policy depend on the contribution of other nations to this good. For example, consider the European Union (EU) which unilaterally committed to reduce emissions by 20% below 1990 levels by 2020. The EU expects that other regions and countries will eventually take on comparable burdens. However, if they choose instead to free-ride on EU efforts, unilateral abatement is likely to become very

costly: carbon intensive industries might relocate from the EU to countries with less stringent policies (carbon leakage) with the result that EU reduction efforts would yield little or no impact on global emissions.[7] The behavior of other countries therefore is a key parameter in assessing the optimal level of national/regional carbon policy.

In sum, carbon policy deals with a so-called 'super-wicked problem' (Lazarus, 2009) that is characterized by deep uncertainties, many interdependencies, and social dynamics. Once we learn more about these factors, carbon policy might have to change. The flexibility to update policy according to new incoming information is therefore valuable. Note that the presence of positive uncertainty rules out any easy way to distinguish opportunism from reasonable responses to changed circumstances. For example, it may not always be possible for government to determine whether higher than expected abatement costs are a consequence of strategic moves on the private sector side or simply a bad state of nature (Rodrik and Zeckhauser, 1988). Similarly, the diversity of ways in which circumstances can change provides government with plenty of excuses to opportunistically adjust its policy.

3.3 Political volatility

The above analyses build on the assumption of a benevolent and unitary policymaker whose sole objective is the maximization of a common social welfare function. Under a

[7] If, however, a global cap can be agreed upon in the near future, Europe is likely to benefit from an early-mover advantage (Edenhofer et al., 2009). The benefit of timely redirecting investments to low-carbon technologies and infrastructure is projected to exceed the costs of a higher cumulative reduction commitment.

public choice perspective, however, people and preferences in government alternate and various stakeholders with conflicting views and interests seek to influence policies to their own advantage. Incumbents may be inclined to use carbon policy for maximizing votes by, for example, reducing the carbon price for spurring economic growth before an upcoming election.[8] Further, policy risk arises when shifting majorities in politics lead to an alternation of represented special interests (Strausz, 2009). Based on different ideologies and constituencies, carbon policy may look very different depending on which political party is in charge.

Another source of political volatility is changing public opinion. Although the equilibrium preference for climate protection may be relatively stable over time, the public's temporary awareness of environmental problems may be subject to issue attention cycles (Downs, 1972). Peaks in problem awareness (e.g. after climate-related disasters) can lead to more stringent carbon policy (Brunner, 2008). By the same token, carbon policy may eventually be weakened when other issues such as unemployment move up the political agenda. Indeed, it seems likely that political volatility is skewed toward the downside (less stringent carbon constraints) rather than the upside because of the asymmetric temporal cost structure of carbon pricing. Whereas abatement costs accrue immediately, benefits largely materialize in the distant future in form of avoided impacts from climate change. Although many people feel morally obliged to abate their adverse bearing on posterity, the temporary readiness to sacrifice current income to

[8]. See Drazen (2000) for a review of the empirical evidence of political business cycles in fiscal and monetary policy. It is, however, unclear whether similar patterns can be expected to occur in carbon policy.

protect future generations from serious harm may wane under difficult economic conditions.[9]

Carbon policy is hence at risk to be undermined by the constant economic pressures that prefer to roll-over mitigation cost to posterity. A society interested in providing credible incentives for emissions abatement would want to reduce short-term political volatility. The cost of commitment, however, is that it also increases the hurdle for policy change when collective preferences in regard to climate protection move toward a new equilibrium. Commitment then raises questions of democratic legitimacy as it confines policymakers' ability to quickly respond to new preferences.[10]

3.4 Balancing commitment and flexibility

Risk sharing

The dilemma of carbon policy is that society is forced to choose a balance between the different benefits and costs of commitment. Determining the appropriate degree of commitment is beyond the scope of our analysis (see Blackmon and Zeckhauser, 1992, for an attempt in utility regulation). We want to emphasize, however, that regardless of the commitment level policymakers enshrine in their policies, the ultimate outcome of

[9] If all societal groups had their interests represented, then all external effects would become internalized and the political equilibrium would be socially efficient (Aidt, 1998). However, pressure groups representing the interests of future generations tend to be relatively weak (Tremmel, 2006, discuss some models of institutionalization), and even in a purely intragenerational context, collective action problems arise. As Olson (1971) argues, economic interest groups tend to voice their preferences more effectively than public interest groups because they usually are well organized, homogenous and able to provide benefits to their exclusive membership.

[10] The debate over constitutionalism versus democracy nurtures similar questions. Holmes (1988) reviews the arguments and concludes that constitutional rules promote rather than limit democratic decision making. As he puts it, a constitution is a limit imposed by 'Peter when sober on Peter when drunk'. See also Lazarus (2009) who reviews arguments in the context of climate change policy.

their decision is the allocation of risk between public and the private actors. Under complete flexibility, the risk of policy change is fully borne by the private sector. Firms react by either postponing investment or increasing their required rate of return which is not necessarily inefficient from a social perspective. Efficiency depends on who is best able to carry the risk in question. Optimal risk allocation requires that actors accept risk in proportion to their ability to bear it (Hepburn, 2006). IEA (2007) maintains that governments are better placed to underwrite some carbon policy risks for a number of reasons. First, the long-term and incalculable scope of climate change (and therewith carbon pricing policy) impede insurability, and private agents might not be able to relocate and diversify policy risk. Moreover, if government faces a political incentive to change policy (e.g. for pleasing voters by lower carbon and hence energy prices), it can reap the benefits without bearing the costs. The costs of policy change will be more carefully taken into account if policymakers have a share in them.

The current commitment gap

Although risk sharing seems appropriate on efficiency grounds, carbon policy, as currently practiced in most countries lacks credible commitment to long-term objectives. Politicians are quick to sign up to ambitious aspirations in the form of "reducing emissions of greenhouse gases in aggregate by 80% or more by 2050" (G8, 2009, p. 19) but remain reluctant to enshrine necessary incentives in credible policies. The first commitment period of the Kyoto Protocol expires in 2012, with some signatories (e.g. Canada) steering toward explicit non-compliance. What happens after 2012 is still subject of strenuous climate negotiations. With regard to domestic policies, the USA is contemplating the introduction of long-term emissions caps but prospects remain equally

unclear. In Europe, the EU ETS extends until 2020 without specifying legal carbon constraints beyond this date.[11] In most countries, long-term reduction commitments only exist in form of political declarations. Policymakers who are interested in triggering the profound economic transition deemed necessary to limit global warming might want to entrench their aspirational targets in more credible structures.

4 Commitment devices

What can policymakers do to increase investors' confidence in long-term carbon policy, and what are appropriate institutions to implement a sensible balance of flexibility and commitment? We surveyed the literature on commitment devices and grouped them into three distinct strategies: legislation, delegation, and securitization. By and large, legislative devices leave more flexibility than securitization. Securitization, on the other hand, offers a robust foundation for commitment but is less suited to respond to new realities. Delegation seems to be able to combine flexibility and commitment to a certain extent. Our review, however, is only indicative and the question of how individual devices in the end could work out depends on their exact design and the adopting country's institutional environment.[12]

[11] EU Directive 2009/29/EC specifies an annual linear reduction factor of 1.74% that applies to the emissions cap beyond 2020. Article 9, however, explicitly states that the reduction factor shall be reviewed without indicating for what reasons, in which direction, and to what extent it may change.

[12] Spiller (1996) examines political institutions in the USA and Britain with regard to their ability to promote credible commitment in utility regulation. Lazarus (2009) reviews legal commitment strategies for US climate change policy.

4.1 Legislation

Response rules and governance structure

Given the large uncertainties prevalent in carbon policy, the vehicle for commitment should be a response rule, i.e. a policy which is itself contingent on other factors. Ulph and Ulph (2009) point out that many authors somewhat artificially generate a commitment problem in their analyses by only allowing policymakers to commit to a fixed carbon price (tax rate) or quantity (emissions cap) which is supposed to remain constant. Instead, policymakers can formulate a rule rather than a rate that sets the price or quantity of emissions conditional on pre-defined parameters (e.g. new insights on climate science or outcomes of international negotiations), limiting the risk of opportunistic discretion and partly reconciling policy flexibility and commitment. To avoid incentive distortions, parameters should be chosen such that regulated entities have no influence over their development (Rodrik and Zeckhauser, 1988). For example, including abatement cost as one variable of the response rule carries the risk of distortions provided the private sector has influence over abatement costs.

There are two general limitations to built-in responsiveness: First, it is impossible to formulate rules that hold under all contingencies, a deficiency well known in contract law. One may therefore leave some generalized freedom to respond to a genuinely unforeseen circumstance. Evidently, such *force majeure* provisions constitute loopholes for opportunistic policy adjustments (Dixit, 1996). Second, even if writing fully contingent contracts were possible, the occurrence of foreseen contingencies must be observed and assessed before it can filter through to rule response. Legislation therefore needs to structure the processes under which response rules are monitored, implemented,

and, in case of emergency, adjusted. Providing for a governance framework that structures these processes in a transparent and accountable way is thus a key element of credible carbon policy.

Of course, the legal quality of rules matters for their level of credibility. Commitment by means of constitutional law puts a very high hurdle to adjustments as parliaments usually need a qualified majority for constitutional amendments. Statutory law typically requires simple majorities. While there exists no case of constitutional carbon constraints, the United Kingdom was the first country worldwide to enact a fully comprehensive climate governance framework in statuary law. The UK Climate Change Act of 2008 stipulates 'legally-binding' interim (2020) and long-term (2050) targets for emission reductions (UK CCA, 2008). It also set up a governance structure by defining the duties and powers of government, parliament, and an independent advisory body in monitoring, implementing, and last but not least updating targets when learning about relevant parameters (international climate politics, scientific insights) occurs.

Clarity over long-term carbon constraints is essential. Equally important, however, is breaking up the long-term commitment into near-term incentives whose impacts can be timely monitored and evaluated. To this end, the UK CCA introduced a carbon budgeting system where every single budget covers a period of five years and at least three budgets must be set in advance.[13] Setting budgets not only takes account of the overarching long-term target but also of a wide range of near-term factors such as economic and

[13] Budgets cover the entire UK economy, including those sectors covered by the EU ETS. Having a ceiling on trading-sector emissions may eventually generate conflicts with EU law where a sectoral limit within the ETS cap is not foreseen (Sina et al., 2009). This is one reason why commitment devices should strive to match the governance level of relevant carbon pricing instruments such as the EU ETS.

technological development (Hill, 2009). In addition, the UK government intends to break down accountability to departmental level where each minister is responsible for meeting the sub-budget for his or her economic sector (DECC, 2010). The downside of short-term budgets, however, is that they may hinder the intertemporal equalization of marginal cost. Efficient budgets require that the government knows the development of abatement cost over the entire time horizon.

Enforceability and public scrutiny

What self-given 'legally-binding' targets and budgets mean in the end may not be clear at first sight. After all, every subsequent legislature will have the authority to change laws and subsequent governments will be able to change the degree of enforcement. Legislation, however, raises the discursive hurdle for policy change. Targets can no longer be silently dropped when they become inconvenient. Changing laws entails a visible and perhaps politically costly process if constituencies are not convinced of the action's legitimacy.

Governments sometimes choose to ignore legislated commitments instead of changing their legal basis. The ability to internally enforce targets against a non-complying government varies over jurisdictions. For example, consider unbalanced carbon budgets in the UK CCA. In theory, every stakeholder could take the government to court if a carbon budget was not met. In practice, judicial review is restricted to procedural misdemeanor in this issue area, and case law demonstrated that such a challenge is likely to fail (Hill, 2009). While the potential for judicial review is limited in the UK, other legal systems allow a greater role for courts or citizens in ensuring effective

enforcement.[14] But judicial procedures may be too time-consuming to be practical. The deviating government may be long out of office before courts sanction non-compliance.

The main motivation for government to avoid non-compliance with the law is probably public scrutiny. If a governing majority anticipates that the political costs of pursuing a certain course of action will be losing public support, then this route will be less attractive. Hence, carbon policy should be deliberately designed so as to encourage public scrutiny by, for example, earmarking revenues from emissions trading for redistribution purposes. A large share of the proceeds from auctioning emission permits could be recycled back to consumers via annual lump-sum payouts.[15] By mitigating (for the poorest households potentially reversing) its regressive distributional impact (Burtraw et al., 2009), the 'climate dividend' could create long-term political support for carbon pricing. It would restructure the incentives for the ultimate enforcer, namely the electorate, to have the policy implemented over time.

4.2 Delegation

The general limitation of legislation as a commitment strategy is that no rule is carved in stone. No government can enact laws or regulations that successors cannot revoke or dilute. A credible policy is therefore one that tries to insulate implementation from day-to-day politics. Delegating part of the authority to institutions with a time horizon beyond

[14] For example, the US legal system offers more opportunities to sue a non-compliant government. For Germany, Sina et al. (2009) explore the potential of applying a CCA-like framework and highlight the power of the Federal Constitutional Court to enforce climate legislation.

[15] A congressional draft for climate legislation in the USA included provisions on earmarking revenues from auctioning (see Cantwell and Collins, 2010).

the current legislative period may be a mean to this end. In principle, these institutions can take two forms: advisory and agency.

Advisory

An advisory, or watchdog, is a government-independent monitoring entity.[16] It is delegated the authority to advise and monitor government's performance on a regular basis. The UK CCA institutionalized a regular reporting and monitoring cycle through the government-independent Committee on Climate Change. The Committee advises the UK parliament on carbon budgets and policies and monitors the country's progress along the transition path through annual progress reports. The merit of having an independent watchdog lies in forcing government to justify its actions on a regular basis (Lazarus, 2009). Yet the organization itself does not suffice to increase policy credibility. Germany, for example, has three different government-independent advisory bodies for environmental policy none of which comes close to the Committee's high public profile in the UK.[17] A legal obligation for government to regularly obtain and respond to the organization's advice, as laid down in the UK CCA, and the choice of figureheads with influence in politics and business is critical to give it an authoritative standing. Time will show whether the CCA's political clout suffices to effectively check political opportunism.

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[16] A related concept is that of guardians. Guardians attempt to counter-balance the myopic bias of parliaments by deliberately representing the interests of future generations. For example, Hungary installed a Parliamentary Commissioner for Future Generations who has formal participation and review rights during policy formation. For a review of different models of intergenerational representation, see Tremmel (2006).

[17] The Sachverständigenrat für Umweltfragen (founded in 1971), the Wissenschaftlicher Beirat für Globale Umweltveränderungen (1992), and the Rat für Nachhaltige Entwicklung (2001).

Agency

In contrast to advisory where policy control remains with the government, an agency is an institution which is delegated the authority to implement the policy on government's behalf. Two issues play a key role in the rationale for delegation: reputation and objectives. First, Barro and Gordon (1983) investigate how government reputation could mitigate the problem of time-inconsistency in monetary policy. But the transience of leaders and ruling majorities in politics leads to heavy discounting of the future value of reputation. Independent agencies which are insulated from political cycles have stronger incentives to build up and retain reputation over longer time horizons (Persson and Tabellini, 1994). Second, in the context of commitment agents can be most valuable when their objectives are distinct from those of the delegating principal (Schelling, 1956). Political opportunism often results from the fact that governments face multiple and at times conflicting objectives (e.g. low energy prices and climate protection). With delegation, the number of objectives per agency can be reduced. 'Political unbundling' (Brunekreeft and McDaniel, 2005) then eases the pressure to renege on past commitments and may help to increase policy credibility in investors' view.

The literature on the benefits of central bank independence inspired Helm et al. (2003) to transfer this device to carbon policy.[18] Similar to monetary policy where the central bank is assigned to meet an inflation target, a carbon agency or 'carbon central bank' could be delegated the duty and powers to meet a certain temperature or emission target by, for example, setting a carbon tax. If the initial staff has some belief in the task and may be

[18] At the international level, Barnes et al. (2008) propose to create an Earth Atmospheric Trust which administers the global carbon budget with the aim to maximize the long-term benefits on behalf and in the long-term interest of global society.

self-selected for this belief, the evolving organizational culture and sense of mission will create a barrier to change (Wilson, 1989). The separation of politics and administration enables the government to commit to the original program while the rationale/legal constraints of Weberian bureaucracy insulate agents from efficiency-undermining political pressures (Moe, 1990). The agency retains the flexibility to react to changing circumstances but it does so within clearly defined bounds as laid down in its mandate. As such, delegation might be able to combine the advantages of credible commitment and flexibility.

Limits to institutional independence

If one argues that independent agents can solve the commitment problem in carbon policy, one needs to show when and why independence is costly to reverse. The central bank model has demonstrated how institutional independence can create credibility for time frames relevant for inflation targeting (Cukierman et al., 1992). If a government wanted to regain influence over monetary policy (e.g. to boost economic growth for an upcoming election by lowering interest rates), the mere announcement of doing so could raise the level of expected inflation, undermining the political goal of price stability. Before government actually regains control over monetary policy to produce the benefits it seeks, it will pay the costs of its attempt, deterring the action in the first place. Time frames in carbon policy, however, are considerably longer than in monetary policy and the inertia in the built energy system might allow governments to abolish carbon agency independence without immediately suffering the costs of this action in form of

significantly higher emission levels.[19] Note that an actual reversal of institutional independence is not even necessary. The mere threat to abolish independence suffices to influence agency decisions (McCubbins and Schwartz, 1984). Moreover, as Helm et al. (2003) point out, the trade-off between economic growth and monetary stability exists only in the short run. Carbon policy, in contrast, has to balance the objectives of low energy prices and climate protection over longer time spans. To a certain extent, carbon pricing implies an intergenerational redistribution of welfare where the present generation bears costs (higher energy prices) to the benefit of future generations (lower damage cost from climate change). Delegating carbon policy to an independent agency may hence face substantial resistance from those groups who argue that the task of resolving intergenerational distributional conflicts should remain within democratic institutions.

4.3 Securitization

As mentioned above, constitutions offer a robust fundament for commitment because political hurdles to change constitutional provisions are high. An integral part of most constitutions is the protection of private property. Securitization as a commitment strategy leverages on these provisions by entrenching commitments in private property rights and contracts.

Contracts and carbon pricing

From an economic perspective, the legal characterization of commitment matters insofar as it impacts incentives. The less reliable a commitment is, the lower are market

[19] We thank Karsten Neuhoff for pointing this out.

participants' incentives to invest in its implications. In this context, it is worth to consider feed-in tariffs for renewable energy sources. A major strength of feed-in tariffs is that they provide a legal guarantee of revenues. Lowering the tariff within the guaranteed period faces high legal hurdles because it undermines contractually agreed payments and directly devalues investors' property.[20] Carbon taxes and emission caps, in contrast, can be adjusted freely without violating any contractual agreements. In fact, the power to introduce and abolish taxes at discretion is constitutive for parliamentarian sovereignty, and political constitutions shield rather than confine this power. Moreover, taxes seem less suitable to establish credible commitment because, in contrast to tradable permits, they do not directly create a financial market constituency interested in the continuation of the policy.

The introduction of contracts in carbon pricing therefore rests on the use of quantity-based instruments. The conventional view among economists is that tradable emission permits represent property rights. Legal experts, however, maintain that permits only grant a limited authorization rather than a private property right *per se* (Cole, 1999; Woerdman, 2005). Allowance holders do not own disposal space in the atmosphere. Rather, regulators recognize property rights *in allowances* and market participants can receive, hold, and transfer allowances. The value of allowances of course depends on regulation and regulators can modify or terminate trading regulations without necessarily

[20] Nevertheless, feed-in tariffs too may involve regulatory risks. In Spain, the government announced to cut remuneration for existing wind power plants retro-actively in order to manage mounting subsidy payments. But market participants belief that this cut is unlikely to affect investors' property because it only comes into force when a certain (relatively high) number of operating hours is exceeded (Platts, 2010).

infringing property rights. Hence, the establishment of a tradable permit system where participants hold emission 'rights' provides no sufficient protection against opportunism.

Enhanced tradable permit systems

Enhanced tradable permit systems build on current allowance markets but add some additional features. One means to strengthen the commitment to trading systems is to prolong the validity of permits (McKibbin and Wilcoxen, 2007). Long-dated permits allow their owners to emit one unit of emissions each year over the lifespan of the permit (e.g. 30 years). Permit owners will have an interest in keeping the system running and the cap tight because that increases the scarcity value of their asset. They form a countervailing constituency against political attempts to dilute commitments by subsequent governments. To allow for flexibility, a fixed supply of long-dated permits could be combined with a variable supply of annual permits that can be adjusted in response to new information and preferences. However, long-dated permits may be prone to strategic investment hold-up (Biglaiser et al., 1995) as permit owners with market power might be inclined to strategically under-invest in abatement, thereby driving up permit prices and increasing the market value of their assets.

With put-options on emission allowances, investors could hedge their low-carbon assets against downside carbon price risk while also providing government with a contractual incentive to honor its commitment (Laffont and Tirole, 1996; Kemp and Swierzbinski, 2007; Ismer and Neuhoff, 2009). [21] The government, having sold the option, would face a financial incentive to adhere to set targets and keep permit prices above the committed

[21] Put-options could be partly seen as an equivalent to feed-in tariffs in terms of incentive- and risk structure: they too ensure that part of the costs of learning effects are borne by tax payers.

minimum. If the volume of outstanding options is sufficiently large, a price floor for emission allowances will emerge in the carbon market. As financial contracts, put-options are protected by constitutional provisions and can be enforced against government through independent courts. While they represent a powerful commitment device, regulators can freely choose the overall level of aspired commitment via three parameters: strike price, number of options issued, and duration of options (Ismer and Neuhoff, 2009). Increasing the strike price, volume of options, or durations strengthens the commitment.

Carbon bonds and contracts

Carbon bonds and carbon contracts are both devices that can be implemented as complements to existing cap-and-trade systems. First, consider a government that issues a bond whose coupon payment negatively correlates with the market price of allowances in an emissions trading system (Mainelli et al., 2009). Project developers investing in low-carbon technologies could buy this bond in order to hedge against carbon price risk. The carbon bond would transfer part of the risk to government which then faces a financial incentive to keep prices in the permit market high. The device leverages on the credibility governments seek on international bond markets because breaking with this kind of commitment imposes high costs in form of higher risk premiums for public finance. The degree of commitment can be chosen via pay-off structure, duration, and the aggregate volume of outstanding bonds.

Second, complementary to the institutional choice of cap-and-trade stands the possibility of government to auction off long-term procurement contracts over the supply of emission reductions (Newbery, 2003; Helm and Hepburn, 2007). Firms bid their prices

for a specified quantity of emission reductions, and the government closes a contract with the lowest bidder. Tenders can be made technology-blind. Carbon contracts provide firms with a forward revenue stream with long-term price certainty. The government, in contrast, could resell emission credits into cap-and-trade systems such as the EU ETS. However, carbon contracts generate emission reduction credits versus an assumed baseline (analogue to credits stemming from the Clean Development Mechanism of the Kyoto Protocol). As such, their use is confined to sectors and installations not covered by cap-and-trade systems.

4.4 Creating countervailing constituencies

What is the common theme of commitment devices? In our view, the key to understanding credible commitment lies in what Dixit (1996) termed a theory of "transaction-cost politics" or Spiller (1996), less elegantly, dubbed a "transactions cost-cum-positive political theory" approach. Commitment devices place political transaction costs in the path of policy change in order to mitigate the risks of opportunism. They create or back long-term countervailing constituencies interested in the continuation of the policy. Partly, this strategy relies on the introduction of additional formal or informal veto players in the political system (Tsebelis, 2000). Political transaction cost can accrue in various forms: bad press, the need to seek cross-partisan consensus, logrolling, loosing votes, lower contributions from interest groups, admonition from courts, financial expenditures, etc. Political transaction costs do not put an absolute limit to government flexibility. Rather, they provide future majorities with an incentive to adhere to the announced course of action by decreasing the gains from deviation.

There remain, however, many open questions both in theory and in practice. Our review lacks an analytical framework able to compare the net-benefits and feasibility of individual proposals. Both factors depend on a country's objectives and institutional endowment and can therefore only be assessed on a case-by-case basis. The development of a political transaction-cost framework for carbon policy and its application to a case-specific institutional context is a task that is left to subsequent work.

5 Conclusion

There is a fundamental trade-off between flexibility and commitment in carbon policy, and the benefit of commitment decisively depends on the source of regulatory uncertainty. We identified three sources of carbon policy uncertainty: First, in a deterministic setting, the strategic interaction between government and firms may have adverse effects if policy is flexible. The mere anticipation of time-inconsistent decisions leads to investment-hold up. Ratchet effects occur where firms see a chance of influencing future policy choice by changing their own performance. Commitment to future policy is valuable in this setting. Second, under uncertainty, commitment may lead to socially inefficient outcomes if it impedes government's flexibility to respond to unforeseen developments in science, technology, and international politics. The presence of uncertainty also makes it difficult to distinguish opportunism from reasonable responses to changed circumstances. Third, political volatility in the domestic arena amplifies investment risks but strong commitment which binds successive majorities raises questions of democratic legitimacy. In brief, the dilemma of carbon policy is that society is forced to choose a balance between the different benefits and costs of

commitment. The degree of government commitment determines the allocation of risks between public and private actors. Weak commitment imposes most risks on the private sector. Current carbon policy around the world is largely characterized by relatively weak commitments. Governments interested in triggering the economic transition deemed necessary to mitigate climate change might want to entrench long-term carbon policy in more credible structures.

How can governments attain a higher degree of commitment and credibility? The paper reviewed commitment devices that internally restructure the incentives for successive governments to adhere to set policies. The underlying rationale of legislation, delegation, and securitization is to create and back countervailing constituencies with a long-term interest in emissions abatement. First, legislation can provide a transparent governance structure for setting, implementing, and updating carbon policy. A legal duty to write carbon budgets ensures accountability and continued attention to the policy issue. While enforceability cannot be generally guaranteed, earmarking carbon revenues for redistribution to consumers is one way of ensuring public scrutiny over time. Second, delegation insulates interests dedicated to emissions abatement from day-to-day politics while preserving the capacity for flexible adjustments. The institutional mandate may define monitoring and advisory duties. It may also delegate the authority to set policy on government's behalf to an independent carbon agency. Clearly defined agency objectives together with stronger incentives to retain reputation can improve the credibility of delegated policy. Third, securitization protects investors' stakes in carbon markets by entrenching commitment in enforceable contracts. In particular, put-options on emission allowances fit well with the institutional setting of cap-and-trade systems. In sum, these

strategies may help to anchor private sector expectations of the future profitability of emissions abatement.

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