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Unconventional Determinants of Greenhouse Gas Emissions: The role of trust

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ABSTRACT
Social norms have been included in the theory of collective action to overcome difficulties in explaining why commons may perform better when self-regulated. The role of trust has been identified in several contexts of local social dilemmas, but only recently has been extended to global commons, based on large descriptive evidence collected by Elinor Ostrom. However, no quantitative evidence was available until now. Using a dataset of 29 European countries over the period 1990–2007, we provide empirical evidence in favour of the role of trust in global dilemmas. We find a non-negligible impact of trust on greenhouse gas emissions, which can support Ostrom's intuition on the social roots of pro-environmental behaviour.

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Introduction

Climate change is one of the principal challenges facing humans in the 21st century, and we observe two main patterns in the way we deal with this issue. At the global level, the day of a binding agreement including all principal emitters and targeting a sharp reduction in worldwide greenhouse gas emissions is still to come, although recent Conferences of the Parties have suggested a potential deadline for binding abatement targets in 2020. Stalling negotiations are in line with the main theory of collective action, predicting large free-rider behaviour and thus huge difficulties in solving this type of global public good dilemma (cf. Hardin, 1968; Olson, 1965). Indeed, as the costs of climate change mitigation are local while the benefits are mainly regarded as global, a prisoner's dilemma arises. In this context, non-cooperative behaviour is supposed to be the only rational strategy and the public good is not provided. However, individuals may depart from this narrow definition of 'rationality' and social dilemmas may be better addressed with different lenses: 'A more fruitful approach may lie in permitting the possibility that the person is *more* sophisticated than the theory allows' (Sen, 1977: 341) and does not follow the 'rational' selfish strategy. Indeed, despite the reticence of most governments to engage in coordinated international policies, examples of unilateral policies, local actions and individual ecological behaviours are increasingly available. For instance, a few countries have already adopted carbon taxes to stimulate a shift towards a greener economy (Baranzini and Carattini, 2014). In this paper, we aim to contribute to explaining why countries

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and individuals may adopt or accept climate-friendly behaviours and policies, despite the global public good characteristics of climate change mitigation.

We draw on the contributions of Elinor Ostrom and other institutional scholars and apply an empirical framework to determine countries' greenhouse gas emissions. We focus on the importance of social norms, and in particular of trust, in the determination of individual and collective behaviour. As highlighted by Ostrom and Ahn (2003: xvi): 'The ideas fundamental to the social capital approach cannot be entirely captured by the first-generation collective-action theories that tend to reduce "cultural" aspects such as trust, trustworthiness, and norms to incentives embedded in social structures of interaction [...] Trustworthiness is an independent and nonreducible reason why some communities achieve collective action while other fail.'

The concept of trust, understood as mirroring an expectation of trustworthiness, has been applied to the problem of common pool resources and local environmental public goods to explain why self-organized solutions may perform better than regulated environments. A recurrent illustration refers to water management in developing countries: field evidence shows that overuse could be lower with self-management than with external control, i.e. the prisoner's dilemma does not necessarily hold when people trust each other (cf. Joshi *et al.*, 2000). Outwith the environmental sphere, the concept of trust has been used in the development literature, in particular by Putnam *et al.* (1994) and Fukuyama (1995), who identify trust as the key social value for sustained economic growth, and by Knack and Keefer (1997), Zak and Knack (2001) and Tabellini (2010), who show the positive role that trust plays in supporting growth.

In this paper, we aim to explore whether trust has an impact on greenhouse gas emissions, by referring conceptually to the literature criticizing the conventional collective action theory based on local and communitarian environmental solutions, while borrowing the empirical methodology from applications in development economics. Ours is not the first attempt to relate social norms, namely trust, with global public goods such as climate change. The seminal paper of Ostrom (2009) disputes the validity of the traditional view, which contends that the global scale of climate change hampers the emergence of grass roots collective action and dispersed forms of unilateral action, i.e. cooperation is even more unlikely than with local issues. Supported by the collection of case, field and laboratory studies presented by Poteete *et al.* (2010), Ostrom stresses the limits of conventional theory arguing that it can fail to predict the realized outcome also with global issues, especially whenever participants see each other as trustworthy (i.e. 'effective reciprocators'). In particular, she suggests that the same mechanism of trust that leads commons to be successfully managed by self-organized institutions could be effective also with global issues. That is, in a given context, individuals can commit to reduce their own emissions and comply with their commitment, especially when they trust that others are also sharing the same responsibility and engaging in the same social behaviour. To see this mechanism at work, we need to scale down the focus from the global perspective. Thus, we can realize how social norms help to overcome the global property of climate change, promoting effective local efforts.

On the empirical side, Grafton and Knowles (2004) propose a series of cross-sectional regressions attempting to identify an effect of social capital on several measures of local environmental performance. They find very little evidence in favour of an effect of social capital, including trust. The authors point to a series of empirical difficulties related to the dataset, concerning the measures both of social capital and of environmental quality, which could explain this outcome.

Our aim is to generalize Ostrom's intuition and to assess whether the effect of trust is visible not only in small case studies, but also at an aggregated level. In this way, we improve the seminal contribution of Grafton and Knowles (2004) in four ways. First, the measure of environmental quality that we use concerns global pollutants rather than local contaminants. We thus test the full extent of Ostrom's hypothesis on global dilemmas. Second, this measure is compatible across time and countries and does not present the weaknesses of indices and similar built-in measures of environmental quality. Third, we use a larger set of data that allows for multivariate panel analysis and fixed effects, which limit the risk of omitted variable bias and allow us to focus on changes over time. Fourth, our dataset of European countries consists of relatively similar economies, also contributing to reduce the bias possibly caused by missing variables.

Hence, we perform an econometric analysis assessing the effect of trust on greenhouse gas emissions. We end up with a negative coefficient implying a decline in emissions of 0.24% following a percentage increase in trust,

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ceteris paribus. This fresh evidence is in line with the updated theory of collective action and supports its underlying economic intuition.

The remainder of the paper is structured as follows. The section below reviews the economic motivations. We then present the data, discuss the methodological issues related to the measure of trust and describe the econometric strategy. Empirical results are then provided followed by a concluding section.

Linking Trust and Greenhouse Gas Emissions

We expect trust to have a threefold impact on greenhouse gas emissions. First, trust may have a direct effect by promoting pro-social and environmentally conscious behaviour at the individual level (e.g. biking to work rather than driving), as illustrated by the large surveys in this field of Pretty and Ward (2001) and Poteete *et al*. (2010). According to the latter, trust plays a crucial role as the norm defining the actual level of cooperation (cf. Figure 1): if agents acting in a given context perceive most individuals as reciprocators (i.e. trustworthy), we may expect them to adopt a more cooperative behaviour (e.g. pro-environmental). In this way, trust generates reciprocity: a mechanism based on the social 'obligation' to reciprocate leads people to invest in collective action, being confident of other people doing the same (Pretty and Ward, 2001).

Cooperative behaviour in general and pro-environmental behavior in particular may also come from intrinsic moral norms. Although in society there may be a fraction of 'Kantian' mostly unconditional cooperators tending to behave ethically (see the discussions in Knack and Keefer, 1997, and Roemer, 2010), their effort may be too meagre to cope with climate change. This paper thus focuses on conditional cooperation, where the expectation of reciprocation shapes individual behaviour. Nyborg *et al*. (2006) formalize it as follows. For a given individual, choosing a more expensive green product over the grey alternative yields a self-image benefit from behaving in tune with the social norm. Hence, this benefit depends on what the norm is, as well as on the overall external environmental benefit, which relates to environmental awareness and consumer-perceived effectiveness. That is, the larger the share of consumers going green, the larger the self-image benefit. If benefits from being green exceed the cost differential, the total payoff (i.e. personal welfare) is higher buying green. Empirical evidence from a choice experiment supports this formalization: testing the willingness-to-pay of Swedish students to withdraw emissions allowances from the European carbon trading market, Lindman *et al*. (2013) show that the expected participation rates at the population level have a positive effect on students' voluntary participation in the carbon market. However, we argue that in most cases individuals cannot really observe how green the others may be, but do have

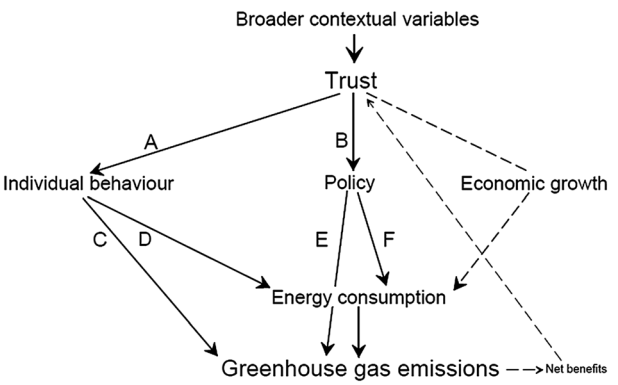

Figure 1. From trust to greenhouse gas emissions. (Note: own figure based on Poteete *et al*. (2010). According to the authors, the level of trust that other participators are reciprocators affects the level of cooperation and in turn generates a beneficial outcome, which in this framework would be a reduction in emissions. The effect of trust on emissions goes through three channels, as described in the text. Paths A to F are detailed below. The figure is clearly not exhaustive. Our focus is on trust, but other factors may affect individual behaviour (or policy or economic growth). In the case of, for example, individual behaviour, see the reference to moral norms and environmental awareness with respect to the model of Nyborg *et al*. (2006).)

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a general expectation of the level of trustworthiness in the context where they live. In this spirit, we relate trust to pro-environmental behaviour (channel A in Figure 1).

Second, following Ostrom (2009) trust may have an impact on local, regional and national environmental policy as it influences collective action. Although there is some theoretical and empirical literature analysing the effect of environmental policy on trust and intrinsic motivation and suggesting a crowding-out if the policy change makes agents less trustful (see, for example, Frey, 1997; Cardenas *et al.*, 2000; Frey and Jegen, 2001), the reverse link from trust to environmental policy remains largely unexplored. Ostrom posits that trust and environmental policy are complements: in some cases, only collective action allows policies to exist and be followed in a manageable way (i.e. without excessive costs of enforcement). She also predicts a crowding-in, if the policy change makes agents more trustful (Ostrom, 2009). Trust is thus the key for having diligent and proactive citizens. She explains in this way the large list of environmental programmes undertaken at any level (municipal, regional, inter-regional, etc.) and mentioned in her work. Her intuition is included in the analysis of Grafton and Knowles (2004) and supported by the empirical evidence of Owen and Videras (2008). In a cross-sectional examination of 66 countries, the latter find that trust is positively correlated with the amount of local Agenda 21 programmes implemented in a given place. The magnitude of this effect is considerable: the authors suggest that an increase of 10% in trust lifts the expected number of programmes by up to 70%.

From a conceptual perspective, this second link could be introduced in the model of Nyborg *et al.* (2006) by assuming that the green option does not refer to a green good, but rather to a basket of, for example, climate policies. In this perspective, voting green may thus generate a similar self-image benefit as buying green.

Further evidence in this sense comes from a growing body of literature following an environmental psychological approach. Stern *et al.* (1999) theorize how engagement in collective action aiming at affecting climate policy, both actively (e.g. writing letters, contributing financially to environmental movements, demonstrating, i.e. environmental citizenship and activism) and passively (e.g. accepting higher taxes), responds to a feeling of obligation to contribute to the provision of a collective good. In this framework, social and personal norms interact and contextual factors such as social expectations and trust contribute to explain pro-environmental behaviour in the public sphere along with moral motivations (Stern, 2000). Survey-based empirical evidence supports this norm-activation mechanism, by using measures of policy-related collective action, such as being in favour of higher energy prices (i.e. energy taxes) and of subsidies to energy efficiency and renewables, signing petitions for tighter environmental laws, and supporting green taxation of imports (e.g. Stern *et al.*, 1999; Gärling *et al.*, 2003; Steg *et al.*, 2005; see also the survey of Steg and Vlek, 2009).

Trust may thus affect policy (channel B in Figure 1). Yet, we acknowledge that in some cases Ostrom's intuition may look counterintuitive. In fact, in the absence of trust (or at very low levels) there may be some substitution between policy and trust. For instance, Baranzini *et al.* (2010) consider a global public good problem such as tropical forest conservation and find that when people do not expect spontaneous efforts by others, they prefer to contribute to a mechanism that is strict and enforceable (i.e. a hypothetical global tax) compared with a mechanism based on voluntary agreements (i.e. a voluntary fund for forest conservation). However, one would argue that in such a situation it would be unclear who would promote such a policy. In reality there is no global tax to protect tropical forests. In our view, despite the positive demand for environmental policy, the latter fails to rise due to the same reason that leads to the development of its demand, i.e. the lack of trust. That is, at very low levels of trust we may see a pattern of substitutability on the demand side but which is not matched by policy suppliers (i.e. institutions, as collective action is lacking). We thus suggest that pro-social behaviour and policy are more likely to go hand in hand rather than be substitutes.

Third, trust may influence emissions through the channel of economic growth (see Knack and Keefer, 1997; Zak and Knack, 2001). However, our focus is on trust and collective action towards environmentally friendly changes. For that reason, our empirical strategy is limited to the impact of trust on environmental behaviour and policy. We would thus not assess the full net effect of trust on greenhouse gas emissions, which may be positive. As the channel through economic growth is not considered in our empirical specification, we present the relative path in Figure 1 as a dashed line.

In Figure 1, the mechanism of Poteete *et al.* (2010) is updated by introducing the link between trust and greenhouse gas emissions. This link is expected to go mainly through lower energy consumption. In this sense, energy consumption acts as a mediator, in the spirit of Baron and Kenny (1986). Indeed, we would expect an

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increase in pro-environmental behaviour (A) to lead to lower energy consumption (path D), as we would expect local, regional and national environmental policy to do this (paths B and F). However, both individual behaviour and policy could also affect emissions without passing by the level of energy consumption, e.g. by affecting the energy-mix (i.e. technological development and adoption) or non-energy emissions. That is why we include two additional arrows for paths C and E.[1] Finally, following Poteete *et al.* (2010), we add the option of a feedback mechanism, reinforcing the existing pattern. For climate change, direct benefits of climate policies or green behaviour may not be visible for the individual, but those efforts could contribute to more perceptible local co-benefits, for example in terms of better air quality. However, we do not expect this effect to be particularly large as to be an issue for identification. We thus use again a dashed line.

Methodology

Data Sources and Measurement Issues

We access the Eurostat database for 30 European countries over 1990–2007, namely 27 members of the European Union (Greece is excluded, due to missing values, as well as the recent member Croatia) and the European Free Trade Association members Iceland, Norway and Switzerland. Our sample includes nine transition economies. Eurostat provides the data for all the explicative variables used in the econometric model except trust, which comes from the World Values Survey (WVS).[2] The variable trust that we use in this study is the share of respondents marking the answer 'Most people can be trusted' when asked 'In general, do you think that most people can be trusted, or that you cannot be too careful in dealing with other people?'. The alternative answer is 'You cannot be too careful in dealing with other people'. The number of individuals surveyed depends on both timing and country: observations vary between a minimum of 375 (for Malta in 1991) and a maximum of 2574 (for Belgium in 1990). In general, the largest part of our values is given by a sample reaching or exceeding the symbolic threshold of 1000 individuals.

Unfortunately, we do not possess yearly observations for trust, given that the survey is administered sporadically and with different timing across countries (i.e. one wave can take more than 1 year to be completed). The latest available wave is of 2007. Therefore, the sample ends in 2007 and has a theoretical maximum of 540 observations. Countries included in the sample represent more than 10% of world greenhouse gas emissions (UNEP, 2012).

The main descriptive statistics are provided by Table 2. Greenhouse gas emissions present very large variation, as they depend closely on the economy's size. In per-capita terms, each European citizen emits about 11 tonnes of CO_2-equivalent emissions per year on average over the observed period. As shown by Figure 2, per-capita greenhouse gas emissions decreased in European countries in the early 1990s and levelled off thereafter. However, in the transition economies, the early 1990s are characterized by a sharp change in the economic structure and a dramatic collapse of output, resulting in a strong decrease in emissions. Thereafter, the transition economies switched to a recovery path, but emissions lagged behind until 2000. All this suggests dealing carefully with this subset of countries.

Manufacturing represents on average about 20% of European gross domestic product (GDP). Since Eurostat does not include mining and fossil fuel extraction in the category manufacturing (but only fossil fuels refining), we decide to add mining and resource extraction to manufacturing whenever data are available (cf. Xu and Ang, 2013). This is economically justified by the large energy-intensity of mining and resource extraction, which we relate to the so-called 'composition effect'. Looking at the data, we see an important structural change taking place in European economies during the 1990s and the 2000s, with the largest drops in manufacturing share being related to transition economies (from more than 30% of GDP to 20% in about two decades).

As it is common in the literature, trade openness is given by the sum of imports and exports over GDP (trade intensity ratio). Trade openness evolves similarly for both transition and Western European economies, with the average level of trade moving from about 40% of GDP in 1990 to slightly less than 60% in 2007. However, cross-

[1]Path E relates to the so-called 'weak Porter hypothesis' (see Baranzini and Carattini, 2014, and Ambec *et al.*, 2013, for an empirical review; Acemoglu *et al.*, 2012, for a theoretical analysis).
[2]See Table 1 for data sources.

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Variable	Database	Eurostat table	Measure	Unit
Greenhouse gas emissions	Eurostat	env_air_gge	Greenhouse gas emissions	10^3 of tons of CO_2 equivalent
GDP per capita	Eurostat	nama_gdp_c	GDP at current prices	Euro per inhabitant
Trust	World Values Survey	–	Most people can be trusted	Percentage of positive answers
Manufacturing	Eurostat	nama_gdp_c sbs_na_2a_mil	Manufacturing, value added	Percentage of GDP
Imports	Eurostat	nama_exi_c	Imports at current prices	Percentage of GDP
Exports	Eurostat	nama_exi_c	Exports at current prices	Percentage of GDP
Energy	Eurostat	nrg_100a	Gross inland energy consumption	10^3 of tons of oil equivalent
Population	Eurostat	demo_pjan	Population on 1 January	Number of persons
Deflator	Eurostat	teina110	GDP deflator	Index (2000 = 100)

Table 1. Data source

Variable	Unit	Mean	SD	Min.	Max.	*n*
Greenhouse gas emissions per capita	10^3 tons of CO_2 equivalent	0.011	0.004	0.004	0.035	539
Real GDP per capita	Euros of 2000	19 747.18	12 622.49	1218.981	71 428.57	438
Trust	Share of positive answers	0.352	0.148	0.099	0.68	340
Manufacturing	Share of GDP	0.197	0.056	0.075	0.453	460
Trade openness	Share of GDP	0.494	0.250	0.165	1.764	484
Energy consumption per capita	10^3 tons of oil equivalent	0.004	0.002	0.002	0.014	538

Table 2. Dependent and independent variables: summary statistics

country differences are important. On average, transition economies are related to larger trade openness. Yet, Western small open economies such as Belgium, Ireland, Luxembourg and Malta show even larger values.

Our main variable of interest is trust. Data inspection shows some supportive variation over time in the level of trust.[3] For instance, trust in Spain increased from 34.3% in 1990 to 39.8% in 1995, but then decreased to 34% in 2000 and 20% in 2007. Trust also shows large variation between countries. Although the average shows moderate levels of trust for Europe (i.e. one out of three respondents stating that most people are trustworthy), extremes indicate relatively low levels of trust for Cyprus, Portugal and Romania (with values below 10%) and large levels of trust at the other end of the spectrum, mainly for Scandinavian countries (about two out of three respondents trusting most people).

As trust is not directly observable, it can only be approximated from individual perceptions in surveys. A long list of potential biases could arise from survey measures, such as selection issues, translation difficulties (i.e. different framing) and response bias (cf. Knack and Keefer, 1997). For example, in their study of trust and economic growth, Knack and Keefer (1997) point to a selection bias related to the WVS measure of trust potentially leading to over-correlation with education and income. However, they argue that this issue mainly applies to developing countries. Ostrom and Ahn (2003) present other drawbacks of survey measures related to trust. For instance, it seems that measures from the General Social Survey, another large-scale survey similar to the WVS but administered only to the United States population, do not lead to good forecasts of individual cooperation in the laboratory.

However, other studies reviewed by Ostrom and Ahn (2003) provide a more optimistic picture, showing that although general survey questions may struggle to depict the trust pattern (e.g. if a participant trusts the other participants when playing first), they are generally successful in predicting trustworthiness (e.g. the amount of money given back by trustees if players in the first round decide to trust). Furthermore, Knack and Keefer (1997)

[3]We start with 84 values for trust and interpolate linearly to reach 340 observations. In a conservative vein, we do not extrapolate. Furthermore, by extrapolating we would have had to deal with negative (thus zero) values, which is a very extreme case. Yet, the number of observations used for the estimations varies depending on the completeness of control variables. Our own computations show that the way we ipolate does not have a particular impact on the empirical findings in the next section, for example by applying cubic or cubic spline ipolations and multiple imputation techniques. We match the WVS measures of trust for Great Britain and West Germany with Eurostat variables for the UK and Germany, respectively (cf. Knack and Keefer, 1997).

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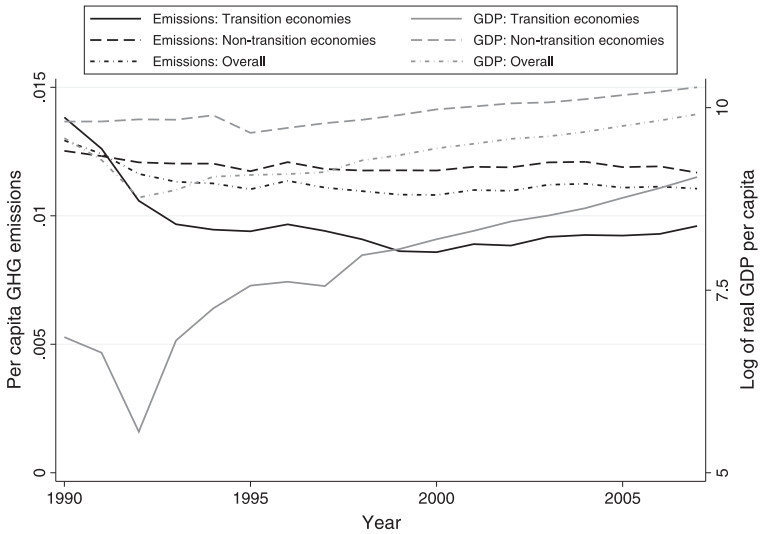

Figure 2. Evolution of greenhouse gas emissions per capita over 1990–2007 for the whole sample and subsets of countries. (*Source*: own computations.)

not only provide a list of potential risks linked to the WVS measure of trust, but also favourable evidence for its application. In particular, they test whether the ambiguous terminology used in the question (i.e. the reference to 'most people') may lead respondents to think of other people as their family, which is not necessarily the scope of trust for our study, as we are interested in trust in the others in a wide sense.[4] The authors point out that in low-trust countries a large share of interactions probably occur within the family, which could eventually lead to a bias. Yet, they find a low correlation (of 0.24) between the WVS measure of trust and the measure of trust in the family. We are thus more confident that our variable measures trust in the others in a large sense. The authors also look at the nexus between the WVS measure of trust and the share of returned wallets in a cross-country experiment wherein wallets were 'lost' with $50 in cash and a card with the owner's contact, finding a supportive correlation of 0.67. In addition, correlations tend to become higher when controlling for income per capita (thus trying to simulate the reaction to a purchasing-power-adjusted 'lost' wallet, i.e. testing an individual's 'real' trustworthiness; see also Grafton and Knowles, 2004).

In the same vein, we examine the link between the measure that we chose for this study ('Most people can be trusted') and additional measures of trust that were included in the WVS, although for some waves only. In particular, we consider the answers to the questions 'Trust: other people in country', 'Do you think most people try to take advantage of you?', 'Trust: people you know personally', 'Trust: people you meet for the first time' and 'Trust: your neighborhood'. This investigation confirms our priors. Trusting other people in the country is positively correlated with the measure of trust that we use. We find positive and significant links both in correlation tables and with panel regressions for both the positive answers, namely 'Trust completely' and 'Trust a little', as well as for the sum of the two.[5] Therefore, we are confident that the national measure of trust that we include in our empirical framework makes sense and captures a plausible range of social interactions to be linked with collective action.

'Take advantage of you' is very highly correlated with trust (correlation of 0.88). The correlation is positive because the variable is coded with a 10-point scale whose maximum indicates an expectation of full fair treatment. 'Take advantage of you' and 'Most people can be trusted' provide different and comparable answers to a very similar question, but framed differently. This is very helpful as it allows to double-check respondents' answers (although framing may matter).

Not surprisingly, both 'Trust: people you know personally' and 'Trust: people you meet for the first time' are strongly correlated between themselves (0.75) and with 'Most people can be trusted' (0.6 and 0.72, respectively).

[4]More precisely, we shall say that we mainly focus on 'intrinsic reciprocity' rather than 'instrumental reciprocity'. Knack and Keefer (1997) use the term 'generalized trust' referring to the same concept. Cf. Sobel (2005) for a discussion on terminology and sound economics of reciprocity.
[5]All following measures except 'Take advantage of you' are coded according to the following answers: 'Trust completely', 'Trust a little', 'Not trust very much' and 'Not trust at all'. We use the two positive answers and their sum (as the percentage share of total answers).

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As trust is self-reinforcing and can be accumulated, it follows from practice that people tend to apply their own experience in shaping their everyday behaviour while interacting with new agents (Pretty and Ward, 2001).

The correlations for 'Trust: your neighborhood' go in the same direction. It is correlated at 0.84 and 0.86 with 'Trust: people you know personally' and 'Trust: people you meet for the first time', respectively, and at 0.6 with 'Most people can be trusted'. The evidence concerning the last three variables is encouraging as we focus on a global dilemma that needs to be dealt with through cooperation between people at different scales. That is, it seems that the social context matters and at different levels.[6] Therefore, we are confident that the variable trust that we chose from the WVS has the potential to perform well and can thus be used in quantitative studies, even where it would measure trustworthiness more than trust (cf. Knack and Keefer, 1997; Pretty and Ward, 2001; Ostrom and Ahn, 2003). Moreover, we are reassured that our measure performs well in explaining trust between citizens of the same country as well as in narrower contexts.

Econometric Approach

Starting from earlier empirical work on environmental quality (see, in particular, Antweiler *et al.*, 2001) and following the previous discussion on trust and emissions, we may suppose that the relevant drivers of per-capita greenhouse gas emissions are the level of per-capita income, the economy's composition, the economy's openness to trade and the level of trust, as given in the following equation:

$$Emissions_{i,t} = \propto_i + \beta_1 GDP_{i,t} + \beta_2 Manufacturing_{i,t} + \beta_3 Trade_{i,t} + \beta_4 Trust_{i,t} + \varepsilon_{i,t} \quad (1)$$

where $Emissions_{i,t}$ is per-capita greenhouse gas emissions at time t in country i (in log); $GDP_{i,t}$ is real GDP per capita (in log); $Manufacturing_{i,t}$ is the aggregated industrial sector's share in the economy; $Trade_{i,t}$ measures trade openness; $Trust_{i,t}$ is the share of the population showing trust as measured by the WVS; α_i is a country-specific fixed effect; and $\varepsilon_{i,t}$ represents the error term.

The estimated coefficients can be directly interpreted in terms of elasticities, as all variables are in logs or in shares.

The use of panel-data methods allows for different specifications, in particular the use of fixed- and random-effects estimators. In their seminal contribution, Antweiler *et al.* (2001) evaluate the limits of one or the other approach in a similar framework in which they have a panel of 293 observation sites measuring sulphur emissions in 109 urban areas across 44 countries, looking for the effect of trade on emissions. In particular, they remark that fixed-effects estimators treating country-specific excluded variables as constants are appropriate when the aim is to apply the model to the countries in the sample, as we do. In our framework, it would be difficult to argue that our set is a random sample of countries from a larger underlying population. Inconsistency related to omitted variables would be the consequence of applying random effects when not appropriate, whereas the intrinsic drawback of a fixed-effects model is represented by the fixed effects themselves, i.e. the need to simplify the model by assuming country effects to be constant and focusing on variation over time. The Hausman test (Hausman, 1978) supports the theoretical arguments. As a consequence, we introduce country-specific fixed effects in eqn (1).[7]

Except for trust, the determinants of emissions included in eqn (1) are standard with respect to the literature. We control for structural changes in the composition of the economy using the share of manufacturing, following Cole (2000), Cole (2004) and Buehn and Farzanegan (2013). We then take into account the remaining effect of income per capita, as in Antweiler *et al.* (2001). Observing the effect of trade openness is central in Antweiler *et al.* (2001) and in other studies dealing with geographical carbon leakage. De Melo and Mathys (2010) review the main links between trade and the environment: trade liberalization may increase economic activity (although we already

[6]All correlations we refer to are statistically significant at least at 10%. However, further studies are needed to have more robust results. Indeed, all these variables are not included in all WVS waves as it is 'Most people can be trusted'. Hence, the explanatory power is limited by the small number of available observations.

[7]The Hausman test rejects the null of always consistent random-effect estimators with a $\chi^2_5 = 80.12$ and $\chi^2_4 == 8.32$ with and without per-capita energy consumption, respectively ($P = 0.0000$ and 0.0804). The Breusch and Pagan Lagrangian multiplier test for random effects gives $\chi^2_1 = 1025.08$ and $\chi^2_1 = 1161.83$, respectively ($P = 0.0000$ in both cases).

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control for GDP per capita), may lead to specialization, displacement of polluting activities and structural changes (although we already control for most energy-intensive industries), and may also affect the type of technology used to produce goods and services within the country. We expect the measure of trade openness to capture predominantly the last effect.

Energy consumption is a frequently recurring control variable in the literature (cf. Buehn and Farzanegan, 2013), but it is not included in model (1), which estimates the final effect of trust on emissions (Figure 1). Energy consumption enters model (2), whose role is two-fold. First, it tests the effect of energy consumption on emissions, which is expected to be positive and significant. Second, it tests for residual mediation. Provided that eqn (1) shows a significant effect of trust on emissions, if energy mediates trust, the relationship between the latter and emissions should be substantially reduced or even no longer significant.[8] Model (2) is given as follows:

$$Emissions_{i,t} = \propto_i + \beta_1 GDP_{i,t} + \beta_2 Manufacturing_{i,t} + \beta_3 Trade_{i,t} + \beta_4 Trust_{i,t} + \beta_5 Energy_{i,t} + \varepsilon_{i,t} \quad (2)$$

where $Energy_{i,t}$ stands for per-capita gross inland energy consumption (in log). A last step is required for mediation, testing the effect of trust on energy (paths A plus D and B plus F). If energy is a valid mediator, the coefficient for trust should be significant. Model (3) displays then an analogous specification for energy consumption:

$$Energy_{i,t} = \propto_i + \beta_1 GDP_{i,t} + \beta_2 Manufacturing_{i,t} + \beta_3 Trade_{i,t} + \beta_4 Trust_{i,t} + \varepsilon_{i,t} \quad (3)$$

In theory, additional levels of mediation could be tested. For instance, paths A and B could be tested controlling whether environmental policy does act as a mediator from trust to energy consumption and to what extent. However, there is a shortage of data on policy, as discussed in the next section.

To summarize, the expected impacts of the included variables are as follows:

- Real income per capita (+): although there is no clear-cut evidence for the precise role of income per capita on global emissions, general consensus points to a positive effect due to the dominance of the so-called scale effect.
- Manufacturing (+): we expect industry to be on average more emissions-intensive than services and an increase in the share of manufacturing to be positively related to emissions.
- Trade (±): there is no conclusive evidence on the effect of trade on emissions, even if we control for income per capita and manufacturing.
- Trust (–): trust is supposed to foster collective action towards cleaner goods, greener attitudes and perhaps more effective environmental policy. We thus expect trust to decrease emissions by reducing energy consumption.
- Energy (+): energy consumption is directly and positively linked to emissions, provided that energy sources are mainly fossil fuels.

We discuss the outcome of the estimations in the next section.

Empirical Results

Estimation results for models (1), (2) and (3) are displayed in Table 3. Columns (1) and (2) show the estimates for model (1), testing the direct effect of trust on greenhouse gas emissions.[9] Column (1) includes transition economies, whereas all other columns do not. Regressions in columns (1) and (2) provide very large goodness of fit, but which are in large part driven by fixed effects, as shown by the difference between overall-R^2 and within-R^2. Robustness

[8]Baron and Kenny (1986) refer to 'perfect mediation' when the residual effect of the independent variable on the dependent variable controlling for the mediator is zero. In this framework, a positive residual effect could be expected as it would imply that the effect of trust on emissions is mediated also by the energy-mix and non-energy emissions, i.e. paths C and E. Instead, a non-significant coefficient for trust would suggest that almost all mediation goes through energy consumption, although we would refrain from calling it perfect mediation for straightforward empirical reasons. In our view, this is the best way to assess the impact of trust on the energy-mix, which is not really available in the data. Hence, we omit a specific model for this path but still test its plausibility adding some variables to the main specifications (see next section).
[9]The model is assumed to be linear with logs and estimated with ordinary least squares.

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	Greenhouse gas emissions			Energy consumption
	Model (1)		Model (2)	Model (3)
	(1)	(2)	(3)	(4)
Trust	−0.269** (0.114)	−0.242** (0.110)	0.022 (0.744)	−0.321*** (0.101)
Real GDP per capita	−0.023** (0.011)	0.088*** (0.033)	−0.070*** (0.024)	0.192*** (0.030)
Manufacturing	1.414*** (0.240)	2.241*** (0.344)	1.106*** (0.238)	1.384*** (0.317)
Trade	−0.210*** (0.068)	−0.569*** (0.115)	−0.440*** (0.076)	−0.157 (0.105)
Energy consumption	—	—	0.821*** (0.054)	—
Constant	−4.045*** (0.152)	−5.080*** (0.333)	0.805* (0.446)	−7.171*** (0.307)
Country fixed-effects	Yes	Yes	Yes	Yes
Observations	257	197	197	197
Countries	29	20	20	20
Within-R^2	0.277	0.287	0.694	0.327
R^2	0.970	0.970	0.987	0.983

Table 3. Empirical results based on models (1), (2) and (3)
Source: Own computations.
Notes: standard errors in parentheses. The dependent variable is greenhouse gas emissions per capita, in logs. Panels are unbalanced. Columns (2) to (4) do not include transition economies. Asterisks indicate significance at the *90, **95 and ***99% confidence levels.

tests for model (1) without transition economies are shown in Table 4. Results are robust both to heteroscedasticity and autocorrelation. Indeed, the Wald test rejects the null of homoscedasticity in our panel, as well as the Breusch–Pagan (Cook–Weisberg) test. We thus allow errors to be heteroscedastic in Table 4, where model (1) is estimated using heteroscedastic-consistent White standard errors and bootstrapped standard errors (with 50 replications) [cf. columns (2) and (3), respectively]. Significance is reduced only slightly. The Wooldridge test for first-order autocorrelation then rejects the null hypothesis of no autocorrelation. We also allow for autocorrelation in the residuals estimating Driscoll–Kraay heteroscedastic and autocorrelated standard errors [cf. column (3)]. Coefficients of interest are still statistically significant. This holds true for the whole sample, i.e. including transition economies. We also test for multicollinearity: for model (1) the mean variance inflation factor is 6.96 with fixed effect, 1.35 without. Both values are below the common threshold value of 10, and the second is even below the more restrictive threshold value of 5. Multicollinearity is not an issue also for model (2), which includes energy consumption as a regressor, and for model (3).

	Greenhouse gas emissions			
	(1)	(2)	(3)	(4)
Trust	−0.242	* (0.140)	* (0.146)	** (0.091)
Real GDP per capita	0.088	** (0.035)	** (0.039)	* (0.044)
Manufacturing	2.241	*** (0.297)	*** (0.376)	*** (0.490)
Trade	−0.569	*** (0.095)	*** (0.100)	*** (0.122)
Constant	−5.080	*** (0.363)	*** (0.384)	*** (0.438)
Standard errors	—	White	Bootstrap	Driscoll-Kraay

Table 4. Robustness tests for model (1)
(1) Provides the coefficients of column (2) in Table 3. Source: Own computations. Notes: the remaining columns show standard errors (in parentheses) as defined in the table. Panels are unbalanced. Transition economies are excluded. Driscoll-Kraay standard errors are estimated with default lags, T = 18. Asterisks indicate significance at the *90, **95 and ***99% confidence levels.

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We begin looking at the reported estimates in Table 3 by focusing on columns (1) and (2). Coefficients for most control variables behave as expected. As we control for manufacturing (a proxy for the composition effect), the coefficient for GDP per capita is considered to capture both a scale and a technique effect.[10] This coefficient is negative and significant with the full sample (1), but it becomes positive and significant when transition countries are excluded from the sample (2). The case of transition economies is exceptional. For instance, Millock *et al.* (2008) find a very large technique effect for CO_2 emissions in transition economies. Their explanation refers to the simultaneous heritage of devastated environmental resources and unsuccessful planned economies in ex-Soviet countries. In particular, they mention a series of environmental stresses especially related to ex-communist countries, many of them being linked to global pollutants such as greenhouse gases. Jobert *et al.* (2010) use the terminology 'ecologists despite themselves' for Eastern European countries that experienced the collapse of the Soviet Union. Overall, the positive coefficient for GDP per capita is in line with most studies focusing on global pollutants and in particular CO_2, which represents the bulk of greenhouse gas emissions (see Lin and Li, 2011, for a recent assessment).

In line with expectations, a greater share of manufacturing implies higher emissions. Taking the coefficient of column (2), an increase of 1% in the share of manufacturing leads to an average increase in emissions of 2.2%, everything else fixed (cf. Jobert *et al.*, 2010, for a similar finding and discussion).

Trade openness is associated with a negative effect. As we control for the share of manufacturing in the economy, we expect this effect to be related to the technique effect, i.e. the exposition of exporters to new markets with their own standards, the effect of foreign investment and technology transfers. However, it is also possible that it accounts for firms' relocation of 'dirty' activities that is not fully captured by the control variables.

As expected, the coefficient for trust is negative and statistically significant. An estimate of –0.24 implies that a change of 1% in trust (i.e. 1% of respondents switching from the answer 'You cannot be too careful in dealing with other people' to the option 'Most people can be trusted') leads to a decline in per-capita greenhouse gas emissions of 0.24%.[11] The magnitude of the effect related to trust seems considerable for a variable that was neglected until very recently and thus justifies its inclusion as a determinant of greenhouse gas emissions.

The coefficient for trust is, however, not robust to the inclusion of energy consumption. That is, in model (2), which adds energy consumption, the coefficient for trust becomes non-significant, as shown by column (3). This result is in line with our previous discussion, as we expect trust to decrease energy consumption both directly and indirectly. Regarding the coefficient for energy, its sign is in line with expectation, as well as the boost in the goodness of fit. The estimate of column (3) implies that for a 1% increase in energy consumption, emissions increase by 0.8%, which makes sense given that not all energy sources are related to all greenhouse gases in the same way. We also see that all control variables are stable to the inclusion of energy consumption, which is a positive sign of robustness. The exception is GDP per capita, which turns out to be negative. However, this comes as no surprise, as the scale effect is likely to be captured by the coefficient of energy consumption, which controls for the dirty component of economic growth.

The last step for testing mediation consists in estimating the impact of trust on energy consumption. Estimates for model (3) are shown by column (4). We find that trust does indeed affect energy consumption, and with a negative sign. The coefficient of –0.32 implies that a 1% increase in the level of trust would lead to a reduction in energy consumption of about 0.3%. Control variables behave very similarly to model (1). Indeed, a larger share of manufacturing is related to greater energy consumption, as well as GDP per capita. Abstracting from issues of endogeneity, which are not crucial while dealing with controls, column (4) would suggest that economic growth is responsible for higher energy consumption, thus supporting the positive coefficient on emissions. The coefficient for trade becomes instead non-significant. Interestingly, it may imply that trade does not affect emissions through the level of energy consumption but through its content (i.e. the energy-mix), which may support the technique effect.

Altogether, Table 3 provides evidence in favour of the role of energy consumption as mediator. The results also rule out the mediation of the energy-mix, or of non-energy emissions. However, we take them as evidence that the largest effect goes through the level of energy consumption and not through its content, rather than as a case of perfect mediation. We also perform some additional mediation regressions with a series of variables proxying

[10]In this sense we follow the standard approach in the literature, even though some conceptual doubts can be casted about the plausibility of a technique effect (cf. Roca, 2003; Dinda, 2004).
[11]This figure is robust to the addition of a time trend or time dummies. Results are available upon request.

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technology or the energy-mix, for example patents, dirty sources such as coal and oil, share of renewable energy, share of nuclear energy (cf. Roca *et al.*, 2001; Buehn and Farzanegan, 2013).[12] Yet, the coefficient for trust is not affected. Hence, we conclude that we fail to find evidence on the role of the energy-mix as mediator.

Because it is possible that trust has a delayed impact on emissions, we account for a non-simultaneous relationship by introducing lags between trust and emissions per capita. We expect that the influence of trust decreases with time and we are interested to know how long the 'memory' is influencing emissions. However, we find that including lags does not substantially improve our model (results not reported here). We estimate an optimal lag for each time series (i.e. for each country *i*) with a sufficient number of observations, borrowing from the tools of vector autoregression (VAR) analysis. Only in a minority of cases does the optimal lag exceed the fourth lag. However, autocorrelation is still present even at the fourth lag, according to a Lagrange-multiplier test. Hence, we prefer to rely on the contemporaneous model presented here.

As already discussed, the impact of trust on energy consumption and thus emissions may cumulate the impact on individual behaviour and environmental policy (paths A and B). Obviously, we would have preferred to disentangle the two effects, for example by isolating the role of environmental policy. However, environmental policy is very difficult to measure and proxies barely capture the panoply of possible local and national efforts. Yet, we consider some indicators for domestic and international policy (i.e. top-down initiatives) such as Eurostat's total environmental tax revenue and the policy components of the Climate Change Cooperation Index (C3-I) and of the Climate Change Performance Index.[13] Unfortunately, the overlap between our panel and the latter is too little to obtain any meaningful result. Instead, we are able to test for mediation with the remaining indicators. Although we find a negative effect of both environmental taxation and the C3-I on the level of energy consumption, the coefficient for trust is unaffected. In addition, the estimate for the C3-I does not reach statistical significance. This evidence does not favour the policy channel, but this may be due to the variables used, which are only rough proxies for the sum of local, regional and national efforts towards curbing energy consumption and reducing greenhouse gas emissions.

Hence, we look back to the WVS and examine the relationship between trust and collective action as expressed by the following two statements: 'Would give part of my income for the environment' and 'Increase in taxes if used to prevent environmental pollution'. In both cases the possible responses are 'Strongly agree', 'Agree', 'Disagree' and 'Strongly disagree'. In total 125 observations are available for the first question (out of 35, by interpolation). If we take the share of people answering 'Strongly agree' and 'Agree' to the first question, the correlation with 'Trust most people' is positive (0.23) and significant (at 1%). Regressing 'Give part of income' on GDP per capita, the time trend, fixed effects and trust leads to a positive coefficient for trust of 0.792, significant at 1%. This suggests that an increase of trust by 1% leads to an increase of about 0.8% of people accepting to forsake part of their income to help the environment. For the question on environmental taxation, we find a correlation of 0.29 with trust, significant at 1% (based on 192 observations out of 54). By regressing 'Increase in taxes if used to prevent environmental pollution' on income per capita, existing levels of environmental taxation, the time trend, fixed effects and trust, we find a coefficient for trust of 0.581, statistically significant at 1%. This coefficient implies that a change of 1% in trust leads to a 0.6% increase in people strongly agreeing or agreeing to increase taxes used for environmental purposes. Arguably, it implies being ready to give up part of their income. However, the correlation between 'Give part of income for the environment' and 'Increase in taxes' is of 'only' 0.7, leaving room for direct pro-environmental behaviour. Given the small set of observations and the previous discussion, we take these findings as descriptive evidence supporting the case for further analyses on the policy channel. That is, we leave for future studies the task to measure the contribution of each of the two channels, as well as the net impact on emissions (including the trust-to-growth effect). Indeed, we recall that because we control for GDP per capita in the

[12]All variables come from Eurostat. Patents stands for patents applications to the European Patent Office. Results are available upon request.
[13]Total environmental tax revenue is available, for example, as a percentage of GDP (cf. Costantini and Mazzanti, 2012). The C3-I is developed by Bernauer and Böhmelt (2013) and updates the Cooperation Index of Baettig *et al.* (2008). The C3-I's policy component evaluates the efforts of a country towards the success of international negotiations, by giving marks based on commitments to the United Nations Framework on Climate Change (UNFCCC), ratification of the Kyoto Protocol, emissions reporting and financial contributions to the UNFCCC structure. Instead, the policy component of the Climate Change Performance Index, released by Germanwatch, is based on local climate change experts' opinions. The C3-I dates back to 1997 and encompasses 172 countries, whereas the Climate Change Performance Index delivers reliable policy evaluation from 2006 (available in the index of 2007, cf. Burck and Bals, 2012).

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econometric framework, we do not provide a full picture on the role of trust as a determinant of emissions through not only individual behaviour and policy, but also economic growth. In addition, it may be appropriate to include trust in foreign people in the analysis of the policy channel.

Another avenue for future research would be to analyse how societies can address the issue of trust and foster the level of cooperation among individuals. Some recent studies convey converging evidence emphasizing the need to target the 'push factors' determining environmental behaviour through normative discourses (e.g. by exhibiting the neighbours' level of cooperation), attempting to stimulate agent's trust in a shared effort towards climate change mitigation (e.g. Cialdini, 2003; Schultz *et al.*, 2007; Steg and Vlek, 2009; Lindman *et al.*, 2013; Von Borgstede *et al.*, 2013). More generally, reducing inequalities, improving institutional quality and enhancing education (especially teaching cooperation) should contribute to building trust (Knack and Keefer, 1997; Zak and Knack, 2001). Given that these represent major tasks, from a policy and governance perspective it may thus be important to use the already existing trust networks (see Catney *et al.*, 2013) and overcome the social barriers hampering the emergence of new ones (Catney *et al.*, 2014). Both policy-makers and practitioners may look with interest at the recent evidence showing how, for instance, green technologies such as solar photovoltaic systems spread over neighbourhoods through social interaction, as shown by Bollinger and Gillingham (2012; see also Currarini *et al.*, 2014). Finally, improving the quality, quantity and understanding of data on trust (and on social norms more generally, pro-environmental behaviour, environmental collective action and environmental policy) would allow substantial advancement in this research area. Indeed, we recall the limits of our measure of trust and agree with Glaeser *et al.* (2000) that measurement and interpretation of trust represents an important lacuna of the research fields relying upon this variable. For instance, further experimental evidence in the same spirit as Glaeser *et al.* (2000) may help to elucidate the microeconomic mechanisms analysed here in their aggregated form. The availability and possibility to apply instrumental variables may also contribute to perfecting the structural model underlying the regressions and provide causation rather than correlation.

Conclusions

Recent contributions to the theory of collective action have shown that predicted non-cooperative attitudes in social dilemmas sometimes fail to be verified empirically. This evidence supports the new strand of research highlighting the importance of social norms and social contextualization for understanding collective action. However, until recently, social aspects of economic behaviour related to environmental goods were confined to local issues. Elinor Ostrom extended the concept, revealing the extent of grassroots projects tackling climate change from different perspectives. This phenomenon was in the public eye, but an important contribution was necessary to realize what has then become evident: struggling international negotiations are only one side of the coin of climate change mitigation. Ostrom (2009) explains the willingness of many citizens to provide collective efforts to curb emissions as the result of trust among them, broadening the trust-and-reciprocation mechanism of commons.

We apply her insights and test for an aggregated effect of trust on greenhouse gas emissions and offer evidence in favour of the Ostrom Hypothesis. Indeed, we find a negative effect of trust on emissions, based on a panel of 29 European countries over the period 1990–2007. The estimated negative elasticity would imply that a 1% increase in trust would reduce emissions by 0.24%, by leading to a decline in energy consumption of about 0.32%.

The correlation between trust and growth (Knack and Keefer, 1997; Zak and Knack, 2001) and the nexus we find from trust to emissions may explain why some economists have attempted to link income growth with emissions in a non-linear way. In our opinion, trust and social values may contribute to resolve Esty and Porter's (2005) quest for an explanation beyond the Environmental Kuznets Curve regarding cross-country differences in environmental pressures. Hence, not accounting for trust would lead to an omitted variable bias attributing to other variables, such as income per capita, the effect of trust and social values.

In conclusion, we agree with Elinor Ostrom and co-authors with the need of a paradigm shift in the way environmental issues are analysed from an economic perspective and in the choice of the relevant factors to be considered.

Several caveats limit the interpretation of our results beyond their context and create the basis for further research. First, we use an imperfect measure of trust, which is collected only occasionally. Second, we provide an aggregated result, but we are not able to disentangle the ways that lead trust to be effective in reducing emissions.

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Third, we do not assess the net effect of trust, which should also encompass the growth-driven impact on emissions. Fourth, how policy-makers can act on and upon trust and social values remains largely unexplained, although some of the contributions mentioned herein have started to target the issue.

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