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Research on Aspects of Ireland's Environment, Consumer Behaviour and Health: ESRI Environment Research Programme 2016-2018

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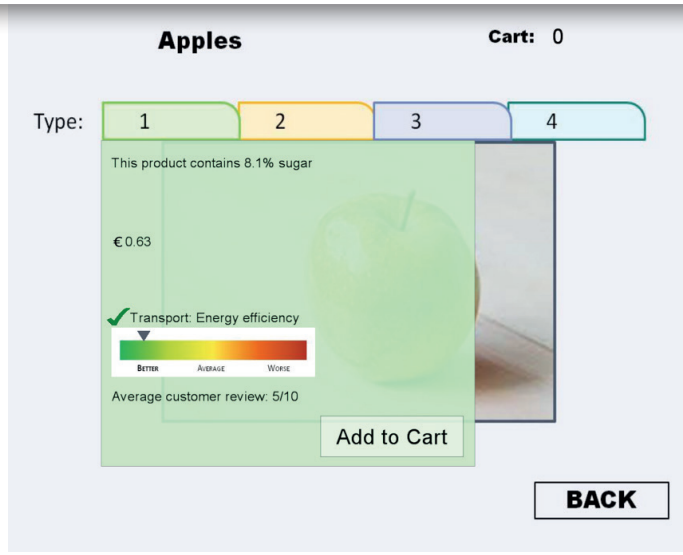

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Government of Ireland

ENVIRONMENTAL PROTECTION AGENCY

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- the contained use and controlled release of Genetically Modified Organisms *(GMOs)*;
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- Office of Evidence and Assessment
- Office of Radiation Protection and Environmental Monitoring
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet regularly to discuss issues of concern and provide advice to the Board.

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Contents

Acknowledgements ii

Disclaimer ii

Project Partners iii

List of Figures vii

List of Tables viii

Executive Summary ix

1 Introduction 1

2 Identifying and Estimating the Environmental Effects of Selected Fiscal Instruments 3

2.1. Introduction 3

2.2 Fiscal Instruments in Ireland 4

2.3 Case Studies 4

2.4 Conclusions and Recommendations 4

3 Health and Well-being Benefits of a Clean and Healthy Environment and Environmental Amenities in Ireland 6

3.1 Introduction 6

3.2 Data from The Irish Longitudinal Study of Ageing 6

3.3 High Radon Areas and Lung Cancer Prevalence 7

3.4 Urban Green Space and Obesity in Older Adults 8

3.5 Coastal Blue Space and Mental Health of Older Adults 10

4 Picture or Playground: Valuing Coastal Amenities 12

4.1 Introduction 12

4.2 Data and Methods 12

4.3 Results 12

5 Changes in Land Cover and Urban Sprawl in Ireland in Comparative Perspective from 1990 to 2012 14

5.1 Introduction 14

5.2 Data and Methods 14

5.3 Results 14

6 Use of Behavioural Economics Laboratory Experiments to Examine Environmental Influences on Consumer Behaviour 16

6.1 Introduction 16

6.2 Experiment 1: Effects of Label Format and Frame on Consumers' Decisions 17

6.3 Experiment 2: Effects of Cost Information Versus Emissions Information on Consumers' Car Preferences 25

6.4 Final Notes 31

7 Behavioural and Experimental Tests of the Long-term Benefits of the Green Schools Programme 32

7.1 Introduction 32

7.2 Methods 34

7.3 Results 36

7.4 Discussion 38

8 Evaluating Health Benefits Derived from Green and Blue Spaces using a Choice Experiment Survey 40

8.1 Introduction 40

8.2 Methodology and Data 40

8.3 Results 43

8.4 Conclusion 49

9 Recommendations 51

References 53

Abbreviations 58

Appendix 1 Image Credits 59

List of Figures

Figure 3.1.	Marginal effects of green space quintile (relative to the third quintile) on the probability of obesity	9
Figure 5.1.	Distance of new artificial areas to existing artificial structures for Ireland and "other Europe" over the period 1990–2012	15
Figure 6.1.	Information about the same product presented according to different conditions of format and frame	17
Figure 6.2.	Examples of shopping lists presented to participants	18
Figure 6.3.	Depiction of different sections of one shopping environment and of how a product could be selected	20
Figure 6.4.	Depiction of how different options for one product were presented	21
Figure 6.5.	Mean score of products selected by participants according to attribute, information format and information frame	22
Figure 6.6.	Mean scores for the standardised versus specific information formats, by attribute and session	24
Figure 6.7.	Identical trial shown across different blocks	27
Figure 6.8.	Numbers of participants selecting the cars emitting the lowest NO_x emissions on more or less than 50% of trials per condition.	29
Figure 7.1.	Months spent in schools signed up for and active in the Green Schools Programme, by individual participants	37
Figure 7.2.	Mean score of products chosen by students on environmental friendliness and nutrition, by information format	38
Figure 8.1.	Example of a choice card	44
Figure 8.2.	Probability of experiencing poor physical health status by number of green and blue space visits per month	46
Figure 8.3.	Marginal probabilities: change in probability of poor physical health status associated with monthly green and blue space visits	46
Figure 8.4.	Association between probability of being "very satisfied" with life and monthly green and blue space visits	47
Figure 8.5.	Marginal probability: change in probability of being "very satisfied" with life associated with monthly green and blue space visits	47

List of Tables

Table 2.1.	Environmental effects identified for fiscal instruments in Ireland	3
Table 3.1.	Odds ratios for the main factors included in the simplified model	8
Table 4.1.	Standardised monetary price effects of key regressors	13
Table 6.1.	Age distribution of participants	19
Table 6.2.	Random intercept models for scores based on environmental ranking of chosen products or ranking by nutrition/effectiveness	23
Table 6.3.	Random intercept models for scores based on environmental ranking of chosen products or ranking by nutrition/effectiveness, including interactions with session	24
Table 6.4.	Fixed-effect logit models for correctly selecting a product that matched the environmental or nutritional/effectiveness directive	25
Table 6.5.	Categories of NO_x emissions and hypothetical additional tax charges	26
Table 6.6.	Efficiency conditions	28
Table 6.7.	Mixed-effect logistic models for the probability of selecting lower NO_x-emitting vehicles, with random intercept by participant	30
Table 6.8.	Mixed-effect logistic models for the probability of selecting the more fuel-efficient vehicle, with random intercept by participant	31
Table 7.1.	Questions from the survey on habits	36
Table 7.2.	SRBAI and SRHI questions provided to participants	37
Table 7.3.	Descriptive statistics on participants' engagement in environmental and health-related activities	39
Table 8.1.	Description and descriptive statistics of model variables	41
Table 8.2.	Attributes and levels included in the study	43
Table 8.3.	Results of the structural model	45
Table 8.4.	Preferences for green and blue space attributes	48
Table 8.5.	Marginal effects of green and blue space attributes: number of additional visits	49
Table 8.6.	Expected change in the number of green and blue space visits with different arrangements of green and blue space attributes	49

Executive Summary

The Economic and Social Research Institute (ESRI) Environment Research Programme brings together a diverse set of research topics in which the environment interacts with economic and social processes. In partnership with the Environmental Protection Agency (EPA), the study team has sought to bring new data and analytical methods to bear on topics relevant to environmental policymaking and policy implementation. The results are reported under three headings, each capturing a different approach to gathering evidence.

Assembling Data from Many Sources to Characterise Policies that Affect the Environment

Fiscal instruments such as taxes and subsidies can affect the environment, but consideration of such effects has often been neglected when instruments were initially designed. The research team carried out a study assessing the environmental impact of existing and potential fiscal instruments in Ireland. The first part of this study involved a high-level assessment of the potential environmental impacts of 142 instruments. This considered the incentives that a particular measure imposes, the likely resulting behaviour and the subsequent expected environmental impact. Environmental impacts were classified into the domains of climate change, air quality, water quality and land. In total, 246 impacts were identified, so on average measures impact on more than one domain. The most widespread impact identified was on climate change emissions, with 98 measures having impacts. The least common impact found was on water, with 23 measures having impacts. Just over half of the measures assessed are likely to have some positive impact.

Four measures were selected for a more detailed assessment of the size and nature of the environmental impact:

1. the lower excise duty on diesel than on petrol;
2. the essential fuel user's rebate scheme;
3. the introduction of an air passenger charge as a proxy for a tax on aviation fuel; and
4. the zero value-added tax (VAT) rate on fertilisers.

Although the effects of any one measure might be thought of as relatively small, together they have a significant negative impact on the environment. Ignoring such effects can have significant efficiency implications, as negative environmental impacts have costs for individuals and, in relation to climate change, for the state and the world. Similarly, positive environmental effects of fiscal measures should be explicitly acknowledged and considered in decision-making.

Transforming and Combining Existing Data in New Ways to Allow Analysis that is More Robust

Recent advances in the availability of large-scale, nationally representative, geo-coded data on the health of the population, coupled with the increasing availability of geographical data on risk factors and environmental exposures with regard to human health, provide new opportunities for applied, policy-relevant research on the environment and health in Ireland. This strand of the research involved three environment–health studies using individual-level data on people aged 50+ years in Ireland from The Irish Longitudinal Study on Ageing (TILDA):

- *Radon risk and lung cancer prevalence*. Respondents living in an area in which 10–20% of households were above the national radon reference level (200 Bq/m^3) were 2.9–3.1 times more likely to report a lung cancer diagnosis than those who lived in areas in which less than 1% of households were above the national reference level.
- *Urban green space and obesity rates*. Respondents living in areas with the lowest and the highest shares of green space within a 1.6 km buffer zone of their residence had a higher probability of being classified as obese. Other urban characteristics may mediate this relationship, because respondents in areas with both the lowest and the highest shares of green space had a higher probability of being obese than those in areas with intermediate shares.

- *Coastal blue space and risk of depression*. TILDA respondents with the highest share of sea view visibility had significantly lower depression scores, even when distance from the coastline was also included in the model, along with many other individual-level socioeconomic factors. This result supports the idea that visual exposure might be the main channel for beneficial mental health effects from coastal blue space on older adults.

The value of environmental attributes can also be estimated "top-down", considering a broader range of possible contributing benefits in a less specific way. Again, using spatial data on coastal blue space views and proximity, a study was carried out to estimate the economic value of blue space exposure in Ireland's housing markets. Being near beaches and similar shorelines attracted a sizeable premium in both sale and rental markets, as did the breadth and depth of sea views.

A further study examined the substantial changes in land cover and land use that Ireland has experienced since 1990. Two main trends are highlighted: land classified as urban has increased at a higher rate than in the rest of Europe and, relative to other European countries, urban areas were created in more remote locations, resulting in sprawl. Sprawl has been associated with a wide range of adverse effects for the economy and the environment, including increased emissions as a result of commuting and inefficient residential energy use. Statistical analysis was also employed to test for sprawl. This shows that low-density areas exhibited higher growth in population density and building stock, confirming that the population structure has become more dispersed over time.

Collecting New Data that Relates Human Behaviour to Environmental Conditions and Outcomes

Three studies focused on how consumers respond to different means of giving information. The first experiment was on the effects of label format and frame on consumers' decisions. In this experiment, the researchers directly compared the effects of different formats of environmental information on adult consumers' choices. The study also examined how consumers respond to these means of giving information in different contexts, specifically when they are making time-limited decisions compared with when there is no explicit time limit, and when they are asked to identify products meeting specific criteria compared with choosing products according to subjective preferences. The results indicate that participants chose products ranked higher on target criteria, such as environmental friendliness or nutrition, when information was given in the colour-coded, standardised format than when it was given in a specific, verbal format. For environmental product information, in particular, the colour-coded, standardised format was particularly effective when participants were making decisions under a time limit, and it improved their ability to correctly identify environmentally friendly products overall.

The second experiment involving adult consumers examined the effects of cost information versus emissions information on consumers' car preferences. This study looked at how different means of presenting consumers with a hypothetical tax instrument related to cars' nitrogen oxide (NO_x) emissions affected their expressed preferences between identical pairs of cars. As expected, participants were more likely to select vehicles with low NO_x emissions when a charge was imposed on NO_x emissions. Providing information about the level of NO_x emissions of a vehicle was more effective than giving details about the financial cost of the NO_x charge on the vehicle, which participants may have found to be a more abstract concept. Additional control variables based on differences in car price, CO_2 motor tax and running costs were included and each of these had a significant effect. A separate analysis of ways to show efficiency information indicated that participants were more likely to select the more efficient vehicle if the fuel cost figure was displayed as a financial cost per given distance or time, rather than as the time or distance that one could drive for a set financial cost.

The research focus moved to children in the third study, which examined the pro-environmental habits of a large sample of Transition Year[1] students in Ireland, as well as their decision-making in relation to different formats of information about products'

1 In the Irish secondary school system, Transition Year is a 1-year programme taken after the Junior Cycle (lower secondary) and before the 2-year Leaving Certificate (upper secondary).

environmental impacts. As well as experimenting on children's reactions to label format and frame, as discussed above for adults, the researchers used the participation of their schools in a pro-environmental education programme, the Green Schools Programme, to examine how introducing environmental concepts and behaviours in childhood affects children's habits and their processing of environmental product information in adolescence.

This study did confirm that secondary school students dealt with information about products in different formats in a similar way to adults. Progress on the second objective of examining how pro-environmental educational programmes affected the choices and self-reported habits of secondary school students may have been limited by the sample size available in the study. The analysis did not find a statistically significant association between the overall level of environmentally friendly choices and time spent in Green Schools. However, students who had had a longer exposure to the Green Schools Programme appear to have responded to the information differently from peers with a lower exposure, choosing more environmentally friendly products when the information was in a standardised than in a specific format. Finally, students who had spent longer in Green Schools had stronger pro-environmental habits, but also stronger health-related habits. This result may therefore not be an effect of the programme, but an effect of overall schooling. Conversely, participation in the Green Schools Programme may provide students with the tools to develop and engage in positive habits across many domains.

The literature on health and the environment suggests that there is an association between the characteristics of urban green and blue spaces and the health conditions of visitors. The final study covered in this report evaluated health benefits derived from green and blue spaces using a choice experiment survey. This work was co-funded by the Health Service Executive, as well as the EPA. Two outcome indicators were used, one related to physical health and one to well-being, and the survey was applied to a representative sample of urban dwellers in Ireland. The research presented here confirms the positive association between green and blue space visits and health status. The second aspect of the research examined whether or not there are particular park attributes associated with high visitation rates. All park attributes that were considered showed a statistically significant impact on the level of park visitation, but the attributes with the greatest marginal impact related to visitor facilities (e.g. toilets, coffee shop, gym equipment) rather than physical characteristics of the park (e.g. size, tree cover).

1 Introduction

The Economic and Social Research Institute (ESRI) Environment Research Programme brings together a diverse set of research topics in which the environment interacts with economic and social processes. In partnership with the Environmental Protection Agency (EPA), the study team has sought to bring new data and analytical methods to bear on topics relevant to environmental policymaking and policy implementation.

This report synthesises the results from the programme, which has involved 2 years of research across seven work packages. These work packages can be grouped into three strands based on the approach taken to information gathering:

1. Assembling data from many sources to characterise policies that affect the environment.
    - Identifying and estimating the environmental effects of selected fiscal instruments (Chapter 2).
2. Transforming and combining existing data in new ways to allow analysis that is more robust.
    - Health and well-being benefits of a clean and healthy environment and environmental amenities in Ireland (Chapter 3).
    - Picture or playground: valuing coastal amenities (Chapter 4).
    - Changes in land cover and urban sprawl in Ireland in comparative perspective over 1990–2012 (Chapter 5).
3. Collecting new data that relates human behaviour to environmental conditions and outcomes.
    - Use of behavioural economics laboratory experiments to examine environmental influences on consumer behaviour (Chapter 6).
    - Behavioural and experimental tests of the long-term benefits of the Green Schools Programme (Chapter 7).
    - Evaluating health benefits derived from green and blue spaces using a choice experiment survey (Chapter 8).

These research topics were selected through a process of dialogue involving EPA and ESRI staff. Throughout, the partners sought to identify opportunities that offered both policy relevance and scope for robust empirical analysis. One topic, identifying and estimating the environmental effects of selected fiscal instruments, proved to be amenable to analysis using data already available in the policy system. Even in this case, full analysis of most fiscal instruments would require more data to be collected.

However, another early insight was that there was great potential to add data on local environmental conditions to existing socioeconomic datasets containing rich information on large numbers of individuals. Both public and private sector organisations collect individual-level socioeconomic information, whether on the full population through the census or on subpopulations through large sample surveys. These data are referred to as microdata. At the same time, administrative data on local environmental conditions have become available for increasing numbers of topics and across broader geographical areas. Fortunately, both types of information tend to include spatial location identifiers. This means that variables capturing local environmental information can often be added to socioeconomic microdata files, provided that data protection and confidentiality requirements can be met. The availability of this information on individuals' environmental exposures, together with their socioeconomic circumstances, behaviours and outcomes, means that new types of analysis are possible. The second strand of this research programme includes three studies that applied this approach in different ways. The researchers are particularly grateful to The Irish Longitudinal Study on Ageing (TILDA) and daft.ie for facilitating access to microdata and for working with the research team to link new variables to the microdata.

Finally, there are many policy-relevant questions that simply cannot be addressed using existing data. For these, advanced survey methods and laboratory experiments can be used to gather information for rigorous analysis of human behaviours and preferences related to the environment. In recent years, there have been major advances in the

methods used and practical experience with gathering data on peoples' preferences and their behaviour when making choices. Collecting new data brings its own challenges, but it confers unique advantages in allowing better experimental control of the context in which the data are obtained and enabling a good fit between the experimental design and the policy or implementation questions being addressed. The third strand of the programme includes three topics using these methods.

For one of these topics, "Evaluating health benefits derived from green and blue spaces using a choice experiment survey", the Health Service Executive (HSE) also provided co-funding to the programme.

Much of the research carried out under the programme has been published in peer-reviewed journal articles or reports. In these cases, this report provides a summary of the research; additional material can be found in the full publications (Chapters 2–4). In other cases, research has only recently been completed and this report contains a more detailed account of the work (Chapters 5–8). The remainder of the report discusses each of the topics in turn, before summarising the recommendations arising from the research.

2 Identifying and Estimating the Environmental Effects of Selected Fiscal Instruments

By Edgar Morgenroth, Martin Murphy and Kyle Moore (ESRI).

2.1. Introduction

The fiscal system has powerful effects in imposing incentives on firms and individuals. Taxes discourage and subsidies encourage activities. When fiscal measures are being developed, they are usually assessed in terms of their implications for the Exchequer; for example, a reduced tax rate or an allowance reduces the amount of tax revenue collected. The effect of fiscal measures on their targeted activity is also often assessed; for example, the employment creation effects of investment incentives have been analysed. Likewise, the environmental effects of some measures aimed at achieving environmental goals have been assessed. However, the environmental effects of fiscal measures that are not specifically aimed at achieving environmental objectives are often not quantified.

In common with other developed countries, a large number of fiscal measures have been adopted in Ireland. These include reduced tax rates, tax exemptions, tax allowances and direct subsidies. However, as many of the measures that had been enacted in the past decade resulted in significant reductions in tax revenue and had questionable effects, the number of tax expenditures has been reduced significantly over recent years.

The report on which this chapter is based focused on assessing the environmental impacts of existing and potential fiscal instruments in Ireland. The study started by conducting a simple assessment of potential environmental impacts of a large number of existing and potential fiscal instruments. This considered the incentives that a particular measure imposes on individuals or firms, the likely resulting behaviour and the consequent expected environmental impact. In total, 142 measures were considered. The environmental impacts identified cover the main domains of climate change, air quality, water quality and land; 246 impacts were enumerated, of which just over half were deemed to have some potential positive impact (Table 2.1). This implies that, on average, a given measure affects more than one domain. The most frequent area on which impacts were found was climate change emissions, with 98 measures having an impact. The least common area on which impacts were identified was water, with 23 measures having an impact.

The initial assessment of environmental impacts of the 142 measures stopped short of estimating the scale of each environmental impact or providing an in-depth assessment of the effects. To achieve this, a more thorough analysis will be necessary. Such an analysis would require knowledge of the extent of the benefit and the likely behavioural response and, if conducted for all measures, would be a significant research task beyond the scope of this study. Therefore, a number of detailed case study analyses were performed to assess the impact of some measures more fully.

Table 2.1. Environmental effects identified for fiscal instruments in Ireland

Domain of effect	Positive	Negative	Total
Air	40	27	67
Water	10	13	23
Land	17	41	58
Emissions	57	41	98
Total	124	122	246

Source: Morgenroth *et al.* (2018). © The Economic and Social Research Institute.

2.2 Fiscal Instruments in Ireland

The first task in the study was to identify the fiscal instruments that were to be analysed. The Revenue Commissioners identified 102 tax exemptions in 2012 and just 15 tax expenditures in 2015. Furthermore, the Revenue Commissioners provide details about the value-added tax (VAT) treatment of different products and services. Many details, such as exempt categories or reduced rates of VAT, are explicitly identified in government publications; however, others are not as clearly highlighted, such as the zero VAT on fertiliser use. A third category of fiscal instruments includes those that are common in other countries but that are not used in Ireland. For example, taxes on the extraction of aggregates are employed in many European Union (EU) countries but not in Ireland. A case could be made that this is a form of tax expenditure. These and other potential fiscal instruments are more difficult to identify, but a search of the literature and the internet sites of tax authorities in other countries was used to compile as comprehensive a list as possible.

The broader term "fiscal instrument" is used to encompass both explicit tax expenditures and other fiscal measures that affect the absolute and relative taxation of goods, services and activities. For example, a lower rate of VAT is not included in the official list of tax expenditures but clearly might affect behaviour.

The second task was to assess the potential environmental impact of each fiscal instrument. Measures could have a range of effects on different aspects of the environment. This study considered the emission of greenhouse gases (GHGs), emissions that impact on local air quality, impacts on water and impacts on soils. Noise pollution was not considered here, as this is often dependent on the way in which an activity is carried out rather than the activity itself.

2.3 Case Studies

The assessment of fiscal measures in the previous subsection shows that many have a negative environmental impact, e.g. higher emissions of pollutants. Four case studies were used to quantify these negative effects by calculating the positive environmental effect associated with removal of the measures.

Agriculture and transport were the two largest contributors by sector to overall GHG emissions in 2015, accounting for 33.1% and 19.8%, respectively (EPA, 2017). Additionally, the two sectors are projected to account for 76% of non-Emissions Trading Scheme (ETS) emissions in 2020 (EPA, 2016a). Therefore, four fiscal measures were selected that were found to negatively affect the emissions from these sectors. These are the difference in excise rates between petrol and diesel, the zero VAT rate on fertiliser, the diesel rebate scheme for the haulage industry and the possible introduction of an air passenger duty (APD).

2.4 Conclusions and Recommendations

A large number of fiscal measures were found to have some effect on at least one environmental domain and some impact on more than one aspect of the environment. However, for many the impact was likely to be limited. Not all measures have negative effects and it is worth noting that, in general, these measures are not directly aimed at achieving environmental objectives.

From the large set of measures that were assessed to have negative environmental effects, four were selected for a more detailed assessment of the size of the environmental impact. The choice reflected data availability and the fact that transport and agriculture account for the largest shares of GHG emissions. In relation to transport, the lower excise duty on diesel than on petrol, the essential fuel user's rebate scheme and the introduction of an APD as a proxy for a tax on aviation fuel were considered. The zero VAT rate on fertilisers was analysed in relation to the environmental impact from agriculture.

Although the effects of any individual measure might be thought of as relatively small, together they have a significant negative impact on the environment. If only these four measures were addressed, CO_2 emissions could be reduced by 1.1%, nitrogen oxide (NO_x) emissions by 1.34% and PM_{10} emissions[2] by 1.47%. The absolute reduction of emissions in tonnes was quite large for each of the three pollutants.

2 Atmospheric particles with an aerodynamic diameter of less than 10 µm.

Overall, the analysis shows that the environmental impact of the fiscal system should be studied more carefully, as some measures have significant environmental costs. The appropriate reform of these measures could make a significant contribution to reducing Ireland's GHG emissions and reducing local pollution.

The analysis also shows that many fiscal measures have environmental impacts that have largely been ignored in their initial design. Ignoring these impacts can have significant efficiency implications, as negative environmental impacts have costs for individuals and, in relation to climate change, for the state and the world. Similarly, positive environmental effects of fiscal measures should be explicitly acknowledged and considered in decision-making. The positive effects should also be assessed *ex post*, to see how significant they really are. In this respect, it is important to collect the appropriate data. For example, it would be difficult to assess the effectiveness of a bike-to-work scheme, which should have a significant positive environmental effect, if little is known about the number of beneficiaries and their travel behaviour.

The research underpinning this chapter has been published in a separate report (Morgenroth *et al*., 2018).

3 Health and Well-being Benefits of a Clean and Healthy Environment and Environmental Amenities in Ireland

3.1 Introduction

The built and natural physical environment is an important component of the "social determinants of health", i.e. the conditions in which we live, work and play have an important role in determining health and well-being outcomes (WHO, 2008). Environmental factors such as green and blue space (Lachowycz and Jones, 2011; Gascon *et al.*, 2017), air pollution (Clancy *et al*., 2002; Janke *et al*., 2009) and noise (Murphy and King, 2014; Christensen *et al*., 2015) have all been shown to be important determinants of health and well-being. Reflecting the importance of this link, one of the seven key actions from the latest EPA State of the Environment report is "Recognition of the benefits of a good quality environment to health and wellbeing" (EPA, 2016b).

Recent advances in the availability of large-scale, nationally representative, geo-coded data on the health of the population, coupled with the increasing availability of geographical data on risk factors and exposures for human health, provide new opportunities for applied, policy-relevant research on the environment and health in Ireland.

Data on a range of local environmental risk factors and amenities (or disamenities) in Ireland are available in geo-coded form, and this work package linked selected exposure variables to each individual's residential location in TILDA surveys to generate a proxy for the extent of exposure to each environmental factor of interest. Statistical methods can be applied to these variables to help explain a range of health benefits/outcomes for the older adult population in Ireland. This approach offers new ways to examine the health benefits of a clean and healthy environment and other local characteristics, such as environmental amenities. The value and distribution of such benefits have implications for public policies on environmental protection, health and spatial planning.

A key methodological issue with research of this kind is identifying causality in the relationship between environment and health. Poor health, poor ambient environmental conditions and low socioeconomic status are often correlated (Layte *et al*., 2007), with the result that it is often difficult to disentangle the causal impact of environmental factors on health. One benefit of using individual-level microdata is that detailed information on such confounding factors is available. This offers advantages over studies using only aggregate data. Area-level studies can test whether differences in average exposures or socioeconomic factors are associated with differences in average health outcomes for groups of subjects, but with microdata one can test whether individual differences (which likely vary more than the averages) show such effects. In addition, in some cases sources of random variation in environmental factors across the population can also be used to identify causal effects.

The next section of this chapter describes the TILDA data, from which information is available on health outcomes and socioeconomic factors affecting individuals. Geographic information system (GIS) data on harmful exposures and environmental amenities can be drawn from a variety of administrative and scientific sources. Sections 3.2–3.4 then describe the research findings for studies relating a range of health outcomes to radon risk, urban green space and coastal blue space, respectively.

3.2 Data from The Irish Longitudinal Study of Ageing

The Irish Longitudinal Study of Ageing surveys a nationally representative sample of over 8000 individuals aged over 50 years. It began in October 2009 and, since then, three further waves of data collection have been completed and a fifth is nearly ready. In addition to extensive information on household structure and socioeconomic characteristics, TILDA provides detailed information on numerous doctor-diagnosed health conditions (e.g. chronic lung disease, asthma, angina, cancer) and validated indicators of well-being and mental health. The dataset also includes objective indicators of health collected as part of an extensive nurse-led health

assessment (e.g. blood pressure and cardiovascular health; eye health; physical functioning – grip strength, walking speed and bone density; dental health; and blood biomarkers for conditions such as cholesterol and diabetes). All participant addresses in TILDA are geo-coded.

3.3 High Radon Areas and Lung Cancer Prevalence

By Seraphim Dempsey, Anne Nolan and Seán Lyons (ESRI).

Exposure to radon gas is thought to be the second most important cause of lung cancer worldwide after smoking. This naturally occurring radioactive gas can seep into houses from beneath the ground or can emanate from certain building materials. Ireland has relatively high indoor radon concentrations, estimated to be the eighth highest level among Organisation for Economic Co-operation and Development (OECD) countries.

This research examines data on TILDA respondents from Waves 1–3 to determine whether living in an area with a greater risk of radon exposure is associated with higher odds of a lung cancer diagnosis. The research considers other risk factors such as smoking and age in order to isolate the possible effect of radon.

3.3.1 Data and methods

It can be difficult to disentangle the effects of an environmental threat, such as radon, from other factors that increase cancer risk. One might notice that cancer is more common in some places than others, but perhaps smoking is also more prevalent in those places or there is a greater number of older residents in the area. Either of these factors would increase cancer risk compared with other areas and, if they are not taken into account, their effects could be mistaken for the impact of radon. As discussed earlier, TILDA provides information on individuals' health outcomes and socioeconomic circumstances. It contains detailed health information from over 5000 individuals in Ireland aged over 50 years – including whether or not they have had a diagnosis of lung cancer – as well as many other self-reported and objective indicators for each respondent.

Crucially, TILDA data can be linked to local environmental information, in this case, data on the radon exposure risk in the area where each respondent lives. The EPA (2019a) has published a radon risk map that divides Ireland into five zones with increasing levels of risk, from places where less than 1% of houses are expected to have more indoor radon than a set reference level (200 Bq/m^3) to places where more than 20% of houses might be above this level.

Statistical methods are used to see how the odds of a lung cancer diagnosis vary among areas with a higher or a lower radon risk, controlling for individuals' smoking history, age, gender, level of education and the population density in their locality.

3.3.2 Results and policy implications

In TILDA, 13% of respondents were living in an area in which more than 20% of households were above the national radon reference level of 200 Bq/m^3. The analysis shows that those living in an area where 10–20% of households were above the national reference level for radon exposure were also about three times more likely to report a lung cancer diagnosis than those living in an area where less than 1% of households were above the national reference level. However, there was no evidence of an increased probability of cancer in the zone where the radon risk was highest (more than 20% of households above the reference level). Table 3.1 shows how the key factors in the model affected the odds of reporting a lung cancer diagnosis. Factors are compared with their reference categories.

In common with previous research, smoking was shown to be the greatest risk factor for lung cancer and risk rose with age. However, it is not possible to prove that any particular factor causes another using these data alone, as it may be possible that there are other factors that are associated with both living in a high radon risk area and lung cancer that one cannot observe in the data.

These results are consistent with the view that radon exposure poses a risk to many Irish households. For those living in an area with a higher risk of indoor radon, there is guidance available from the EPA on how to reduce radon exposure in homes (EPA, 2019b).

A question remains as to why living in the zone with the highest radon risk did not seem to confer

Table 3.1. Odds ratios for the main factors included in the simplified model: logit regression estimating the probability of a lung cancer diagnosis with a reduced set of control variables ($n = 5590$)

Dependent variable: lung cancer	Odds ratio	Robust standard error
Remaining radon categories	Ref.	Ref.
10–20% of households are above 200 Bq/m^3	3.12	1.40**
Never smoked to 30 smoking years	Ref.	Ref.
31+ smoking years	8.88	3.23***
Age	3.75	1.68***
Age squared	0.99	0.00***
Male	Ref.	Ref.
Female	1.98	0.71*
1st to 4th quintiles of electoral district population density	Ref.	Ref.
5th quintile of electoral district population density	2.25	0.94*

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

Source: Reprinted from *Journal of Environmental Radioactivity*, vol. 182, Dempsey, S., Lyons, S. and Nolan, A., High radon areas and lung cancer prevalence: evidence from Ireland, pp. 12–19, copyright 2018, with permission from Elsevier.

a higher probability of lung cancer. This could indicate that campaigns by public authorities to get households to protect their dwellings in areas with the most radon have had some success. To test the importance of this factor, one would need to study where and how these campaigns were conducted. Another possibility is that statistical "noise" led the models to miss an effect that is actually still there. A final possibility is "survivor bias", whereby those who had already died from lung cancer were not in the sample used for the study.

A variety of policy measures could help to further reduce radon exposure. Public authorities have previously undertaken awareness campaigns, but perhaps these could be made more effective at influencing behaviour. Regulatory policy options could be considered, such as requiring testing prior to the sale or rental of dwellings (akin to the Building Energy Rating scheme), as well as economic measures, such as providing incentives to radon-proof buildings in areas that are at risk. To design the best mix of policies, it will be important to understand why many people in high-risk areas do not invest in radon protection measures.

The research underpinning this study has been published in a peer-reviewed academic journal (Dempsey *et al*., 2018).

3.4 Urban Green Space and Obesity in Older Adults

By Seraphim Dempsey, Anne Nolan and Seán Lyons (ESRI).

Nearly four out of five Irish adults over the age of 50 years are classified as overweight or obese, according to their body mass index (BMI). The problem is significant for other age groups as well. Obesity confers a higher risk of health problems including cardiovascular disease, diabetes, osteoarthritis and some cancers. One contributor to this problem in recent decades is thought to be the shift of the population into urban areas, which is often accompanied by a less physically active lifestyle.

Some international research suggests that green spaces, such as parks in urban areas, can encourage physical activity and help to reduce the rate of obesity in the urban population. However, this relationship is difficult to isolate because obesity rates can be influenced by many socioeconomic characteristics and behaviours. This study linked data on BMI for the subset of TILDA respondents living in urban areas of Dublin, Cork, Galway, Limerick and Waterford to digital maps showing how much green space is near their homes. Statistical tools were then used to see whether those living in areas with more or less green space are at an increased risk of obesity after taking into account

many other socioeconomic characteristics of these individuals.

3.4.1. Data and methods

Information on individuals' BMI and other socioeconomic characteristics is available in TILDA Wave 1, collected in 2009–2011. To calculate BMI, TILDA nurses measured the height and weight of study participants, so the researchers are confident that these measurements are accurate. The dataset contains other relevant data, including age, income and educational attainment.

The researchers calculated the share of green space in a 1.6-km circle around each participant's home and then classified participants into five "quintiles" of green space, from the lowest to the highest share. There are many ways to estimate the availability of green space to urban residents, but the share of green space in a zone around the home is a popular method among researchers studying this topic. This statistic does not directly measure how much each person uses parks or other green spaces or how accessible they are; instead, it is a "proxy" variable that was included to capture the relative availability of green space in different residential areas. Statistical tools were then used to check how the probability of being obese (BMI ≥ 30 kg/m^2) varies across areas with more or less green space, controlling for characteristics of individuals and areas that might be related to obesity, e.g. age, income, gender, smoking, level of education or the presence of a mobility impairment.

3.4.2. Results and policy implications

People living in urban areas with a medium amount of green space showed a lower risk of obesity than those living in urban areas with the most or least amount of green space (Figure 3.1). The relationship was statistically significant and large: people who lived in an area with the lowest or highest share of green space were 13 percentage points more likely to be obese than those who lived in an area with the medium amount of green space.

It is not surprising that those living in urban neighbourhoods with very little green space might have a higher risk of obesity, but why might the greenest urban areas also have elevated obesity rates? It seems likely that there is some other feature of the urban landscape that affects the relationship

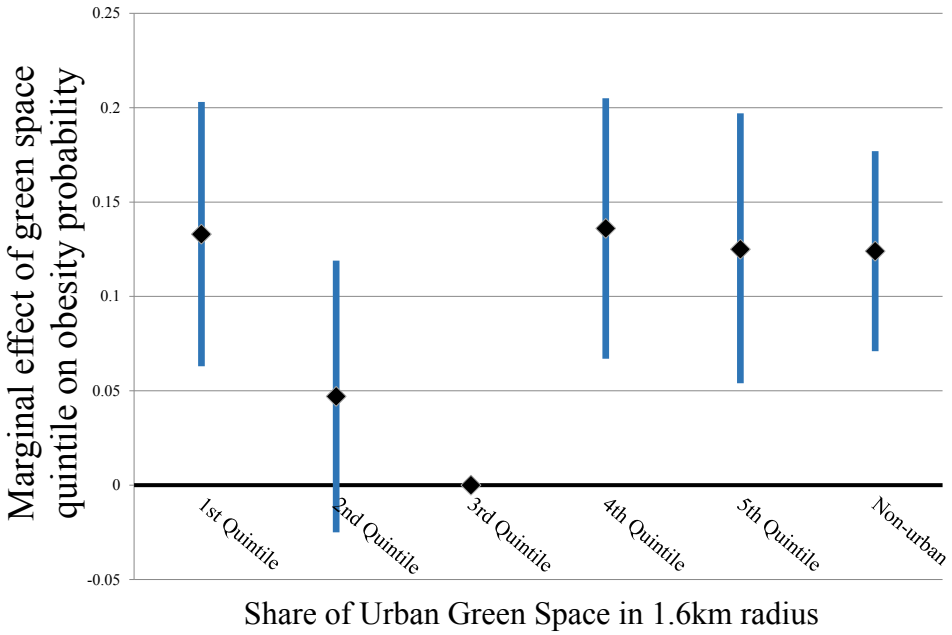


Figure 3.1. Marginal effects of green space quintile (relative to the third quintile) on the probability of obesity. Vertical bars represent 95% confidence intervals. Source: reproduced from Dempsey *et al.* (2018b). This article is an open-access article published under the terms of the Creative Commons Attribution-NonCommercial-No Derivatives License (CC BY NC ND) (https://creativecommons.org/licenses/by-nc-nd/4.0/).

between green spaces and obesity. For green spaces to encourage physical activity and thereby benefit health, they need to be not only available, but also accessible. For example, it may be that people walk less in areas on the outer fringes of urban areas because these areas lack footpaths.

However, considering the data used in this study, one cannot rule out the possibility that the lower obesity risk in areas with a medium amount of greenness might actually be driven by other unidentified factors affecting BMI in these areas. Research using data that are more detailed on land use will be needed to better understand the complex relationships between neighbourhood characteristics and health-enhancing behaviours.

The research underpinning this study has been published in a peer-reviewed academic journal (Dempsey *et al*., 2018b).

3.5 Coastal Blue Space and Mental Health of Older Adults

By Seraphim Dempsey (ESRI), Mel T. Devine (University College Dublin), Tom Gillespie (NUI Galway), Anne Nolan (ESRI) and Seán Lyons (ESRI).

3.5.1 Introduction

Most research linking the natural environment to health outcomes has focused on green space. However, there is evidence that exposure to "blue space" also confers various health benefits. Blue space is defined by the BlueHealth project (Grellier *et al*., 2017) as "outdoor environments either natural or manmade that prominently feature water and are accessible to humans either proximally (being in, on or near water) or distally/virtually (being able to see, hear or otherwise sense water)".

A systematic review by Gascon *et al*. (2017) reports a positive association between blue space and mental health, well-being and physical activity. However, results for general health, obesity and cardiovascular health are less clear. Four of the studies reviewed by Gascon *et al.* (White *et al*., 2013a,b; Alcock *et al*., 2015; Triguero-Mas *et al*., 2015) specifically address the relationship between exposure to blue space and depression.

Why might blue space exposure assist mental health? Nutsford *et al*. (2016) emphasise three possible channels. The first two channels are indirect, with the third being direct:

1. encouragement of physical activity (e.g. swimming, walking on beaches), which in turn is linked to mental and physical well-being;
2. increased social interaction, leading to a greater sense of belonging and social cohesion; and
3. acting directly as therapeutic or salutogenic (health and well-being promoting) places.

This study made a unique contribution to the literature by examining the association of both proximal and visual measures of coastal blue space with risk of depression among older adults in Ireland.

3.5.2 Data and methods

Similar to the research described in sections 3.3 and 3.4, the researchers relied on Wave 1 data gathered by TILDA on individuals aged over 50 years living in Ireland. The indicator of depression risk used in this study was each individual's score on the Center for Epidemiologic Studies Depression Scale (CES-D). This self-reported metric uses a set of questions to measure depressive symptomatology and it has been used widely in studies of older adults.

Data on TILDA respondents were linked to information on the blue space exposure at their place of residence. This was measured in two ways. Proximity to blue space was calculated based on the straight-line distance from each residence to the nearest point on the coastline, which is a measure commonly used in international research on blue space. A more novel measure of sea views was also calculated: the share of coastal blue space in the total space visible from each respondent's home:

$$\text{Seaview} = \frac{\text{Simulated visible sea area}}{\text{Total area within local horizon}} \qquad (3.1)$$

Both proximity and views were estimated for all TILDA respondents living within 10 km of the coastline and these variables were divided into categories of ascending blue space exposure to help protect confidentiality. Including both visual and proximal exposures allowed the researchers to test whether

these different forms of exposure had independent effects and enabled examination of which might be more strongly associated with depression risk in older people.

3.5.3 Results and discussion of findings

When coastal proximity and coastal views were both included in the model, only the individuals in the highest category for share of coastal views showed a significantly lower risk of depression than those with no views. There was some evidence of a beneficial association between coastal proximity and depression risk, but this was no longer statistically significant when views were included. The scale of the association between visual blue space exposure and reduced depression risk was large. By way of comparison, it is commonly understood that depression risk is higher among those on the lowest incomes. Being in the highest coastal view category compared with the lowest showed a similar drop in depression risk to being in the second quintile of income rather than the lowest, or a decrease of 9.58% of a standard deviation (SD) in the CES-D scores.

These findings are supportive of the view that the primary channel for mental health benefits of blue space for older people is visual. However, the nature of the data means that one cannot be certain that blue space caused a reduction in depression risk, only that the association between them was consistent with the possibility of a beneficial effect. Nevertheless, the association was large in absolute terms. In measuring this association, the researchers also allowed for many other factors that might be expected to affect depression risk. Further research is needed to convincingly establish the line of causation and attribute these effects to underlying mechanisms (e.g. unpacking possible associations with mediators such as social engagement, physical activity and stress).

Moreover, as the current study focused exclusively on older adults, it would be useful to explore whether people in other life stages show similar results. The methods used here could also be applied in other jurisdictions where data on relevant health outcomes are available at the individual level, provided the data include spatial locations.

The research underpinning this study has been published in a peer-reviewed academic journal (Dempsey *et al*., 2018).

4 Picture or Playground: Valuing Coastal Amenities

By Tom Gillespie (NUI Galway), Stephen Hynes (NUI Galway) and Ronan C. Lyons (Trinity College Dublin).

4.1 Introduction

Understanding consumer preferences for housing is useful for policymakers in its own right and also because of what one can learn from it about the economic value of local amenities. Although there is no explicit price for many neighbourhood amenities, property market data can be used to reveal the value that market participants place on such characteristics. In essence, a property can be thought of as a bundle of physical attributes and local amenities. Using statistical methods, it is possible to estimate the part of the value contributed by each of these components.

This study used data from Ireland's property market to estimate the economic value of coastal blue space. Compared with international studies on similar topics, the data sample available for Ireland is unusually large and includes both sale and rental information. It also spans a period with both growing and contracting market conditions. Most importantly, it is possible to separately estimate the premium values commanded by coastal proximity and views. This can help cast light on whether market participants mainly value the recreational (i.e. "playground") opportunities offered by coastal blue space or the aesthetic aspects (i.e. the "picture").

4.2 Data and Methods

A large sample of prices, rents and characteristics of residences was obtained from the daft.ie property listings website. This dataset covers approximately 160,000 properties for sale and 340,000 properties for rent from quarter 1 2006 to quarter 2 2017. As well as information on the prices and rents offered by vendors, there is information on structural characteristics known to affect property values, such as the building type (e.g. apartment or one of various types of houses) and number of bedrooms and bathrooms. Many other characteristics were identified from the text information contained in each advertisement. A set of local or neighbourhood characteristics was linked to the property data based on the spatial location of each property.

Adding to the local characteristics, GIS software was used to generate information about a property's distance from the nearest point on the coastline and the extent of any sea views it might enjoy. Coastal distance variables distinguish between coastline with cliffs, beaches with a Blue Flag designation, other beaches and sand/shingle. A three-dimensional "viewshed" simulation analysis was carried out to characterise the extent of the sea views for each property. These variables take the form of novel metrics for the horizontal breadth and vertical depth of sea views. Data from property advertisements indicating the presence of sea views were also used to enrich this analysis. As a check of the robustness of these metrics, a separate measure of sea views was tested for a subsample based on data from light detection and ranging (LIDAR) measurements.

The price of each property was modelled using hedonic regression methods, as a function of its attributes and local amenities. This is a well-established approach in economics and effectively divides the price into components associated with each housing attribute or amenity, as well as taking into account general changes in house prices over time for each local property market. A similar set of models was estimated to explain rental values.

4.3 Results

"Blue space" amenities were found to have a significant positive value in the Irish housing market. Proximity to both shingle/sand coastline and designated beaches enjoyed premium prices. Sea views also showed a positive valuation, using both breadth and depth indicators. These picture and playground effects were independently significant, taking into account the correlation between living near the coast and having a view of the sea. The results were similar for rents, although the blue space premium on rents was generally lower than for sales.

The effects were large enough to be economically important. For example, moving a property 400 m away

from a designated Blue Flag beach would imply about a 2% fall in its sale price on average. For a property close to the sea, moving from the average (median) sea view to the top quartile is associated with about a 10% higher price. The price effects associated with varying levels of distance and views are summarised in Table 4.1.

The results are subject to some caveats, however, notably that sea views were simulated rather than measured, and sale prices and rents were based on offers rather than final transaction prices. Nevertheless, a range of checks carried out by the researchers suggested that the broad findings were robust.

This study demonstrates that coastal amenities offer significant flows of societal value, some of which are capitalised in the form of housing wealth. Governments may choose to draw on elements of this value as a contribution to the costs of maintaining coastal amenities, for example by applying property taxes. Methods such as those used in this study can help inform local infrastructure cost–benefit trade-offs, for example when assessing whether or not to build a sea wall that would limit sea views but also reduce future costs associated with coastal erosion.

There may also be planning implications associated with the finding that residential coastal proximity and views are highly valued. High-density development closer to coastlines might have significant economic and societal value if the benefits are not fully offset by flood risk and other negative factors.

The research underpinning this chapter has been published in a working paper (Gillespie *et al.*, 2018) and is under peer review by a journal.

Table 4.1. Standardised monetary price effects of key regressors

Variable	Sales			Rentals (monthly)		
	1 SD effect	Mean	SD	1 SD effect	Mean	SD
Distance to:						
Shingle (m)	€10,377	3622	2992	€20.38	3358	2676
Beach (m)	€1721	5976	4268	€6.61	5761	3668
Blue Flag beach (m)	€6225	10,643	7595	€4.62	9878	6772
Cliffs (m)	–€6983	8007	4618	€19.56	9050	4079
Sea view:						
Breadth (inner score)	€5118	82	71	€27.03	109	82
Distant (middle score)	€646	170	149	€12.85	169	141
Depth (°)	€10,724	2.12	1.68	€11.31	1.50	1.48

The above table shows 1 SD price effects, together with mean and SD values, for seven key regressors, using results from the nationwide samples, as shown in Tables 2 and 3 in Gillespie *et al.* (2018).

5 Changes in Land Cover and Urban Sprawl in Ireland in Comparative Perspective from 1990 to 2012

By Achim Ahrens and Seán Lyons (ESRI).

5.1 Introduction

Economic development involves changes to the way that land is used, often transforming natural green spaces to artificial landscapes. One function of strategic urban planning is to manage this process and limit the negative consequences of economically and environmentally inefficient land-use patterns. However, policymakers often find it difficult to resist local developments that suit some individuals or firms but have negative societal consequences. Many such decisions can lead to increasingly land-intensive, low-density and scattered use of land. This phenomenon is referred to as sprawl. This study compared changes in the patterns of land use in Ireland with corresponding changes in other European countries during the period from 1990 to 2012. A new statistical test for sprawl was also developed and applied to the Irish case.

5.2 Data and Methods

The main data source was the Corine Land Cover programme managed by the European Environment Agency. This programme uses satellite images to classify areas across Europe into categories based on what vegetation or structures cover the land. For example, some areas are classified as pasture or forest and others are described as urban fabric or industrial sites. As the focus of the research was on changes in land use, the analysis investigated transformations of land cover over time, such as urbanisation (changing from natural to artificial landscapes) or afforestation (planting new forests). These transformations were used to compare trends in land use in Ireland with trends in land use in other European countries.

A formal test for sprawl was also developed based on the intuition that, if populations and buildings are clustered in a few areas, the level of sprawl tends to be low. On the other hand, if populations and buildings are distributed uniformly across space, sprawl is at its maximum potential. The approach in this study used statistics to test whether growth in population density has been faster in previously low-density (i.e. rural) areas than in high-density (i.e. urban) areas.

5.3 Results

The biggest transformations in land area involved forests and agricultural land, partly because the stock of land used for such purposes was (and is) much larger than that used for urban areas or other artificial landscapes. Afforestation was particularly high in Ireland, involving about one-third of the transformed area; the rest of Europe experienced a small net reduction in forest area. Agricultural intensification (i.e. from pasture to arable) also represented a significant amount of transformed land. In total, between 1990 and 2012, 11.9% of land was transformed in Ireland compared with 4.2% in the rest of Europe. Conversion was higher in Ireland in all categories studied (urbanisation, intensification of agriculture, extensification of agriculture, afforestation and deforestation) apart from two: construction and management of water bodies, and de-urbanisation.

Urbanisation made up a smaller share of total land transformations, accounting for 6.3% of total transformations in Ireland and 12.9% in the rest of Europe. Although the rate of urbanisation slowed down significantly in Ireland after 2006, it remained more stable in the rest of Europe. It is important to track trends in urbanisation as de-urbanisation is rare, making transformations into urban areas effectively permanent. New land area for industrial purposes increased as a share of total urbanisation over the period, from less than 10% during 1990–2000 to 50% in 2006–2012. On the other hand, the formation of non-agricultural green spaces (e.g. parks) fell from 25% to less than 5%. Similarly, the formation of other urban fabrics decreased from almost 50% to 25%.

The study found that, relative to other European countries, urban areas created in Ireland tend to be further away from other developed areas, resulting in sprawl (see Figure 5.1, which shows that there was a

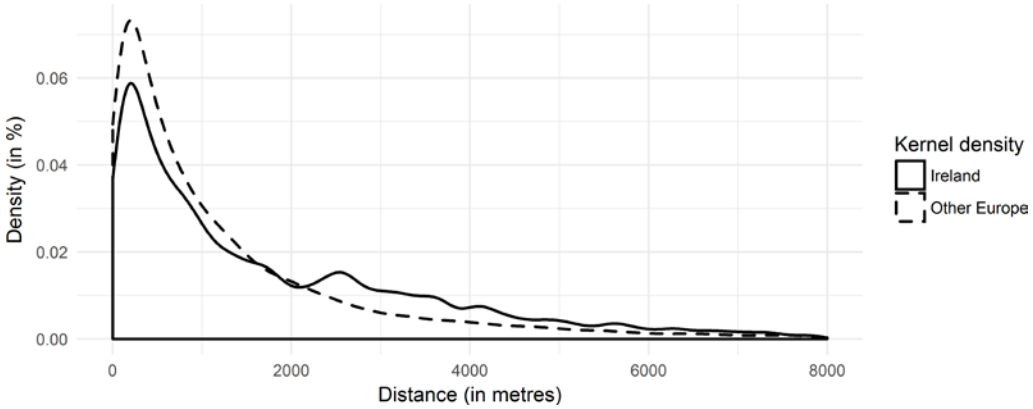


Figure 5.1. Distance of new artificial areas to existing artificial structures for Ireland and "other Europe" over the period 1990–2012. Source: Ahrens and Lyons (2019). This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).

higher density of new artificial areas created more than 2 km from existing artificial structures in Ireland than in the rest of Europe). This makes Ireland an important case study for other countries experiencing rapid economic growth and extensive construction activity. Using a new statistical test for sprawl, robust evidence was found that low-density areas in Ireland exhibited a higher growth in population density and building stock than high-density areas, implying that the population structure was becoming more dispersed over time. Past research has shown that sprawl and the transformation of urban green spaces into artificial land uses can have harmful effects on public health, quality of life, the cost of providing transport, efficiency of energy distribution, costs of providing public services and the quality of the environment. To address such adverse effects requires effective policies that can alleviate sprawl.

The research underpinning this chapter has been published in a peer-reviewed academic journal (Ahrens and Lyons, 2019).

6 Use of Behavioural Economics Laboratory Experiments to Examine Environmental Influences on Consumer Behaviour

By Áine Ní Choisdealbha and Peter D. Lunn (ESRI).

6.1 Introduction

Environmental protection is a multifaceted challenge requiring an array of solutions. One approach is to change individual or household behaviour (Dietz *et al*., 2009). This approach is necessarily a composite of many different strategies given the number of household behaviours that require energy use or that have other environmental impacts, and the range of economic, psychological and contextual factors driving each of these behaviours. Recent work in environmental economics has recognised this and has reached beyond traditional "rational choice" theory, which struggles to characterise behaviour accurately in the "non-market" domain of the environment. Recent approaches have sought to exploit advances in behavioural economics, in which psychological mechanisms are incorporated into models of economic decision-making and behaviour (Shogren and Taylor, 2008; Shogren *et al*., 2010;).

The behavioural approach has increased the use of experimental methods. One significant contribution to environmental protection and management has been to inform interventions designed to promote energy conservation. Many effective interventions have been tested in randomised controlled trials and field experiments, including energy labelling (Deutsch, 2010; Kallbekken *et al*., 2013), educational programmes (Boudet *et al*., 2016) and feedback (Allcott, 2011; Lynham *et al*., 2016). However, although experimental studies like these are effective tests of whether a particular intervention works, it is not always possible to infer why the intervention works (Cartwright, 2007; Ludwig *et al*., 2011). In some cases, interventions that have been found to be effective in some contexts are not effective in others. For example, although labelling appliances with the cost of energy use affected purchases among Finnish consumers (Kallbekken *et al*., 2013), no effects were found for a similar intervention conducted in Ireland (Carroll *et al*., 2016). Likewise, an educational programme enacted with Girl Scouts in California was effective in teaching concepts about energy conservation and encouraging related behaviours, whereas a matched intervention did not have effects on concept learning and behaviours related to food and transport efficiency (Boudet *et al*., 2016). In seeking interventions that are likely to generalise effectively beyond the specific study context, and consequently to be of use to environmental managers in multiple locations and across multiple domains, experiments need to be designed that identify and test relevant cognitive mechanisms (Ludwig *et al*., 2011; Lunn and Ní Choisdealbha, 2018).

To this end, this chapter describes two laboratory experiments designed to investigate how the provision of different types of information affects consumers' decisions about the same products. The researchers exploited existing theories in cognitive psychology and behavioural economics on how information processing is affected by cognitive demand (Chaiken and Maheswaran, 1994; Evans, 2008) and how the framing of information can affect choices (Levin and Gaeth, 1988; Levin *et al*., 1998). The first experiment examined how information provided regarding a product's environmental impact (e.g. recyclability, carbon footprint), in a number of different formats, affected the overall environmental friendliness of participants' baskets at the end of the experiment. The researchers manipulated whether the same information was presented in a standardised, colour-coded format or in a written format, and whether it was framed to emphasise a product's environmental impact in a positive or negative light. Participants were tasked with making multiple choices, akin to completing a weekly list of groceries. Additional manipulations allowed the researchers to test whether or not the effects of information about products' environmental impacts differed when consumers had limited time to make their decisions and whether or not different formats of information made it easier for consumers to identify environmentally friendly products.

Whereas products in the first experiment were relatively heterogeneous, inexpensive and of low "involvement" (i.e. real-world consumers are unlikely to commit extensive decision-making time to them), the second experiment examined decisions in relation to an infrequently purchased product that represents a substantial financial decision for most consumers. This involved studying how the framing of an environmentally motivated hypothetical tax instrument affected consumers' preferences for different cars. In this case, consumers made repeated decisions between pairs of cars and the investigators varied whether the presentation of tax information emphasised a car's emissions or the financial cost of those emissions to the consumer.

Neither experiment was intended to be prescriptive in its conclusions for policymakers. The labelling formats used in each experiment were designed purely for experimental use and not for policy implementation. Rather, this pair of experiments was designed as a means of demonstrating that consumers evaluate and use the same information differently, depending how it is presented. This is likely to be particularly important in the domain of environmental protection, as individuals vary in their motivations and environmental values (Dietz *et al*., 2005; Stern *et al*., 1993). Consequently, it may be beneficial to find a means of presenting environmental information to consumers in a way that will affect the behaviour of a "typical" consumer, and not just the most environmentally committed consumers.

6.2 Experiment 1: Effects of Label Format and Frame on Consumers' Decisions

6.2.1 Overview

The difference in environmental impact between an individual choosing a locally grown piece of fruit and an individual choosing a piece of fruit flown from overseas may appear small, but grocery and household products are consumed in such high volumes that the potential effects of consumers switching to more environmentally friendly options could be substantial (Upham *et al*., 2011). Many programmes for providing environmental information about such products currently exist and have been shown to be effective (e.g. Teisl *et al*., 2002; Bjørner *et al*., 2004). The current study examined how the manner in which environmental information is presented to consumers affects their tendency to choose environmentally friendly options. Participants in this experiment were given a task in which they had to complete multiple shopping lists in an experimental environment designed to be like an online shop. In this way, the researchers were able to examine the effects of the experimental manipulations in a relatively naturalistic setting.

The information presented to consumers varied in a couple of ways. First, the information about each product was presented either as specific, verbal information or as a particular position on a colour-coded scale (Figure 6.1). Some existing labelling policies mandate that environmental claims about

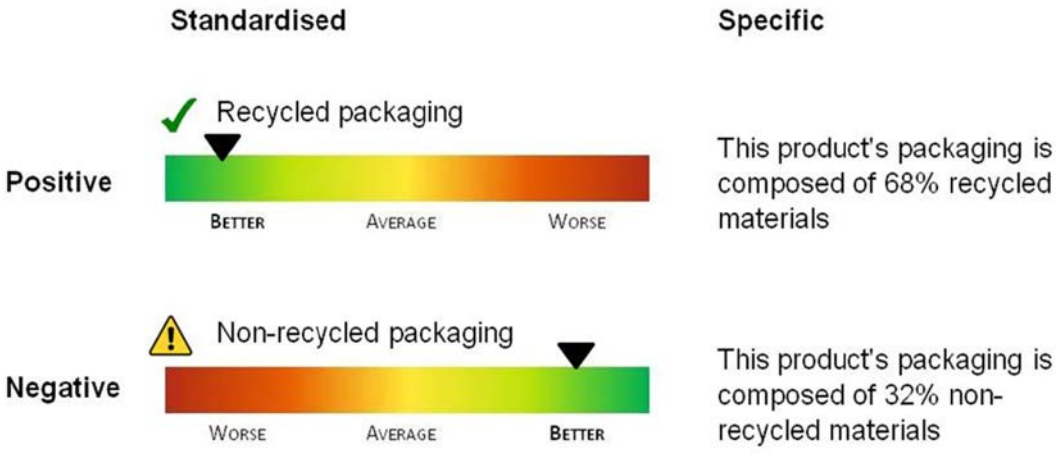


Figure 6.1. Information about the same product presented according to different conditions of format and frame.

products are backed up with specific information (e.g. Federal Trade Commission, 2012), whereas others present information on relative scales that allow different but similar products to be directly compared (e.g. EU energy efficiency label). In order to use eco-labels in their decisions, environmentally motivated consumers must trust those labels (Thøgersen, 2000). Specific information about environmental impacts improves consumers' trust (Atkinson and Rosenthal, 2014). In field studies, simplified, colour-coded information has been shown to be effective in shifting consumers' purchases to more environmentally friendly options (Vanclay *et al*., 2011). In this experiment, both types of label format were used to see if one format resulted in consumers purchasing more environmentally friendly products than the other.

The second way in which the researchers manipulated the information given to consumers was based on its frame, that is, whether it was presented in a positive or a negative light. In other contexts, consumers have been shown to rate the same product differently depending on how its attributes are presented. A famous example is that consumers prefer beef labelled as "75% lean" to identical beef labelled as "25% fat", even after taste tests (Levin and Gaeth, 1988). Existing research suggests that, in the environmental domain, consumers are more responsive to negative information (Grankvist *et al*., 2004; Borin *et al*., 2011). However, this experiment enabled the researchers to examine the interaction between format and frame, to determine if consumers evaluated negative environmental information differently when it was presented on a colour-coded scale relative to when it was presented as specific facts and figures.

The task performed by participants also varied in two ways. First, participants were asked to complete two shopping lists simultaneously (Figure 6.2). They were then asked to complete a list such as that in Figure 6.2a according to their own preferences. Finally, they were asked to imagine that a friend or family member had asked them to complete the list in Figure 6.2b and to choose products according to the requests of that person. This approach was designed to examine not only participants' overall tendency to select environmentally friendly options for each product on both lists, but also whether or not they were able to correctly identify environmentally friendly options. Although consumers tend to report a preference for "accurate" environmental product information (D'Souza *et al*., 2006), their understanding of what different "eco-labels" mean varies (Grunert *et al*., 2014). Creating an effective means of presenting information to consumers does not need to be about "nudging" or changing behaviour but about giving consumers transparent information that is not unnecessarily complex and that they can use in their decision-making (Sunstein, 2014). Indeed, consumers are more likely to use environmental information

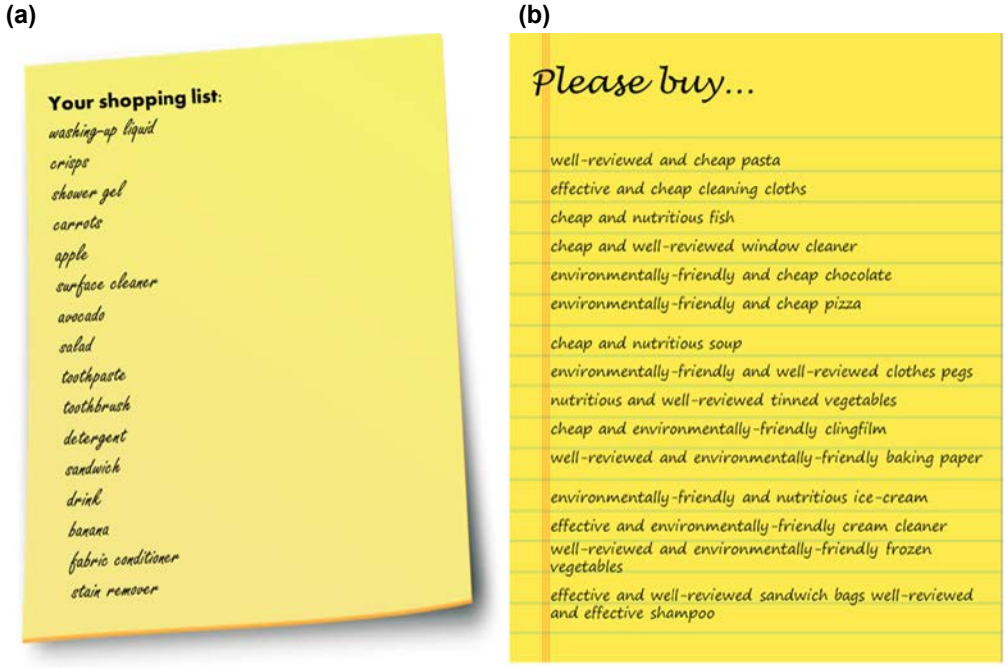


Figure 6.2. Examples of shopping lists presented to participants

in their purchase decisions when they understand what it means (Grunert *et al*., 2014). Consequently, an effective labelling programme will be one that allows consumers to identify environmentally friendly products, regardless of their own pro-environmental attitudes or motivations.

Second, participants undertook the shopping task twice. First, they carried out the task with no time limit given, although a maximum upper limit of 45 minutes was applied. Then, they were given new lists and a shopping environment with new options for each product and were asked to complete as much of each list as possible within 15 minutes. This manipulation was introduced because grocery shopping may be conducted when consumers are in different mental states (e.g. under increased time pressure), and time limits are known to render shopping according to one's plans more difficult (Park *et al*., 1989). This manipulation allowed the researchers to examine whether or not the different formats and frames of environmental information had different effects when consumers were under increased time pressure. In fact, shopping tasks with time limits and specific directions have been used in clinical contexts to examine cognitive impairments in planning and performing tasks efficiently (Shallice and Burgess, 1991). Given that environmental friendliness may not be as important an attribute to consumers as, for example, price or brand, it is important to know whether certain formats of environmental labelling affect consumers' decisions even when they are under increased task demand or cognitive load.

6.2.2 Methods

Sixty Dublin consumers (30 female, 30 male) were recruited by a market research company and were paid €15 for their time. Participants were balanced by employment status (employed, unemployed, retired and student) to match the local population distribution. The age distribution of participants is shown in Table 6.1.

The experimental environment resembled a typical supermarket website, with sections for food and household products and a cart for chosen products. This "online shop" was programmed in PsychoPy for Python (Peirce, 2007, 2009) and presented to participants on a laptop computer. Two visually distinct shops were programmed, each of which had the same types of products available, but with different options on offer. For example, each offered apples, but the types of apple on offer were different. Each participant completed the non-time-limited task in one environment and the time-limited task in the other environment. Figure 6.3 shows some of the different sections of the shop, giving an example of how these could be navigated to find a product. Participants would choose one of the four options for each product by clicking the "Add to Cart" button and could return to their decision and choose a different product later, replacing the previous choice. Participants were provided with a pen to tick items off their lists and make notes as they completed the task.

In total, 32 items across both lists were presented to each participant in each iteration (timed, untimed) of the task. For each of these 32 items, there were four options available. Each product was presented with four pieces of information – its price, an average customer review score, information about its environmental impact, and information either about its nutritional quality (for food products) or about its effectiveness (for household products). This fourth piece of information was also presented according to the manipulations applied to the environmental information, that is, it could be presented in a positive or a negative frame or in a specific or a standardised format. This allowed the researchers to examine whether the effects of information presentation applied specifically to environmental information or were more general.

The format and frame of information given about each option for a particular product were constant for a particular participant. For example, for one participant, all four options for a salad might be shown

Table 6.1. Age distribution of participants

	Age band (years)				
	18–24	25–34	35–44	45–54	55–70
Number of participants	12	12	13	13	10

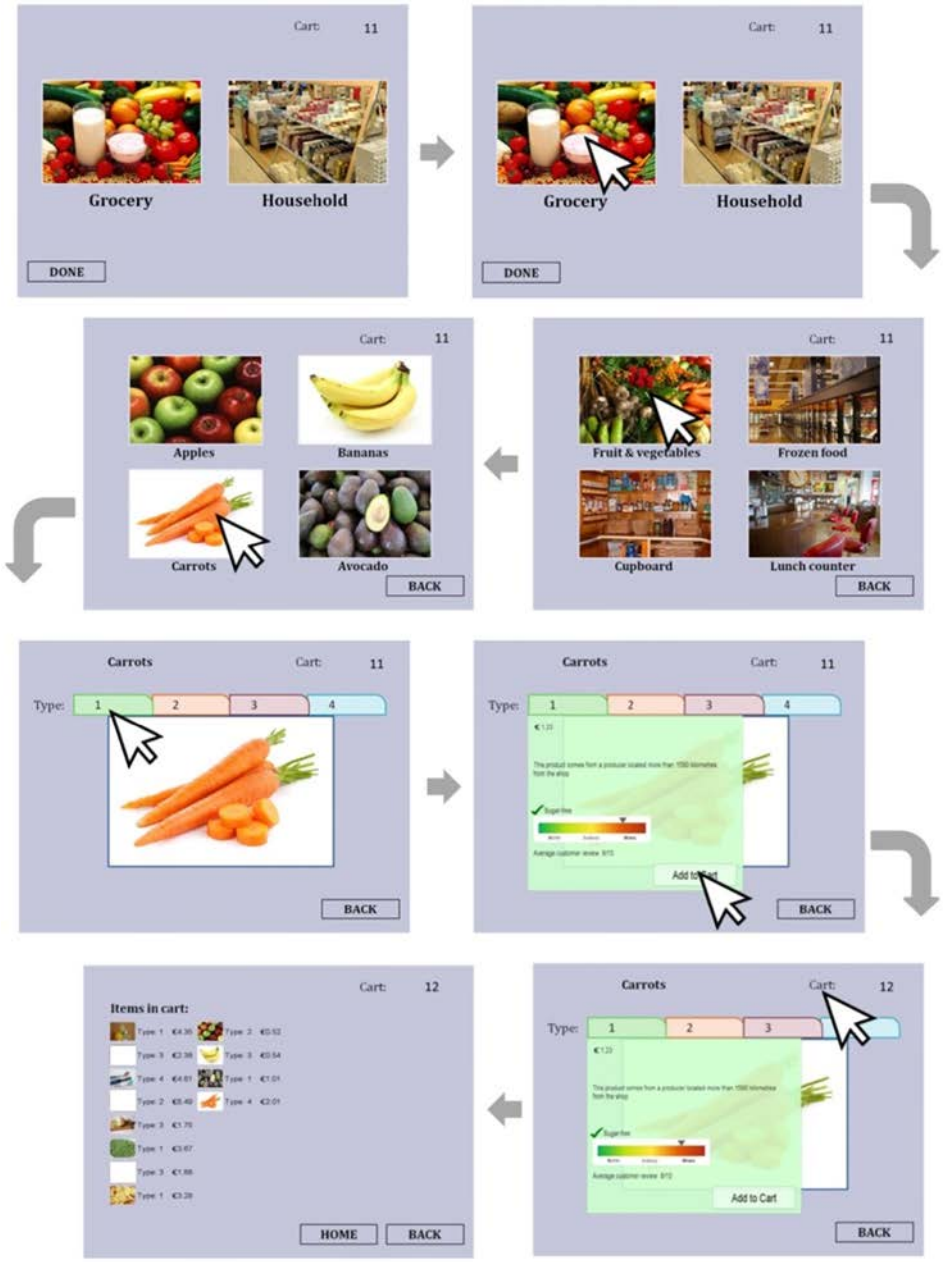


Figure 6.3. Depiction of different sections of one shopping environment and of how a product could be selected. Please see Appendix 1 for image credits.

with negatively framed, colour-coded environmental information and positively framed, colour-coded nutritional information. Other products would have different combinations of format and frame conditions. An example of how the information might differ across various options for the same product is shown in Figure 6.4.

An important note on how the products were designed is that each product was the best for one of the four attributes (price, review, nutrition/effectiveness and environmental impact), the second best for another, the second worst for another and the worst for another. The attributes were also paired for each product. For example, if environmental friendliness and price were paired, the cheapest product would be the second most environmentally friendly and the most environmentally friendly would be the second cheapest. In this way, if a participant's shopping list for their imagined family member or friend asked them to choose an environmentally friendly and cheap product, the participant would have to decide which attribute to prioritise in their decision-making or whether to

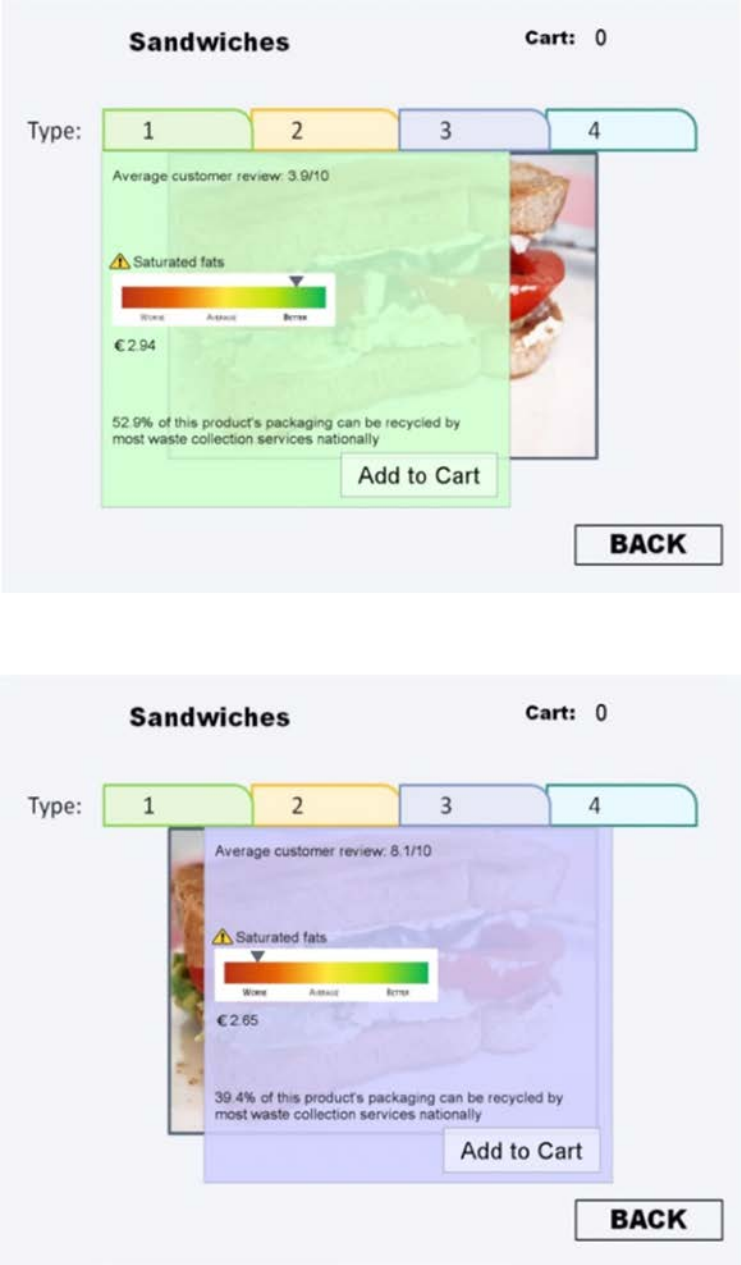


Figure 6.4. Depiction of how different options for one product were presented. Please see Appendix 1 for image credits.

use another attribute such as a review score as a tie-breaker.

6.2.3 Results

As expected, participants did not complete as many of the 32 items on their lists (i.e. did not add one option to their cart for all 32 products) in the time-limited task as in the task without time limits. The difference was small but statistically significant – participants completed a mean of 31.4 trials of 32 in the untimed task and 28.5 trials of 32 in the timed task. This amounted to 21 participants out of 60 who did not complete the untimed task and 38 out of 60 who did not complete the timed task.

Four products in each task had the same condition pairing (colour-coded and positive, colour-coded and negative, specific and positive, specific and negative) and appeared on the same shopping list (the participant's own list or their friend/family member's list). As noted previously, each product was ranked in first to fourth position for each attribute (e.g. cheapest, second cheapest, second most expensive,

most expensive). Each ranking position was given a score of 0 (worst) to 3 (best) and these scores were summed for the four products with the same conditions of format and frame appearing on the same list, with a maximum score of 12. When participants made choices on fewer than four of these products, the score was normalised.

On average, the rank (from 0 to 3) for each attribute of products chosen by each participant was similar (price: mean 1.53, SD 0.25; average customer review: mean 1.52, SD 0.22; environmental friendliness: mean 1.4, SD 0.17; nutrition/ effectiveness: mean 1.54, SD 0.19). The mean environmental score (0–12) of selected products by participants was 5.57, with a SD of 0.69, and the mean nutrition/effectiveness score was 6.17, with a SD of 0.78.

The descriptive results in Figure 6.5 suggest that, across both environmental attributes and the matched attributes (i.e. effectiveness or nutrition), participants selected products ranking higher on environmental friendliness when the information was presented in the relative, colour-coded format than when it was presented in the specific, verbal format. There does not appear to be an effect of positive or negative information frame.

This result was borne out in the mixed-effects regression models in Table 6.2. The only significant information-related effect was the effect of label format and this effect held for both the environmental product ranks and the control (nutrition or effectiveness) ranks. Two control variables were included in this model. First, a time limit indicator was included to test if participants differed in their overall choices of products based on environmental friendliness when they were making decisions under a time limit. This was not the case. Second, participants were occasionally directed to select environmentally friendly products by the second shopping list. The overall rankings of products selected by participants were compared based on how many of the items on the friend or family member's shopping list, within the same condition (same format, same frame), contained an environmental directive. Depending on how many trials of the group of four were completed, the set of trials containing a directive could represent a varying proportion of trials, as illustrated by the categories in Table 6.2. The results are as one might expect. Relative to when participants made decisions for their own "subjective" list, which had no attribute-related directions, participants were inclined to choose lower-ranked products when fewer than half of the trials contained an environmental direction and to choose higher-ranked products when more trials contained environmental directions.

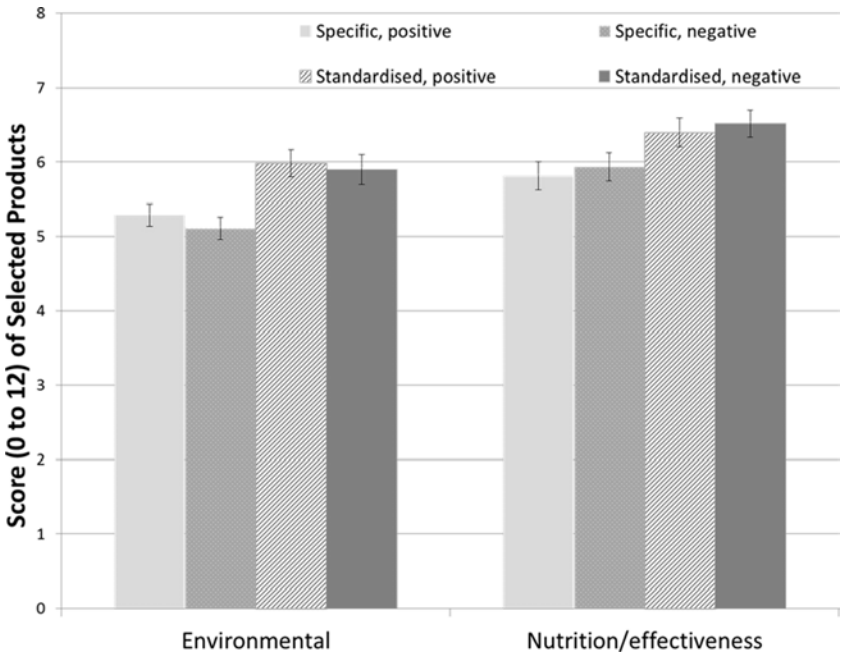


Figure 6.5. Mean score of products selected by participants according to attribute, information format and information frame.

Table 6.2. Random intercept models for scores (0–12) based on environmental ranking of chosen products (E1) or ranking by nutrition/effectiveness (N1)

Coefficient	E1	N1
Specific	Ref.	Ref.
Standardised	0.8 (0.21)***	0.63 (0.21)**
Positive	Ref.	Ref.
Negative	–0.14 (0.21)	0.14 (0.21)
Standardised*negative	0.11 (0.3)	0.08 (0.29)
Time limit	–0.19 (0.15)	–0.21 (0.15)
Directions contain attribute		
Subjective	Ref.	Ref.
0	–2.6 (0.46)***	–2.944 (0.413)***
¼ or ⅓	–0.86 (0.22)***	–1.754 (0.239)***
½	0.08 (0.2)	–0.356 (0.201)
⅔ or ¾	1.03 (0.24)***	0.54 (0.226)*
All	1.68 (0.41)***	1.844 (0.433)***
Constant	5.31 (0.19)***	6.105 (0.193)***
Participants	60	60
Observations	956	955

The results are presented as coefficients (standard errors).
***$p<0.001$; **$p<0.01$; *$p<0.05$.**

These results are mirrored in the model for the control attributes.

A second pair of models is shown in Table 6.3. These examined an interaction between the time limit and the format of the information provided to participants. In these cases, the results for the environmental attributes and the control attributes differed. Whereas a main effect of format remained significant for the control attributes, the format effect was significant for the environmental attributes only when participants engaged in the task with the 15-minute time limit.

This model specification revealed that, although participants selected less environmentally friendly products overall under the time limit, the products that they selected under the time limit were more environmentally friendly when the information given was in the standardised, colour-coded format than when it was in the specific, verbal format. This effect is shown in Figure 6.6.

Another aim of this experiment was to examine not only if participants chose more environmentally friendly products in response to specific formats or frames of information, but also if they were more likely to correctly identify environmentally friendly products in response to specific types of information. In this case, the analysis focused only on information format and examined whether the time limit would affect participants' ability to glean accurate information from the presented information. The researchers analysed the choice made by each participant for each item on the friend or family member's list with an environmental direction (or a nutrition/effectiveness direction), rather than grouping the items as in the analyses described earlier. "Correct" trials were classified as those in which, when directed to find an "environmentally friendly and cheap" product, for example, participants selected either the cheapest and second most environmentally friendly option or the most environmentally friendly and second cheapest option. The results in Table 6.4 show that, for items with a direction to find an environmentally friendly option, participants were more likely to correctly select a product when the information was provided in a standardised, colour-coded format than in a specific, verbal format. Note that these models were run as fixed-effect models because of a skew in the data, with the median participant used as the base case.

The same effect was not found for items for which the participant was directed to find a nutritious or effective

Table 6.3. Random intercept models for scores (0–12) based on environmental ranking of chosen products (E2) or ranking by nutrition/effectiveness (N2), including interactions with session (untimed versus time limit)

Coefficient	E2	N2
Specific	Ref.	Ref.
Standardised	0.38 (0.21)	0.63 (0.21)**
Positive	Ref.	Ref.
Negative	–0.09 (0.15)	0.19 (0.15)
Time limit	–0.66 (0.21)**	–0.26 (0.21)
Standardised*time limit	0.95 (0.29)**	0.1 (0.29)
Directions contain attribute		
Subjective	Ref.	Ref.
0	–2.63 (0.46)***	–2.93 (0.41)***
¼ or ⅓	–0.84 (0.22)***	–1.76 (0.24)***
½	0.06 (0.2)	–0.35 (0.2)
⅔ or ¾	1.06 (0.24)***	0.54 (0.23) *
All	1.63 (0.41)***	1.82 (0.43)***
Constant	5.52 (0.19)***	6.06 (0.21)***
Participants	60	60
Observations	956	955

The results are presented as coefficients (standard errors).
***$p<0.001$; **$p<0.01$; *$p<0.05$.**

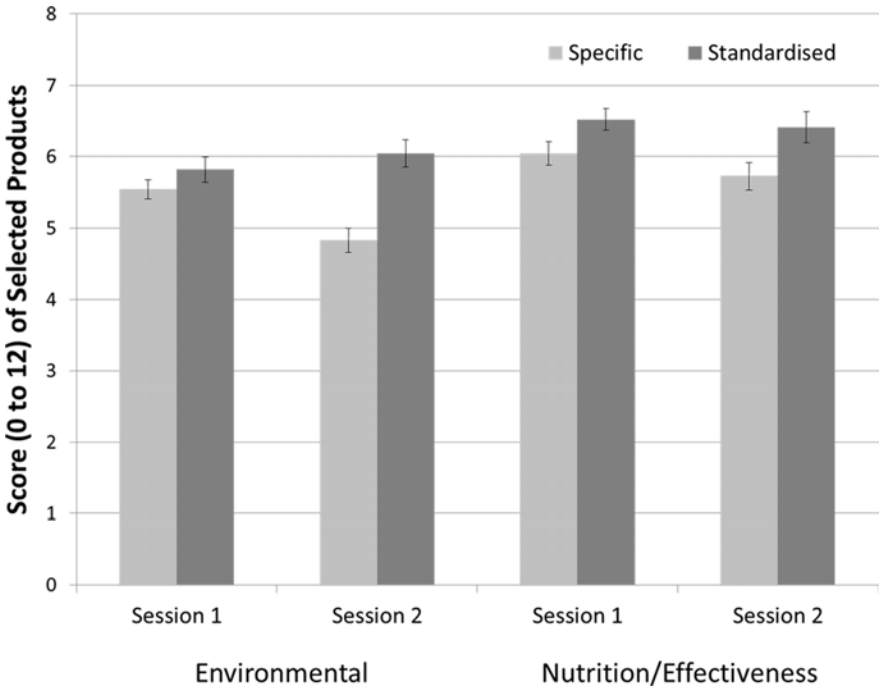


Figure 6.6. Mean scores for the standardised versus specific information formats, by attribute and session. Error bars show the standard error of the mean.

Table 6.4. Fixed-effect logit models for correctly selecting a product that matched the environmental (E3) or nutritional/effectiveness (N3) directive

Coefficient	E3	N3
Specific	Ref.	Ref.
Standardised	0.91 (0.25)***	0.28 (0.24)
Time limit	–0.13 (0.23)	0.01 (0.23)
Standardised*time limit	0.21 (0.37)	0.25 (0.36)
Constant	0.85 (0.6)	0.87 (0.6)
Observations	809	839

The results are presented as coefficients (standard errors).
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.**

product. Participants were no less likely to select the correct products when under time pressure than when given unlimited time, nor did the format of the information have a particularly strong effect under the time limit in this case.

6.2.4 Summary

Previous behavioural and survey research has suggested that environmental labelling can be effective at influencing consumer behaviour (e.g. Teisl *et al.*, 2002; Bjørner *et al.*, 2004; Vanclay *et al.*, 2011). However, in most cases these studies examine the overall effects of a particular information format or type of label. This experiment directly compared the effects of different formats of environmental information on consumers' choices. It also examined how consumers respond to these means of giving information in different contexts, specifically when they are making time-limited decisions compared with when there is no explicit time limit, and when they are asked to identify products meeting specific criteria compared with choosing products according to subjective preferences. The results indicate that participants chose higher ranked products when information was given in the colour-coded, standardised format than when information was given in a specific, verbal format. For environmental product information, in particular, the colour-coded, standardised format was particularly effective in two contexts. First, when participants made decisions under a time limit, they chose products that were more environmentally friendly when information was given in a colour-coded, standardised format than when information was given in the specific format. Second, when information was given in a colour-coded, standardised format, it resulted in participants correctly identifying environmentally friendly products more often. Although the experiment was not intended to advocate for a particular format of environmental information labelling, it does illustrate the benefit of testing labels or information provision policies across multiple decision-making contexts before implementation.

6.3 Experiment 2: Effects of Cost Information Versus Emissions Information on Consumers' Car Preferences

6.3.1 Overview

Energy use has been a common target for behavioural research and interventions intended to have an environmental impact. This is because there is a direct financial incentive for consumers to reduce their energy use – using less energy leads to lower energy bills. Drawing consumers' attention to the long-term financial cost of energy-using products has been shown to alter consumer choices in favour of more efficient options (Deutsch, 2010; Kallbekken *et al.*, 2013). Tax instruments can be used in a similar way to provide a financial incentive for consumers to make more environmentally friendly choices. The current experiment examined how different means of presenting consumers with a hypothetical tax instrument related to cars' NO_x emissions affected their expressed preferences between identical pairs of cars.

In Ireland, motor tax on cars registered since July 2008 has been applied based on their CO_2 emissions. Although taxes of this kind have been effective in reducing carbon emissions across many EU Member States (Dineen *et al.*, 2018), they can lead (and have led) to an increase in the proportion of diesel cars

purchased (Hennessy and Tol, 2011). In the 3 years before the tax was switched to this basis (2006–2008), an average of 29.2% of new privately registered cars each year were diesel vehicles, whereas, in the most recent 3 years available (2014–2016), 71.5% of new privately registered cars were diesel vehicles.[3]

The shift to diesel vehicles, although reducing carbon emissions, has led to an increase in emissions of NO_x. The inclusion of a NO_x component in motor tax has been suggested in other jurisdictions as a potential means of alleviating such emissions (Drummond and Ekins, 2016). In Ireland, NO_x levels may be up to 28% higher in 2020 than they were before the implementation of the 2008 motor tax system (Leinert *et al*., 2013). Although further research on specific impacts is required, increasing the number of diesel vehicles on the road affects air quality, which, in turn, is likely to affect health outcomes (Shaw *et al*., 2014). Poor air quality may also be a risk factor for dementia (Killin *et al*., 2016; Carey *et al*., 2018).

This study created a hypothetical motor tax component based on the NO_x emissions of vehicles. The assumed "cost" per tonne of NO_x emitted was based on the Department of Transport, Tourism and Sport's Common Appraisal Framework.[4] The hypothetical annual tax charged for NO_x emissions was based on the cost of emissions expected if the car was driven the average distance travelled by Irish private vehicles per annum.[5] To mimic the exponential nature of the CO_2 emissions-based motor tax, costs were linked to specific ranges of emissions. The ranges were defined based on EU directives to reduce cars' exhaust emissions by implementing specific standards for car manufacturers. Cars that emitted NO_x at or below the Euro 6 (petrol) standard of 60 mg/km had the NO_x-related charge halved or, at the lowest level, eliminated. Cars that emitted more NO_x than the Euro 6 standard but less than the Euro 3 standard (150 mg/km) had the charge doubled. The Euro 3 standard was the first to set limits for NO_x as a single set of emissions. Finally, cars that emitted more than twice the Euro 3 standard (≥300 mg/km) had the charge quadrupled.

Participants were presented with 36 different pairs of cars, with each pair repeated four times with the motor tax presented in different ways. With the exception of an initial condition that had no NO_x-related charge applied to the motor tax, the difference between the choices was the manner in which the NO_x-related charge was displayed. For this reason, the precise level of the charge was unimportant (except that one would expect higher costs to be less acceptable to consumers) – what was important was whether consumers responded differently when the tax was presented in different ways. Nonetheless, the hypothetical NO_x charges are displayed in Table 6.5.

A secondary manipulation was the provision of information about the cars' fuel efficiency, to examine whether giving participants information on fuel usage in terms of cost (e.g. cost per 100 km, cost per week of driving) or in terms of usage (e.g. kilometres or weeks of driving per €100) would affect their preferences. Crucially, it also tested whether presenting these costs as large, long-term costs or small, immediate costs would have an effect. In the context of energy-using appliances, although presenting cost of use to consumers can push their decisions towards more efficient options, even if the upfront cost of an

Table 6.5. Categories of NO_x emissions and hypothetical additional tax charges.

	Emissions (mg/km)										
	<30	30–45	45–60	60–80	80–100	100–125	125–150	150–200	200–250	250–300	>300
Cost (€)	3	4.50	6	8	10	12.50	15	20	25	30	50
Adjusted charge (€)	0	2	6	16	22	30	39	60	85	110	200

3 See https://www.cso.ie/multiquicktables/quickTables.aspx?id=tea03 (accessed 20 August 2019).

4 See http://www.dttas.ie/sites/default/files/publications/corporate/english/common-appraisal-framework-2016-complete-document/common-appraisal-framework.pdf, p. 88 (accessed 20 August 2019).

5 The figure used for calculations was 17,000 km per annum. Actual figures: 17,367 km in 2015 and 18,000 km in 2016. See https://www.cso.ie/en/releasesandpublications/ep/p-tranom/to2016/rtv/ (accessed 20 August 2019).

appliance is higher, if the period over which the cost of use is presented is too short (making the cost appear lower) this effect does not occur (Heinzle, 2012). Cars are high-cost purchases and therefore it is possible that only costs displayed for long periods of use (e.g. years) or long distances (1000s of kilometres) will have an effect on consumers' stated choices.

6.3.2 Methods

Ninety-five participants were recruited by a market research company. Participants were aged between 22 and 60 years. They took part in this experiment as the third of a set of three consecutive experiments on consumer reasoning and consumer choices and had a short refreshment break before starting this experiment. The experiment was conducted in line with ESRI ethics board guidelines. Participants were paid €30 for their participation in the set of experiments.

The stimuli presented to participants appeared as in Figure 6.7. For each two-alternative choice, participants viewed multiple attributes about both cars – an image of the car, the manufacturer name, the model name, the price, the motor tax and efficiency information (which was presented on screen as the "running cost"; participants were told that this was the cost of fuel). Fuel cost and motor tax information varied across blocks of the experiment. Participants' choices were made on a laptop computer and the experimental environment was programmed in PsychoPy (Peirce, 2007, 2009).

There were 18 subsets of cars, split across three ages (new, 5-year-old second-hand car and 10-year-old second-hand car) and six types (supermini, small hatchback, hatchback/estate, estate/family saloon, SUV/people carrier and luxury saloon/coupé). Nine cars were selected for each subset. Each subset contained a variety of petrol and diesel vehicles and, except for the 10-year-old second-hand category, at least one electric or hybrid vehicle. Cars were selected so that there would be variation in the tax categories that the cars fell into for CO_2 and NO_x emissions.

The cars that participants viewed were selected using the UK Vehicle Certification databases from 2007 to 2016. Information on fuel cost, NO_x emissions, and

Figure 6.7. Identical trial shown across different blocks. In (a), no NO_x charge was added to the annual motor tax. In (b), the NO_x charge was added but not partitioned. In (c), the NO_x charge was again shown unpartitioned, but with the car's level of emissions per kilometre driven displayed. Finally, in (d), the motor tax was partitioned into its existing component and the hypothetical NO_x charge.

CO_2 emissions was extracted from these databases. Prices for new cars were based on car dealers' advertising materials. Prices for 5-year-old and 10-year-old cars were set by visiting a popular national website for second-hand cars and using the value of the median-priced advertised car (for the given make, model, fuel type and year).

The presentation of this tax information varied across blocks as follows, as shown in Figure 6.7. In block 1, the motor tax presented was the standard, CO_2-based emissions tax. In block 2, the NO_x-related charge was added to this standard tax. In block 3, the NO_x-related charge was added and the car's NO_x emissions in milligrams per kilometer were also provided. In block 4, the motor tax was partitioned into the standard, CO_2-based component and the NO_x-related charge.

NO_x emissions were also calculated for electric vehicles and for the electric component of plug-in hybrid vehicles' energy use by obtaining information on the proportion of non-renewables in the fuel mix used by the Irish energy sector, along with the sector's NO_x emissions and overall energy consumption in the country. These figures were used to calculate NO_x emissions per kWh; using information on the distance driven per kWh by each car, the NO_x emissions emitted by each car in a year of driving the average distance (17,000 km) were calculated.

Efficiency information varied on two dimensions: the size of the figure presented and the unit of usage. The unit of usage also varied on two dimensions. First, usage could be expressed in terms of distance travelled or time spent travelling; second, it could be expressed as the cost of travelling a fixed distance or for a set amount of time or as the distance or time that one could drive for a fixed cost. This resulted in 16 efficiency conditions, shown in Table 6.6. These were counterbalanced across participants. Each participant saw one of each unit size (one per block) and one of each unit type (one per block). The combinations of unit size and type, and the block in which they appeared, were pseudorandomised per participant.

Participants were instructed to consider the next time they would buy a car and the type of car they might buy; they were told that they would be making decisions about which car they preferred between many pairs of cars. They were asked to narrow down the type of car they might buy, first by selecting the age of car they preferred and then by selecting the type of car they preferred. In each block of the study participants made choices between all possible pairings of the resulting nine cars, giving 36 trials per block. In this way, participants made decisions between the same pairs in each block, although the order in which the 36 choices were presented varied by block. Participants clicked on whichever of the two cars they preferred to select it. The left–right positioning of each option was pseudorandomised.

Before the first block, the different attributes of the cars were explained to participants, including that fuel cost per time (or time of driving per fuel cost) was based on an average driving distance of 17,000 km per year. Participants were told to consider that, if they drove more or less than that, the cost to them would likely be higher or lower, respectively, than the cost presented on screen. The nature of motor tax, i.e. the way it is based on CO_2 emissions, was also briefly explained. The differences between electric, plug-in hybrid, battery hybrid and petrol/diesel vehicles were also explained, which included flagging the typical range of an electric vehicle between charging (distinguishing between newer and older models in this case). This explanation was given to offset the potentially unrealistic preference that might be given to electric vehicles relative to participants' real-world choices, based on their low fuel cost relative to other vehicles. Participants were also given an explainer sheet that recapped this information about average driving distance and different vehicle types.

Table 6.6. Efficiency conditions

Size	€ per time	Time per €	€ per distance	Distance per €
Small	€ per day	Days of driving per €100	€ per 100 km	km per €50
Small to mid	€ per week	Weeks of driving per €100	€ per 1000 km	km per €100
Mid to large	€ per month	Months of driving per €1000	€ per 7500 km	km per €500
Large	€ per year	Years of driving per €5000	€ per 20,000 km	km per €1000

Before the second block, participants were told that a charge based on NO_x emissions had been added to the motor tax for the vehicles and were given an explanation about why this had been added (i.e. because of environmental damage and health problems caused by NO_x). The application of NO_x charges to electric vehicles was also explained (i.e. energy generation results in NO_x emissions). Before the third and fourth blocks the additional manipulations were also explained. Participants were told that, in block 3, each car's emissions per kilometre driven would be shown and that, in block 4, the tax would be split into the standard component and the NO_x emissions-related charge and that these would need to be added together to find the annual motor tax due on each car. At the end of the experiment, participants answered additional questions related to the experiments in which they had participated. The two questions related to this experiment asked whether they were current car owners and whether they intended to purchase a car in the next year, next 3 years or next 5 years or had no plans to purchase a car.

6.3.3 Results

A logistic mixed-effects model was used to examine how the different means of presenting information on NO_x emissions affected the probability of participants selecting the car with the lowest NO_x emissions in each condition. When the motor tax displayed had no NO_x-related component, 39 out of 95 participants selected the car with the lowest NO_x emissions in more than half of the trials (i.e. choices); this number rose to 48 participants when the NO_x component was added. Figure 6.8 illustrates this change across conditions. This descriptively suggests that the hypothetical tax chosen was large enough to create a financial incentive for participants to change their preferences, and this was borne out in the statistical model (Table 6.7). The model used the second condition, in which the existing CO_2-related and hypothetical NO_x-related components were displayed as a single figure. This allows one to see changes in consumers' responses based on the information given and not on the financial incentive of the tax. This number rose again to 67 participants when the quantity of emissions was displayed and to 57 participants when the motor tax was partitioned into existing (CO_2-related emissions) and NO_x-related components.

The results show that participants were less likely to select the low NO_x-emitting vehicle in each pair when there was no NO_x charge than when the NO_x charge was included. They were more likely to select the low NO_x-emitting vehicle in the third and fourth conditions, in which additional information was given. Furthermore, they were more likely to select the car with the lowest NO_x emissions when the level of emissions was displayed in milligrams per kilometre driven than when the financial cost of the NO_x charge

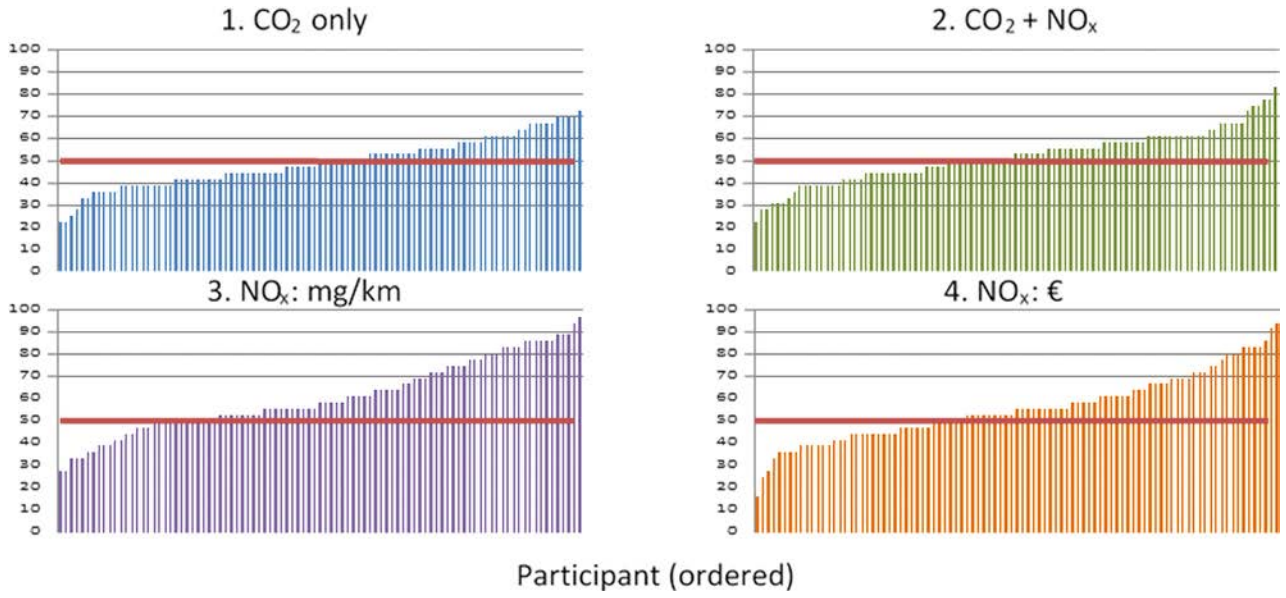


Figure 6.8. Numbers of participants selecting the cars emitting the lowest NO_x emissions on more or less than 50% of trials per condition.

Table 6.7. Mixed-effect logistic models for the probability of selecting lower NO_x-emitting vehicles, with random intercept by participant

Variable	Coefficient	Standard error	95% confidence interval
Block			
CO_2	–0.116*	0.05	–0.214, –0.018
Mg/km	0.385***	0.051	0.286, 0.484
NO_x € (partitioned)	0.169**	0.05	0.071, 0.268
ΔCO_2 tax	0.0003***	0.00006	0.0002, 0.0004
Δrunning cost	–0.011**	0.003	–0.017, –0.005
Δprice (000s)	0.04***	0.004	0.035, 0.051
Constant	0.085	0.06	–0.32, 0.203

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

was partitioned from the existing motor tax. Additional control variables based on differences in car price, CO_2 motor tax and running cost were included and each of these had a significant effect. Participants' tendency to select higher priced cars was not as surprising as it appears. Each participant was told to select a subset of cars to choose between at the beginning of the experiment and the range of prices was displayed at this point; therefore, participants were not choosing between cars that they had deemed to be unaffordable.

A similar logistic mixed-effects model was run for the efficiency information. This model examined participants' likelihood of selecting the more fuel-efficient vehicle (i.e. the vehicle with the lower fuel cost per distance or time travelled or the vehicle that would travel a greater distance or for more time given a fixed cost of fuel). This is shown in Table 6.8. The size of the efficiency information figure was considered "small" if it showed days or kilometres travelled per €50 or cost (in €) of driving per day or per 100 km. It was considered small to mid-sized if it showed weeks or kilometres travelled per €100 or cost (in €) of driving per week or per 1000 km. It was considered mid-sized to large if it showed months or kilometres travelled per €500 or cost (in €) of driving per month or per 7500 km. It was considered large if it showed weeks or kilometres travelled per €1000 or cost (in €) of driving per year or per 20,000 km. No significant effects were found except that participants were more likely to select the more efficient vehicle if the fuel cost was displayed as a financial cost per given distance or time, rather than as the time or distance that one could drive for a fixed financial cost.

6.3.4 Summary

As in the previous experiment, the results suggest that the manner in which information is given to consumers sometimes affects how they make decisions. In this experiment, it is notable that participants were presented with identical decisions in the second, third and fourth blocks of the experiment, i.e. blocks varied only in their presentation of cost and motor tax information, but vehicle choices nonetheless differed significantly across these blocks. The difference between the third block, in which emissions figures were given, and the fourth block, in which a partitioned price was given, requires further study to arrive at a full explanation. One possible interpretation may be that the third block allowed participants to actively select the vehicles with the lower emissions, whereas in the fourth block they had to make inferences from the information on cost. Another interpretation may be that the emissions figures appeared more salient, perhaps because they related directly to the impact on air quality, whereas the partitioned charge may have been more abstract. The lack of robust effects of the efficiency information potentially suggests that the time periods chosen for investigation, up to and including the cost of a year of driving, were not long enough to affect consumers' decisions, as one might have expected from other energy efficiency studies (e.g. Deutsch, 2010). It may be necessary to provide the cost of running a car for its lifetime (or the anticipated period of ownership) to see any effects of how the fuel cost is presented, as in the appliance study by Heinzle (2012).

Table 6.8. Mixed-effect logistic models for the probability of selecting the more fuel-efficient vehicle, with random intercept by participant

Variable	Coefficient	Standard error	95% confidence interval
Size of figure (relative to smallest figure size)			
Small to mid-sized	–0.071	0.055	–0.179, 0.036
Mid-sized to large	0.035	0.055	–0.073, 0.143
Large	–0.023	0.055	–0.131, 0.085
Figure as € (relative to time/ distance)	0.238***	0.055	0.13, 0.346
Mention of time (relative to distance)	0.069	0.054	–0.037, 0.175
Figure as €*mention of time	–0.129	0.078	–0.282, 0.024
Constant	0.804***	0.089	0.63, 0.979

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

6.4 Final Notes

The studies described in this chapter demonstrate how behavioural approaches can be used to study how consumers will respond to different means of giving information. This is particularly compelling in the environmental domain as information about the environmental impact of products is often abstracted from the attributes that consumers care most about, for example price, brand or the experience of using that product. Both of the experiments show that consumers will respond to information differently depending on how it is displayed. The first experiment also showed that factors unrelated to the information given, such as time pressure, could affect how consumers receive that information. Consequently, when considering how best to provide consumers with information to benefit their decision-making and help them to take environmental factors into account, it is important to consider the contexts in which consumers will make those decisions.

7 Behavioural and Experimental Tests of the Long-term Benefits of the Green Schools Programme

By Áine Ní Choisdealbha, Peter D. Lunn and Terence J. McElvaney (ESRI).

7.1 Introduction

Key research on environmental behaviour focuses on individuals' values (e.g. Dietz *et al*., 2005) and on how individuals can be motivated to act on pro-environmental values by their beliefs and personal norms; that is, if an individual believes that something they value is threatened (e.g. the environment) and believes that their actions can counter this threat, they act on those values because they feel a moral obligation to do so (Stern *et al*., 1999). However, many environmental problems are so substantial that collective change is preferable to the actions of a motivated few. For example, Dietz *et al*. (2009) calculated that, if US households changed their actions in relation to 17 household behaviours, in relatively minor ways, national carbon emissions could drop by up to 7.4%. The problem, of course, is how to motivate those behaviours. Although mandates and bans are powerful regulatory tools, their application to the behaviours listed by Dietz *et al*. (2009) – such as line-drying clothes, "trip-chaining" or combining multiple car trips, and tuning one's car and one's appliances more often – could be extreme. As an alternative solution, policymakers may try to change the behaviour of individuals and of their households through behavioural means. Habits are, by definition, patterns of behaviour that are difficult to break, but it may be possible to promote pro-environmental habits among individuals by intervening at the right time, for example in childhood, as self-control is developing but before there are challenges to impulse control in adolescence (Casey *et al*., 2008; Steinberg, 2008).

This study examined the pro-environmental habits of a large sample of Transition Year[6] students in Ireland, as well as their decision-making in relation to different formats of information about products' environmental impacts. The researchers used the participation of their schools in a pro-environmental education programme, the Green Schools Programme, to examine how introduction to environmental concepts and behaviours in childhood affects their habits and their processing of environmental product information in adolescence.

7.1.1 Motivation and contextual factors in encouraging pro-environmental habits

There are many ways to help people engage in pro-environmental behaviours when pro-environmental values are not strong or when inertia is high. For example, when a "default" option is available to consumers it can be set to an environmentally friendly option or, alternatively, consumers can be asked to actively choose between "green" options, which are environmentally friendly, and other, "grey" alternatives (Sunstein and Reisch, 2014). Many consumers may care about the environment but are not sufficiently motivated to, for example, change their fuel supplier to a "green" option – active choosing means that they must select a green or grey option rather than being defaulted into the less environmentally friendly choice.

However, as consumers and as individuals, the things that we do from day to day are not necessarily one-off decisions, but ongoing behaviours. Behaviours can become habitual, which means that it becomes increasingly difficult to change them. Swim *et al*. (2014) note that policies to help people engage in pro-environmental behaviours, such as reducing energy use, should consider the social and environmental context in which those behaviours take place, and should target behaviours that people are motivated to change and which they can change. Motivation to change can be increased through extrinsic factors, such as financial incentives or recognition from others. However, the authors note that, even if a person is motivated to behave in an environmentally friendly

6 In the Irish secondary school system, Transition Year is a 1-year programme taken after the Junior Cycle (lower secondary) and before the 2-year Leaving Certificate (upper secondary).

manner, they still need to have the knowledge of how to do so and the skills to enact that knowledge.

Although the need to actively choose between options, whether between products to purchase or behaviours to engage in (e.g. walking versus driving), may lead consumers to seek the information they need to make informed decisions (Sunstein and Reisch, 2014), it is still important that consumers know how to find and use that information. Many studies have shown that providing consumers with information about their energy use can lead to reductions in that energy use. For example, Lynham *et al*. (2016) found that providing consumers with real-time information about their energy use reduced the amount of energy they used at peak times. They also found that, even when consumers stopped receiving such information, they continued to show a decrease in energy use over subsequent weeks. The authors suggested that this was the result of a learning effect, in which the original provision of information helped consumers learn how to reduce their energy use. Similarly, Allcott and Rogers (2014) describe an intervention in which consumers received monthly reports about their energy usage. The households participating in this programme continued to reduce their energy use, even 2 years after the reports were stopped, potentially as a result of having learned how their behaviour affected their monthly reports or of having adjusted their energy-use habits.

What these studies suggest is that a combination of active behaviour change and learning facilitated individuals and households in changing their behaviour and the environmental impact of this behaviour. Education programmes targeted at young people can have a similar effect. For example, Boudet *et al*. (2016) report on an intervention delivered to Girl Scouts in California. This programme was designed to teach concepts about energy conservation and to help participants retain that information and practice how to enact it, and it also provided external feedback as well as teaching participants to monitor their own behaviour. They found that the programme was effective in promoting energy-saving behaviours among the Girl Scouts and their families and that the effects persisted even 7–8 months after the end of the 8- to 12-week programme.

That effects of such programmes can be found in children aged 8–10 years and the fact that effects permeate to their households suggests that delivering interventions through group activities may be beneficial. The Green Schools Programme delivered by An Taisce[7] in Ireland was initiated in 1996. Nine hundred schools had registered for the programme by the end of 2001 and over 93% (3800+) of Irish primary- and second-level schools were participating in the programme by 2016. This programme involves environmental education and practical participation by pupils to improve waste, water, energy, biodiversity and other environmental measures in their schools. Consequently, most 15- and 16-year-old students in Ireland will have encountered both knowledge- and action-based education on environmental issues, but the number of years that they have spent in a Green School may vary, as might the age at which they first encountered the programme. One aim of this study was to test if these differences would affect adolescents' ability to use environmental information in their decisions, as well as their engagement in pro-environmental habits, under the assumption that those who had spent longer in the project would better understand related concepts and know how to enact pro-environmental behaviours.

7.1.2 The power of habit in childhood and adolescence

The reason why this study focused on adolescents was to examine differences between those who first encountered the programme as a child and those who encountered it as an adolescent. Adolescents are known to engage in risk-taking or impulsive behaviour (Steinberg, 2008). This is thought to be as a result of the developmental changes that take place during the teenage years, when neural substrates related to social and emotional processes develop along a more rapid trajectory than those supporting executive function, which allow us to exert control over our behaviour (Casey *et al*., 2008). It is not that the ability to control one's behaviour regresses during adolescence; rather, the ongoing development of self-control is challenged by an increased responsiveness to social factors such as (perceived) judgment by peers.

7 A charity involved in the preservation of Ireland's natural and built heritage.

Self-control failures are related to both engagement in intrinsically rewarding habits and a failure to form habits that are not intrinsically rewarding or to engage in behaviours that are not intrinsically motivating. Although there is little work on adolescents' pro-environmental habits, there is much work on their habits in relation to obesity, nutrition and health. Impulsivity in behaviour is related to obesity in childhood (Puder and Munsch, 2010). Verdejo-García *et al*. (2010) also found that adolescents with a BMI that was higher than the normal range showed poorer performance on some measures of executive function than their peers, particularly in relation to inhibition (i.e. stopping oneself from responding automatically to something) and decision-making. This relationship between executive function and childhood obesity was found in an analysis of research spanning multiple decades (Liang *et al*., 2014). Of particular note, in one study, children who showed better self-control at the age of 10 years were found to have a lower BMI than their peers 3 years later, even when factors such as socioeconomic status and happiness were controlled for (Duckworth *et al*., 2010). Thus, it may be that children who have better self-control are protected against developing poor food-related habits in adolescence. Potentially, this is because their ability to engage in self-control continues into adolescence – or it may be that they had already developed good habits in childhood, which were then strong enough not to change in adolescence.

This was another objective of the current study – to determine if students who encountered the Green Schools Programme in childhood and who potentially developed related habits through the programme would then be more likely to engage in those habits in adolescence. The study also examined the strength of those habits, to see if those who had an opportunity to develop them earlier, as part of the programme in school, would have stronger habits. However, educational programmes can play a role in changing habits even among adolescents. For example, programmes designed to help adolescent boys reflect on their behaviour instead of responding automatically (i.e. according to habit) have been found to be effective at improving their outcomes in school and at reducing arrests (Heller *et al*., 2017).

7.1.3 The study

The Green Schools Programme, as noted above, is present or has been present in almost all schools in Ireland. For this reason, it was not possible to carry out a randomised controlled trial or field trial to examine its effects. Instead, the researchers examined differences in the environmental habits of Transition Year students and matched information on the schools that they had attended, and the years that they attended, to data from An Taisce on schools' participation in the programme. This involved measuring both self-reported habits and responses to the same consumer decision-making paradigm as in Chapter 6, Experiment 1. This allowed the researchers to examine both students' pro-environmental habits and their processing of environmental information, thus capturing the effects of the Green Schools Programme on their engagement in pro-environmental behaviour (and the automaticity of that behaviour) and on their ability to apply knowledge about environmental concepts to their decisions. As a control, the study compared the processing of environmental information in decision-making and pro-environmental habits to the processing of nutrition information in health-related habits. One limitation of the study is that it was not possible to control for participants' exposure to pro-environmental concepts at home or in other contexts.

Although the sample size was chosen based on power analyses conducted after a pilot study, this pilot study was conducted at only one school and suggested that the effect of the programme, if present, would be small and difficult to detect. For this reason, a lack of effect in this study may simply imply that other factors, such as the home context, may be more powerful than the effect of the school-based programme or that the study was not powerful enough (i.e. did not have a large enough sample size) to detect the effects of the school-based programme. The study received ethics approval from an ethics panel convened at the ESRI.

7.2 Methods

7.2.1 Participants

In total, 323 students (123 female and 200 male) across nine schools participated in the study. Schools were mixed between urban and rural areas and

between single-sex female, single-sex male and mixed schools. The schools represented seven counties across four provinces. All students were in Transition Year.

All students who participated in the study had consent from their parent or legal guardian and also provided written assent for participation in the study. The study took place in a room at their school and students took part in groups of up to 10. Data were collected between March and May 2018.

7.2.2 Materials and procedure

Information sheets and consent forms were sent to parents/guardians to fill in and return via their child's school, along with a form to list all schools attended by their child and the months in which their child had attended those schools. This information was then matched to the database provided by An Taisce on schools' participants in the Green Schools Programme.

The study consisted of three parts. First, students were given a diary to fill out, based on the day reconstruction method (DRM; Kahneman *et al*., 2004). They were told to think of the previous day (or another day in the previous week) and write in a diary about what they had done. Given the limited time that researchers could spend in the schools, and because of the need to keep students' participation to one class period, the researchers altered some aspects of the DRM. In the DRM, participants segment their day into morning, afternoon and evening and then further break it down into "episodes" or parts of their day in which they were in the same place, engaging in the same activity or with the same people. In this study, students were asked to select up to three "episodes" or events in the morning, afternoon and evening. Second, because the researchers were interested in daily habits, students were prompted to think about whether the things that happened in their day were typical or not. The researchers did not read what the students had written; it was simply an exercise to remind students what had happened in their day, to help them fill in the subsequent survey on their habits. This diary was given in paper form and was collected at the end of the students' participation. Diaries were not looked at by the researchers and were disposed of for shredding.

The second part of the study involved the shopping task described in Chapter 6. This was completed on a laptop computer, with paper shopping lists. There were a few differences between the task completed in this study and that described in Chapter 6. First, instead of presenting students with 16 food products and 16 household products, all 32 products in the "online shop" were food products. Second, given that no differences in effects between product information presented in a positive frame and product information presented in a negative frame were seen in the study in Chapter 6, information about the products' nutritional content or environmental impact was manipulated based only on whether it was presented in a standardised, colour-coded format or in a specific, verbal format. Finally, students completed the task only once. In this case, they were given a 15-minute time limit and were instructed to complete as many of the items on both lists as possible. To recap, one of these lists was to be completed according to their own preferences and the other was to be completed according to the directions given by a hypothetical friend or family member who had asked them to do their grocery shopping for them.

The third part of the study was a survey. Like the shopping task, this was completed on a computer. Students were instructed to use the diary (DRM) that they had filled out at the beginning of the study to answer a series of questions. They first entered the number of episodes that they had written about for the morning, afternoon and evening periods (the computer program would not allow them to enter more than three episodes for each period). All subsequent questions were answered using tick boxes. The questions that they were asked for each episode are shown in Table 7.1.

Finally, participants answered questions on the activities, listed in Table 7.1, that they had ticked as having engaged in during one or more episodes of their day. These questions were based on a standardised measure of habit, the Self-Report Behavioural Automaticity Index (SRBAI; Gardner *et al*., 2012). This measure is itself based on the Self-Report Habit Index (SRHI; Verplanken and Orbell,

Table 7.1. Questions from the survey on habits

Question	Possible answers
Where were you during this episode?	1. School
	2. Home
	3. Out and about (e.g. shopping centre, house of a friend, on a hike, restaurant)
	4. At an afterschool or weekend activity (e.g. sports club, music lessons, youth club)
	5. Other
When you do this activity, do you usually do it at this time?	1. Yes
	2. No – I usually do it earlier in the day
	3. No – I usually do it later in the day
	4. No – I don't usually do it at a specific time
Did you do any of the following things during the episode? Click all that apply	Saving water (e.g. turning off the tap while washing hands, turning off the shower while shampooing)
	Taking public transport
	Turning off the light when leaving a room
	Turning off or unplugging appliances (e.g. computer, television, toaster) when done with them
	Separating waste (e.g. putting paper in the recycling bin, recycling glass)
	Doing something because you know it is environmentally friendly (e.g. when choosing what activity to do, what transport option to use, which product to buy)
	Walking or biking
	Snacking
	Doing something because you know it is healthy (e.g. when choosing what activity to do, what transport option to use, which product to buy)
	Paying attention to the amount of unhealthy stuff in your food (e.g. salt, sugar, saturated fat)
	Paying attention to the amount of healthy stuff in your food (e.g. protein, vitamins, fibre)
	Exercising
Think about the activity you were doing, the activity that defines this episode of your day. How often do you do this activity?	1. Daily
	2. Every few days
	3. Every week or two
	4. Monthly
	5. Less often
When you do this activity, do you usually do it at the location you selected on the last page, or another location?	1. The selected location
	2. Another location
	3. No specific location

2003), but is a shorter version that has been shown to result in similar scores. One additional item was included from the SRHI that is not included in the SRBAI, which was a question about feeling unusual if one does not engage in the habit. The questions provided to participants are reproduced in Table 7.2. These questions were repeated for each habit ticked by the participant, with the habit that they were answering about written at the top of the screen in the form, for example, "Snacking is something …" (where "snacking" was one of the habits ticked). Participants answered on a five-point Likert scale, from "strongly agree" to "strongly disagree".

7.3 Results

7.3.1 Schools attendance

The parents of 314 students provided information on the schools attended by their child. Of these, five provided information that resulted in an unrealistically high number of months of school attendance (i.e. more than 164 months, or 14 years of school, which allows for participants to have attended a primary school with a pre-school year and/or to have repeated a year).

Excluding these five students, participants had spent a mean of 111.5 months (SD 37.5 months)

Table 7.2. SRBAI and SRHI questions provided to participants

Question: [habit] is something …	Index
1. I do automatically	SRHI, SRBAI
2. I do without having to consciously remember	SRHI, SRBAI
3. That makes me feel weird if I do not do it	SRHI
4. I do without thinking	SRHI, SRBAI
5. I start doing before I realise I'm doing it	SRHI, SRBAI
6. I would find hard not to do	SRHI, SRBAI

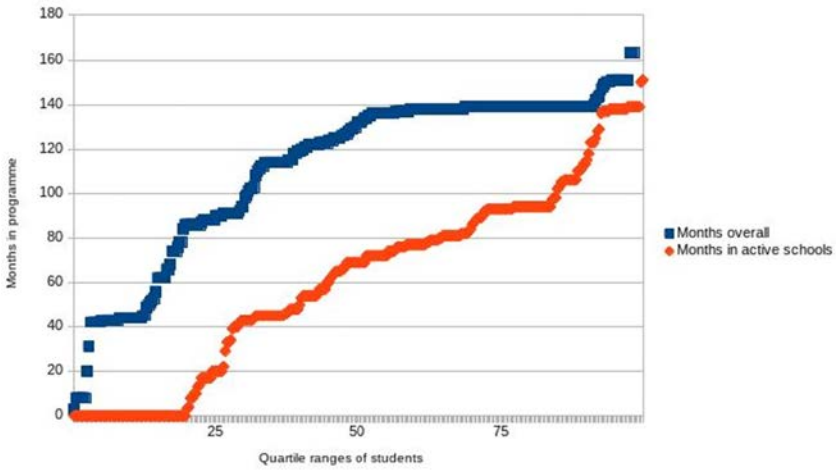


Figure 7.1. Months spent in schools signed up for and active in the Green Schools Programme, by individual participants

attending schools that were participating in the Green Schools Programme, with a median of 130 months, inclusive of summer breaks. Accounting only for time spent in schools that had not become inactive in the programme before participants attended them, this figure decreased to a mean of 60.6 months (SD 42.4 months) and a median of 69 months. The distribution of students' attendance at schools participating in, and active in, the Green Schools Programme is shown in Figure 7.1.

The earliest date of first attendance at a Green School (active or inactive) was 1 September 2005 and the latest was 1 February 2018. In total, 25% of students were attending a Green School by 1 September 2006, either because they had started at a Green School or their school had become active in the programme, and 75% were attending a Green School by 25 November 2010. Thirty-nine students had never attended an active Green School. Of those who had attended an active Green School, the figures were flatter – 50% had started by 1 September 2006 and 75% had started by 1 September 2008.

7.3.2 Shopping task

As noted previously, the shopping task given to participants was broadly similar to that given to the adults in Experiment 1 in Chapter 6. On average, participants completed 23.7 of the 32 items on the shopping lists (median 24, SD 6.4 items). Of the 16 trials that involved a direction (e.g. the student was asked to select a product that was both cheap and environmentally friendly), participants got an average of 9.1 items correct (median 10 items), with a SD of 4 items. As a proportion of the number of these trials that the students actually completed, 79.9% of "direction" trials were correctly completed (SD 18.7%).

In this study, the maximum summed score per group of products from the same list and within the same condition was 24 instead of 12, as products varied with regard to one condition only (information format). Figure 7.2 suggests that students' choices in this task

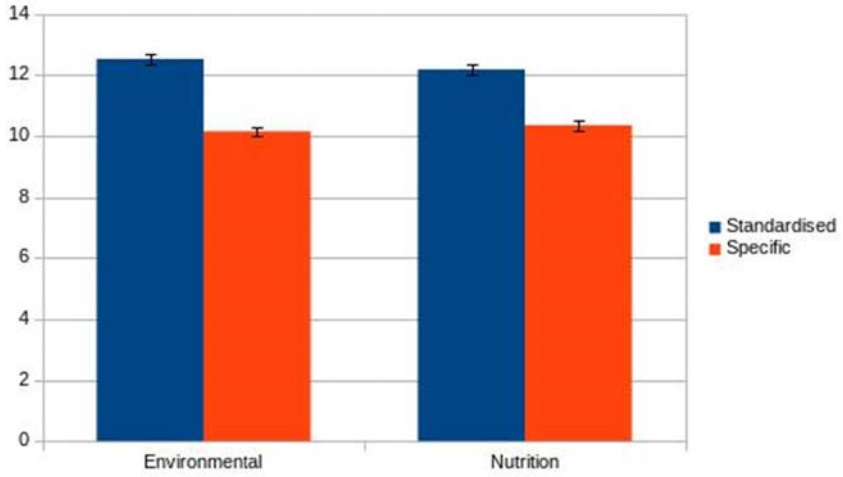


Figure 7.2. Mean score of products chosen by students on environmental friendliness and nutrition, by information format. Data are expressed as mean ± standard error of the mean.

were affected by the information format, just as adults' choices were.

There was no correlation between students' overall tendency to select environmentally friendly products and the number of months that they had spent in a Green School [$r(313) = 0.01$, $p = 0.8$], nor was there a correlation between their tendency to select nutritious products and the number of months that they had spent in a Green School [$r(313) = 0.06$, $p = 0.29$]. There was a significant correlation between the number of months spent in a Green School and the difference in students' mean score for selected products when environmental information was standardised rather than specific [$r(313) = 0.19$, $p < 0.001$]. This means that students who attended Green Schools for longer tended to choose higher ranked products based on the standardised, colour-coded labelling format relative to the specific labelling format. There was no such correlation for differences in choices of products based on nutrition score [$r(313) = 0.06$, $p = 0.29$].

7.3.3 Habits

For each episode of the day, participants could select as many of the 12 actions in Table 7.1 that applied. Table 7.3 shows how many participants indicated that they engaged in any of these actions across any episode. It also shows the average habit inventory score for each item. A score of 1 indicates a response of "strongly disagree", whereas a score of 5 indicates a response of "strongly agree".

The Pearson correlation between months spent in a Green School Programme-participating school and the habit index score for overall environmental behaviours is small but significant [$r(300) = 0.14$, $p < 0.01$]. This relationship remains significant when only months spent in an active Green Schools are considered [$r(298) = 0.11$, $p < 0.05$]. The relationship between the health-related behaviours habit index score and time spent in a Green School is significant for time spent in an active school [$r(318) = 0.115$, $p < 0.025$] but not for overall time spent in a Green School [($r(318) = 0.08$, $p = 0.07$].

7.4 Discussion

This study had two main objectives. The first objective was to test the effects of information format on environmental product choice among children, in parallel with the research carried out in adults reported in Chapter 6. This study confirmed that secondary school students dealt with information about products in different formats in a similar way to adults. The second objective was to gain some insight into how ongoing educational programmes related to pro-environmental behaviour affect the choices and self-reported habits of secondary school students. Although the saturation of the programme in Irish schools makes a direct test of effects

Table 7.3. Descriptive statistics on participants' engagement in environmental and health-related activities

Activity	SRHI score, mean (SD)	No. of participants
Environmental activities		
Saving water	2.82 (0.69)	171
Taking public transport	2.21 (0.86)	90
Turning off lights	2.94 (0.86)	245
Turning off appliances	2.55 (1.01)	217
Separating waste	2.41 (0.94)	161
Doing something because it's environmentally friendly	2.51 (0.79)	129
Overall	2.55 (0.66)	300
Health-related activities		
Walking or biking	2.87 (0.91)	241
Snacking	2.64 (0.94)	253
Doing something because it's healthy	2.71 (0.85)	181
Paying attention to unhealthy contents of food	2.46 (0.98)	194
Paying attention to healthy contents of food	2.56 (0.89)	198
Exercising	2.89 (0.96)	203
Overall	2.63 (0.68)	320

The data indicate the average habit inventory score and the number of students who engaged in the activity at least once.

difficult, a number of patterns are evident in the data. Students with a longer exposure to the Green Schools Programme appear to have responded to the information differently from peers with a lower exposure and chose more environmentally friendly products when the information was in a standardised format than when it was in a specific format. This was in contrast to the researchers' expectations: it was expected that students who had been in the Green Schools Programme might be better equipped to deal with the more complex, specific information. Second, students who had spent more time in Green Schools did not necessarily make more environmentally friendly choices overall. Although in contrast to expectations, this result is not surprising as students may learn about the environment and develop pro-environmental values in other contexts (e.g. at home or when socialising with peers). Finally, the results indicate that students who spent more time in Green Schools had stronger pro-environmental habits, but they also had stronger health-related habits. This result may therefore not be an effect of the programme, but an effect of overall schooling. Conversely, participation in the Green Schools Programme may provide students with the tools to develop and engage in positive habits across many domains.

8 Evaluating Health Benefits Derived from Green and Blue Spaces using a Choice Experiment Survey

By John Curtis and Gianluca Grilli (ESRI).

8.1 Introduction

Green and blue spaces within cities provides several benefits to users, including psychological restorative experiences, physical activity and social interactions. In addition, green and blue spaces are increasingly associated with better health conditions from both a physical and a mental point of view (Lafortezza *et al*., 2009; Barton and Pretty, 2010; Dempsey *et al*., 2018b,c). Users of green spaces often exhibit positive health indicators, including better psychological status, lower blood pressure and reduced risk of serious diseases (Lee and Maheswaran, 2011). Although proximity might be important for well-being, health gains are mainly connected with physical activity (such as walking, running, swimming and cycling) and therefore the direct use of green and blue spaces is a necessary condition to derive these benefits. There is evidence that people engage in more physical activity if there is a higher availability of green and blue spaces (Richardson *et al*., 2013; Schipperijn *et al*., 2013). Increasing levels of physical activity is beneficial not only at the individual level but also from a social perspective. For example, a UK study estimated that a permanent reduction of 1% in the sedentary population would provide a social benefit of £1.44 billion per year (CJC Consulting *et al*., 2005). For this reason, it is important to understand people's preferences for green and blue spaces, their habits with regard to using these spaces and the expected economic benefits as green and blue spaces become more attractive to people (Nordh *et al*., 2009).

Considering the importance of visiting green and blue spaces for individual health, the aim of the research described in this chapter was twofold. First, it considered how several health indicators are associated with visits to green and blue space, which helps to understand the benefits associated with current green and blue space units available within cities. As a second step, it examined people's preferences for green and blue space attributes using a choice experiment methodology, through which the utility provided by each single attribute was evaluated separately. In this way, it assessed the potential increase in the average number of visits for different arrangements of green and blue space, which might lead to improvements in health indicators. This work was co-funded by the HSE, in addition to the EPA.

8.2 Methodology and Data

8.2.1 Data collection and description

Data originated from a questionnaire survey that was administrated face-to-face by a professional survey company, which included a representative sample of 1050 adults living in Irish urban areas, stratified by age, gender, education and place of residence. The questionnaire was composed of 39 questions organised into five thematic sections. Section A collected information on current use of and attitudes towards green and blue space. Section B captured preferences for green and blue space attributes. Section C asked questions about leisure time and physical activity, section D asked questions about general well-being and section E collected personal and sociodemographic information. To benefit from existing research, the questions related to physical activity and individual health were similar to those in previous surveys (e.g. TILDA and Healthy Ireland). Table 8.1 provides some descriptive statistics.

The sample was gender balanced (50% of respondents were male and 50% were female) and the mean age of participants was 45 years (minimum 18 years, maximum 89 years). With respect to educational level, 44% had a secondary school education, 38% had a bachelor's degree and almost 15% had a master's degree or higher. With regard to occupation status, 41% of the sample had a full-time occupation, 13.5% had a part-time job, about 4% were self-employed, 19% were retired and 5.5% were students. Some 6% of respondents were unemployed

Table 8.1. Description and descriptive statistics of model variables

Variable	Description	Mean (SD)	Min.	Max.
Age	Age of respondents	45 (16)	18	89
Uni_degree	1 respondent has a university degree	0.44 (0.49)	0	1
	0 otherwise			
Dog	1 respondent owns a dog	0.35 (0.48)	0	1
	0 otherwise			
Child_visits	1 respondent never visited GBS in childhood	0.03 (0.18)	0	1
	0 otherwise			
Fin_comfort	1 respondent is in financial comfort	0.72 (0.44)	0	1
	0 otherwise			
Household	Number of people in the household	3.17 (1.36)	1	12
Busy_hours[a]	Busy hours per week for activities (working, sports, etc.)	24.95 (17.73)	0	81
Neighbourhood	1 respondent lives in safe neighbourhood	1.42 (1.20)	0	4
	0 otherwise			
Illnesses	1 respondent has a long-standing illness	0.15 (0.35)	0	1
	0 otherwise			
Comm_car	1 respondent goes to GBS by car	0.48 (0.50)	0	1
	0 otherwise			
Comm_mot	1 respondent walks or cycles to GBS	0.30 (0.45)	0	1
	0 otherwise			
Total_activity	Number of occasions of physical activity during the week	1.44 (1.27)	0	4
q25_food	Number of meals in which respondent eats fruit/vegetables	8.80 (1.44)	2	10
Hardworker	1 for manual jobs	0.23 (0.42)	0	1
	0 otherwise			
q21_smoke_dummy	1 smoker	0.18 (0.39)	0	1
	0 otherwise			
q22_drink	Number of weekly alcohol units	5.7 (3.37)	0	26

GBS, green and blue space.

[a]To calculate the busy hours variable the numbers of hours per week that respondents had commitments on a regular basis (e.g. work, sports) were summed.

and looking for a job; the remainder were unemployed, not looking for job or refused to answer this question. The median income class was between €30,000 and €40,000 per annum. The average number of visits to a green and blue space in the previous 4 weeks was 7.73 (SD 8.38).

8.2.2 Statistical analysis

Green and blue space and health associations

The first part of the analysis investigated the association between the current use of green and blue space and health. A simple model could include the number of visits to green and blue space as the explanatory variable for some indicators of physical health and well-being. However, this approach might not be appropriate for at least two reasons. First, the number of visits to green and blue space is itself a function of other observable characteristics of an individual. Second, the stated number of visits to green and blue space may suffer from measurement errors, which makes this variable correlated with the error term and subject to an endogeneity problem (Cameron and Trivedi, 2005). To overcome these potential biases, a structural equation model was estimated by maximum likelihood using a two-stage procedure. The first stage set up an equation in which the number of visits to green and blue space was regressed against a set of individual characteristics:

$$N_i = f(\beta' X_i) \quad (8.1)$$

where χ_i is a set of individual characteristics and β is a vector of parameters to estimate. The number of

visits takes a non-negative integer value; therefore, count data estimators such as Poisson and negative binomial (NB) are suitable models for the analysis. A NB model was used because, compared with the Poisson model, it accounts better for over-dispersion. The NB log-likelihood function takes the form (Hilbe, 2011):

$$\left(\mathrm{y} \mid \mu,\alpha\right) = \frac{\Gamma\left(\alpha^{-1}+y\right)}{\Gamma\left(\alpha^{-1}\right)\Gamma\left(y+1\right)}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu}\right)^{\alpha^{-1}}\left(\frac{\mu}{\alpha^{-1}+\mu}\right)^{y} \quad (8.2)$$

where $\mu=\beta'\chi_i$ is the mean of the distribution, y is the individual number of trips, Γ is the gamma function and α is an over-dispersion parameter. In the second stage, the expected value of green and blue space visits was used as one of the explanatory variables for two other equations, one for a well-being indicator and one for a physical health indicator:

$$\begin{aligned} WBS_i &= g\left(\gamma E\left[N_i\right]+\theta M_i\right) \\ PHS_i &= z\left(\rho E\left[N_i\right]+\varphi M_i\right) \end{aligned} \quad (8.3)$$

where WBS_i is an indicator of well-being, E[N_i] is the expected individual number of trips to green and blue space, γ is a vector of coefficients indicating the effect of E[N_i] on well-being, M_i is a vector of individual-specific covariates multiplied by their coefficients θ, PHS_i is an index of physical health, ρ is the coefficient indicating the effect of the number of visits to green and blue space on physical health and φ is the effects of individual variables on $PHSi$.

Heath indicator variables were created and included in different specifications of the logit model, based on the structure of the questions on health status from the respondent questionnaire. The indicator PHS_i is a binary dummy variable indicating poor physical health status or otherwise, and it was therefore modelled with a binary logit regression model, whose probability density function is as follows (Greene, 2003):

$$Prob\left(\ PHS_i = p \mid X\right) = \frac{e^{\theta M_i}}{e^{\theta M_i}+\ 1} \quad (8.4)$$

The well-being indicator was instead modelled using the ordered logit estimator, because it has five ordered outcomes. Ordered logit assumes that the response variable is continuous but observed only in a discrete setting, and the probability that the indicator assumes a certain value lies between two threshold parameters that have to be estimated. With respect to the *MHS_i* equation, the probability that the indicator falls into a given class is described by the following equation (Greene and Hensher, 2009):

$$P\left[WBS_i = n\right] = \left\{ \begin{array}{c} i_1 \ if -\infty < \gamma E\left[N_i\right]+\theta M_i < \tau_1 \\ i_2 \ if \ \tau_1 < \gamma E\left[N_i\right]+\theta M_i < \tau_1+\delta_i \\ \ldots\ldots\ldots\ldots\ldots\ldots \\ i_k \ if \ \tau_{(k-1)} < \gamma E\left[N_i\right]+\theta M_i < +\infty \end{array} \right\} \quad (8.5)$$

where $\tau_1 \ldots \tau_n$ are threshold parameters for the k classes and $\delta_1 \ldots \delta_{k-1}$ represent class width. The final log-likelihood function is the sum of the log-likelihood function of the previous three equations:

$$LL_{joint} = LL_{N_i} + LL_{WBS_i} + LL_{PHS_i} \quad (8.6)$$

All of the models were estimated using R. A big challenge was to create effective health indicators from the information collected in the survey. Regarding physical health, respondents were asked whether they suffered from one or more illnesses, such as pulmonary disease, asthma, diabetes, kidney problems, arthritis, back pain, neck pain, high blood pressure or allergies, and whether they had had a stroke or a heart attack in the past. With respect to well-being, respondents were asked about their general life satisfaction and if they experienced depression, as well as about their mood and temperament in the past few weeks. To maximise the informative potential of the data, a sensitivity analysis was conducted by running several models that used a combination of these questions as dependent variables with the same set of covariates and then choosing the preferred model based on the log-likelihood value. Models did not differ significantly and no sign changes were observed in the coefficients. The log-likelihood was maximised when using a physical health indicator created as a combined binary measure of high blood pressure, stroke and heart attack and a well-being indicator given by a question that captured the general level of life satisfaction.

Preferences for green and blue space attributes

In section B of the questionnaire, respondents were asked to evaluate and compare different options for green and blue space and to indicate the number of visits that they would be likely to undertake in a 4-week period. Relevant attributes were first identified from the literature on green and blue space. The final list of attributes is shown in Table 8.2.

Table 8.2. Attributes and levels included in the study

Attribute	Metric	Levels
Size	Hectares – for convenience and to help you visualise size, we will compare park size to the playing field at Croke Park, which is 1.25 hectares	2.5, 7.5, 12.5, 17.5 hectares (corresponding to 2, 6, 10 and 14 Croke parks, respectively)
Blue space	Water bodies in the park	Flowing water such as a river or canal or seaside
		Water bodies such as a lake or pond
		No water bodies present
Paved or hard surface paths	Three types of pathways	Few paths
		Medium number of paths with geometric layout
		High number of paths with random layout through park
Facilities	Facilities in the park	Public toilets
		Free-to-use gym equipment
		Coffee shop
		No facilities
Trees	Three levels of tree density	Low, with few trees
		Medium, considerable number of trees
		High, substantial number of trees
Distance from home	We indicate distance in kilometres. The equivalent distance in miles is also shown here	km: 0.8, 1, 1.6, 3.2, 6.4, 10
		Miles: 0.5, 0.6, 1, 2, 4, 6.2

Twenty-four cards were developed containing two alternatives, each based on manipulating individual attribute levels, a third option expressing the possibility of visiting green and blue spaces different from those hypothesised and an opt-out option indicating no visits to green and blue space. The full set of choice cards was divided into four blocks of six cards so that each respondent faced only six choices. The allocation of attribute levels onto the cards was carried out using nGene software. An example of a choice card is provided in Figure 8.1.

Respondents were asked to state the number of visits that they would be likely to make to each public park alternative. If they preferred not to visit parks at all, they could choose the opt-out alternative.

The data were analysed using a random utility model framework, in which the individual utility U_i is assumed to be composed of a deterministic and observable component V_i, which can be expressed as a linear combination of attributes and coefficients, and a stochastic disturbance η_i. More formally:

$$U_i = V_i + \eta_i \quad (8.7)$$

The most appropriate statistical model to use depends on the assumed distribution of the error term. A typical approach is to assume a Gumbel-distributed error, which leads to a conditional logit model. In a conditional logit model, the response variable is the frequency of visits, which is transformed in proportions and modelled as the probability of choosing one alternative. This approach has the limitation of giving little information on the expected change in the number of visits to green and blue space in the presence of changes in parks attributes. To overcome this limitation, the number of visits is modelled as a count variable, using the same NB specification used in Equation 8.2.

8.3 Results

8.3.1 Green and blue space visits and health effects

The results of the structural model of park visits and health outcomes are reported in Table 8.3. Concentrating on the green and blue space equation, age showed a small positive and significant effect on use of green and blue space, suggesting that the frequency of visits was higher among older people. People with a university degree were also more likely to visit than respondents without a degree. The number of visits by people owning a dog was

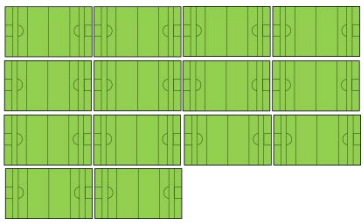
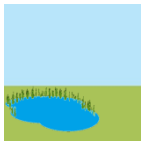
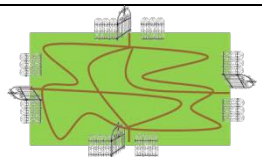
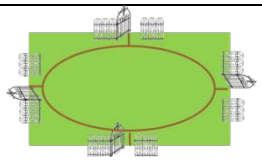
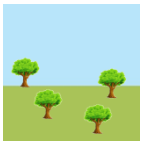
Attribute	**Alternative 1**	**Alternative 2**		
Size	 2.5 hectares (2 Croke parks)	 17.5 hectares (14 Croke parks)	**I will make some visits but not to one of the these**	**I will not visit public parks at all**
Blue space	 Lake or pond	 No waterbodies		
Walking or running path	 High number of paths	 Few paths		
Facilities	 No facilities	 Coffee shops		
Trees	 Medium number of trees	 Few trees		
Distance from home	3.2 Km (2.0 miles)	1.6 Km (1.0 miles)		
Number of monthly visits				

Figure 8.1. Example of a choice card.

Table 8.3. Results of the structural model

Variable	GBS equation		PHS equation		WBS equation	
	Estimate	SE	Estimate	SE	Estimate	SE
Age	0.007***	0.002				
Uni_degree	0.256***	0.063				
Dog	0.344***	0.061				
Child_visits	–0.24	0.190				
Fin_comfort	0.137*	0.074				
Household	0.017	0.023				
Busy_hours	–0.001	0.002				
Neighbourhood	–0.022	0.025				
Illnesses	–0.238**	0.093				
Comm_car	2.979***	0.146				
Comm_mot	3.432***	0.143				
Total_activity	0.087***	0.024				
Gbs.const	–1.844***	0.220				
Alpha	0.55***	0.034				
E[GBS_visits]			–0.253***	0.072	0.08*	0.047
q25_food			–0.179***	0.026	0.212***	0.048
Hardworker			–0.391	0.284		
q21_smoke_dummy			–0.22	0.277	–0.562***	0.171
q22_drink			–0.035	0.030	–0.01	0.019
τ_1					–3.387***	0.596
τ_2					1.07***	0.340
τ_3					1.966***	0.230
τ_4					2.767***	0.114
Log-likelihood	–2561		–302		–939	
Total log-likelihood	–3803					
Obs	958					

***p*<0.10; ****p*<0.05; *****p*<0.01.**
GBS, green and blue space; SE, standard error.

significantly larger than average, which is in line with research findings in England (White *et al*., 2018).

The coefficient for the "Child_visits" variable was negative but not significantly different from zero, i.e. respondents with children did not visit parks with a higher frequency than respondents without children. Respondents in financial comfort were more likely to make a larger number of trips. Neither household size nor number of working hours, nor neighbourhood condition, was associated with higher visiting levels. People with a long-standing illness were less likely to visit, as expected and indicated by the negative "Illnesses" variable. The means of transport used to commute to green and blue space was also a significant variable affecting the number of visits, with people commuting by car, bike or walking being more likely to visit than a baseline of respondents commuting by public transport. The number of visits was likely to be larger for people who use parks to practise physical activity. The coefficient for alpha was highly significant, which supports the hypothesis that there might be data over-dispersion and indicates that

the NB model is more appropriate than the Poisson alternative.

Moving to the equation describing physical health, the coefficient on the expected number of visits, i.e. "E[GBS_visits]", was negative and statistically significant. This indicates that respondents with more visits to green and blue space were less likely to suffer from high blood pressure or to have experienced a stroke or a heart attack. Similar results were found for respondents who reported a high level of consumption of fruit and vegetables, i.e. "q25_food". In this sample, no significant association was found between the incidence of self-reported smoking and level of alcohol consumption and physical health status.

In the well-being equation, a positive coefficient was observed for expected green and blue space visits, indicating that increasing the number of visits to green and blue space is associated with a higher reported level of well-being. The well-being indicator was also positively related to good dietary habits and negatively related to alcohol consumption, whereas it was not associated with smoking in a significant way.

These results suggest that a greater number of visits to green and blue space was associated with better health outcomes in terms of both physical health and well-being. This association is depicted graphically in Figure 8.2, in which the probability that a respondent has a poor physical health status (i.e. likely to suffer with high blood pressure or to have experienced a stroke or a heart attack) is associated with reduced levels of green and blue space visiting. The overall incidence of poor health status in the sample was approximately 10%. The probability of poor health status associated with respondents with one green and blue space visit per month was 0.15, whereas the probability of poor health status associated with respondents with 15 green and blue space visits per month was 0.07. Higher levels of green and blue space visiting were associated with lower probabilities of poor health status but the decline was less dramatic. The marginal probability associated with green and blue space visits is plotted in Figure 8.3, which highlights the dramatic drop in probability of poor health status associated with an increase in the number of green and blue space visits to a relatively moderate level, i.e. 8–15 visits per month or 2–4 times

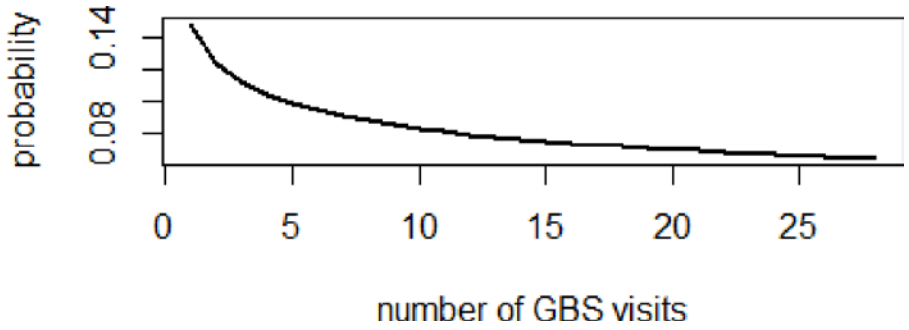


Figure 8.2. Probability of experiencing poor physical health status by number of green and blue space (GBS) visits per month.

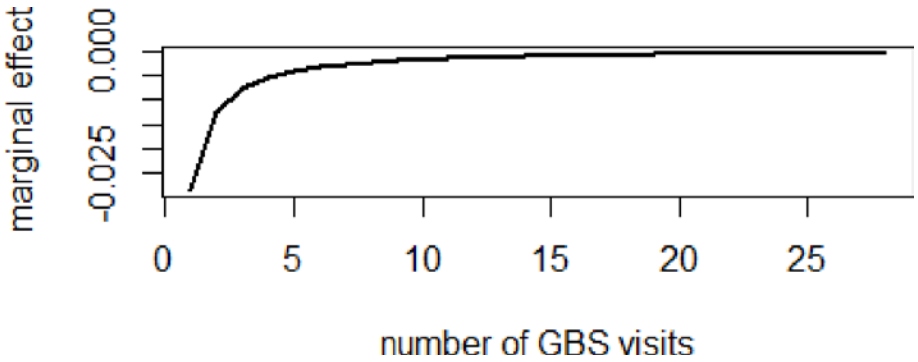


Figure 8.3. Marginal probabilities: change in probability of poor physical health status associated with monthly green and blue space (GBS) visits.

per week. What is of practical relevance from a health and public policy perspective is whether the estimated marginal probabilities plotted in Figure 8.3 are statistically different from zero. Marginal probabilities that are statistically different from zero indicate where additional green and blue space visits are associated with better health outcomes, i.e. a lower probability of high blood pressure, stroke or heart attacks among the surveyed sample, in a statistically significant way. Initial model estimates indicate that this occurs at a low number of green and blue space visits.

Well-being was measured on a five-point ordinal scale from “very dissatisfied” to “very satisfied”, as opposed to a binary scale in the case of physical health status. For ease of exposition, results are presented for well-being for just one of the five categories, respondents expressing that they were “very satisfied” with their life as a whole. Similar to the physical health results, both probability of well-being status and the marginal probability are presented. Figure 8.4 plots the association between the probability that a respondent indicated that they were “very satisfied” with their life as a whole and their visiting of green and blue space.

Figure 8.5 plots the marginal probability and, similar to the results for physical health status, it illustrates the dramatic change in probability of participants being “very satisfied” with their life associated with different levels of green and blue space visits. The greatest effect occurs as the number of green and blue space visits increases from a low level, with the marginal impact being quite low after approximately five visits per month. With just one green and blue space visit per week, the probability of a respondent being “very satisfied” with their life increases by approximately 3 percentage points. There are commensurate changes in the probabilities in the other response categories.

8.3.2 Preferences for green and blue space attributes

Table 8.4 reports the analysis of preferences for green and blue space attributes, displaying a panel NB model with both fixed- and random-effects specifications. The number of respondents was reduced to 861 in the fixed-effect specification because 97 respondents declared zero visits for all alternatives; therefore, they had no within-group

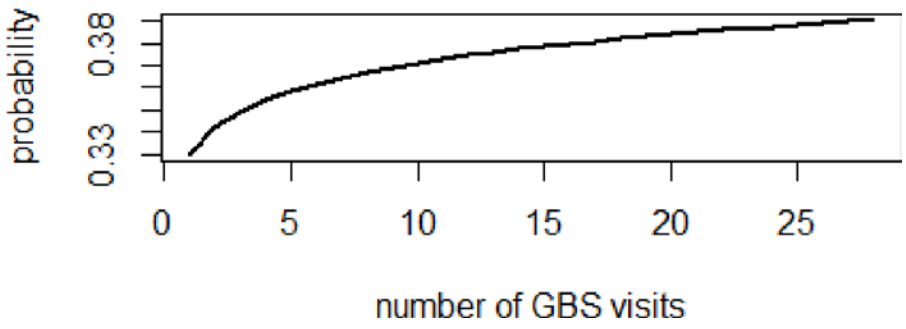


Figure 8.4. Association between probability of being “very satisfied” with life and monthly green and blue space (GBS) visits.

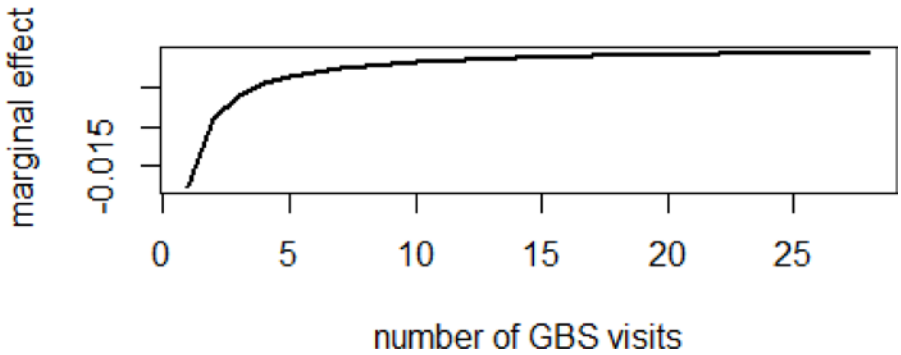


Figure 8.5. Marginal probability: change in probability of being “very satisfied” with life associated with monthly green and blue space (GBS) visits.

Table 8.4. Preferences for green and blue space attributes

Model attribute	Fixed effects (SE)	Random effects (SE)
Size	0.00565*** (0.00205)	0.00630*** (0.00204)
Pond	0.224*** (0.0246)	0.230*** (0.0246)
Fl_water	0.201*** (0.0240)	0.208*** (0.0239)
Path_Med	0.0354 (0.0245)	0.0399 (0.0244)
Path_Lot	0.0753*** (0.0240)	0.0800*** (0.0239)
Coffee	0.340*** (0.0278)	0.348*** (0.0278)
Gym_Fac	0.244*** (0.0295)	0.252*** (0.0294)
Toilets	0.331*** (0.0284)	0.338*** (0.0284)
Tree_Med	0.0368 (0.0242)	0.0417* (0.0241)
Tree_Man	0.0724*** (0.0241)	0.0777*** (0.0240)
SQ_Const	–2.452*** (0.0489)	–2.435*** (0.0489)
Distance	–0.0553*** (0.00315)	–0.0550*** (0.00314)
R_const		0.262*** (0.0493)
S_const		0.334*** (0.0555)
Observations	15498	17244
AIC	40616.4	49739.2
BIC	40708.2	49847.8

***p*<0.10; ****p*<0.05; *****p*<0.01.**
AIC, Akaike information criterion; BIC, Bayesian information criterion; SE, standard error.

variation. All attributes are statistically significant at the 1% significance level, implying that they all contribute to decisions about green and blue space utilisation.

All attributes, with the exception of distance, had a positive effect and were therefore associated with higher levels of individuals' utility. In contrast, the coefficient indicating distance of green and blue space from home was negative. This means that respondents were more likely to visit green and blue space close to their home than distant green and blue space, which is in line with expectations.

Marginal effects are reported for each attribute in Table 8.5 from both fixed- and random-effects model estimates. For continuous variables, e.g. size and distance, the estimates are interpreted as the marginal expected variation in the number of trips for a unit increase in size or distance. When the variables are coded as binary dummies, the interpretation is the expected variation in the number of visits related to a discrete change from 0 to 1, i.e. from absence to presence of the level. Levels providing the largest expected increase in the number of visits were the presence of water (both flowing or as a pond), toilets, facilities to practise physical activities and coffee shops. For example, the mean number of proposed visits to a park increased by a quarter if the park had public gym facilities. Conversely, distance to a park decreased the probability of visiting, but the effect was relatively weak. For each 1 km increase in distance to a park, the proposed mean number of visits per month declined by just 0.055. A medium level of path provision, as described in Table 8.2, was not statistically significant, whereas the medium level of tree cover was significant only at the 10% significance level in the random-effect specification, suggesting that implementing these characteristics would not provide additional utility for visitors.

Rather than focus on individual marginal effects, the analysis examined marginal green and blue space visits across a number of part attribute scenarios using a small park within 2 km of home and without gym, toilet or coffee shop facilities as the baseline. These scenarios are presented in Table 8.6, with the change in the mean number of visits also reported. The scenarios in Table 8.6 show how different park attributes could be substituted to achieve an increase in the mean number of visits. Increasing park size or adding water features may not be practically feasible,

Table 8.5. Marginal effects of green and blue space attributes: number of additional visits

Model attribute	Fixed effects	Random effects
	Marginal effect	Marginal effect
Size	0.006***	0.006***
Pond	0.224***	0.23***
Fl_water	0.201***	0.208***
Path_2	0.035	0.04
Path_3	0.075***	0.08***
Coffee	0.34***	0.348***
Gym	0.244***	0.252***
Toilet	0.331***	0.338***
Tree_2	0.037	0.042*
Tree_3	0.072***	0.078***
Dist	–0.055***	–0.055***

*$p<0.10$; **$p<0.05$; ***$p<0.01$.

Table 8.6. Expected change in the number of green and blue space visits with different arrangements of green and blue space attributes

Model attributes	Scenario				
	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Size (ha)	2	4	7	10	16
Pond	No	No	Yes	Yes	Yes
Flowing water	Yes	Yes	No	No	Yes
Path	Medium	Medium	Large	Large	Large
Coffee shops	No	No	No	No	Yes
Gym facilities	No	No	No	Yes	Yes
Toilets	No	Yes	Yes	Yes	Yes
Av. distance (km)	2	1	0.8	0.4	0.4
Expected number of visits per month (SE)	0.19 (0.03)	0.60 (0.04)	0.73 (0.04)	1.01 (0.05)	1.61 (0.07)

SE, standard error.

but park configuration and visitor facilities (e.g. toilets, coffee shops, gym equipment) might encourage greater levels of visiting.

8.4 Conclusion

The literature on health and the environment suggests that there is an association between the characteristics of urban green and blue spaces and health conditions of visitors (Lee and Maheswaran, 2011; Hartig *et al.*, 2014; WHO, 2016; Kondo *et al.*, 2018). In the current study, researchers investigated this relationship for two indicators, one related to physical health and one related to well-being, using a representative sample of urban dwellers in Ireland. The research presented here confirms the positive association between green and blue space visits and health status. The second aspect of the research examines whether there are particular park attributes associated with high visiting rates. Identifying such key attributes and expanding their provision in existing park spaces can increase green and blue space visiting and indirectly contribute to improved health outcomes.

The research on the impact of green and blue space attributes on visiting levels considered features such

as park size, water features and visitor facilities, as well as factors such as level of tree cover or path provision. The research used a choice experiment methodology and asked survey participants to indicate how the frequency of park visits might change in response to a series of hypothetical scenarios. All park attributes that were considered had a statistically significant impact on the level of park visiting, but the attributes with the greatest marginal impact relate to visitor facilities (e.g. toilets, coffee shop, gym equipment) rather than physical characteristics of the parks (e.g. size, tree cover).

Unlike park attributes such as size and location, which are difficult to change, the key attributes driving visiting rates are potential options for change for all public parks. To increase utilisation rates of public parks, urban councils should consider options to increase the provision of visitor facilities within parks. As higher levels of green and blue space visiting were associated with improved health outcomes, there may be a case for using public health budgets to help finance investment in public parks.

9 Recommendations

Although public policy at EU, national and local level has made considerable strides in recent decades towards recognising the value of the environment and protecting or enhancing many aspects of it, the research found that a significant proportion of fiscal measures, intentionally or inadvertently, provide negative environmental incentives.

Recommendation 1: The environmental impact of the fiscal system should be studied more carefully, as some measures have significant environmental costs. The appropriate reform of these measures could make a significant contribution to reducing Ireland's GHG emissions and reducing local pollution.

Recommendation 2: Positive environmental effects of fiscal measures should also be explicitly acknowledged and considered in decision-making. Where possible, positive effects should be assessed *ex post*, to see how significant they really are. To facilitate *ex post* analysis of programme effects, suitable data collection methods need to be in place before measures are implemented.

Two of the studies carried out in this programme examined different aspects of the societal value of urban green space. International evidence on the health benefits of urban green space does seem to be borne out in Ireland, with evidence of a beneficial relationship between urban green space and obesity risk. However, this relationship may bear a more complex relationship to local neighbourhood characteristics, such as walkability, than these data could fully explain. The second study asked a large sample of Irish adults a range of questions about their use of green space and their health status and then sought to identify which characteristics of urban green spaces are most effective in encouraging use of these areas. Positive associations were found between use of green space and indicators of both physical health and generalised well-being. The study also yielded detailed information about which attributes might help encourage more use of urban parks.

Recommendation 3: Future research on the health benefits of urban green spaces should incorporate the accessibility of green space (e.g. the network of footpaths) in areas that are more peripheral to urban centres.

Recommendation 4: To increase utilisation rates of public parks, urban councils should consider options to increase the provision of visitor facilities within parks.

Recommendation 5: As higher levels of green and blue space visiting are associated with improved health outcomes, there may be a case for using public health budgets to help finance investment in public parks.

Radon exposure is known to be a risk factor for lung cancer. A study in this programme found evidence of significantly higher lung cancer rates among older people in Ireland living in areas classified with the second-highest level of radon risk. Other results were suggestive of a protective effect from remediation activities in the zone with the highest radon risk, but further data would be required to relate information and remediation policies directly to health outcomes.

Recommendation 6: Public authorities have previously undertaken radon awareness campaigns, but perhaps these could be made more effective at influencing behaviour. Regulatory policy options could also be considered, such as requiring radon testing prior to the sale or rental of dwellings (akin to the Building Energy Rating scheme) or economic measures, such as providing incentives to radon-proof buildings in areas that are at risk. To design the best mix of policies, it will be important to understand why many people in high-risk areas do not invest in radon protection measures.

Another pair of studies took different approaches to quantify some of the benefits of coastal blue space, using novel spatial methods to include both sea views and proximity to coastline in their analyses. Here, too, the results were consistent with the suggestion that there should be positive benefits: the property market clearly values both proximity to and views of coastal blue space, and older people living in areas with the highest share of coastal views in their total viewshed reported a significantly lower risk of depression.

Recommendation 7: The findings in this report underline the public health value of policies to protect and enhance coastal blue spaces and they suggest that urban planners should take such benefits into account.

Recommendation 8: Future research into the mechanisms linking exposure to blue space to mental health would be useful (e.g. by ascertaining the potential associations with mediators such as social engagement, physical activity and stress).

Recommendation 9: This research demonstrates that coastal amenities offer significant flows of societal value, some of which are capitalised in the form of housing wealth. Governments may choose to draw on elements of this value as a contribution to the costs of maintaining coastal amenities, for example by applying property taxes.

Recommendation 10: Measuring the effects of blue space views and proximity on residential house prices and rents can help inform local infrastructure cost–benefit trade-offs, for example when assessing whether to build a sea wall that would limit sea views but also reduce future costs associated with coastal erosion.

Recommendation 11: There may also be planning implications associated with the finding that residential coastal proximity and views are highly valued. High-density development closer to coastlines might have significant economic and societal value if the benefits are not fully offset by flood risk and other negative factors.

Turning to broader aspects of land use in Ireland, the research illustrated the scale of urban sprawl in Ireland over recent years, with some initial statistical investigations into the causes of sprawl carried out. This study points the way towards more sophisticated modelling of what drives sprawl and how it relates to property markets, local employment patterns and a range of related policies.

Recommendation 12: The development of sprawl should be tracked over time in Ireland, using a consistent methodology such as the one developed in this research.

Recommendation 13: Future research should examine the factors encouraging sprawl, such as the effects of housing supply conditions on commuting flows.

Finally, the programme included three studies of consumer choice behaviour using behavioural experiments. Two focused on adults, using sophisticated laboratory experiments to discover how consumers of environmentally related goods respond to different means of giving information. Consumers did respond to information differently, depending on how it was displayed, and the conditions under which choices were made could also affect the choices themselves. This result was also confirmed in a separate study of secondary school children.

Recommendation 14: When considering how best to provide consumers with information to benefit their decision-making and help them to consider environmental factors, it is important to consider the contexts in which consumers will make those decisions.

Recommendation 15: As choices are sensitive to context, it may be helpful to pretest some types of environmental information interventions before applying them in a regulatory context.

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Abbreviations

APD	Air passenger duty
BMI	Body mass index
CES-D	Center for Epidemiologic Studies Depression Scale
DRM	Day reconstruction method
EPA	Environmental Protection Agency
ESRI	Economic and Social Research Institute
EU	European Union
GHG	Greenhouse gas
GIS	Geographic information system
HSE	Health Service Executive
NB	Negative binomial
NO_x	Nitrogen oxides
SD	Standard deviation
SRBAI	Self-Report Behavioural Automaticity Index
SRHI	Self-Report Habit Index
TILDA	The Irish Longitudinal Study on Ageing
VAT	Value-added tax

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AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú
Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:
- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil
- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce
- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol
- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn
- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil
- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta
- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch
- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas
- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta
- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil
Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:
- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

EPA Research Report 295

Research on Aspects of Ireland's Environment, Consumer Behaviour and Health: ESRI Environment Research Programme 2016-2018

Editor: Seán Lyons. Authors: Achim Ahrens, John Curtis, Seraphim Dempsey, Mel T. Devine, Tom Gillespie, Gianluca Grilli, Stephen Hynes, Ronan C. Lyons, Peter D. Lunn, Seán Lyons, Terence J. McElvaney, Edgar Morgenroth, Kyle Moore, Martin Murphy, Áine Ní Choisdealbha and Anne Nolan.

Identifying pressures

This study brings together a diverse set of research topics in which the environment interacts with economic and social processes. Its results are reported under three headings, each capturing a different approach to gathering evidence:

1. assembling data from many sources to characterise policies that affect the environment;
2. transforming and combining existing data in new ways to allow analysis that is more robust; and
3. collecting new data that relate human behaviour to environmental conditions and outcomes.

Informing policy

The research identified a beneficial relationship between urban green space and obesity risk. Positive associations were demonstrated between use of green space and indicators of both physical health and generalised well-being, and detailed information was provided about which attributes might help encourage more use of urban parks.

Evidence was found of significantly higher lung cancer rates among older people in Ireland living in areas classified with the second-highest level of radon risk. Other results were suggestive of a protective effect from remediation activities in the zone with the highest radon risk.

Statistical analysis showed that the property market values both proximity to and views of coastal blue space, and older people living in areas with the highest share of coastal views in their total viewshed reported a significantly lower risk of depression.

The research illustrated the scale of urban sprawl in Ireland over recent years, pointing the way towards more sophisticated modelling of what drives sprawl and how it relates to property markets, local employment patterns and a range of related policies.

Behavioural experiments demonstrated that consumers (both adults and secondary school children) responded differently to environmental information depending on how it was displayed, and the conditions under which choices were made could also affect the choices themselves.

Developing solutions

The report recommends that the environmental impact of the fiscal system should be studied more carefully, as some measures have significant environmental costs, and that positive environmental effects of fiscal measures should also be explicitly acknowledged and considered in decision-making.

Future research on the health benefits of urban green spaces should incorporate the accessibility of green space. To increase utilisation of public parks, urban councils should consider increasing the provision of visitor facilities within parks and, as higher levels of green and blue space visiting are associated with improved health outcomes, there may be a case for using public health budgets to help finance investment in public parks.

There may be options for making radon awareness campaigns more effective at influencing behaviour. To design the best mix of policies, it will be important to understand why many people in high-risk areas do not invest in radon protection measures. Regulatory policy options could also be considered.

Future research on how blue space affects mental health would be useful. The market values coastal amenities highly, so property taxes might make a contribution to maintaining them. Measuring the effects of blue space views and proximity on residential house prices and rents can help inform local infrastructure cost–benefit trade-offs and other planning implications.

The development of sprawl should be tracked over time in Ireland using a consistent methodology. Future research should examine the factors encouraging sprawl, such as the effects of housing supply conditions on commuting flows.

The context in which consumers make decisions is important for considering how best to provide them with information on environmental matters. As choices are sensitive to context, it may be helpful to pretest some types of environmental information interventions before applying them in a regulatory context.

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