Synergies of interventions to tackle climate change - A meta-analysis

PRISMA-P Protocol

SECTION 1: Administrative Information

Title

Item 1a. Synergies of interventions to tackle climate change. A meta-analysis

Item 1b. N/A

Registration

Item 2. The protocol has been registered on the OSF https://osf.io/6c7r2/ on January 27 2022.

Authors

Item 3a.

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Item 3b. Marius Alt developed the protocol, supervised by Nives Della Valle (Joint Research Center, European Commission). Nives Della Valle contributed to the theoretical and motivation parts, Ingrida Murauskaite-Bull for the consults on the conduction on the meta-analysis and contributes to the study-selection process part, and Hendrik Bruns (Joint Research Center, European Commission) consults on the conduction on the meta-analysis.

Amendments

Item 4. If amendments are necessary, an updated protocol will be published on the OSF, including the date of each amendment, a description of the change, and the rationale.

Support

Item 5a. JRC – European Commission, Exploratory Research Programme.

Item 5b. No funder and/or sponsor.

Item 5c. No funder and/or sponsor.

SECTION 2: Introduction

Rationale

Item 6.

1. General Introduction

   There exist a wide variety of policies and programmes which can be implemented to tackle the challenge of climate change. However, to effectively reduce greenhouse gas emissions, a single intervention might not be sufficient to address and render environmental behaviour. Therefore, more research is needed to understand how different policies can be combined and how they consequently affect behaviour. This requires an understanding of the behavioural foundations upon which a certain combination of interventions yields the desired effects. To account for the net-effect of these combined policies, however, it is not sufficient to analyse the effects on target behaviour but must also take into account potential spillovers which can have important implications for the design of a policy mixes. This meta-analysis will build on existing conceptual frameworks to investigate pro-environmental behaviours and their interaction with policy interventions. Therefore, we will collect experimental evidence from the literature from a range of different studies dealing with the effects of synergies of interventions directed towards pro-environmental behaviour. The findings will shed light on the effectiveness of combining traditional and behaviourally informed interventions to assess their synergic effects on the targeted and untargeted behaviour. This will provide the necessary knowledge to inform the design of policies in different domains, such as those aimed at promoting pro-environmental energy behaviours.

2. Relevance and Motivation

   Policy makers are equipped with multiple instruments to target pro-environmental behaviour. However, it is not yet clear, whether combinations of different incentives lead to enhanced effectiveness. It might also be the case that interactions of policies entails substantial unintended consequences. Providing more evidence on this becomes especially crucial in a context in which the policy toolbox becomes richer. It is thus key to identify the behavioural mechanisms that are likely to make a certain policy mix effective over time, and within and across domains.

   To tackle policy problems, policy-making has traditionally relied on mandates or bans (changing the availability of options), financial incentives (subsidies and taxes) and non-regulatory interventions (such as mandatory disclosure of information, for example through product labels), as the behaviour of policy targets was assumed to be sensitive only to changes in incentives and information provision (Hertwig 2017). However, insights from behavioural sciences suggest the behaviour of the policy targets is sensitive to more than the mere provision of additional information and incentives (Loewenstein and Chater, 2017). As an example, experimental studies have shown that individuals engage in certain

behaviours because of a combination of extrinsic and intrinsic motivations (Bowles and Polania-Reyes, 2012). Some individuals might require extrinsic motivations - like those provided by monetary incentives - to engage in certain behaviours. Others might be willing to do so even in the absence of financial incentives (Deci et al., 1999), because they display impure ("warm glow"[1], (Andreoni, 1989) or pure altruism ("pro-social orientation"[2] (Bénabou and Tirole, 2006)).

Disregarding these heterogeneous motives that drive behaviours and how these interact with policy interventions might result in unintended effects. As an example, financial incentives might backfire by *crowding-out* intrinsic motivations, leading individuals to engage less in the target behaviour (Frey and Oberholzer-Gee, 1997; Mellström and Johannesson 2008; Gneezy and Rustichini 2000; Gneezy et al., 2011).
In addition to providing "a more evidence-based understanding of human behaviour to inform the policy-making process" (Troussard and van Bavel, 2018), behavioural sciences have enriched the policy toolbox. For example, given their relative cost-effectiveness (Benartzi et al., 2017), governments are increasingly adopting the so-called *nudges* (Thaler and Sunstein, 2008) in several policy areas, such as energy consumption (Sousa et al., 2016). By altering the decision structure (Münscher, Vetter, and Scheuerle, 2016), nudges can induce a change in target and untargeted behaviours; however experimental evidence on whether they lead to the envisaged direction is mixed (D'Adda et al., 2017; Ghesla et al., 2019).

Another example of behaviourally targeted intervention is that of *boosts* (Hertwig, 2017). By targeting the individual's core competences (Grüne-Yanoff and Hertwig, 2016), boosts enable specific behaviours through the exercise of agency. Therefore, by increasing perceived self-efficacy, they are especially crucial for vulnerable categories (DellaValle and Sareen, 2020). However, their efficacy has been tested only in a few domains (Hertwig and Grüne-Yanoff, 2017).

Apart from the direct effect of interventions on targeted behaviour, many behaviour change interventions include the notion of 'spillover': encouraging people to take up one pro-environmental behaviour may lead them to take up further pro-environmental behaviours. However, with the simultaneous promotion of behaviour changes, sometimes we might observe unintended consequences. One example of such backfiring is that constant remainders about the individual energy savings can lead people to prioritise the importance of individual behaviour over government action and reduce the degree to which they thought energy issues should be a national priority. Thus, it can undermine public support for national-level policies (Raimi, 2017).

Behavioural spillover offers a potential way of encouraging wider, voluntary lifestyle shifts beyond the scope of single behaviour change interventions. This issue is even more compelling given that policy interventions might yield consequences beyond the behaviour that is directly targeted. Extensive experimental evidence has indeed shown that engaging in a certain behaviour affects the probability to engage in subsequent behaviours over time (temporal spillovers, D'Adda et al., 2017), in the targeted domain (behavioural spillovers, Dolan and Galizzi, 2015) and in other domains (contextual spillovers, Sorrell et al., 2020). The latter two are known also as direct and indirect rebound effects (Sorrell et al., 2008). Thus, it is important to include spillover effects in the assessment of the effectiveness of combined interventions to obtain their respective net-effects.

The current global challenges call for more than an isolated policy intervention. Therefore, it is crucial to understand which combination of interventions is effective both at promoting defined target behaviours, and at creating the basis for persistent positive spillovers within and across contexts. By providing a structured meta-analysis on the synergies of different interventions and assessing why and how they are effective at promoting desired behaviour changes, this study will provide the necessary evidence to inform policy makers on how to tackle urgent issues by promoting behaviour changes with a combination of interventions.

3. Objectives

Item 7. With the meta-analysis at hand, we follow the objective to assess whether there exists and which is the effect of combining different interventions, e.g., monetary incentives, sanctions, nudges and boosts, on targeted pro-environmental behaviour as well as on untargeted pro-environmental behaviour. Thereby, we aim at investigating synergies of different interventions. In the analysis, we intend to assess studies that comprise a control treatment, two different interventions and a combination of these two treatments. With respect to effects of a combination of different policy tools, there exist a range of different possible outcomes. Following Drews et al. (2020), we refer to a "backfiring" effect if the combined intervention is less effective than one of the single interventions. The term "weak negative synergy" is applied to describe that the combination of two interventions is at least as effective as one single intervention, but not as effective as the sum of the two single intervention effects. Given the combined intervention is exactly as effective as the sum of the two single interventions, we describe this as "no synergy". Lastly, if the combined effect is larger than the sum of the two individual effects, we define the two interventions to have "positive synergies" if applied jointly.

Research Question 1: Is there an effect from combining interventions on pro-environmental behaviour are most effective in inducing behavioural change towards the intended direction?

In general, there is evidence that traditional economic policies like monetary incentives or sanctions are more effective than behavioural economic interventions in rendering behaviour (Delmas et al. 2013; Maki et al. 2016; Buckley 2020). However, based on the concept of motivational crowding, we assume that intrinsic motivation is reduced by the implementation of compelling policy interventions like monetary incentives or sanctions (Frey and Jegen 2001; Gneezy and Rustichini 2000; Bénabou and Tirole, 2006). This implies that in the absence of this crowding effect, these measures could gain in effectiveness. Instead of directly changing the incentives of a pro-environmental behaviour, nudges and boosts, e.g., do not alter the individual choice set. These measures exploit behavioural shortcomings like status quo bias or cognitive overload or use the power of social norms to affect decision making (Schubert 2017; Carlsson et al. 2021). Thus, we assume that combining different traditional policies among each other or using different behavioural interventions in combination is likely to not lead to strong improvements in the policies effectiveness compared to single interventions. This is because these measures behave as substitutes to one another due to their similarity in functions. Instead, by the not affective the incentive structure, behavioural interventions', they might be capable of serving as complements to traditional economic tools in a policy mix, and thereby enhance the

traditional tools' effectiveness by preventing motivational crowding (Schwartz et al. 2019; Grad et al. 2021). This is summarized in the following hypothesis:

Hypothesis 1: The combination of traditional measures with behavioural policy interventions lead to stronger synergy effects than combinations of interventions from only one of the two domains.

Based on evidence that observability of a prosocial or pro-environmental behavior leads to stronger motivational crowding in case traditional economic interventions are implemented (Sexton and Sexton 2011), we argue that adding behavioural economic interventions to the policy could lead to positive effects. Given that interventions like nudges or boosts have the potential to preserve intrinsic motivation (Grad et al. 2021), it might be the case that this preservation effect works best in case traditional economic interventions lead to strong crowding out of intrinsic motivation. This leads to our second hypothesis:

Hypothesis 2: An increase in the observability of the pro-environmental behavior increases the effectiveness of combining traditional with behavioural economic interventions.

According to the theoretical framework of Benabou and Tirole (2011), a moral behaviour can involve honour and stigma effects depending on its prevalence in society. The former effect is common if a pro-environmental behaviour is rather uncommon, as performing this behaviour provides the opportunity for self-esteem enhancements. Stigma prevails if a pro-environmental behaviour is performed by the vast majority of the population. Thus, diverting from this behaviour is associated with the cost of societal shaming. In both cases, traditional economic interventions are assumed to be less effective. They remove the possibility to appear heroic by performing an uncommon pro-environmental task in the one case. In the other case, the prevalent behaviour is already sufficiently strong to induce compliance within the population. An additional incentive will therefore be not effective. Relating to this, we assume that nudges, e.g., particularly norm-based interventions, have the potential to lead to positive synergy effects if the pro-environmental behaviour is rather uncommon. The nudge shifts the perception of the social norm towards perceiving this task as more common. Thereby, the nudge intervention enhances the effectiveness of the incentive, as it reduces the adverse honour-effects assumed in single traditional economic incentives. Also, if the pro-environmental behaviour is very common, nudges might be capable of complementing financial incentives by either emphasizing the compelling presence of the social norm, or by reaching non-compliers who have not yet adopted the pro-environmental behaviour due to behavioural biases like status quo bias.

Hypothesis 3: The effectiveness of a combination of traditional and behavioural economic measures depends on the public prevalence of the pro-environmental behaviour.

Apart from the direct effect of policies on the targeted behaviour, there has been vast evidence of behavioural spillovers, namely that interventions directed to a certain behaviour can also influence behaviour which takes place in a different context or at a different point in time. Therefore, we extend our analysis of synergies of various interventions to tackle climate change by also analysing how these intervention mixes affect a behaviour which has not been targeted by them. This contributes to a comprehensive assessment of the effects of interacting policy interventions in terms on environmental well-being and allows to isolate the net-effect of these interacting policies. Thus, where provided, we integrate

spillover effects of combined interventions into the analysis of synergies and analyse to which degree the assessment of synergetic effects differ if acknowledging for those spillovers.

Research Question 2: Which combination of interventions on pro-environmental behaviour are most effective in inducing positive spillovers?

In the formation of assumptions on the effects of different policy tools on behavioural spillovers, we rely on former evidence, suggesting a relation between different characteristics of interventions and spillovers. According to Geiger et al (2021), policies that tend to exert high levels of control on individuals are prone to induce negative spillover effects, whereas autonomy-supportive measures are likely to affect spillovers positively. Thus, since traditional policies rather use direct control via monetary incentives or sanctions, behavioural economic interventions tend more towards fostering autonomous decisions. The latter is particularly the case for boost interventions. Based on this, we might expect negative spillovers from traditional policies, whereas behavioural economic interventions might induce positive spillovers. Therefore, a combination of these two are likely to lead to an avoidance of the negative spillover effect obtained from applying traditional economic policies in single-interventions. This results in our fourth hypothesis

Hypothesis 4: Combining traditional economic policies with behavioural economic interventions mitigate the negative spillover effects induced by the traditional economic measures.

SECTION 3: Methods

Eligibility Criteria

Item 8. Table 2 provides an overview of the requirements for articles to be included in the meta-analysis. The criteria were developed based on the PICOS framework and comprise requirements regarding the population, the interventions, the comparator, the outcomes, the study design, the language and the publication status. Regarding the population, it is required that the experimental analysis investigates behaviour of a human sample. As comparators, the articles must provide a study design that includes a control treatment, two single intervention treatments and a joint application of these two interventions. Furthermore, the articles must provide effects of the two interventions, which are commonly applied and must provide evidence on how these interventions affect a certain environmental behaviour. Articles that are eligible for the meta-analysis follow an experimental approach in the form of an RCT or an experimental study, whereas all kind of experimental approaches are included (Harrison and List 2007). Additionally, the articles must be composed in either the English, German, French, or Spanish language. The publication type is restricted to published and unpublished empirical articles, dissertations, or master theses. Also, if the full text is not available and authors will not have responded to the paper request after six weeks, the respective article is not included in the meta-analysis. Lastly, it is required that the articles provide sufficient statistical reporting in order to extract the necessary information to calculate effect sizes.

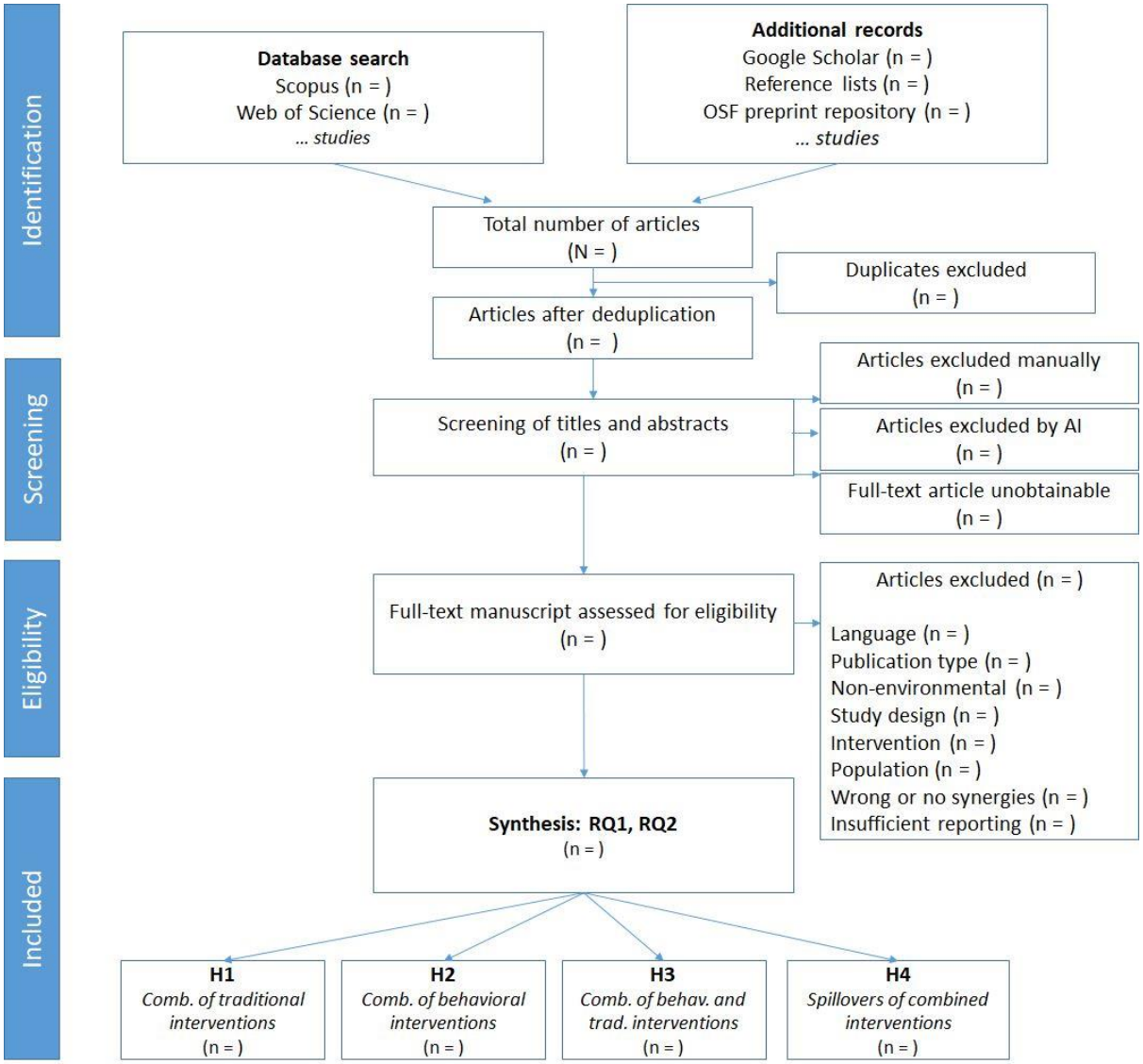
Table 2 – PICOS Elements and Citeria

PICOS Element	Inclusion Criterion	Exclusion Criterion
Population	Human sample	Other population (..)
Interventions	Minimum of two interventions from different clusters of interventions. Three clusters established (material incentives, consequential sanctions, behavioural economic interventions)	Other intervention (..), Less than two interventions (..)
Comparator	Control (i.e. absence of intervention), comparison condition 1 (i.e. at least two single intervention), comparison condition 2 (i.e. joint appliance of the two single interventions)	Other study design (..)
Outcomes	Synergetic effect of two different interventions on environmental outcome	No combination of interventions (..), Non-environmental outcome (..)
Study design	Experiment, RCT	Other study design

Language	English, German, French, Spanish	Other language
Publication Type/Status	Published and unpublished empirical articles, dissertations, and master theses	Other publication type (..)
Full Text	Available online or 6 weeks after request to authors	Full text unobtainable (..)
Sufficient Reporting	Statistical information available or six weeks after request to authors	Insufficinent reporting (..)

Information Sources

- Item 9. Our search strategies comprises of online database searches as well as of additional records. The respective online databases include Scopus, and Social Science Citation Index (Web of Science). As additional records, we will apply searches on Google Scholar, use reference lists of previous literature reviews and meta-analyses and browse the OSD preprint repository. These searches will be carried out after the submission of the pre-registration.



Search Strategy

Item 10. To find relevant studies, we queried the online libraries of 'Web of Science' and 'Scopus' during November 2021. As additional search strategies, we used 'Google Scholar', previous literature reviews and meta-analyses on related topics and scoping of the OSD repository. The queries were restricted to tile, abstract, and keywords, whereas the date of publication was not limited. The pilot-search terms used for the online libraries are reported in Table 3 and 4. The additional search strategies are outlined in Table 5.

In the course of the project, the search might be repeated and updated to provide the most recent findings from the literature.

Table 3 - Search Terms for libraries, Web of Science

PICOS Elements	**Search Terms**

Population		
Interventions	1	TS=(((“price*based*” OR “incent*” OR “mone*induce*” OR "reward*") AND (“price*based*” OR "sanction*" OR "penal*" OR "tax" OR "taxes" OR "charg*" OR "surcharg*" OR "punish*")) OR ((“price*based*” OR “incent*” OR “mone*induce*” OR "reward*") AND ("nudg*"OR "choice architect*" OR "label*" OR "priming*" OR “prime*” OR "prompt*" OR "remind*" OR "feedback" OR "feed-back" OR "default*" OR "commit*" OR “boost*” OR “norm*” OR “intrins*incent*” OR “tailored*information*” OR “information*intervene*” OR “tailored*recommendation*” OR “recommendation*interv*” OR “prais*” OR “non-monetary*”)) OR ((“price*based*” OR "sanction*" OR "penal*" OR "tax" OR "taxes" OR "charg*" OR "surcharg*" OR "punish*") AND ("nudg*"OR "choice architect*" OR "label*" OR "priming*" OR “prime*” OR "prompt*" OR "remind*" OR "feedback" OR "feed-back" OR "default*" OR "commit*" OR “boost*” OR “norm*” OR “intrins*incent*” OR “tailored*information*” OR “information*intervene*” OR “tailored*recommendation*” OR “recommendation*interv*” OR “prais*” OR “non-monetary*”)))
Study design	2	AND TS=(“experiment*” OR "RCT" OR “controlled*trial”)
Comparator		
Outcome	3	AND TS=(“joint*” OR “interaction*” OR “mutual*” OR “combin*” OR “synerg*” OR “mix*” OR “common*” OR “together*” OR “unit*” OR “both” OR “adhere*” OR “bundle*” OR “addi*”)
	4	AND TS=("pro-environment*" OR "proenvironment*" OR "sustainab*" OR "unsustainab*" OR "nonsustainab*" OR "non-sustainab*" OR "eco*" OR "environment*" OR "climate" OR "energy" OR "electric*" OR "renewable*" OR "water" OR "recycl*" OR "car" OR "cars" OR "bus" OR "car-shar*" OR "carshar*" OR "car-pool*" OR "carpool*" OR "public transport*" OR "bicycle*" OR "cycle" OR "cycling" OR "temperature" OR "conserv*" OR "preserve" OR "preserving" OR "pre-serve" OR "pre-serving" OR "donat*" OR "volunteer*" OR "litter*" OR "organic food" OR "vegan" OR "vegetarian" OR "meat" OR ("green*" NEAR/2 ("product*" OR "consum*" OR "purchas*" OR "buy*" OR "power" OR "behavio*" OR "attitud*" OR "intention*")) OR "insulat*" OR "solar" OR "wind power" OR "buying used" OR "second hand" OR "secondhand" OR "buying pre-owned" OR "reus*" OR "re-us*" OR "emission*" OR "carbon*" OR "single-use" OR "disposable*" OR "compost*" OR "travel*" OR "airplane*" OR "plane*" OR "turn-off" OR "turnoff" OR "switch-off" OR “pollut*” OR “CO2”)

Table 4 - Search Terms for libraries, Scopus

PICOS Elements	Search Terms	
Population		
Interventions	1	TITLE-ABS-KEY (((“price*based*” OR “incent*” OR “mone*induce*” OR "reward*") AND (“price*instrum*” OR "sanction*" OR "penal*" OR "tax" OR "taxes" OR "charg*" OR "surcharg*" OR "punish*")) OR ((“price*based*” OR “incent*” OR “mone*induce*” OR "reward*") AND ("nudg*"OR "choice architect*" OR "label*" OR "priming*" OR “prime*” OR "prompt*" OR "remind*" OR "feedback" OR "feed-back" OR "default*" OR "commit*" OR “boost*” OR “norm*” OR “intrins*incent*” OR “tailored*information*” OR “information*intervene*” OR “tailored*recommendation*” OR “recommendation*interv*” OR “prais*” OR “non-monetary*”)) OR ((“price*instrum*” OR "sanction*" OR "penal*" OR "tax" OR "taxes" OR "charg*" OR "surcharg*" OR "punish*") AND ("nudg*"OR "choice architect*" OR "label*" OR "priming*" OR “prime*” OR "prompt*" OR "remind*" OR "feedback" OR "feed-back" OR "default*" OR "commit*" OR “boost*” OR “norm*” OR “intrins*incent*” OR “tailored*information*” OR “information*intervene*” OR “tailored*recommendation*” OR “recommendation*interv*” OR “prais*” OR “non-monetary*”)))
Study design	2	AND TITLE-ABS-KEY (“experiment*” OR "RCT" OR “controlled*trial”)
Comparator		
Outcome	3	AND TITLE-ABS-KEY (“joint*” OR “interaction*” OR “mutual*” OR “combin*” OR “synerg*” OR “mix*” OR “common*” OR “together*” OR “unit*” OR “both” OR “adhere*” OR “bundle*” OR “addi*”)
	4	AND TITLE-ABS-KEY ("pro-environment*" OR "proenvironment*" OR "sustainab*" OR "unsustainab*" OR "nonsustainab*" OR "non-sustainab*" OR "eco*" OR "environment*" OR "climate" OR "energy" OR "electric*" OR "renewable*" OR "water" OR "recycl*" OR "car" OR "cars" OR "bus" OR "car-shar*" OR "carshar*" OR "car-pool*" OR "carpool*" OR "public transport*" OR "bicycle*" OR "cycle" OR "cycling" OR "temperature" OR "conserv*" OR "preserve" OR "preserving" OR "pre-serve" OR "pre-serving" OR "donat*" OR "volunteer*" OR "litter*" OR "organic food" OR "vegan" OR "vegetarian" OR "meat" OR ("green*" NEAR/2 ("product*" OR "consum*" OR "purchas*" OR "buy*" OR "power" OR "behavio*" OR "attitud*" OR "intention*")) OR "insulat*" OR "solar" OR "wind power" OR "buying used" OR "second hand" OR "secondhand" OR "buying pre-owned" OR "reus*" OR "re-us*" OR "emission*" OR "carbon*" OR "single-use" OR "disposable*" OR "compost*" OR "travel*" OR "airplane*" OR "plane*" OR "turn-off" OR "turnoff" OR "switch-off" OR “pollut*” OR “CO2”)

Additional Searches

Table 5 – Additional Searches

Plattform	Description
Google Scholar	Full-text search limited to the first 300 results ((incentive AND nudge) OR (punishment and nudge) OR (punishment AND

	incentive) OR (incentive AND boost) OR (nudge AND boost)) AND (pro-environmental OR sustainable OR green OR climate OR energy) AND experiment
Reference lists	Relevant literature reviews and meta-analysis (e.g., Geiger et al. 2021; Buckley 2020;)
OSD preprint repository (https//osf.io/preprints	Scoping
Open List Calls	/

Study Records

Item 11a. At first the search records will be deduplicated by using endnote. A check through R-Studio will assure the successful removal of duplicates from the records. The initial screening is conducted with the assistance of ASReview to conduct an initial screening given titles and abstracts to assess whether the study qualifies for a detailed eligibility assessment. For the purpose of structuring the eligibility assessment, all the selected items in this phase are listed in a spreadsheet.

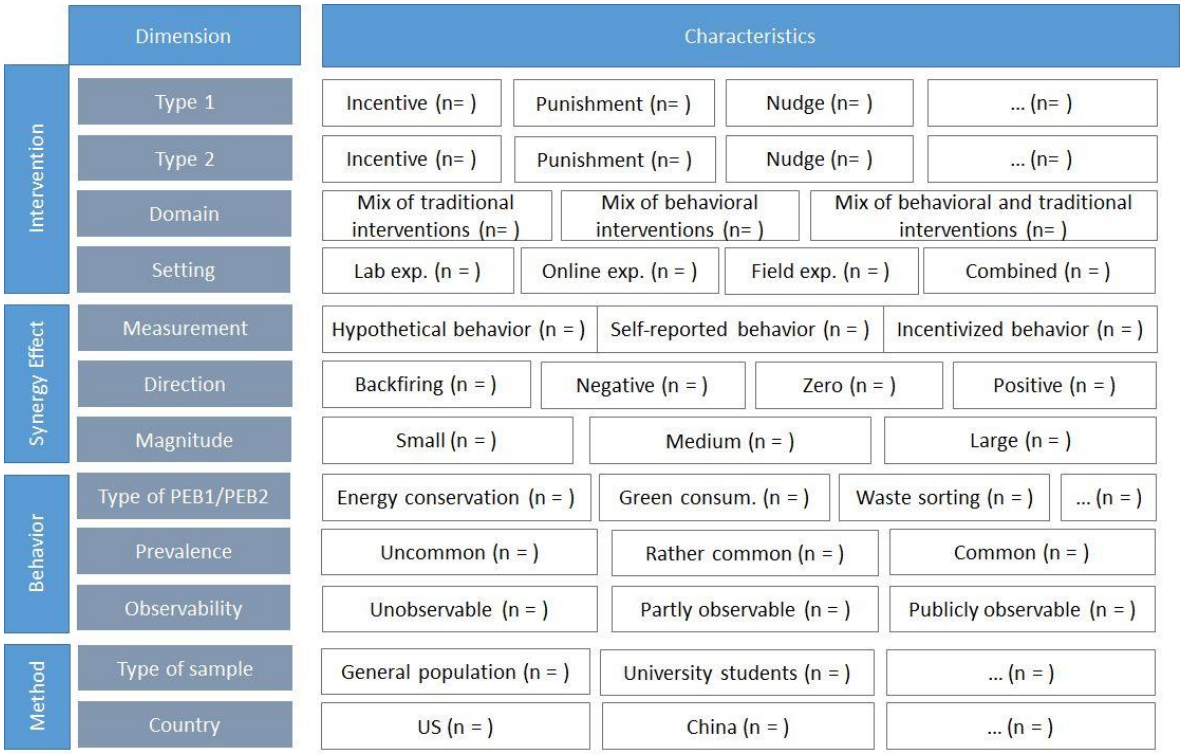
Item 11b. Although it has been recommended to assign two different raters to the two stages (Cuijpers, 2016), we use one rater for the both stages and a second one to make a quality assessment of the choices in the eligibility stage. It is assured that both raters have a clear understanding of the selection criteria and the topic of the meta-analysis. In the eligibility state, the first rater assigns labels given by “include” (fulfils the criteria of the meta-analysis and thereby, represents a relevant study to be part of the literature review), “exclude” (does not fulfil the criteria to be included and will therefore not be part of the meta-analysis), or “maybe” (It is not clear whether the criteria are fulfilled or whether the study is relevant in the context of the literature review) to the studies. Once this selection has been made, the second rater assesses the selection which had been rated as “maybe” to take a final decision.

Item 11c. For the data extraction, due to limited resources, only one rater will extract the necessary data and information from the studies. The rater is prepared for this with the respective guidelines displayed in Table 7. As a quality check, a second rater will make a final quality assessment of the data extracting by randomly assessing the adequate data extraction from studies.

Item 12. Qualitative Synthesis. For the synthesis, the main information are provided in Figure 2. The first dimensions deal with the nature of the interventions applied in the study. Since the studies contain at least two interventions, we distinguish between the intervention “Type 1” and “Type 2”. Here, we allow for each intervention from the traditional or behavioural economic toolbox, excluding command and control policies. In the dimension “Domain”, we distinguish whether the two interventions origin from the same family of interventions (either traditional or behavioural) or whether they come from different intervention families. This facilitates to obtain a notion on how similar the interventions are to each other and whether an appliance of two very different interventions is more effective than applying two rather similar ones. Concerning the setting, we distinguish on the type of the experimental study, differentiating between a laboratory experiment, an online experiment, a field experiment, or a combination of those. In terms of synergy effects, we assess the measurement of pro-environmental behaviour and how it has been elicited (hypothetical behaviour, self-reported behaviour. Incentivized behaviour). Additionally, we retrieve the direction of the synergy effect and its magnitude. On the particular behaviour which is investigated in the

experiment, we collect the type of the pro-environmental behaviour (e.g., recycling, car driving, energy conservation etc.), its observability in the experiment and the prevalence of the behaviour within society. Regarding the method, basic sample characteristics will be collected. These involve whether the sample contains the general population, university students, or another particular subgroup. In addition, information about the country of conduction of the study will be retrieved.

Figure 2: Morphological box of Included Articles



Quantities Synthesis. The coding of study characteristics captures general information in the form of authors, year, title, journal, county, publication status and whether the study was peer-reviewed. In addition, we retrieve and code information on the sample (mean age, gender distribution, the population represented by the sample, the total sample size and the number of treatments). Regarding the interventional characteristics, we aim at eliciting whether the single interventions are effective on the targeted and untargeted behaviour (through spillovers), and whether the combined interventions are effective on targeted and untargeted behaviour. Furthermore, we classify the two single interventions in according to their type (nude, monetary incentive etc.) and code whether the combination of interventions takes place across policy tool domains (e.g., whether a traditional economic intervention is paired with a behavioural economic intervention). In addition, we code to which degree the pro-environmental behaviour in the experiment is visible to others and record how common the pro-environmental task is. The type of experiment is also coded to differentiate between laboratory, online, and field experiment. Regarding the comparators, we assess whether all

treatments required to elicit synergy effects are present. Lastly, the outcome is coded by capturing how the PEB has been measured, by coding the direction of the synergy effect and the spillover of the synergy effect, and the study design denotes if the study actually carried out an experiment.

Table 7 – Coding of study characteristics

Overview	Study Characteristics	Description	Coding
General Information	Author Year Title Journal		
Extrinsic Characteristics	Country		
	Population status		0 = unpublished, 1 = published
	Peer-reviewed		0 =not published in peer-reviewed journal, 1 = published in peer-reviewed journal
Sample characteristics	Mean age		
	Gender distribution (in %)		
	Population counterparts of sample		0 = general population, 1 = university student, 2 = other, 3 = unspecified
	Total sample size N		
	Sample size n per treatment		
Intervention characteristics	Effectiveness in single-intervention (on PEB)		0 = ineffective in single intervention, 1 = only one effective in single intervention, 2 = both effective in single interventions
	Effectiveness in combined application (on PEB)		0 = ineffective in combined intervention, 1 = effective in combined interventions
	Spillover effect in single intervention		0 = no spillover effect in single intervention, 1 = only one spillover effect in single intervention, 2 = both single interventions lead to spillover effects

	Spillover effect in combined application		0 = no spillover effect in combined intervention, 1 = spillover effect in combined interventions
	Type1		0 = nudge, 1 = monetary incentive, 2 = punishment, 3 = other
	Type2		0 = nudge, 1 = monetary incentive, 2 = punishment, 3 = other
	Intervention domains	Domain refers to whether the intervention belongs to the traditional economic toolbox of interventions or whether the intervention can be attributed to the behavioural economic toolbox of interventions	0 = across domain interventions, 1 = within traditional economic intervention domain, 2 = within behavioural economic intervention domain
	Type of experiment		0 = laboratory experiment, 1 = online experiment, 2 = field experiment, 3 = combination, 4 = N/A
Comparators	Comparator condition	Control condition does not impose any intervention; comparison1 refers to the first treatment in which a single intervention is applied; comparison2 refers to the second treatment in which a single intervention is applied; synergy comparator represents the treatment in which both interventions are commonly applied.	0 = control, 1 = comparison1, 2 = comparison2, 3 = synergy comparison
Outcome	Measurement of		0 = hypothetical

	outcome		statement, 1 = self-reported behaviour, 2 = revealed behaviour, 3 = N/A
	Direction of synergy effect	Backfiring implies that the synergy effect is smaller than a single intervention effect; negative states that the synergy effect is lager than the single effect but not as large as the sum of the two single effects; no synergy effect means that the effect is equal to the sum of the single intervention effects; positive implies that the synergy effect is lager than the sum of the two individual effects.	0 = backfiring, 1 = negative, 2 = no synergy effect, 3 = positive
	Direction of synergic spillover effect	Amplifying means that the spillover effect is more negative than the most negative single intervention spillover; mixed implies that the synergy spillover effect is between the spillover effects of the two interventions; mitigating states that the synergy spillover effect is more positive than the most positive single intervention spillover.	0 = amplifying, 1 = mixed, 2 = mitigating,
	Visibility of outcome	If the behaviour is visible to others, like other participants or the general public.	0 = not visible, 1 = visible for other participants, 2 = publicly visible
	Prevalence of behaviour	Whether the pro-environmental behaviour is performed by the majority of the population or whether it's prevalence is	0 = uncommon, 1 = rather common, 2 = common

		rather rare.	
Study design	Study design		0 = no experiment, 1 = experiment, 2 = N/A

Computation and Transformation of Effect Sizes. We extract the means and standard deviations (SD) from the pro-environmental behaviours across treatments, e.g., *control*, *intervention1*, *intervention2*, *intervention1 x intervention2*. Regarding the treatment differences, we identify the effect size, the respective test statistic and the p-values to be able to calculate the Cohen's d based on these information (Galizzi & Whitmarsh, 2019). Since we also aim to investigate the differences in spillover effects between the different treatments, we intend to elicit the effects not only for the targeted behaviour (PEB1), but also for the untargeted behaviour (PEB2). To obtain the Cohen's d for the synergy effects, we rely on the esc R package (Version 0.5.1; Lüdecke, 2019). In case, information is only available graphically, If any information is only graphically available, we will use the R package metaDigitise (Pick et al, 2020) for data extraction.

Outcomes and Prioritization

Item 13. The definition of outcomes are provided in Table 7 of item 12. In case prioritization is necessary, we will use the strategy as follows: (1) If synergy effects of more than two interventions are analysed, we will not include these effects into the meta analysis. (2) If several control treatments are applied, we will only use the main control treatment which best compares to the synergy effect. (3) If spillovers of synergy effects contain several observation points are available, we will use the first observational point.

Risk of Bias in Individual Studies

Item 14. Depending on the time and resources available, we will perform a sensitivity analysis by clustering the papers by quality. For the quality assessment, we will use the NIS Study Quality assessment tools (NIH, 2014a, 2014b). The studies will be evaluated based on selected parts of the "Quality Assessment of Case-Control Studies" and the "Quality Assessment of Controlled Interventions Studies", which comprise assess information on the research question, the study population, the sample size justification, the differentiation of cases from controls, concealed treatment assignment, and random treatment assignment. The quality controls are summarized in Table 8.

Criteria	**Yes**	**No**	**Other (CD, NR, NA)**
Was the research question or objective in this paper clearly stated and appropriate?			
Was the study population clearly specified and defined?			
Did the authors include a sample size justification?			
Were the cases clearly defined and differentiated			

from controls?			
Was the treatment allocation concealed (so that assignments could not be predicted)?			
Was the method of randomization adequate (i.e., use of randomly generated assignment)?			

Data Synthesis

Item 15a. Since we intend to extract sufficient data for to provide an estimate of the synergy effects of different policy interventions, the direct effect of policy mixes will be applied quantitatively. For the spillover effect of synergy effects, it is not a priori clear whether sufficient data can be selected. Therefore, this synthesis will be either qualitative or quantitative depending on data availability.

Item 15b. We will quantitatively analyse the obtained data from the different studies to by calculating the average effect size across all studies and the respective average standard deviation across different interventions mixes. The focus will be on within traditional economic intervention mixes, within behavioural economic intervention mixes, between traditional and behavioural economic intervention mixes. This analysis of will be conducted for the direct effect of policy mixes as well as for the spillover effect of policy mixes. Apart from that, overview tables will be generated displaying the effects of the policy mixes from the different papers grouped by the corresponding domain (within traditional economic intervention mixes, within behavioural economic intervention mixes, between traditional and behavioural economic intervention mixes). If time and resources allow, also a Bayesian meta-analysis approach will be applied to obtain an idea on the probabilities to find effects with certain policy mixes (Geiger et al. 2021).

Sensitivity and Additional Analyses. To assess the robustness of the findings, we use the clustering from item 14, which categorized studies into good, fair, and low quality studies. By only using good or good and fair studies, we analyse to which degree the obtained results are driven by poor quality studies.

Item 15d. Information on the qualitative synthesis are provided in item 12.

Meta-Bias(es)

Item 16. Since publication bias is possibly driving the results of the meta-study, we correct for this by using the contour-enhanced funnel plots (Peters et al. 2008; Geiger et al. 2008). Given evidence of publication biases is detected, we will apply the trim-and-fill method to correct for this (Duval & Tweedie, 2000) will correct for publication bias (Aguinis et al., 2011; Duval & Tweedie, 2000).

Item 17. None.

SECTION 4: Additional Information

Updates of the protocol

This protocol will be updated along the process of the literature review to ensure that changes in the plan of carrying out the meta-analysis are recorded and justified.

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