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Cooperation in the climate commons[1]

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Abstract

Given the global public good properties of climate change mitigation, mitigation efforts have to rely on the willingness of individuals to contribute voluntarily to this public good, by reducing the demand on the environmental commons either in the form of "green" consumer behaviour or through the acceptance of costly climate policy. Both are likely to be necessary. This paper surveys the existing empirical evidence on the scope for cooperation in the climate commons and on the effectiveness of possible interventions to spur it. We survey evidence that suggests a central role for local social norms in the provision of global public goods. We discuss the importance of the visibility of norms and the role of beliefs when such visibility is lacking. We conclude that some actors may behave as conditional cooperators also when confronted with global dilemmas, similarly to what takes place in the local commons.

Keywords Social norms; Collective action; Pro-environmental behaviour; Climate policy; Conditional cooperation

JEL codes D70, F59, H23, M30, Q54, Q58

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1 Introduction

Many situations in everyday life involve social dilemmas, the solutions of which require cooperation. Most of these involve the provision of local public goods, or the management of common-pool resources. Sustaining cooperation in these settings represents one of the major achievements of our society. Indeed, cooperating in social dilemmas requires overcoming the temptation to free-ride. From a narrow economic perspective, cooperation represents an anomaly that hardly fits the ideal of a rational agent (Dawes and Thaler 1988). Yet, cooperation is often observed, suggesting that individuals may be more sophisticated than the theory postulates (Sen 1977). Even though it may be tempting, for the sake of model parsimony, to assume that our societies can dispense with morality and public spirit (Hirschman 1984), understanding cooperation is a crucial and challenging task for economists. As a result, a growing literature has developed in recent decades to emphasise cooperative behaviour in a range of economic interactions in different social environments (see Fehr and Fischbacher 2003).

Natural resource management inevitably involves overcoming local dilemmas. From a standard economic perspective, any situations involving the use of common-pool resources are viewed as susceptible to free-riding, ineluctably leading to over-exploitation (e.g. too much pollution resulting in suboptimal access to clean air). While this has been true in many cases – for instance in competitive environments characterised by open access – other contexts can be more conducive to cooperation. As Ostrom (1990) suggested, cooperative outcomes can be sustained if stakeholders trust each other and trust is maintained through monitoring and sanctioning of norm violators. Ostrom and colleagues surveyed many cases from the field that suggested that commons need not turn into tragedies (Poteete et al. 2010). This body of work, however, focuses on local commons, and successful cases tend to be those where the actors know and can observe one other.

But what about global dilemmas? Can cooperation scale up to the global level? Climate change mitigation presents the toughest conditions for the emergence and stability of international cooperation, due to its global public-good nature: its benefits are enjoyed worldwide, regardless of who shoulders its burden. To make matters worse, mitigation is also plagued by temporal externalities, since mitigation today will mostly benefit future generations. While the potential for

sustained cooperation among small groups is now widely recognised, free-riding is still viewed as the norm in the climate commons. Decades of unsuccessful climate change negotiations lend support to this pessimistic view (Barrett 1994), and there is so far virtually no comprehensive account of the empirical evidence with regard to cooperative achievements in the climate commons (beyond what self-interested actors would unilaterally do). We aim to fill this gap by reviewing the recent literature on the economics of environmental cooperation.

An obvious preliminary question is, why should we observe cooperation when facing a global dilemma? According to Elinor Ostrom, subjects may still be willing to cooperate even in a global setting if they expect others to reciprocate. Ostrom (2009) supports this intuition by showing evidence about a number of local communities and subnational entities that organised and collectively engaged in favour of climate-change mitigation. Recent developments in climate change negotiations have also created renewed interest in cooperation from the bottom up. At the December 2015 Conference of Parties in Paris a "landmark deal" was struck, with an ambition well beyond the highest expectations of many observers; although only time will tell us how effective the treaty will be in fostering emission abatement. This agreement was built on several years of grassroots efforts and unilateral initiatives, including the broadening use of carbon pricing (Baranzini and Carattini 2014; World Bank and Ecofys 2015), which can be seen as costly signals of countries' willingness to cooperate.

Turning pledges, such as the nationally determined contributions agreed in Paris, into policies is the next challenge for governments, a challenge whose failure means facing the threat of severe climate changes (Baranzini et al. 2016). Avoiding dangerous climate change thus requires an additional layer of cooperation, at the domestic level. Whether policy-makers will be able to leverage individuals' willingness to cooperate also depends on their understanding of when and why cooperation in the climate commons works. We thus investigate many public good situations with implications for climate change mitigation. By looking at the deep roots of cooperation, we test empirically the validity of Ostrom's intuition. This survey strives to be extensive, but is not exhaustive due to the large body of cross-disciplinary research that feeds into the topic of climate

cooperation.[2] We gather evidence from microeconomic studies on peer effects in the adoption of renewable energy, on laboratory and field experiments relying on social comparison effects to spur environmentally-friendly behaviour, as well as on the demand for carbon offsets. We complete the survey with an overview of macroeconomic studies on the cross-country adoption of climate-friendly behaviour and policies and discuss several studies on the (un)popularity of climate policy.

By collecting an important set of recent evidence on cooperation in the climate commons, this survey contributes to reconciling different literatures and provides a critical overview of the potential for scaling up localised cooperation efforts. A number of questions remain open, highlighting the gaps in the current state of knowledge, and avenues for future research.

2 Theoretical background

Economics has been traditionally concerned with rational selfishness, under the premise that the representative *Homo economicus* pursues his objectives according to narrow self-interest. This logic is behind the maximisation of utility by consumers, and of profits by firms, which neglects external effects such as environmental degradation, leading to the notion that public goods will be underprovided and commons will be overexploited in the absence of private markets or regulation (Olson 1965; Hardin 1968). This view was well captured by John Stuart Mill (1836), who suggested, "*an arbitrary definition of man, as a being who inevitably does that by which he may obtain the greatest amount of necessaries, conveniences, and luxuries, with the smallest quantity of labour and physical self-denial with which they can be obtained*."

Many social scientists have expressed reservations with respect to the realism of the assumption of selfish rationality as a pervasive driver of human behaviour. The criticisms generally focus on logical, empirical or behavioural/psychological grounds. Amartya Sen is an eminent economist

[2] Other studies in environmental psychology survey in detail some of the aspects covered here. See e.g. Kraft-Todd et al. (2015) for a close look to field experiments promoting cooperation and Drews and van den Bergh (2016) for a review of the socio-psychological factors behind the (un)popularity of climate policy. Nyborg et al. (2016) extend to several social dilemmas the discussion on the importance of social norms, and the visibility of pro-social behaviour, as provided in Kraft-Todd et al. (2015) and in an older version of this paper. Tavoni and Levin (2014) provide a multidisciplinary investigation on the complexity of managing the climate commons.

belonging to the first camp. In the seventies he criticised the narrowness of the economic man portrayed by the then-dominant rational choice theory; he famously exposed the illogical extremes to which self-interested rational "fools" would go in the following passage, concerning an encounter between two strangers (Sen 1977, p. 332):

> *"Where is the railway station?" he asks me. "There," I say, pointing at the post office, "and would you please post this letter for me on the way?" "Yes," he says, determined to open the envelope and check whether it contains something valuable.*

Such a paradoxical situation is suggestive of the distance between reality and how neoclassical economics portrays it, by assuming "standard" preferences. Another famous quote illustrates the paradoxical implications of assuming rational self-interest as the sole guiding principle of human behaviour. Laffont (1975, p. 431) asked this question, when introducing Kantian economics:

> *Why is it, then, that (at least in some countries) people do not leave their beer cans on beaches?*

Buchanan (1967, p. 113) assumed that people behave in a reciprocal way in the provision of public goods as follows: "By increasing rather than by decreasing his own contribution, Tizio may hope that Caio will, over a series of learning and response periods, follow suit and cooperate in response." However, it was not until 1988 that the concept of cooperation entered with some force the mainstream economic arena. In a seminal paper that appeared in the *Journal of Economic Perspectives*, Dawes and Thaler (1988) considered cooperation as one of the anomalies that could not be explained by standard economic theory. While they also reported abundant anecdotal evidence on situations in which cooperation is observed (beyond what rationality predicts), the strongest arguments were drawn from the emergent experimental literature. Experiments had already provided robust evidence of behaviours that could not be explained by standard economic theory. Dawes and Thaler summarised a number of regularities from public good games, showing an important role for altruism and "reciprocal altruism". In the light of the (then) new experimental evidence, the theory needed to be updated.

Local dilemmas

In her influential book, Ostrom (1990) studied the issue of cooperation in local environmental commons. She provided evidence that Hardin's prediction of commons ending in tragic overexploitation in the absence of markets (privatisation) or coercion (government intervention) need not materialise, and indeed is only likely to come true when additional circumstances apply, such as open access to the resource as well as lack of norms, informal institutions and communication opportunities. While these conditions are likely to be met in large and competitive environments, such as global financial markets, Ostrom (1990) demonstrates that this is hardly the case in many local commons, and formalised the mechanisms leading to cooperative outcomes in the management of common-pool resources. Ostrom (2000) provides further evidence challenging the standard theory of collective action and more specifically the prediction that individuals will not contribute any positive amounts to the public good (henceforth referred to as the "zero-contribution" prediction arising from individually rational, but collectively inefficient, free-riding). Following the example of Dawes and Thaler (1988), she reviewed an emerging literature in experimental economics, providing seven stylised facts on cooperation in local settings. We shortly review them here, as they broadly apply to cooperation at large. First, subjects contribute about 40–60% of their endowment in the first round of play in repeated (linear) public goods games. Second, even if contributions decrease in later rounds, they do not converge to zero. Third, beliefs that others will contribute increase one's contribution to the public good. Fourth, learning helps: experienced subjects tend to contribute more (over consecutive sessions in which subjects returned to the lab to play a similar game on a different occasion). Fifth, communication, even if it does not entail a credible commitment (i.e. it amounts to "cheap talk") facilitates cooperation: subjects appear to use it to decrease defection, rather than to fool others into shouldering more of the burden. Sixth, people may be willing to forgo part of their endowment to engage in costly punishment towards non-cooperative players. Seventh, contextual factors, such as the framing of the situation or the use of sanctioning mechanisms, tend to affect the outcome of the game.

In an effort to capture these stylised facts, Ostrom (2000) aimed at building an updated theory of collective action. Her call for a new theory is based on the realisation that there is a significant fraction of conditional cooperators in society, whose behaviour, unlike that of "rational egoists", is compatible with the experimental evidence. The key ingredient of her theory is trust. Conditional

cooperators are likely to cooperate so long as they believe that the other players are trustworthy reciprocators. This conceptualisation is supported by insights from evolutionary theories, suggesting that human beings are inclined to learn social norms, and that with sufficient information on others' behaviour, even obtained from imprecise yet not completely random signals, trustworthy individuals may fare well and spread in societies (Barkow et al. 1995; Cummins 1996). Depending on how precise the signal is, rational egoists may not survive in an evolutionary process (cf. Axelrod 1986).

These insights are strongly related to the lessons that can be learned from evolutionary biology, where a hierarchy of explanations – from genetic relatedness to reciprocal altruism, from reputation and image to social norms and implicit agreements – provide explanations for cooperation at different levels of organisation. Cooperative behaviour in nature, though most apparent perhaps in cooperative breeding or foraging in animals, extends as well to such subtle phenomena as the production of extra-cellular enzymes in bacteria, nitrogen fixation by plants, and the production of antibiotics by microbes and plants alike. Even the uptake of water and nutrients by plants has an obvious analogue in resource use by humans (Zea-Cabrera et al. 2006), with property rights (spatial separation) and social norms contributing to the cooperative outcome in both cases, although in different degrees (Lubchenco et al. 2016).

Related theories of human behaviour have developed over the years, supporting the idea of cooperation at multiple scales (cf. e.g. Fehr and Schmidt 1999; Brekke et al. 2003; Nyborg et al. 2006; Roemer 2010, 2015). Tabellini (2008) and Dixit and Levin (2016), among others, attempt to explain why pro-social behaviour may emerge and persist in societies. In the model of Tabellini (2008), parents rationally decide whether to invest effort in educating their children in a pro-social way and transmitting them pro-social values, depending on the endogenous social entourage and the strength of external enforcement of non-compliance. In Dixit and Levin (2016), the instilment of pro-social preferences is the result of a collective action effort. This model thus captures the efforts undertaken by societies, and not only families, to socialise young individuals in a pro-social fashion (see Bisin and Verdier 2000 and 2001 for other theoretical perspectives). Furthermore, a large body of knowledge has been built up that provides further evidence on the cooperative behaviour of people in local settings (Fehr and Gächter 2000; Fischbacher et al. 2001; Ostrom and

Ahn 2003; Kocher et al. 2008; Poteete et al.2010; Dixit et al.2013). While surprising to many economists who reportedly were not aware of her work prior to 2009, the attribution of the the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel to Elinor Ostrom suggests a general recognition in mainstream economics of the updated theory of collective action.

Scaling up cooperation

The updated theory of collective action provides useful lessons on how to govern local commons. It is however silent, at least at first glance, on how to manage global dilemmas. The facts highlighted above may cease to be valid in a global context, and the lessons derived from them may not apply to global problems. Can we identify an escape route from the tragedy of the commons in global dilemmas, such as climate change mitigation?

A partial answer to this question comes from the influential discussion in Ostrom (2009, cf. also Ostrom 2010, 2012). First of all, she reviewed a long list of efforts, undertaken at the local, regional, and national level to curb greenhouse gas emissions. Doing so, she challenged the zero-contribution prediction in the climate commons. Consequently, she argued that the standard theory of collective action may not be well suited to understand and address climate change mitigation. The limits shown by the standard theory in explaining behaviour at the local level may also have implications for the understanding of global commons, she argued. While on the surface the standard theory may seem to apply relatively well to the case of climate change mitigation, given a long period of rather unsuccessful climate negotiations, it still falls short of explaining the range of grassroots climate-friendly behaviour, which goes against the zero-contribution proposition. While the empirical part of this paper will focus mainly on individual behaviour, the examples of unilateral political action undertaken in the climate commons by non-state actors, such as cities, NGOs and companies, are numerous. UNEP (2015) presents an overview of non-state climate activities, considering about 200 initiatives involving more than 20,000 actors, including local governments, the private sector, and NGOs. According to the same report, these initiatives may be associated with emissions reductions in the range of 2.5-3.3 gigatons of CO_2-equivalent.

Ostrom's explanation for climate-friendly behaviour relates again to localised social norms. Norms tend to guide the choice of the appropriate actions that should be taken in a given context,

and individuals may find it important to gain a reputation for being trustworthy by adhering to such norms; indeed, reputation may be internalised so that one's own self-image is sufficient to evoke norm-friendly behaviour. Hence, one may be willing to contribute to a global public good, for instance by voluntarily reducing GHG emissions, provided that there is agreement on the socially desirable behaviour, and that this behaviour is at least partly visible (more on this below). Accordingly, societies in which moderately high levels of cooperation can be sustained, i.e. with a significant fraction of trustworthy reciprocators, may be particularly apt and prone to deal with issues such as climate change. As a result, the key mechanism leading local commons to be successfully managed may also explain (unilateral) efforts toward climate change mitigation.

Global agreements revisited

International environmental agreements have long been modelled in game theory through coalition-formation games (Hoel 1992; Carraro and Siniscalco 1993; Barrett 1994). The underlying principle is that the equilibrium number of signatories to a self-enforcing international agreement follows from the conditions of internal and external stability. The stability conditions guarantee that no signatory is better off leaving the coalition, and that there is no incentive for a non-signatory to join the coalition. Such conditions are required since treaties such as the Kyoto Protocol (and to an even greater extent the Paris Agreement, which lacks legal force) cannot be enforced by external institutions, due to national sovereignty, and must therefore rely on incentives to overcome the compliance issue.

The established insight from the theory of international environmental agreements is that self-enforcing treaties are unlikely to bring about substantial mitigation efforts, especially when cooperation is most needed, i.e. when the potential gains from cooperation are large due to high mitigation costs and high benefits from mitigation. A more optimistic account is found in Heal and Kunreuther (2012), which instead investigates the implications of the existence of a tipping point in the adoption of climate policies by the international community. The authors offer descriptive evidence on the role of early adopters in triggering a global shift away from the use of damaging pollutants, towards greener alternatives. They mention the following two examples. The first concerns the adoption of unleaded petrol (gasoline) in replacement of leaded petrol: its unilateral adoption by the United States meant that the subsequent adoption's costs for other countries was limited to modifying refinery capacity, since industries exporting to the United States were forced

to transition to lead-free fuel immediately after the move by the early adopter. Thanks to these reduced costs for the followers, the new technology spread quickly worldwide. The second example refers to phasing out chlorofluorocarbons (CFCs), a striking achievement of the Montreal Protocol on Substances that Deplete the Ozone Layer. In this case, the United States' decision to sign the Montreal Protocol hinged on a technological innovation by Du Pont, the world's largest producer of CFCs, allowing the American firm to gain from eliminating CFCs. As in the previous example, strategic complementarity led most countries to phase-out ozone-depleting chemicals.

What other design features are conducive to an effective treaty? The game-theoretic literature on international environmental agreements has identified several mechanisms that have the potential to mitigate the issue of shallowness of the mitigation efforts.[3] These range from expanding the strategy space via side payments and issue linkage (Barrett 2005), to introducing minimum participation rules and heterogeneity (Weikard et al. 2015) and imposing trade restrictions on non-participants (Nordhaus 2015; Barrett 2016).

However, the literature has traditionally modelled governments (and the negotiators acting on their behalf) as rational agents with standard preferences, representing citizens with the same preferences. That is, decision-making is the result of the aggregation of preferences from the *Homo economicus* described above. Only recently, a strand of literature has explored the implications of departing from these assumptions. Examples include introducing preferences for equity (Lange and Vogt 2003; Lange 2006), reference dependence (İriş and Tavoni 2016), and appetite for campaign contributions by policy-makers subject to domestic pressure (Marchiori et al. Tavoni 2017). The above departures from standard assumptions, while modifying different aspects of the game (either the preferences or relaxing the assumption that governments negotiate as unitary agents, absent lobbying), can all rationalise larger coalitions of contributors to the public good as well as, importantly, larger aggregate investments.

[3] The standard models predict either the formation of a large stable coalition which does little abatement or a small stable coalition undertaking greater mitigation efforts by the few signatories, both of which translate into unambitious treaties achieving modest mitigation targets. See de Zeeuw (2015) for a recent review.

Other recent contributions introduce reciprocity in their framework. As discussed in Hovi, Ward, and Grundig (2015), some countries, such as those in the European Union, may be willing to send a costly signal, by engaging in comparatively ambitious mitigation, to reveal credibly their "type" to other conditional cooperators in the group. Modelled as such, climate change mitigation follows a stepwise path, with each step providing a signal to the other players, which gradually learn the other countries' types, and may in turn reciprocate with small commitments. These steps may take the form of a tax on domestic emitters, which may be easily ramped up if others follow suit. The process envisioned by Hovi et al. (2015) is reminiscent of the above-mentioned signalling in local dilemmas, and aims at building trust incrementally. According to the authors, countries that are embedded in dense networks, such as important nodes in trade networks, may also have further opportunities to signal their trustworthiness, as well as more to lose in reputational terms. As observed during the buildup to the 2015 Conference of Parties in Paris, signalling may also provide a "motivational push" for governments to reciprocate others' efforts in a bottom-up approach (Buchholz and Sandler 2016). Interestingly, actors such as the European Union pledged first, preceded only by Switzerland.[4] By pledging first, these actors might have started the process of reciprocation. The EU ambition to be a leader in this virtuous cycle of reciprocation is evident from the bloc's recent announcement of the one-off plan to accelerate its ratification without waiting for each member state to do so, and from the telling reaction of EU climate commissioner Cañete, who commented as follows: "I'm happy but mostly relieved […] if the deal had entered force without the EU, it would have been a tragedy" (quoted in Clark 2016). There is, of course, a complementary strategic reaction that pulls governments in the opposite direction, inaction. That is, a country may be concerned about the consequences of exerting leadership in decarbonisation, due to the risk that stringent targets may negatively affect the competitiveness of its industry in favour of countries with less ambitious policies. The standard threat of free-riding by laggard states has the potential to induce a vicious cycle of decreasing ambition, reinforced by the same preference for reciprocity that is invoked by the 'ratchet mechanism' in the Paris Agreement to increase ambition over time. Ultimately, it is an empirical matter which of the two effects dominates. Whether the Paris Agreement's bottom-up logic will be able to deliver and avoid the trap of inaction that plagued its predecessor, the Kyoto protocol, is likely to depend on whether

[4] Note that Switzerland pledged even higher than the EU, conditionally committing to reduce its greenhouse gas emissions by 50% (versus 40% for the EU) by 2030 with respect to 1990 levels.

enough parties can credibly signal the willingness to lead by shouldering a sizeable share of the burden, above and beyond the current pledges.

Nyborg (2014) introduces reciprocity in a coalition formation model mimicking an international environmental agreement, and analyses the following situation: what if (citizens within) countries had reciprocal preferences? She shows that it is sufficient to have some countries with reciprocal preferences to have larger abatement compared with a baseline case with standard preferences, the bulk of abatements being driven by the fraction of countries with reciprocal preferences. Hence, this model predicts sizeable effort towards climate change mitigation from a subset of countries sharing a similar culture of reciprocity. If the fraction of countries having reciprocal preferences grows sufficiently larger, every country will prefer to contribute to mitigation, regardless of its preferences. Nyborg's conclusions resonate with those of Grüning and Peters (2010), who assume that policies and abatement efforts are visible, so that governments can observe the efforts of others and take them into account when setting their own effort level, aiming at fairness. Reciprocity in efforts thus leads to a convergence in policies across countries, and has the potential to stabilise large coalitions.

Relatedly, Buchholz and Sandler (2016) introduce reciprocal preferences in a two-player game with a leader and a follower. According to their model, people in the follower country may enjoy some "warm-glow"-like benefit by doing their part in supporting the common goal of mitigating climate change. Given this assumption, strategic complementarities between each country's contributions follow from the model. That is, higher contributions from the first country no longer lead to lower contributions (more free-riding) from the second one, but to higher (reciprocal) efforts instead. Furthermore, the follower country may also have the ability to influence the leader with its own contributions. By assuming strategic complementarities between the contributions of the leader and the follower, this model accommodates reciprocal preferences, including Kantian preferences (Roemer 2010, 2015). Since the leader moves first, its efforts act as a signal of goodwill, and have a "trust-building" effect for the follower country. The larger the leader's contributions, the more the follower would believe that the leader would reciprocate its own effort. Hence, the authors conclude, in this perspective unilateral initiatives would no longer be disadvantageous, and leveraging reciprocal preferences may contribute to tackle climate change.

In sum, all of the above modifications of the standard model ease the collective action problem, at least to some extent, showing "some light at the end of the tunnel" (cf. Hovi et al. 2015). The reviewed models may thus be suitable to explain the observed extent of cooperation in the climate commons. While admittedly partial, it is not negligible and may reflect the fact that we are undertaking the initial steps in the above-mentioned reciprocal game. However, this new strand of models still relies on important assumptions, as does the literature reviewed above on scaling up cooperation. The main assumption we consider here is the one related to conditional cooperation. Is there any empirical evidence in support of such behaviour in the climate commons? The next section tackles this question.

3 Empirical evidence

Peer effects

Many works covered by the previous section presume that at least part of the community is willing to conditionally cooperate. However, little evidence is provided in the theoretical literature to support this assumption at the scale required to preserve the climate commons. We attempt to fill this gap in this section. We pay special attention to the visibility of social norms and organise the review in a decreasing order of visibility. Recent spatial analysis has shown that the adoption of rooftop solar photovoltaic (PV) panels is an instance of particularly salient green technology. By virtue of their visibility, rooftops convey information about the norm so that the individuals revising their strategy may "simply mimic [...] the strategy of their neighbor" (Nyborg et al. 2006, p. 357). Empirical evidence of mimicry in technology adoption is provided by Bollinger and Gillingham (2012), whose spatial analysis on the adoption of solar PV relies on Californian data, and Graziano and Gillingham (2014), which focuses on data from Connecticut. Both studies show that peer effects shape the spatial distribution of solar panels, whose adoption is mainly the result of a phenomenon of social contagion. The same mechanism appears to be at work in Europe as well. Using a related approach, Rode and Weber (2016) collect data on more than 500,000 solar panels for Germany and conclude that social contagion also takes place in their context. They

suggest that the existence of a very localised form of social contagion, as they find that early adoption is likely to be imitated by nearby neighbours, but only in a radius of about one kilometre.

Further evidence on the role of visibility as determinant of peer effects in the adoption of green technologies is provided by the case of hybrid cars. As shown by Narayanan and Nair (2013) for California, peer effects drive the adoption of hybrid cars, but only for the Toyota Prius Hybrid and not, for instance, for the Honda Civic Hybrid. While the Prius exists only in its hybrid form and is thus "by construction" a green car, the hybrid versions of the Civic are "visually exact versions of their nonhybrid versions" (Narayanan and Nair 2013, p. 72). Hence, "going green" seems to be contagious only if sufficiently visible. Following Ostrom (2000), driving a Prius would provide at least a noisy signal about others' adherence to social norms and may thus be sufficient to initiate reciprocity among conditional cooperators, while this may not be the case with a Civic. Indeed, "if there is a noisy signal about a player's type that is at least more accurate than random, trustworthy types will survive as a substantial proportion of the population" (Ostrom 2000, p. 145).

Social interventions

In many other cases the norm is not visible by its own nature, but may be made visible through external intervention. An increasing number of studies focus on information campaigns and social marketing interventions aimed at influencing individuals' perception of the social norm. These interventions aim to fuel social contagion. Following Cialdini (2003), descriptive norms (about what people do) have increasingly being associated to injunctive norms (about what people should do) to redirect citizens' behaviour towards socially superior alternatives. Schultz et al. (2007) apply Cialdini's lesson to a field experiment on household energy consumption and find that households tend to converge towards the level of consumption of their neighbours when information about the latter is provided by the experimenters. Of course, this convergence does not necessarily imply lower energy consumption for each household, since those under-consuming could also move their consumption upwards to match the norm. Indeed, the authors find with the descriptive-norm treatment an increase in energy consumption for those households that were below the mean prior to treatment, and a decrease for those that were above. Yet, they know how to address this perverse "boomerang" effect: by reverting to injunctive norms. In the study the injunctive messages consist in giving formal approval to the behaviour of the households consuming less than average, hence

giving value to their efforts. They thus test the effect of a full treatment including both the descriptive and the injunctive norm. As expected, they find a decrease in the amount of energy consumed by households above the mean, whereas no significant change in behaviour is observed for the households below the mean. Hence, the convergence that is observed is not towards the norm, but rather towards the low and desirable level of consumption of below-average households.

A similar experiment was conducted on a much larger scale on behalf of several utilities by the company Opower, which provided treated households with home energy reports designed to spur energy conservation (Allcott 2011). Allcott and Rogers (2014) analyse the long-run effects of the Opower behavioural intervention and find that people react to the comparison with the energy consumption of their neighbours (and with their own past energy consumption) even after several reports. The programme continues to be effective in reducing energy consumption even after half a decade and also after being discontinued, i.e. the previously treated households do not return to pre-treatment consumption levels and keep consuming less energy than the peers in the control group. The cost effectiveness analysis in Allcott and Rogers (2014) confirms how powerful social norms may be.

Observability is also the key feature of another behavioural intervention focusing on the voluntary participation in "demand response" programmes, and studied by Yoeli et al. (2013). The aim of these programmes is to have a pool of households willing to have their energy consumption remotely controlled and potentially reduced during demand peaks to prevent blackouts and costs explosion. Participating households each provide a small contribution to the public good, while carrying the cost of lower comfort due to their electric appliances being remotely switched off. This large field experiment provides evidence based on more than 2,000 participants indicating that the treatment simply showing how many neighbours are taking part in the programme induces much more participation than a monetary reward of $25. The authors argue that even a monetary reward of about $170 may underperform the social norm treatment. Observability is shown to matter for those individuals thinking that voluntary participation in a demand response programme is a public good, confirming that an inclination to cooperate (or reciprocate) is a necessary condition for behavioural change. Finally, greater effects are found when people live in apartment

buildings rather than houses and this difference is explained by the many more interactions between neighbours in the former case.

While in the experimental settings of Schultz et al. (2007) and Allcott and Rogers (2014) households could also save money by adapting their behaviour as desired by experimenters, behavioural interventions can also be effective when the cost of contributing to the public good is clearly positive. Recently, a flourishing literature has assessed the willingness to pay of individuals for climate change mitigation (see Nemet and Johnson 2010 for a review). This literature has focused on both the average and the median willingness to pay (WTP). The reason for this is that while the average WTP is in general positive, often boosted by some outliers, the median WTP tends to be closer to zero, sometimes leading to rather pessimistic inferences for the median voter.

Following Cialdini (2003) and Schultz et al. (2007), Löschel, Sturm, and Uehleke (2013) design an experimental setting in which information about the level of contribution in the control group is provided to the treated group, in terms of WTP for climate change mitigation. However, not all interventions lead to higher provision of the public good. In their experiment, Löschel et al. (2013) find very similar values for the average and median WTPs in the treatment and control groups, since not only those individuals that would have otherwise under-contributed compared to the norm adjusted their WTP upwards, but also those that would have otherwise been "overly" generous preferred to stick to the norm and revise downwards their contribution. Hence, absent any injunctive norm, what the treatment does in this setting is to simply reduce the variance in WTP.

In a similar spirit, Lindman, Ek, and Söderholm (2013) analyse the willingness to pay for carbon offsets of Swedish students and how it depends on the participation of the Swedish population as reported in polls. The numbers for the overall population are however false and deliberately high. Deception allows solving the issue faced by Löschel et al. (2013). Purchase of carbon offsets by students is a positive function of the figures provided for the population, suggesting that making the norm visible may also be effective when this is clearly manipulated. While the use of deception can be challenged on several grounds, the findings of Lindman et al. (2013) may suggest that

cooperation could be spurred by showing large figures for e.g. a subsample of the population that behaves in a particularly climate-friendly way.

Social interventions may not only be effective when it comes to opt for a green product but also when it comes to (state) support for green policies. Bolsen, Leeper, and Shapiro (2014) collected data on about 1,000 students, who participated in a survey on the acceptability of carbon taxes. Students were allocated to different treatments, providing information on e.g. the consensus among scientists or the population on the anthropogenic forces behind climate change. Researchers attributed the figures provided to students to polls carried out by the Pew Research Group. One of these figures suggests that "the vast majority of Americans are willing to drive a smaller car and support legislation that taxes polluters of greenhouse gases" (p. 72). In the econometric analysis, norm-based treatments appear to spur some willingness to cooperate in terms of declaring a support for policies curbing emissions, even though the results are relatively mixed. The authors conclude that "Despite the frequently null effects, the results of our experiments do show that norm-based treatments can to some extent directly shape beliefs, policy support, intentions, and actions" (p. 80).

Beliefs

In most cases, however, it is particularly hard to know the level of cooperation of others. This is actually one of the reasons why Lindman et al. (2013) make up the numbers for the Swedish population's average willingness to pay for offsets. As discussed in the theoretical introduction, when the level of cooperation of others is not known with certainty we can expect people to form beliefs on the expected cooperation from others and behave accordingly. It is an empirical question whether one's expectation of a high level of cooperation in one's environment leads subjects to reciprocate with a high level of cooperation. The research surveyed so far suggests that the visibility of the local norm increases provision to a global public good such as climate change mitigation. The next step consists in assessing whether this relationship also applies to the expectations, in particular to beliefs on others' cooperativeness.

Some evidence suggests that it does, at least to some extent. For instance, when evaluating the willingness to pay by Swiss individuals for climate change mitigation, Blasch and Farsi (2012)

find that the private demand for carbon offsets positively depends on "people's expectation about the percentage of Swiss consumers that participates in voluntary carbon offsetting schemes" (p. 20). In a very similar setting, Schwirplies and Ziegler (2016) use survey data to examine the willingness to pay for climate change mitigation in Germany and United States' samples. The willingness to pay is measured in terms of hypothetical demand for carbon offsets and other environmentally-friendly products. Many variables determine the stated adoption of carbon offsets and the willingness to pay a premium for green products, including other-regarding motives and environmental preferences. Among them there is a variable called "expectation of society", which measures the expectation that people have of the level of cooperation of others in society. The authors find that this variable is a significant driver of stated environmental behaviour in the sample of citizens from the United States, but not for the German sample. The positive and significant coefficient is of interest *per se,* and agrees with the finding of Blasch and Farsi (2012). The difference between Germany and the United States may also call for further investigations on the distribution of beliefs across countries. Descriptive statistics in Schwirplies and Ziegler (2016) show that on average expectations of cooperation from others are substantially higher in the United States.

Trust

Trust has not only been indicated as the key for the successful management of open access resources, but also as an important determinant of prosperity (Fukuyama 1995). The beneficial effect of trust on economic development has also been identified empirically (Knack and Keefer 1997; Zak and Knack 2001; Algan and Cahuc 2010; Tabellini 2010). While recent works have introduced the dark side of social capital (see e.g. Satyanath et al.2013), Ostrom (2009) added a new argument to the bright side: reciprocity based on the behaviour of the local community may also work when the stakes are global.

The evidence provided so far has shown the importance of the local context for the adoption of climate-friendly behaviour with global implications. While reciprocity is found to work in most situations despite the very different contexts, we do not put forward any claim in terms of external validity. If the types of behaviour collected here are however sufficiently widespread and representative of the overall scientific knowledge on the topic, one may expect to find a positive

relationship between trust and pro-environmental behaviour also at the aggregate level. Although still scant, a few works addressing the cross-country differences in efforts for climate change mitigation seem supportive of this fact.

In one of these studies, data on the adoption of sustainable development actions prescribed by Agenda 21 are used by Owen and Videras (2008) to investigate the relationship between trust and the efforts to pursue the goals of sustainable development. Their dataset covers many municipalities in 40 to 60 countries depending on the specifications. Similarly to in the development literature, trust is measured by the World Values Survey. With cross-sectional regressions, the authors find a positive correlation between one country's level of trust and the penetration in its territory of Agenda 21 programmes.

Using the same source of data for trust, Carattini, Baranzini, and Roca (2015) analyse the correlation between this measure of social capital and greenhouse gas emissions for 29 European countries observed over the period 1990–2007. The authors apply a similar setting to the one of Grafton and Knowles (2004), which however focused on local pollutants for a range of developing and developed countries, in order to assess their social determinants. The use of global pollutants in Carattini et al.(2015) reflects the intention to test the full "Ostrom hypothesis", from Ostrom (2009). Their first appraisal supports Ostrom's intuition: the authors find a negative correlation between generalised trust and greenhouse gas emissions. While the authors do not identify the channels leading to this effect, the authors argue that trusting individuals may not only be more willing to adopt pro-environmental behaviour but also to cast yes-votes in favour of stringent environmental policy (more on this in the next section).

Further evidence using similar variables from the World Values Survey is provided by Alló and Loureiro (2014), who survey a large number of empirical studies on the willingness to pay for climate change mitigation and perform a meta-analysis trying to explain the social and cultural determinants of the cross-country differences that they observe in the sample. Alló and Loureiro (2014) find for instance that countries with a high propensity to conform to social norms are associated with willingness to pay for climate change mitigation.

Volland (2017) tests a similar hypothesis with data for residential energy consumption in the United Kingdom. Using the British Household Panel Survey, he finds a negative correlation between the level of trust stated by respondents, and their reported level of energy consumption. In the survey, trust is measured on a ten-point scale. Based on his findings, a one-step increase in trust is correlated with a decrease of about 1% in energy consumption. This is, to the best of our knowledge, the first study providing microeconomic support to the general macroeconomic finding of Carattini, Baranzini, and Roca (2015), and supporting the existence of a specific channel going from trust to individual pro-environmental behaviour.

Local punishment for global defection

Experimental evidence suggests that failing to contribute to a global public good may be punished by local "neighbours", even though the latter may not be benefitting from the global public good being provided. Participants in Milinski et al. (2006) play a nested game in which contributions to a public good game are intercalated by an indirect reciprocity game. The public good game is however designed in an uncommon way. The per capita returns to participants are zero by design (as in the abovementioned experimental approaches using carbon offsets as public good). Participants contribute to a raising-awareness initiative aimed at tackling greenhouse gas emissions. Participants thus contribute to a real global public good, beyond the scope of the laboratory. The first remarkable result is that contributions to the public good are positive, and remain so even over many rounds. The common declining pattern is confirmed, as well as the absence of a convergence to zero. Ostrom's stylised fact resists to the very particular setting of this game. The second remarkable result is that the indirect reciprocity game is used by participants to punish defections in the public good game, even though players do not enjoy the public good, or do so only in a very marginal way. As in Milinski, Semmann, and Krambeck (2002), visible actions and reputation help this outcome.

The findings of Milinski et al. (2006) are confirmed by the experimental setting in Hauser et al. (2016), in which players switch from a "local" public good game played with their two nearest "neighbours", and a larger public good game, defined by the authors as global, and involving all participants. Also in this setting, defection to the "global" public good game is punished locally.

Both experimental studies hence suggest that local social norms matter for the provision of global public goods, and that behaviour on the global scale matters for reputation at the local level.

4 Implications for domestic and international climate policy

The demand for climate policy

At this point, one may ask: If people may be willing to cooperate, why is climate policy so unpopular? This is a legitimate question. Lobbying has proven very powerful in undermining the implementation of proposals for energy taxes (cf. Rocchi et al. 2014), as well as in softening those that were eventually implemented (cf. e.g. Godal and Holtsmark 2001; Bruvoll and Larsen 2004; Lin and Li 2011; Spash and Lo 2012). However, the role of vested interests only explains part of the story. Voters have also hampered the transition towards a greener economy. The constituencies' dislike for environmental taxes has been sufficiently strong to pressure politicians to abandon their proposed reforms, as in the French case of Deroubaix and Lévèque (2006), or to reject the proposed reforms in a ballot, as in the Swiss case in Thalmann (2004) and Carattini et al. (2016). Several studies using survey data and choice-experiment techniques show that the higher the cost of a proposed climate policy, the lower its likelihood to be acceptable for the general public (Sælen and Kallbekken 2011; Brannlund and Persson 2012; Gevrek and Uyduranoglu 2015). However, even revenue-neutral (Dresner et al. 2006) or efficiency-enhancing (Cherry et al. 2012) policies struggle to find some support, even among those individuals that would be net winners (Kallbekken et al. 2011).

Are individuals then completely unwilling to bear some private costs in order to tackle climate change? Probably not. The literature on the acceptability of climate policy, and in particular of energy and carbon taxes, is rather consensual on the following point: while people are concerned by distributional (Bristow et al. 2010; Kallbekken and Sælen 2011; Brannlund and Persson 2012; Gevrek and Uyduranoglu 2015) and competitiveness (see e.g. Thalmann 2004; Carattini et al.

2016) effects, the main obstacle emphasised by the literature, and rarely addressed by policymakers, is that citizens struggle to grasp the difference between "Pigouvian" and "Ramsey" taxes (Kallbekken et al. 2011). Hence, people fail to understand the incentive effect of Pigouvian taxes and thus neglect the taxes' environmental benefits, unless revenues are explicitly earmarked. To frame this phenomenon, Sælen and Kallbekken (2011) coined the term "issue-linkage". Several studies find a significant negative correlation between perceived ineffectiveness of environmental taxes and their acceptability (Bristow et al. 2010; Kallbekken and Sælen 2011; Sælen and Kallbekken 2011), which may also depend on the expectation of local co-benefits (Baranzini and Carattini 2017). In this respect, Carattini et al. (2016) show that it is sufficient to provide the general public with information on the potential greenhouse gas emissions associated with carbon taxes, for instance simulating their effects with a computable general equilibrium model, to increase acceptability. This includes progressive and revenue-neutral designs, i.e. designs that do not require the earmarking of revenues for environmental purposes. Providing information may act as a valid substitute to the use of trial periods, which may be harder to implement in the case of climate policy than in other contexts. Trial periods have received increasing attention following the political success of the Stockholm congestion charge, and their utility in increasing the acceptability of Pigouvian taxes has been supported with experimental evidence (Cherry et al. 2014). Real-world evidence also suggests that environmental instruments are more popular *ex-post* than *ex-ante*, as shown with panel data by Carattini, Baranzini, and Lalive (2016) and with poll data for the British Columbia carbon tax by Murray and Rivers (2015).

Thus, this strand of literature suggests that moderate energy and carbon taxes may be acceptable for part of the population provided that people see them as economic instruments correcting prices for externalities, rather than as a pretext for fiscal purposes. It also suggests that the difficulties faced by policymakers when trying to put forward concrete proposals may be partly imputable to their inability to communicate the benefits of environmental taxes over other, more popular, "soft" policies (see Steg et al. 2006; Heres et al. 2017). As noted above, being reminded of the willingness of others to contribute to climate change mitigation (either domestically or abroad) may also be a driver of higher acceptability, even though further studies are necessary to complement the results of Bolsen, Leeper, and Shapiro (2014). Unwanted impacts such as adverse distributional effects on low-income households should of course be addressed as well.

Cooperation between countries

This brings us back to the question we raised at the start: Can cooperation as evidenced in small groups be scaled up to the global level, in particular when state actors are involved? As the size of the ensemble becomes larger, the feedback mechanisms become weaker. Relatedness declines, reciprocal altruism becomes less of a force, recognition and reputation less effective. The standard game-theoretic approaches, which generally assume two players, become less appropriate. A new body of mathematical techniques, broadly called "mean-field games", seems to hold promise (Jovanovic and Rosenthal 1988; Huang et al. 2006; Lasry and Lions 2007; Nourian et al. 2014); but to this point, little has been done in the application of this approach to multi-party negotiations.

Overall, little is known, still, regarding the mechanisms that led countries to adopt climate change legislation and opt for climate policies characterised by different stringencies over the last two decades. Some countries acted as forerunners, introducing carbon taxes already in the early '90s. In spite of the many exemptions to energy-intensive industries, the Scandinavian carbon taxes (Finland 1990, Sweden 1991, Norway 1991, Denmark 1992) may have contributed to start the reciprocating process that led to the Kyoto Protocol and to the Paris Accord. We do not know, however, whether the Scandinavian governments were expecting other countries to follow suit, or if they anticipated that mitigation efforts elsewhere would take place at the slow pace that was to be observed.

As in the case of peer effects (Bollinger and Gillingham 2012), previous experiences with the tools of climate policy may have contributed to the diffusion of climate policy through learning processes. The slow pace of progress in international negotiations has also contributed to the multiplication of actors aiming at tackling climate change and leading to a polycentric approach to climate change mitigation (Ostrom 2009; Jordan et al. 2015). Policentricity implies local commitments to global dilemmas. Evolution has discovered modularity as a mechanism for the creation of building blocks and evolutionary progress (Clune et al. 2013). Cooperation within modules is indeed easier to attain, and then these modules may serve as building blocks for wider agreement (see also Hannam et al. 2015).

Some patterns of reciprocity may have also played a role. To assess the international drivers of climate legislation's adoption, Fankhauser, Gennaioli and Collins (2016) examined the largest available dataset on the passage of climate bills across 66 countries in the world (see also Nachmany et al. 2014). They emphasise three major drivers of adoption: first, belonging to the Kyoto Protocol is clearly a positive driver of climate change legislation, as one would expect. Second, being the organiser of a Conference of the Parties has a similar effect, suggesting that reputation matters also for countries. Finally, they find that in the last decades one of the main determinants of countries' adoption of climate change laws has indeed been the passage of such laws elsewhere. Sauquet (2014) finds a similar pattern looking at the ratification process, in particular among the countries he defines as "peers". This finding points to an important and yet under-researched role for contagion in the international diffusion of climate policy, and more generally for reciprocity among voters and countries.

As discussed in Nyborg (2014), cooperation is much easier to obtain when countries have reciprocal preferences. If countries are reciprocators (because their citizens are), bottom-up approaches such as the pledge-and-review system may effectively catalyse cooperation. While the pledge-and-review system was not a prerogative of the 2015 Paris Conference of the Parties, as it featured in the Copenhagen Accord of 2009, a pragmatic bottom-up approach was never sought prior to Paris. Along the road to Paris, the expectations of 2009 for a top-down, post-Kyoto legally-binding treaty gave way to a pragmatic resolution to build the agreement around the so-called Intended Nationally Determined Contributions, unilateral pledges to be submitted by governments in the year leading to the Paris conference. As anticipated, probably with the aim of stimulating reciprocity, national and supranational actors such as Switzerland and the European Union pledged very early in 2015, and pledged to take on abatement efforts of the order of 40–50% with respect to the 1990 baseline. More committed countries thus took the lead by pledging first and relatively high, in the hope that others would follow. Many countries followed through, submitting relatively ambitious pledges with respect to expectations and historical efforts. More committed countries even led a secret international coalition, the "high-ambition coalition", which contributed to overcome the last disagreements and reach a compromise on a final text. These examples of international collective action suggest that reciprocity may be an important driver of action in the climate commons. Significant early commitments (unilateral initiatives, early pledges and

multilateral secret agreements) were necessary to forge a coalition and reach consensus among parties with extremely different interests. Many governments have devoted much time and resources to the public good represented by the creation of an international agreement, in spite of the highly uncertain outcome. Such collective action is a necessary condition for treaties to exist, which goes beyond the purely selfish interest of countries. As Nordhaus (2015, p. 1362) puts it, "treaties do not spring full grown", but require much cooperation and collective action beforehand.

5 Conclusions

According to standard economic theory, little cooperation should be observed in the climate commons, besides what is rationalisable based on the expected benefits that can be appropriated from undertaking mitigation efforts. We provide a review of cases and situations in which individuals appear to behave cooperatively in the face of this global dilemma. We analyse such cases and, following the procedure outlined by Elinor Ostrom, we test and reject the "zero-contribution" proposition. We conclude that the reviewed empirical evidence suggests that, similar to other domains, individuals are more willing to cooperate to tackle climate change than theory predicts, even absent specific "carrots and sticks" mechanisms. We do not argue, however, that the observed level of cooperation suffices to solve the social dilemma. Hence, we suggest some ways to leverage people's proclivity for cooperation, and increase their contribution to climate change mitigation.

We argue that social norms explain much of the cooperative behaviour observed and reviewed in this paper. It is difficult to reconcile the observed empirical evidence with behaviour solely driven by selfish calculus related to local co-benefits. We focus on the empirical literature on peer effects, social comparisons, trust and climate-friendly behaviour, which points to the importance of local norms in shaping behaviour in the global commons. Ostrom's argument for polycentricity in dealing with climate change relates to the famous slogan "Think Globally, Act Locally". We argue that a non-negligible portion of individual contributions to climate change are the result of people providing global benefits while adjusting to local norms. Thus, our findings tend to suggest a different reading of the motto, as follows: "Think Locally, Act Globally".

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