Progress and Implications of Experimental Research in the Field of International Environmental Policy

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Abstract. Given the importance of experimental methods in the field of environmental policy, this paper aims to analyze the trend and use of experimental methods in the environmental policy domain in the past 20 years from a methodological perspective. The sources of the literature review are 253 papers from the top 100 environmental policy SSCI-listed journals using laboratory, survey and field experiments. The analysis of the overall situation (nationality, journal) and the specific situation (research theme, experimental design and sample) reveals that most of the current experimental research in this field is focused on topics such as "energy" and "environmental protection and sustainable development", and the most common experimental designs are single-factor design and between-subjects design, with the majority of subjects participating in experimental research being the public and students. Finally, this paper discusses the prospects of experimental research in the field of environmental policy in future and gives corresponding suggestions, taking into account the analysis of the current situation and trends of experimental research in environmental policy.

Keywords: Environmental policy, laboratory experiments, field experiments, survey experiments, visibility of experimental design.

1. Introduction

With the increasing emphasis on causal inference and empirical research in the field of environmental policy, the experimental method has become an indispensable methodological tool in environmental policy research. However, no research has yet systematically analysed and sorted out experimental research in this field, which to a certain extent may affect the effective communication and methodological dissemination of experimental research. Therefore, this paper intends to systematically review the experimental research in environmental policy in the past 20 years, starting from the types and basic logic of experimental methods. In terms of chapter layout, the second part introduces the process of data selection and the selection of variables for analysis; the third part analyses the use of experimental methods in environmental policy; and on this basis, the fourth and fifth parts put forward corresponding research recommendations and implications. The aim of this paper is to analyse and understand the main features and trends of current experimental research in the field of environmental policy, in order to enrich the academic community's understanding of experimental research in this field and to enlighten future research, with a view to providing a contribution to the basic knowledge base of the relevant disciplines in a methodological sense.

2. Data and Methods

The data sources and screening methods for this paper are shown below.

Step 1: Journal screening. The top 100 journals in the category of impact factor in the field of environmental policy were selected from the Science and Technology Citation Index - Web of Science database of the Institute of Scientific Information. The journals containing experimental research were selected and irrelevant journals were excluded, leaving a total of 84 journals.

Step 2: Literature screening. Among the screened journals, a total of 3944 relevant articles were screened from the Science and Technology Citation Index - Web of Science database of the Institute of Scientific Information, with TS=(experiment*) AND SO= ("journal name"), time range "2000-2020", and literature type "article".
Step 3: Data cleaning. The 3,944 articles were manually read to determine whether they were indeed experimental articles, and if not, they were excluded. Next, studies on laboratory experiments, survey experiments and field experiments were selected, and studies on natural experiments, quasi-experiments, review papers and a small number of studies claiming to be experimental studies but are actually surveys were excluded, leaving a total of 253 articles. The literature screening process is shown in Figure 1.

3. Data Analysis

The results of the data analysis can be divided into two parts: the first part is a description of the overall situation of experimental research in the field of environmental policy, including the publication of the literature over the years and the geographical distribution characteristics of the studies; the second part is an analysis of the specific studies of the three types of experimental methods, including the themes of the studies, the use of experimental designs, the types of samples and recruitment, and the selection of dependent variables, etc.

3.1 Overview of the General Situation

First, this paper analyses the number of publications and the distribution of the three types of experimental studies in each journal over time, as shown in Figures 2, 3 and 4. In general, the number of publications of all three types of experimental studies showed an increasing trend year by year. Specifically, the journals with the largest distribution of the three types of experimental articles are *Nature Climate Change, Environmental Communication, Energy Policy, Global Environmental Change,* and *Ecology Economics.* These five journals account for nearly 40% of the total number of experimental articles.

![Figure 1. Literature Screening Process](image)

![Figure 2. Trends in the Distribution and the Number of Laboratory Experiment Research Papers in Journals (2000-2020)](image)
Secondly, this paper analyses the geographical information (country of affiliation) of all authors in the database. In terms of geographical distribution, the authors of the three types of experimental studies are concentrated in the United States (35%), Germany (10%) and the United Kingdom (7%), mainly in developed countries such as Western Europe and North America, which account for more than one-half of the total number of studies. In terms of international collaboration, studies of cross-national survey experiment studies account for a proportion of the total number of studies (22%), while cross-national field experiment studies account for a very small proportion (3%).

3.2 Analysis of Situations in Specific Studies

3.2.1 Research Themes

Based on the analysis of the literature and keywords, it can be found that the current experimental studies in foreign environmental policy are focused on "environmental protection and sustainable development" and "energy", but with different emphases. The following paragraphs will introduce the themes of the three types of experimental articles in turn.

In laboratory experiment studies, environmental protection and sustainable development are the research themes of the majority of articles, while there are relatively few articles on the topic of
energy. Specifically, research in environmental protection and sustainable development can be divided into two main aspects. On the one hand, research related to environmental protection, i.e. the impact of framing effects in environmental protection information, whose interventions include various forms such as text, pictures and images (Charry & Parguel, 2019, Keane & Smith, 2015, Hofman & Hughes, 2018). On the other hand, there is research related to sustainable development, including corporate and personal sustainable development. The corporate level of sustainable development involves multiple relationships between corporate social responsibility and employees, job seekers and consumers(Alniacik et al., 2011, Huber et al., 2017, Liao et al., 2020); while the individual level of sustainable development focuses on pro-environmental behaviours (Evans et al., 2013). Research in the energy sector has focused on the impact of different booster strategies on subjects' energy-saving behaviour, such as social booster, significant booster, etc.(Bergquist & Nilsson, 2018, Maan et al., 2011). The word cloud of this type of experimental research is shown in Figure 5.

![Figure 5. The Word Cloud for Laboratory Experiment Research](image)

In the survey experiment studies, there are more articles with "energy" as a research theme than "environmental protection and sustainable development" theme. Specifically, research in the field of energy can be divided into three main aspects. Firstly, clean and renewable energy. Secondly, clean energy-related technologies. This covers both technologies in a broad sense and specific technologies such as wind power, wind turbines, fracking, etc. (Shen et al., 2019, Walker et al., 2017, Liebe et al., 2017, Christenson et al., 2017). Third, clean energy-related policies, including energy use and energy taxes. The energy taxes mainly include taxes on electricity, gasoline, carbon, etc. (Nicolson et al., 2017, Kaplowitz & McCright, 2015, Jagers et al., 2019).

The research in the field of environmental protection and sustainable development can be divided into two main aspects, with the main research in the sustainable development focusing on the factors influencing public environmental behaviour (Van Der Linden & Behavior, 2015, Steinhorst & Matthies, 2016). The research in environmental protection includes animal protection, natural resource conservation, etc. (White et al., 2017, Capstick et al., 2016), and a large part of this research is focused on the topic of climate change. This session mainly focuses on the political, academic, and social dimensions of climate change (Van der Linden et al., 2019, Kotcher et al., 2017). The word cloud for this type of experimental research is shown in Figure 6.

![Figure 6. The Word Cloud for Survey Experiment Research](image)
As with survey experiment studies, there are more studies in field experiment studies with energy as a research theme than with nature conservation and sustainable development. Specifically, studies in the energy field have explored the relationship between different boosting strategies and energy-saving behaviours (McCoy & Lyons, 2017, Martin et al., 2018).

Research in the field of environmental protection and sustainable development covers both the natural and social environment. In the natural environment, it covers forest conservation, air conservation, etc. (Andersson et al., 2018, Hine et al., 2011); while in the social environment, it covers a range of pro-environmental behaviours such as buying green products, affordable housing, reducing paper waste, not littering, etc. (Vlaeminck et al., 2014, Zhang et al., 2016, Chakravarty & Mishra, 2019, Dur et al., 2015) In the social environment, a range of pro-environmental behaviours are covered, such as buying green products, economic housing, reducing paper waste, not littering, etc. The word cloud diagram for this type of experimental research is shown in Figure 7.

![Word Cloud](image)

**Figure 7. The Word Cloud for Field Experiment Research**

### 3.2.2 Use of Experimental Designs

In terms of the type of experimental design, three experimental methods used more between-subjects experimental designs and fewer within-subjects and mixed experimental designs. In terms of the other dimension of experimental design (single-factor vs. multi-factor design), single-factor experimental designs were more frequently used in survey and field experiment studies. In laboratory experiment studies, about 60% of the studies used a single-factor experimental design, leaving 40% of the studies using a multi-factor experimental design.

The number of subgroups is related to the number and level of independent variables and the type of experimental design. The specific division of groups for the three types of experimental studies is shown in Table 1.

| Types of Experimental Research | The Minimum Number of Group | The Maximum Number of Group | The Average Number of Group | Lower Quartile | Median | Upper Quartile |
|-------------------------------|-----------------------------|----------------------------|-----------------------------|----------------|--------|---------------|
| Laboratory Experiment Survey | 1                           | 16                         | 4                           | 2              | 4      | 4             |
| Survey Experiment Field      | 1                           | 72                         | 5                           | 3              | 4      | 5             |
| Experiment                   | 1                           | 23                         | 3                           | 2              | 3      | 4             |

### 3.2.3 The Sample Types and the Recruitment

(1) **The Sample Types and the Recruitment to the Experimental Research**

This paper analyses the sample types of the three types of experimental studies. The most frequently used sample for laboratory experiment research was students (41 articles, 71%); followed by the public (10 articles, 17%), including the general public and specific occupations (fishermen, drivers, etc.); and a small number of studies used a combination of students and the public as a sample
(3 articles, 5%). The most frequent sample used in survey experiment research was the public (85 articles, 86%), including the general public and specific occupations (workers, farmers, fishermen, etc.); followed by students (7 articles, 7%); and a small number of studies chose experts (2 articles, 2%) or politicians (2 articles, 2%) as the sample. The most frequently used sample in field experiment research was also the public (43 articles, 44%), with households accounting for the vast majority of experiments as the unit of study; followed by students (19 articles, 19%).

The paper further analyses the sample recruitment of the three types of experimental studies. As shown in Figure 8, laboratory experiment research mostly used direct recruitment methods, including campus and social recruitment, and few studies used indirect recruitment methods. As shown in Figure 9, field experiment research also used more direct recruitment methods, including social recruitment in various venues, as well as recruitment by telephone, mail and email. Of the studies that recruited their samples indirectly, the vast majority chose to recruit through government and school online research platforms, as well as partnerships such as projects, and a very small number chose to recruit using online data from third-party survey agencies.

![Figure 8. Recruitment of Samples for Laboratory](image)

![Figure 9. Recruitment of Samples for Field Experiments](image)

Unlike the first two types of experimental studies which mostly used direct recruitment, as shown in Figure 10, indirect recruitment accounted for the majority of survey experiment research and relied primarily on third-party survey agencies for recruitment. The most commonly used ones include Amazon Mechanical Turk, YouGov, Qualtrics and others. Of the experiments that recruited samples directly, half samples were directly recruited at universities or across the community. The other half of the experiments were recruited by phone, email, maps, social platforms, etc.
Also, the paper further analyses the sampling method for the survey experiment. Of the studies that have reported on the sampling method (63, 66%), nearly 70% of the studies were conducted using non-probability sampling, with the vast majority of them using convenience sampling and the remainder using quota and purposive sampling. The other 30% of studies were conducted through probability sampling, with stratified sampling being the most frequently used.

Finally, the paper analyses the sample sizes of the two types of experimental studies and the results are shown in Table 2. Most of the studies found in this paper do not report how the sample size was derived, but simply give the final sample size.

| Minimum Value | Maximum Value | Lower Quartile | Median | Upper Quartile |
|---------------|---------------|----------------|--------|---------------|
| 45            | 616           | 105            | 180    | 248           |
| 36            | 22011         | 494            | 1042   | 2000          |
| 12            | 41952         | 112            | 310    | 789           |

### 3.2.4 Selection of the Dependent Variable

In this paper, the dependent variables of the three types of experimental research are analysed. As can be seen from Figure 11, the dependent variables of the laboratory experiment research can be divided into three main levels: perceive, attitude and behaviour. In terms of measurement methods, nearly 30% of the studies used scales as the dependent variable, with the Likert scale being the most commonly used and the Semantic differential scale being used.

![Figure 11. Word Cloud of Dependent Variables for Laboratory Experiment Research](image-url)
As can be seen in Figure 12, the dependent variables in the survey experiment research can be categorised into other dimensions such as support, attitude, and perception, with these three research themes accounting for the vast majority of the total research literature. In terms of measurement, nearly 70% of the studies reported on the measurement of the dependent variable, with the most frequently used being 7-point scales, followed by 5-point scales and 10-point scales. The most common type of scale was the Likert scale, while the Bipolar scale and Semantic Differential Scale were also used in some studies.

![Figure 12. Word Cloud of Dependent Variables for Survey Experiment Research](image1)

As can be seen in Figure 13, the dependent variables in the field experiments were mostly objective and observable behaviours, such as the most common (energy, resource) consumption and use, and a range of (pro-environmental) behaviours, such as (green) purchasing, etc.

![Figure 13. Word Cloud of Dependent Variables for Field Experiment Research](image2)

4. Discussion

In the following paragraphs, this paper will further discuss the above key findings and offer some insights into the future of experimental research in the field of environmental policy.

4.1 Research Themes

Firstly, in terms of universality and prevalence, the research themes of the three types of experiments all reflect current important issues. In the context of the climate change and severe environmental pollution, research themes such as "global warming", "pro-environmental behaviour" and "sustainable development" have received a lot of attention.

Secondly, in terms of specificity, laboratory and field experiment studies are more specific than survey experiment studies in terms of research themes. For example, although the three types of experiment studies focus on the topic of "energy", survey experiment studies focus on energy-related issues, such as the acceptance of a new technology, a new policy, etc.; while the laboratory and field experiment studies focus on more specific aspects of energy, such as electricity, wind energy, etc.

Finally, in general, there are disadvantages of having a research topic that is either too abstract or too specific. If the topic is too abstract, the applicability of the findings is too vague, and when the topic is too specific, the findings are less generalisable and the corresponding significance of the research is greatly reduced. Therefore, it is crucial to choose an appropriate research topic. The researcher needs to pay attention to the four crucial aspects, i.e. importance, novelty, scope and operability to find the right topic (Colquitt & George, 2011).
4.2 Use of Experimental Designs

First, current experimental studies have a strong preference for the use of single-factor and between-subjects designs. Through comparison, it is found that more studies use multi-factor designs in laboratory and survey experiments than field experiments. This is mainly because laboratory and survey experiments are experimentally manipulated through a tightly controlled experimental environment, and different versions of questionnaires, thus allowing the analysis of the effects of multiple levels of independent variables on the dependent variable at once in a theoretical sense; field experiments, on the other hand, are manipulated into real-world scenarios where subjects receive a variety of realistic interventions as well as experimental interventions. This makes it difficult to differentiate and control the different levels of the independent variables, and therefore multi-factorial designs are less commonly used (Jackson & Cox, 2013).

Secondly, the number of groups in current experimental studies is generally small, and in a theoretical sense, it is undoubtedly more conducive to the researchers' manipulative treatment. However, due to the complexity of real life, a single independent variable setting often fails to solve the problem and the experimental effect can be greatly weakened (Blom-Hansen et al., 2015). Therefore, in order to better simulate real-world scenarios, the use of multi-factor experimental designs can be appropriately enhanced, along with the use of within-subjects and mixed designs where conditions permit.

4.3 Sample Types and the Recruitment

In terms of sample types, laboratory experiments are problematic in terms of sample selection, with the majority of samples coming from university students and very few from the general public, so the generalisability of their findings has to be questioned. The survey and field experiments, on the other hand, represent an improvement over the laboratory experiments by extending the sample from individual groups to people from all walks of life, thus avoiding the fatigue effect caused by repeated use of the sample, reducing the influence of the "third factor" and thus improving the external validity of the study.

In terms of sample recruitment, the rapid rise in the recruitment of samples through third-party survey agencies has increased the flexibility and convenience of the recruitment process by removing the constraints of a single database. However, the quality of data obtained through third-party survey agencies is still an issue that needs to be investigated, and therefore the selection criteria for data obtained in this way should be further enhanced to improve data quality.

In terms of how the sample for the survey experiments was sampled, most of the current studies used non-probability sampling, which may be due to two reasons: firstly, experimental research seeks internal validity over external validity, i.e. researchers aim to examine causal relationships rather than to generalise to a wider population; secondly, evidence from previous studies suggests that specific non-representative samples (e.g. student samples, internet samples) have good generalisability. However, this sampling approach may lead to the presence of sample selectivity bias, which further affects the accuracy of the experimental findings. Therefore, in future experimental studies, researchers may select samples according to the objectives of their studies. If the main purpose is to validate the theoretical model and explore basic causality, then the use of non-representative samples can meet such needs; if the purpose is to generalise the findings further, then as much as possible, representative sampling of the sample can be conducted, if conditions allow extent possible in order to improve the external validity of the study.

Finally, in terms of sample size, the sample sizes of the three types of experimental studies were highly variable, ranging from a few dozen to several thousand. In terms of how the sample size was calculated, most of the experimental studies did not mention how the sample size was calculated, which could cast doubt on the reliability of the findings and thus reduce the quality of the study. Therefore, when determining the use of sample size, researchers should firstly consider the influence of various factors such as the type of experiment, the experimental design and the conditions under
which the experiment was conducted, and secondly, they can also use statistical tools such as power analysis to determine the sample size based on the expected effect size.

4.4 Selection of Dependent Variables

In terms of the dependent variables for the three types of experiments, the dependent variable for the survey experiments tends to be the subjective feelings of the person, the dependent variable for the field experiments tends to be more of an objective observable behaviour, and the dependent variable for the laboratory experiments contains both subjective feelings and objective behaviour. However, for survey experiments, there may be a distance between discussing subjective feelings alone and the desired action due to the knowledge-action gap. In the case of field experiments, due to spillover effects, the objective behaviour observed in the experiment is inevitably influenced by the social environment rather than by the objective behaviour of the individual arising from subjective feelings. Therefore, the selection of dependent variables for the two types of experiments mentioned above still needs further improvement. Attention should be paid to the comprehensiveness of the selection of dependent variables to avoid favouring one over the other.

5. Conclusion

This paper provides a general introduction to the use of laboratory, survey and field experimental methods in the field of international environmental policy. On this basis, it further analyses and explains the problems worth discussing in the application of the three types of experimental methods and puts forward corresponding countermeasure suggestions. It can be seen that experimental research in the field of international environmental policy is rapidly emerging, and these studies provide new research perspectives and empirical evidence for domestic research. At the same time, world's rapid economic development and social changes provide a large number of research questions with theoretical and practical significance for experimental approaches, and selections with significant international comparative research value may emerge. It is hoped that more researchers will join the ranks of experimental research in the field of environmental policy in the future, giving full play to the advantages of the experimental approach to study and solve theoretical and practical problems in the field of environmental policy.

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