ONLINE ISSUE 2, 2022

VOLUME 10



Science Journal of the Malta Chamber of Scientists

Editor-in-Chief: Cristiana Sebu

Xjenza Online: Science Journal of the Malta Chamber of Scientists www.xjenza.org

Editorial Board



Editor-in-Chief

Prof. Cristiana Sebu Department of Mathematics, University of Malta, Msida MSD 2080, Malta Tel.: +356 2340 2466 cristiana.sebu@um.edu.mt

Senior Editors

Dr Sebastiano D'Amico Department of Geosciences, University of Malta, Msida MSD 2080, Malta Tel. +356 2340 3811 sebastiano.damico@um.edu.mt

Associate Editors

Biological Sciences Dr Sandro Lanfranco sandro.lanfranco@um.edu.mt

Cognitive Sciences and Psychology Prof. lan Thornton ian.thornton@um.edu.mt

Computer Sciences and Communication Technologies Dr Gianluca Valentino gianluca.valentino@um.edu.mt

Economics and Finance Dr Ian Cassar

ian.p.cassar@um.edu.mt

Electrical and Control Systems Engineering Dr Alexandra Bonnici alexandra.bonnici@um.edu.mt

Advisory Board Members

Prof. Vincenzo Crunelli, Cardiff University, UK

- Prof. David Eisner, Manchester University, UK
- Prof. Giacomo Rizzolati, University of Parma, Italy

Prof. Charles V. Sammut, University of Malta, Malta Prof. Frank Vella, University of Saskatchewan, Canada

Prof. Angela A. Xuereb Anastasi, University of Malta, Malta

Editorial Board Members

Dr Samantha Austen, Open University, UK Dr Maurizio Casarrubea, University of Palermo, Italy Dr Maria Cristiana D'Adamo, University of Malta, Malta Dr Katya De Giovanni, University of Malta, Malta Dr Tiziana M. Florio, University of L'Aquila, Italy Dr Robert Frau, University of Calgiari, Italy Prof. David Mifsud, University of Malta, Malta Dr Massimo Pierucci, University of Malta, Malta

Project Editor

Prof. Jackson Levi Said Department of Physics, University of Malta, Malta jackson.said@um.edu.mt

Editorial Assistants

Megan Floyd, Cardiff University, UK FloydMK@cardiff.ac.uk

Publication Manager

Prof. Giuseppe Di Giovanni Department of Physiology and Biochemistry, University of Malta, Msida MSD 2080, Malta Tel.: +356 2340 2776 giuseppe.digiovanni@um.edu.mt

Prof. David C. Magri Department of Chemistry, University of Malta, Msida MSD 2080, Malta Tel.: +356 2340 2276 david.magri@um.edu.mt

Health Sciences Mr Joseph Galea joseph.f.galea@um.edu.mt

Mechanical, Industrial and Manufacturing Engineering Dr Pierre Vella pierre.vella@um.edu.mt

Physics Dr Lourdes Farrugia lourdes.farrugia@um.edu.mt

Social Sciences Prof Godfrey Baldacchino godfrey.baldacchino@um.edu.mt

Statistics and Operational Research Prof Liberato Camilleri liberato.camilleri@um.edu.mt

crunelli@cardiff.ac.uk
eisner@manchester.ac.uk
giacomo.rizzolatti@unipr.it
charles.v.sammut@um.edu.mt
f.vella@sasktel.net
angela.a.xuereb@um.edu.mt

samantha.austen@open.ac.uk
maurizio.casarrubea@unipa.it
cristina.dadamo@um.edu.mt
katya.degiovanni@um.edu.mt
tizianamarilena.florio@univaq.it
roberto.frau@unica.it
david.a.mifsud@um.edu.mt
massimo.pierucci@um.edu.mt

Copy Editor

Julia Curmi Malta Chamber of Scientists, Malta scienceofficer@mcs.org.mt

Web Administrator

Giovanni Faraone faraone.g79@gmail.com Xjenza Online: Science Journal of the Malta Chamber of Scientists www.xjenza.org



Chronological List of Past and Present Editors of Xjenza

The Journal of the Malta Chamber of Scientists

2018 -

Editor: Cristiana Sebu Senior Editors: Sebastiano D'Amico, David Magri Associate Editors: Sandro Lanfranco, Ian Thornton, Gianluca Valentino, Ian Cassar, Alexandra Bonnici, Joseph Galea, Pierre Vella, Lourdes Farrugia, Godfrey Baldacchino, Liberato Camilleri Xjenza Online Vol. 10 Iss. 2 (2022) Xjenza Online Vol. 10 Iss. 1 (2022) Xjenza Online Vol. 10 Special Iss. MNS Proceedings (2022) Xjenza Online Vol. 9 Special Iss. (2021) Xjenza Online Vol. 9 Iss. 2 (2021) Xjenza Online Vol. 9 lss. 1 (2021) Xjenza Online Vol. 8 Iss. 2 (2020) Xjenza Online Vol. 8 lss. 1 (2020) Xjenza Online Vol. 7 Iss. 2 (2019) Xjenza Online Vol. 7 Iss. 1 (2019) Xjenza Online Vol. 6 Iss. 2 (2018) Xjenza Online Vol. 6 Iss. 1 (2018)

2013-2017

Editor: Giuseppe Di Giovanni Associate Editors: David Magri, Ian Thornton, Ian Cassar, Philip Farrugia, Sebastiano D'Amico, Nicholas Sammut, David Mifsud, Godfrey Baldacchino, Liberato Camilleri, Carmel Cefai Xjenza Online Vol. 5 Iss. 2 (2017) Xjenza Online Vol. 5 SI MNS Proceedings (2017) Xjenza Online Vol. 5 lss. 1 (2017) Xjenza Online Vol. 5 Virtual Issue COST (2017) Xjenza Online Vol. 4 Iss. 2 (2016) Xjenza Online Vol. 4 Iss. 1 (2016) Xjenza Online Vol. 3 Iss. 2 (2015) Associate Editors: David Magri, Ian Thornton, Ian Cassar, Philip Farrugia, Sebastiano D'Amico, Nicholas Sammut, Joseph Galea, David Mifsud, Sandro Lanfranco, Mario Valentino, Godfrey Baldacchino, Liberato Camilleri Xjenza Online Vol. 3 Iss. 1 (2015) Xjenza Online Vol. 2 Iss. 2 (2014) Xjenza Online Vol. 2 lss. 1 (2014) Xjenza Online Vol. 1 Iss. 2 (2013) Xjenza Online Vol. 1 lss. 1 (2013)

2003-2007

Editors: Joseph N. Grima and Richard Muscat Xjenza Vol. 12 (2007) Xjenza Vol. 11 (2006) Xjenza Vol. 10 (2005) Xjenza Vol. 9 (2004) Xjenza Vol. 8 (2003)

1996-2002

Editor: Angela Xuereb Associate Editor: Richard Muscat Xjenza Vol. 7 (2002) Xjenza Vol. 6 (2001) Associate Editors: Martin Ebejer and Richard Muscat Xjenza Vol. 5 (2000) Xjenza Vol. 4 Iss. 2 (1999) Xjenza Vol. 4 lss. 1 (1999) Associate Editors: Martin Ebejer, Richard Muscat, and Christian A. Scerri Xienza Vol. 3 lss. 2 (1998) Xjenza Vol. 3 Iss. 1 (1998) Associate Editors: Martin Ebejer, Richard Muscat, Christian A. Scerri and Emmanuel Sinagra Xjenza Vol. 2 Iss. 2 (1997) Xjenza Vol. 2 Iss. 1 (1997) Xjenza Vol. 1 Iss. 2 (1996) Xjenza Vol. 1 Iss. 1 (1996)

Scope of Journal

Xjenza Online is the Science Journal of the Malta Chamber of Scientists and is published in an electronic format. Xjenza Online is a peer-reviewed, open access international journal. The scope of the journal encompasses research articles, original research reports, reviews, short communications and scientific commentaries in the fields of: mathematics, statistics, geology, engineering, computer science, social sciences, natural and earth sciences, technological sciences, linguistics, industrial, nanotechnology, biology, chemistry, physics, zoology, medical studies, electronics and all other applied and theoretical aspect of science.

The first printed issue of the journal was published in 1996 and the last (Vol. 12) in 2007. The publication of Xjenza was then ceased until 2013 when a new editorial board was formed with internationally recognised scientists, and Xjenza was relaunched as an online journal, with two issues being produced every year. One of the aims of Xjenza, besides highlighting the exciting research being performed nationally and internationally by Maltese scholars, is to provide a launching platform into scientific publishing for a wide scope of potential authors, including students and young researchers, into scientific publishing in a peer-reviewed environment.

Instructions for Authors

Xjenza is the Science Journal of the Malta Chamber of Scientists and is published by the Chamber in electronic format on the website: http://www.mcs.org.mt/index.php/xjenza. Xjenza will consider manuscripts for publication on a wide variety of scientific topics in the following categories

- 1. Research Articles
- 2. Communications
- 3. Review Articles
- 4. Notes
- 5. Research Reports
- 6. Commentaries
- 7. News and Views
- 8. Invited Articles and Special Issues
- 9. Errata

Research Articles form the main category of scientific papers submitted to Xjenza. The same standards of scientific content and quality that applies to Communications also apply to Research Articles.

Communications are short peer-reviewed research articles (limited to three journal pages) that describe new important results meriting urgent publication. These are often followed by a full Research Article.

Review Articles describe work of interest to the wide community of readers of Xjenza. They should provide an in-depth understanding of significant topics in the sciences and a critical discussion of the existing state of knowledge on a topic based on primary literature sources. Review Articles should not normally exceed 6000 words.Authors are strongly advised to contact the Editorial Board before writing a Review.

Notes are fully referenced, peer-reviewed short articles limited to three journal pages that describe new theories, concepts and developments made by the authors in any branch of science and technology. Notes need not contain results from experimental or simulation work.

Research Reports are extended reports describing research of interest to a wide scientific audience characteristic of Xjenza. Please contact the editor to discuss the suitability of topics for Research Reports.

Commentaries Upon Editor's invitation, commentaries discuss a paper published in a specific issue and should set the problems addressed by the paper in the wider context of the field. Proposals for Commentaries may be submitted; however, in this case authors should only send an outline of the proposed paper for initial consideration. The contents of the commentaries should follow the following set of rules: 3000 words maximum, title 20 words maximum, references 10 maximum (including the article discussed) and figures/tables 2 maximum.

News and Views The News section provides a space for articles up to three journal pages in length describing leading developments in any field of science and technology or for reporting items such as conference reports. The Editor reserves the right to modify or reject articles for consideration as News.

Invited Articles and Special Issues Xjenza regularly publishes Invited Articles and Special Issues that consist of articles written at the invitation of the Editor or another member of the editorial board.

Errata Xjenza also publishes errata, in which authors correct significant errors of substance in their published manuscripts. The title should read: Erratum: "Original title" by ***, Xjenza, vol. *** (year). Errata should be short and consistent for clarity.

Submission of Manuscripts

Manuscripts should be sent according to the guidelines given hereafter to xjenza@mcs.org.mt.

Referees All manuscripts submitted to Xjenza are peer reviewed. Authors are requested to submit with their manuscript the names and addresses of three referees, preferably from overseas. Every effort will be made to use the recommended reviewers; however the editor reserves the right to also consult other competent reviewers.

Conflict of Interest Authors are expected to disclose any commercial or other types of associations that may pose a conflict of interest in connection to with the submitted manuscript. All funding sources supporting the work, and institutional or corporate affiliations of the authors, should be acknowledged on the title page or at the end of the article.

Policy and Ethics The work presented in the submitted manuscript must have been carried out in compliance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans (http://www.wma.net/en/30publications/10policies/b3/index.html); EU Directive 2010/63/EU for animal experiments (http://ec.europa.eu/environment/chemicals/lab_animals/legislation_en.htm); Uniform Requirements for manuscripts submitted to Biomedical journals (http://www.icmje.org). This must be stated at an appropriate point in the article.

Submission, Declaration and Verification Author(s) must only submit work that has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that is not under consideration for publication elsewhere, that has been approved for publication by all authors, and tacitly or explicitly, by the responsible authorities where the work was carried out, and that, if accepted, will not be published elsewhere in the same form, in English or in any other language, including electronically, without the written consent of the copyright-holder.

Permissions It is the responsibility of the corresponding author of a manuscript to ensure that there is no infringement of copyright when submitting material to Xjenza. In particular, when material is copied from other sources, a written statement is required from both the author and/or publisher giving permission for reproduction. Manuscripts in press, unpublished data and personal communications are discouraged; however, corresponding authors are expected to obtain permission in writing from at least one author of such materials.

Preparation of Manuscripts

Xjenza accepts submissions in MS Word, Libre Office Writer and LATEX, the latter being the preferred option. Anyone submitting in LATEX should use the journal template, the latest version of which can be found at http://github.com/hicklin/ Xjenza-Journal-Template. All the necessary files to run the LATEX document should be supplied together with the rendered PDF.

If a word processor is used the styling should be kept to a minimum. Bold face and italic fonts, as well as subscript and superscript text may be used as required by the context. Text should be in single-column format and the word processor options should not be used in order to justify text or hyphenate words. Alongside the native format of the word processer, a PDF file, generated by the word processor, must be provided. Furthermore, artwork should be in accordance with the artwork guidelines given below and must be submitted separately from the word processor file. Similarly, the bibliographic data of the cited material should be submitted separately as an Endnote (*.xml), Research Information Systems (*.ris), Zotero Library (zotero.splite) or a $\mathsf{BiBT}_\mathsf{FX}$ (*.bib) file.

Article Structure

A manuscript for publication in Xjenza will typicall have the following components: Title page, Abstract, Keywords, Abbreviations, Introduction, Materials and Methods, Results, Discussion, Conclusions, Appendices and References.

The manuscript will be divided into clearly defined and numbered sections. Each numbered subsection should have a brief heading. Each heading should appear on its own separate line. Subsections should be used as much as possible when cross-referencing text, i.e. refer to the subsection by the section number.

Title page

- The title should be concise yet informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.
- Author names and affiliations. Indicate the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lower-case superscript number immediately after each author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address.
- Corresponding author. Clearly indicate who will handle correspondence at all stages of refereeing and publication, including post-publication. Ensure that telephone and fax numbers (with country and area code) are provided in addition to the e-mail address and complete postal address. Contact details must be kept up to date by the corresponding author.
- Present/permanent address. If an author has changed the address since the work described, this can be indicated as a footnote to the author's name. The address at which the author actually did the work must be retained as the main, affiliation address. Superscript Arabic numerals are used for such footnotes.

Abstract A concise and factual abstract is required of up to about 250 words. The abstract should state briefly the background and purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so

it must be able to stand alone. For this reason, references and nonstandard abbreviations should be avoided. If essential, these must be defined at first mention in the abstract itself.

Abbreviations Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention as well as in the footnote and should be used consistently throughout the text.

Introduction State the objectives of the work and provide an adequate background, avoid a detailed literature survey or a summary of the results.

Materials and Methods Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.

Results Results should be clear and concise. Numbered/tabulated information and/or figures should also be included.

Discussion This should explore the significance of the results of the work, yet not repeat them. Avoid extensive citations and discussion of published literature. A combined section of Results and Discussion is often appropriate.

Conclusions The main conclusions based on results of the study may be presented in a short Conclusions section. This may stand alone or form a subsection of a Discussion or Results and Discussion section.

Appendices Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

Acknowledgements Collate acknowledgements in a separate section at the end of the article before the references. Do not include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided assistance during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

Units Follow internationally accepted rules and conventions: use the international system of units (SI). If other units are mentioned, please give their equivalent in SI. Anyone using LaTEX should use the package siunitx in all cases.

Footnotes Footnotes should be used sparingly. Number them consecutively throughout the article, using superscript Arabic numbers. Many word processors build footnotes into the text, and this feature may be used. Should this not be the case, indicate the position of footnotes by a superscript number in the text and list the footnotes separately at the end of the article. Do not include footnotes in the Reference list.

Table FootnotesIndicate each footnote in a table with a super-script lower case letter.

Artwork Electronic artwork general instructions:

- Make sure you use uniform lettering and sizing of your original artwork.
- Save text in illustrations as 'graphics' or enclose the font.
- Only use the following fonts in your illustrations: Arial, Courier, Times, Symbol or Computer Modern Roman, the latter is preferred.
- Number the illustrations according to their sequence in the text.
- Name your artwork files as 'figx' or 'tabx' where x corresponds to the sequence number in your document.

- Provide captions to illustrations separately.
- Produce images near to the desired size of the printed version or grater.
- Make sure that the artwork has no margins and borders.
- Submit each figure as a separate file.

Formats Regardless of the application used, when your electronic artwork is finalised its file format should be one of the following (note the resolution requirements for line drawings, halftones, and line/halftone combinations given below):

- PDF or SVG: Vector drawings. Embed the font or save the text as 'graphics'.
- JPEG or PNG: Color or grayscale photographs (halftones): always use a minimum of 300 dpi.
- JPEG or PNG: Bitmapped line drawings: use a minimum of 1000 dpi.
- JPEG or PNG: Combinations bitmapped line/half-tone (color or grayscale): a minimum of 500 dpi is required.

Where possible use a vector format for your artwork (PDF or SVG). If this is not possible, supply files that have and adequate resolution.

Colour Artwork Make sure that color artwork files are in an acceptable format (JPEG, PNG, PDF or SVG) and have the correct resolution.

Figure Captions Ensure that each illustration has a caption. Supply captions separately, not attached to the figure. A caption should comprise a brief title (not on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum, but explain all symbols and abbreviations used.

Tables Number tables consecutively in accordance with their appearance in the text. Place footnotes to tables below the table body and indicate them with superscript lowercase letters. Avoid vertical rules. Be moderate with the use of tables and ensure that the data presented in tables do not duplicate results described elsewhere in the article. Large tables should be submitted in CSV format.

Citations and References Reference and citation styles for manuscripts submitted to Xjenza should be in accordance to the APA v6 style.

Citation in text References to cited literature in the text should be given in the form of an author's surname and the year of publication of the paper with the addition of a letter for references to several publications of the author in the same year. For further information regarding multiple authors consult the APA v6 guidelines. Citations may be made directly

Kramer et al. (2010) have recently shown ...

or parenthetically

as demonstrated (Allan, 2000a, 2000b, 1999; Allan and Jones, 1999).

Groups of references should be listed first alphabetically, then chronologically. When writing in LATEX use $textcite{}$ and $parencite{}$ for the respective cases mentioned.

The reference section Every reference cited in the text should also be present in the reference list (and vice versa). The reference list should also be supplied as an Endnote (*.xml), Research Information Systems (*.ris), Zotero Library (zotero.splite) or a BiBTEX (*.bib) file. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication. Consult the APA v6 guidelines for multiple authors. Below are some examples of referencing different bibliographic material.

Reference to a Journal Publication

- Agree, E. M. and Freedman, V. A. (2011). A Quality-of-Life Scale for Assistive Technology: Results of a Pilot Study of Aging and Technology. *Phys. Ther.*, 91(12):1780–1788.
- McCreadie, C. and Tinker, A. (2005). The acceptability of assistive technology to older people. *Ageing Soc.*, 25(1):91–110.

Reference to a Book

- Brownsell, B. (2003). Assistive Technology and Telecare: Forging Solutions for Independent Living. Policy Press, Bristol.
- Fisk, M. J. (2003). Social Alarms to Telecare: Older People's Services in Transition. Policy Press, Bristol, 1st edition.

Reference to a Chapter in an Edited Book

Brownsell, S. and Bradley, D. (2003). New Generations of Telecare Equipment. In Assist. Technol. Telecare Forg. Solut. Indep. Living, pages 39–50.

Web references The full URL should be given together with the date the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately or can be included in the reference list.

References in a Special Issue Please ensure that the words 'this issue' are added to any references in the list (and any citations in the text) to other articles in the same Special Issue.

Journal Abbreviations Journal names should be abbreviated according to:

-Index Medicus journal abbreviations: http://www.nlm.nih.gov/ tsd/serials/lji.html;

-List of title word abbreviations: http://www.issn.org/ 2-22661-LTWA-online.php;

-CAS (Chemical Abstracts Service): http://www.cas.org/sent. html.

Video data Xjenza accepts video material and animation sequences to support and enhance the presentation of the scientific research. Authors who have video or animation files that they wish to submit with their article should send them as a separate file. Reference to the video material should be clearly made in text. This will the modified into a linked to the paper's supplementary information page. All submitted files should be properly labelled so that they directly relate to the video files content. This should be within a maximum size of 50 MB.

Submission check list

The following list will be useful during the final checking of a manuscript prior to sending it to the journal for review. Please consult the Author Guidelines for further details of any item.

- One author has been designated as the corresponding author with contact details:
 - E-mail address.
 - Full postal address.
 - Telephone and fax numbers.
- All necessary files have been sent, and contain:
 - All figures are given separately in PDF, SVG, JPEG of PNG format.
 - Caption for figures is included at the end of the text.

- All tables (including title, description, footnotes) are included in the text and large tables have been given separately as CSV.
- The reference list has been given in XML, RIS, zotero.splite or BIB file format.
- Further considerations
 - Abstract does not exceed about 250 words.
 - Manuscript has been 'spell-checked' and 'grammarchecked'.
 - References are in the required format.
 - All references mentioned in the reference list are cited in the text, and vice versa.
 - Bibliographic data for all cited material has been provided.
 - Permission has been obtained for use of copyrighted material from other sources (including the Web).
 - A PDF document generated from the word processor used is submitted.

After Acceptance

Use of the Digital Object Identifier The Digital Object Identifier (DOI) may be used to cite and link to electronic documents.

The DOI consists of a unique alpha-numeric character string which is assigned to a document by the publisher upon the initial electronic publication. The assigned DOI never changes. Therefore, it is an ideal medium for citing a document, particularly 'Articles in press' because they have not yet received their full bibliographic information. When you use a DOI to create links to documents on the web, the DOIs are guaranteed never to change.

Proofs, Reprints and Copyright The corresponding author will receive an electronic proof of the article and have an opportunity to review editorial changes and to double-check accuracy of content, tables, and statistics before publication. A list of any necessary corrections should be sent by email to the managing editor within a week of proof receipt to avoid unnecessary delays in the publication of the article. Alterations, other than essential corrections to the text of the article, should not be made at this stage. Manuscripts are accepted for publication on the understanding that exclusive copyright is assigned to Xjenza. However, this does not limit the freedom of the author(s) to use material in the articles in any other published works.

Xjenza Online: Science Journal of the Malta Chamber of Scientists www.xjenza.org



The Future of Scholarly Publishing is Open Access

Cristiana Sebu^{*1}

¹Department of Mathematics, University of Malta, Msida, Malta

Dear readers and authors of Xjenza Online, as Editorin-Chief, I am also pleased to announce the release of the second regular issue of 2022 of Xjenza Online.

In 2022, Malta Chamber of Scientists celebrated its 30th anniversary, so you should not be surprised to learn that the journal is 28 years old! The way we communicate, connect and share has changed drastically since 1996 when the journal was first launched in a printed format, and even more since 2013 when the journal was relaunched as an online free open access journal. This has deeply impacted scientific research and academic publishing as well. Open access is currently the way for academics to publish and achieve a worldwide audience. The future of scholarly publishing lies in open access due to the easy access and distribution of academic publications which are important to everyone: authors, readers, and funders. It has almost become an incentive to researchers to publish open access in recent years, as it is a huge opportunity to broaden the impact of their work. However, some scientific communities remain adamant to publish in open access journals because of the expensive publication fees and concerns about the quality of the peerreview process. In this context, the service Xjenza Online has provided to the local and international scientific community is truly exceptional as the publications are not only open access, but free of charge and the Editorial Board is dedicated to rigorous and fair peer-review. Malta Chamber of Scientists has, therefore, to be commended for their commitment to provide the infrastructure and manpower to keep the journal running through donations and sponsorships which most of the time are rather modest or one-offs.

In this context, we are excited to share with you our latest open access publications included in the current issue.

The issue opens with an article by Vella and Camilleri which presents a detailed decomposition method to explain changes in poverty when the poverty line is not fixed and depends on the income distribution. Empirical illustrations based on EU-SILC data for Malta between 2005 and 2018 revealed that the poverty line and income growth were the most important contributors to poverty changes, especially during periods of rapid income growth.

Next, the article by Fabri et al. examines the macroeconomic and socioeconomic determinants of early school leaving (ESL). The outcomes highlight the complexity of ESL involving nonlinearity, equifinality, and asymmetric relations. Inequality and parental education emerge as key determinant of ESL.

The paper by Cutajar et al. presents a step-by-step guide on how to set up a valuable and informative mixed method evaluation strategy of large-scale science festivals and events.

Visanich presents then an interesting study on public opinion and protest efficacy in the context of the proposed yacht marina in Marsaskala. The research identifies the underlying factors causing individuals' concerns on the proposed development. Results point to the social, environmental and economic impacts that this development would have, particularly on the community infrastructure of the locality of Marsaskala.

The issue concludes with an article by Borg Muscat et al. on the factors influencing the abundance and distribution of feral pigeons in urban environments in Malta, an important contribution towards a tailormade and economical scientific management plan for controlling feral pigeons in urban settings.

I also conclude by wishing you a very Happy New Year 2023 filled with good health and many scientific discoveries! The main goals of the coverage will remain the same in 2023 and in the future (at least for the next five more years of my editorship), namely to serve the local professional scientific community, to publish high-quality original findings in a peer-reviewed environment, and to help early-career researchers to advance their scientific discourse in the community.



Xjenza Online: Science Journal of the Malta Chamber of Scientists www.xjenza.org DOI: 10.7423/XJENZA.2022.2.01

Research Article



A Decomposition of Poverty Headcount: Income and Population Dynamics

M. Vella*1 and G. Camilleri1

¹Centre for Labour Studies, Department of Economics, University of Malta, Msida, Malta

Abstract. We formalise and present a detailed decomposition method to explain changes in poverty when the poverty line is not fixed and depends on the income distribution. Using the shift-share simulation approach, we decompose poverty change into four components, namely income growth, change in inequality, change in poverty line, and change in total population. We provide empirical illustrations with EU-SILC data for Malta between 2005 and 2018. We find that the poverty line and income growth have been the most important contributors to poverty changes, especially during periods of rapid income growth. This decomposition can be used either to interpret changes between two periods or to microsimulation models of taxes and benefits.

Keywords: At-risk-of-poverty rate, relative poverty, shift-share.

1 Introduction

The proportion of people in material deprivation in Malta almost halved in 2018 to 8.7% compared to the year when the indicator started to be surveyed, 2009. Yet, with a few exceptions, the number of individuals at-risk-of-poverty increased at a yearly rate to reach 16.8% by 2018. At first glance, such divergent trends may seem unusual and underscore that poverty dynamics and related indicators require a more detailed assessment.

There is no single definition of poverty in a society: value judgments play an important role. Whether poverty is absolute or relative has long been debated. Some say that the poverty line should reflect the absolute poverty threshold, i.e., the cost of purchasing a fixed basket of goods and services that enables people to meet their basic needs; the demarcation between poor and non-poor. Others argue that we should instead look at poverty as a

*Correspondence to: M. Vella (mvell31@um.edu.mt) © 2022 Xjenza Online relative threshold, i.e., relative to the country's standard of living. Those who view poverty in relative terms would argue that the poorest members of society appear to have lagged behind the rest; hence the term at-risk-of-poverty. In the absence of an absolute poverty indicator, debates about poverty can easily become deadlocked, as a change in relative poverty does not necessarily reflect a change in absolute poverty.

Social scientists are often interested in explaining why or how at-risk-of-poverty rates change over time. Microsimulation modelling applications, e.g., EUROMOD (Sutherland, 2007), have aided the analysis by evaluating the immediate impact of socio-economic policies on individuals and households. However, in most applications, the poverty line is not fixed and is set as a percentage of the median income of the total population in each year. As a result, the relative poverty line can change from year to year, making it difficult to interpret changes in poverty as a real change or simply as a consequence of a mechanical change in the poverty line. Interpreting poverty change is complex because it mirrors not only gross income change, which reflects labour market developments, but also changes in tax and benefit parameters, the underlying income distribution, and population change. Failure to consider these four components may lead to misinterpretation of the change, and even skewed results. For example, the poverty threshold may fall faster than average income when the economy sinks into a recession, and the poverty rate decreases as a result (Koutsampelas, 2014). While it appears that the number of people previously living just below the poverty line has escaped poverty, after accounting for the decline in the poverty line, poverty would have increased. As a remedy one can set the poverty threshold as fixed in the previous years to avoid conflicting results (Picos et al., 2016), but this comes at the cost of losing important information about the dynamics of poverty.

In this paper, we contribute to literature and policy analysis by presenting a quadruple decomposition method that breaks down changes in poverty into four components, namely:

- i. changes in the poverty line, which depends on the income of the non-poor,
- ii. changes in the underlying income distribution that change due to market and policy developments,
- iii. income growth, and
- iv. population changes.

We argue that demographic change is another important factor, especially for small countries undergoing rapid demographic transformation, even for developed countries. As a case study, we use Malta, which we consider a classic example due to its small size and ageing population. Malta has become heavily dependent on migration flows to sustain economic growth, with sharp changes in the poverty line and income as well modest higher inequalities at the high end of the income distribution (Vella et al., 2021).

Second, this methodology is of great interest to policy makers and social scientists, as we are able to analyse the components that contribute to the change in poverty, to understand what caused the change in poverty dynamics and their magnitude. Different contributions require different packages of measures to tackle poverty. For example, if poverty is caused by income inequality, this would require a redistributive policy, while poverty, which is mainly caused by the poverty line, might be best addressed by uprating those on fixed incomes and consequently not falling behind the others.

Finally, using the shift-share simulation approach and building on the method proposed by Günther (2007), we set up the theoretical framework of a four-way decomposition. By applying this methodology on Maltese data between 2005 and 2018, this is, to our knowledge, the first such attempt for Malta. We find that the components of the poverty line and income growth have been the most important contributors to poverty changes, particularly during periods of rapid income growth. We also find that the population contribution is particularly relevant in countries undergoing rapid demographic change, such as the admission of a large proportion of refugees and migrant workers.

The paper is organised in four sections as follows. Section 2, which follows this introduction, presents the theoretical framework for decomposing the headline poverty rate. Section 3 uses Malta as a case study and presents recent trends in the four components of poverty, namely income growth, income distribution, population changes and poverty line changes. The section also reports the decomposition exercise. Section 4 will conclude the study and puts forward a number of implications that are derived from the results presented in the previous section.

2 Theoretical Framework

Drawing from Kakwani (2000) and Mishra (2015), assume that there is a population set N = 1, ..., n of nindividuals. For each $i = 1, ..., n, x_i \in \mathbb{R}_+$ is the income of individual i. Let vector $(x_1, ..., x_n) \in \mathbb{R}_+^n$ be income ranked in non-decreasing order. All finite income distributions are represented by $\mathcal{D} = \bigcup_{n \ge 1} \mathbb{R}_+^n$. For any given poverty line $z \in \mathbb{R}_{++}$ and for any distribution $x \in \mathcal{D}$, the set of poor people is defined as $Q(x, z) = \{i \in N/x_i < z\}$, and the number of poor by q(x, z). Let σ_x be income distribution of the population and μ_x be the mean income of the population. We define the poverty headcount in period t as $P(\mu_t, \sigma_t, z_t) = q(x, z)$.

We now consider two time periods and start with the quadruple decomposition. In each period we consider the mean income of the population μ_t , the income distribution σ_t , the poverty threshold z_t , and the population size η_t with t = 1, 2. The changes in poverty along the period can be decomposed as follows:

$$\Delta P_{(t+1,t)} = [P(\mu_{t+1}, \sigma_t, z_t, \eta_t) - P(\mu_t, \sigma_t, z_t, \eta_t)] + [P(\mu_t, \sigma_{t+1}, z_t, \eta_t) - P(\mu_t, \sigma_t, z_t, \eta_t)] + [P(\mu_t, \sigma_t, z_{t+1}, \eta_t) - P(\mu_t, \sigma_t, z_t, \eta_t)] + [P(\mu_t, \sigma_t, z_t, \eta_{t+1}) - P(\mu_t, \sigma_t, z_t, \eta_t)] + R_{t+1}$$
(1)

 $P(\mu_t, \sigma_t, z_t, \eta_t)$ is the measure of poverty with a mean income μ_t , an income distribution σ_t , a poverty line z_t and a population size η_t over the period t.

The first component corresponds to the change in poverty explained by *income growth*, keeping all other components constant. Another way of depicting the income growth components is to plot income on the horizontal axis, count how many people earn that particular income level, and then stack them so that the number on the vertical axis represents them (figure 1). From the hypothetical example, it can be seen that a rightward shift in income distribution through income growth will lift people out of poverty. This is because, all else being equal, fewer people will fall below the poverty line represented by the vertical line.

The second component measures the change in poverty, which is explained by changes in *income distribution*, with other factors remaining unchanged. As movements in income distribution become more unequal, it becomes more difficult to lift people out of poverty. Figure 1 presents a hypothetical case by showing that when the new income distribution is significantly lower than the previous income distribution, poverty will increase and lifting people out of poverty through growth alone is likely to become increasingly difficult.

The third component corresponds to the change in poverty, which is explained by changes in the *poverty line*, everything else remaining constant. The direct effect of a higher poverty line leads to a higher poverty rate. As shown in figure 1, it can be seen that the higher the threshold, the higher the proportion of poor people.

The fourth component captures the impact of population change on poverty. Importantly, in this decomposition we distinguish between changes in income distribution due to changes in inequality and demographic changes. In times of rapid *population change*, especially in times of migration, we expect the impact of income distribution to be substantial when these interactions are taken into account. The effect of population curve, with many more people living at or near the poverty line, everything else remaining constant.

 R_{t+1} represents the residual term, which is the interaction term between all components.

In the decomposition, the size of each component is path dependent, that is, it depends on whether one considers the growth, distribution, poverty line, and population components first, or other order combinations. In the quadruple decomposition, we consider 4! = 24 interaction paths for each component. This effectively means that 96 interaction paths are modelled, and therefore the residual can be eliminated.

It is noteworthy that the methodology used is an accounting decomposition and does not take into account dynamic changes in poverty outcomes. Income growth thus reduces poverty, while inequality, the poverty line and population growth increase poverty, assuming the other components remain unchanged. The income and population components only reflect average change, but if most of the income and/or population change has occurred amongst in the richest or poorest households, this will be reflected in the inequality change component.

Let $\dot{\mu}$ be average income growth, $\bar{\mu}_{(t+1)}/\bar{\mu}_t - 1$, and $\bar{\mu}$ be mean income for a given year and let $\dot{\eta}$ be population growth.

In the decomposition exercise, the income growth effect is calculated as follows:

$$\Delta P_{t+1}^{\mu} = [P(\mu_{t+1}, \sigma_t, z_t, \eta_t) - P(\mu_t, \sigma_t, z_t, \eta_t)] \frac{6}{24} + [P(\mu_{t+1}, \sigma_{t+1}, z_t, \eta_t) - P(\mu_t, \sigma_{t+1}, z_t, \eta_t)] \frac{2}{24} + [P(\mu_{t+1}, \sigma_t, z_{t+1}, \eta_t) - P(\mu_t, \sigma_t, z_{t+1}, \eta_t)] \frac{2}{24} + [P(\mu_{t+1}, \sigma_t, z_t, \eta_{t+1}) - P(\mu_t, \sigma_t, z_t, \eta_{t+1})] \frac{2}{24}$$
(2)

10.7423/XJENZA.2022.2.01

$$+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_{t+1}, \eta_t) - P(\mu_t, \sigma_{t+1}, z_{t+1}, \eta_t)\right] \frac{2}{24} \\+ \left[P(\mu_{t+1}, \sigma_t, z_{t+1}, \eta_{t+1}) - P(\mu_t, \sigma_t, z_{t+1}, \eta_{t+1})\right] \frac{2}{24} \\+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_t, \eta_{t+1}) - P(\mu_t, \sigma_{t+1}, z_t, \eta_{t+1})\right] \frac{2}{24} \\+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_{t+1}, \eta_{t+1}) - P(\mu_t, \sigma_{t+1}, z_{t+1}, \eta_{t+1})\right] \frac{6}{24} \\$$

Using the same analogy as before, the first component corresponds only to the change in poverty over two periods due to a change in average income, with income distribution, poverty live, and population unchanged. Besides this, to derive the full effect of income growth, we account for interactions with income, so the order of the components would not affect the derived results. In fact, the last component captures the effect of a change in average income, this time, income distribution, poverty live, and population take on the next period's value. Similarly, the second component also captures the impact of a change in average income on poverty, but this time the income distribution is unchanged from that of the next period. The third component captures the effect of a change in average income, but includes the next period's population size, while the fourth component uses the next period's poverty threshold, and so on. The fractions represent the weighted contribution of each respective component to the overall income effect. The smaller fractions represent the relative weights for all other possible interactions with income, using either the previous or next period's values. In this way, the residual is eliminated.

Likewise, the inequality component is given by:

$$\begin{split} \Delta P_{t+1}^{\sigma} &= \left[P(\mu_t, \sigma_{t+1}, z_t, \eta_t) - P(\mu_t, \sigma_t, z_t, \eta_t) \right] \frac{6}{24} \\ &+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_t, \eta_t) - P(\mu_{t+1}, \sigma_t, z_t, \eta_t) \right] \frac{2}{24} \\ &+ \left[P(\mu_t, \sigma_{t+1}, z_{t+1}, \eta_t) - P(\mu_t, \sigma_t, z_{t+1}, \eta_t) \right] \frac{2}{24} \\ &+ \left[P(\mu_t, \sigma_{t+1}, z_t, \eta_{t+1}) - P(\mu_t, \sigma_t, z_t, \eta_{t+1}) \right] \frac{2}{24} \\ &+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_{t+1}, \eta_t) - P(\mu_{t+1}, \sigma_t, z_{t+1}, \eta_t) \right] \frac{2}{24} \\ &+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_t, \eta_{t+1}) - P(\mu_t, \sigma_t, z_t, \eta_{t+1}) \right] \frac{2}{24} \\ &+ \left[P(\mu_t, \sigma_{t+1}, z_{t+1}, \eta_{t+1}) - P(\mu_t, \sigma_t, z_{t+1}, \eta_{t+1}) \right] \frac{2}{24} \\ &+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_{t+1}, \eta_{t+1}) - P(\mu_t, \sigma_t, z_{t+1}, \eta_{t+1}) \right] \frac{2}{24} \\ &+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_{t+1}, \eta_{t+1}) - P(\mu_t, \sigma_t, z_{t+1}, \eta_{t+1}) \right] \frac{2}{24} \end{split}$$

The poverty threshold component is given by:

$$\Delta P_{t+1}^{z} = \left[P(\mu_{t}, \sigma_{t}, z_{t+1}, \eta_{t}) - P(\mu_{t}, \sigma_{t}, z_{t}, \eta_{t})\right] \frac{6}{24} \\ + \left[P(\mu_{t+1}, \sigma_{t}, z_{t+1}, \eta_{t}) - P(\mu_{t+1}, \sigma_{t}, z_{t}, \eta_{t})\right] \frac{2}{24} \\ + \left[P(\mu_{t}, \sigma_{t+1}, z_{t+1}, \eta_{t}) - P(\mu_{t}, \sigma_{t+1}, z_{t}, \eta_{t})\right] \frac{2}{24} \\ + \left[P(\mu_{t}, \sigma_{t}, z_{t+1}, \eta_{t+1}) - P(\mu_{t}, \sigma_{t}, z_{t}, \eta_{t+1})\right] \frac{6}{24}$$
(4)

www.xjenza.org



Figure 1: Changes in the components of poverty

Note: The vertical solid lines represent the poverty threshold, with the dashed line representing the adjusted poverty threshold.

$$+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_{t+1}, \eta_t) - P(\mu_{t+1}, \sigma_{t+1}, z_t, \eta_t)\right] \frac{2}{24} \\+ \left[P(\mu_{t+1}, \sigma_t, z_{t+1}, \eta_{t+1}) - P(\mu_{t+1}, \sigma_t, z_t, \eta_{t+1})\right] \frac{2}{24} \\+ \left[P(\mu_t, \sigma_{t+1}, z_{t+1}, \eta_{t+1}) - P(\mu_t, \sigma_{t+1}, z_t, \eta_{t+1})\right] \frac{2}{24} \\+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_{t+1}, \eta_{t+1}) - P(\mu_{t+1}, \sigma_{t+1}, z_t, \eta_{t+1})\right] \frac{6}{24} \\$$

The population component is estimated by:

$$\begin{split} \Delta P_{t+1}^{\mu} &= \left[P(\mu_t, \sigma_t, z_t, \eta_{t+1}) - P(\mu_t, \sigma_t, z_t, \eta_t) \right] \frac{6}{24} \\ &+ \left[P(\mu_{t+1}, \sigma_t, z_t, \eta_{t+1}) - P(\mu_{t+1}, \sigma_t, z_t, \eta_t) \right] \frac{2}{24} \\ &+ \left[P(\mu_t, \sigma_{t+1}, z_t, \eta_{t+1}) - P(\mu_t, \sigma_{t+1}, z_t, \eta_t) \right] \frac{2}{24} \\ &+ \left[P(\mu_t, \sigma_t, z_{t+1}, \eta_{t+1}) - P(\mu_t, \sigma_t, z_{t+1}, \eta_t) \right] \frac{2}{24} \\ &+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_t, \eta_{t+1}) - P(\mu_{t+1}, \sigma_{t+1}, z_t, \eta_t) \right] \frac{2}{24} \\ &+ \left[P(\mu_{t+1}, \sigma_t, z_{t+1}, \eta_{t+1}) - P(\mu_{t+1}, \sigma_t, z_{t+1}, \eta_t) \right] \frac{2}{24} \\ &+ \left[P(\mu_t, \sigma_{t+1}, z_{t+1}, \eta_{t+1}) - P(\mu_t, \sigma_{t+1}, z_{t+1}, \eta_t) \right] \frac{2}{24} \\ &+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_{t+1}, \eta_{t+1}) - P(\mu_{t+1}, \sigma_{t+1}, z_{t+1}, \eta_t) \right] \frac{2}{24} \\ &+ \left[P(\mu_{t+1}, \sigma_{t+1}, z_{t+1}, \eta_{t+1}) - P(\mu_{t+1}, \sigma_{t+1}, z_{t+1}, \eta_t) \right] \frac{6}{24} \end{split}$$

The components can be interpreted using the same analogy as above. The poverty change can now be estimated as:

$$\Delta P_{t+1} \cong \Delta P_{t+1}^{\mu} + \Delta P_{t+1}^{\sigma} + \Delta P_{t+1}^{z} + \Delta P_{t+1}^{\eta}, \quad (6)$$

and be expressed in terms of either population or headcount ratio by dividing each component by population size, n. Let ΔP_{t+1}^{μ} be the change in poverty due to the income growth component, ΔP_{t+1}^{σ} is the change brought about by income distribution component, ΔP_{t+1}^{z} represents changes in poverty due to the poverty line effect, and ΔP_{t+1}^{η} be the change in poverty attributed to the population size component. The STATA command file used to generate the results in Section 3 is included in the Appendix.

10.7423/XJENZA.2022.2.01

3 An Empirical Example: The Case of Malta

3.1 Poverty in Malta

We begin the analysis with the headline indicator of poverty for the period 2005–2018. The headline poverty indicator is the incidence of poverty by counting the people in poverty and expressing them as a proportion of the total number of people in society. The headcount poverty measure ignores the actual incomes of the poor, save for the fact that they fall below the poverty line.

Between 2005 and 2018, the number of people below the relative poverty line rose from approx. 57,000 to around 79,000, with the poverty rate increasing from 14.4% to 16.9% (figure 2). The general conclusion is that there is a higher incidence of poverty and that this incidence is generally increasing over the years, apart from some periods, despite normalising the indicator by population size. The reason for this is that as income levels change over time, so does the poverty line and income distribution.

The dynamics shown in figure 2 do not mean more people cannot lead decent lives, but more members of society seem to have fallen behind the rest. It is of interest to analyse which factors had the greatest impact on these changes in poverty rates.

3.2 Changes in Income and Poverty Line

We expect that an increase in the poverty threshold leads to an increase in the headcount indicator, everything else remaining constant. Figure 3 shows how mean and median household equivalised income changed during under study. Since the poverty line is defined as 60% of median equivalised household disposable income, both the median income and the poverty threshold lines follow the same trajectory. It can be seen that the largest increases in income occurred in 2008 and 2014–2017. In the 2000s and early 2010s, the Maltese economy was bound by a process of aligning public finances with the Maastricht



Figure 2: Poverty Headcount Indicators in Malta

criteria and an excessive deficit procedure, which in the process slowed economic momentum. Having said that, the emergence of sectors such as financial services and remote gaming were the key sectors driving growth, hence the emergence of a two-speed economy. Income levels fell only once in 2010, reflecting the effect of the recession¹. In addition, concurrent to the increase in the incidence of relative poverty is a steady rise in the poverty threshold. The increase in relative poverty does not mean that more people cannot live a decent life, but that more members of society appear to have lagged behind the others.

3.3 Changes in Income Inequality

Another factor related to poverty dynamics is income inequality. A priori, the effect of a change in the income distribution could be interpreted differently since it can affect both the bottom and the top of the distribution. First, higher income inequality could be viewed to mean that more people are at the bottom of the distribution. Alternatively, this could result in more people being at the top of the income distribution.

A review of headline statistics for Malta shows that the Gini coefficient increased from 27.0 to 28.7 between 2005 and 2018 (figure 4). A coefficient of 0 means perfect equality, where everyone has the same income. In contrast, a coefficient of 100 implies absolute inequality if only one person has all the income. This development shows that inequality has increased over the past thirteen years despite social policies. However, social assistance from the state dampened the general increase in inequality. In addition, a more detailed analysis for the same period shows that modest higher inequalities happened at the high end of the income distribution. A more detailed analysis is provided by Vella et al. (2021).

3.4 Changes in Total Population

Another important factor related to the poverty indicator is total population. The size of population often goes unnoticed in economically advanced countries, but has a great deal of say for poverty dynamics, especially for small economies.

Malta is the smallest EU Member State, with a population of less than half a million, which acceded to the EU on May 2004 and adopted the euro in January 2008. Due to its small size and ageing population, Malta has become heavily dependent on migration inflows to sustain rates of economic growth above EU-average. According to Eurostat, the population living in Malta increased by 20% during the survey period, mainly due to large economic immigration flows from EU and non-EU countries (figure 5). The share of foreign workers increased rapidly considering that in 2019 almost one in four workers was foreigner compared to only 5.6% in 2008 (DG for Economic and Financial Affairs (ECFIN), 2019, 2020).

A priori, a larger population increases the number of people living below the poverty line, all other things remaining constant. Furthermore, it can also be argued that the interaction between population and inequality has become more pronounced due to the dichotomous profile of economic migrants, ranging from professional to elementary occupations, and the rapid per capita inflow of irregular migrants. We also expect that the inequality component will be sizeable over the recent years due to recently

¹The income reference year of the SILC survey is one calendar year prior to the survey year. For example, the income collected in 2010 refers to the calendar year 2009.









introduced programmes to address at-risk-of-poverty and social exclusion, including increasing pensions, reducing taxes for all workers, and a new housing benefit in order to improve rent affordability in the private sector (Ministry for Finance (MFIN), 2019).

3.5 Decomposition Analysis

In this section, we use equation (6) to study the poverty dynamics in Malta between 2005 and 2018 and present the results in figure 6 and table 1. Figure 6 shows the decomposition of change in poverty headcount in thousands, while table 1 shows the poverty rates and the contribution of each component to the change in the poverty rate, i.e., by dividing the number of poor people by size of the population.

All years have been characterised by income growth,

and 2010 was the exception, reflecting the global recession of 2009. Disposable income growth has, on average, exerted a downward pressure of 1.9 p.p. between 2005 and 2012 and of 2.4 p.p. during the 2013—2018 period. Because the poverty threshold depends on the median

equivalised disposable income we expect the threshold to rise rapidly in a growing economy, but conversely fall in a recession. With the exception of 2010, the poverty line again put upward pressure on poverty. The impact of changes in the poverty line depends not only on the magnitude of the change, but also on the distribution of the poor—that is, the number of people just living below or above the poverty line. If people are concentrated around the poverty line, then more elastic poverty is proportional to changes in the threshold. Seven out of thirteen periods were characterised with poverty threshold



Figure 5: Total Population

contribution that outweighed income growth contribution, implying that the poverty threshold has risen faster than average income.

The inequality change effect shows the extent to which poverty has been changed by income inequality. The contributions move in parallel with changes in the Gini coefficient. Again, the effect swings from positive to negative over time but, overall the magnitude of the upside contribution exceeded the negative contribution. This means that inequality tendencies lead to poverty, everything else remains constant.

Finally, the impact of total population change shows that, other things being equal, the impact of economic growth on poverty is dampened by an increase in total population. The population effect has been amplified in recent years due to reliance on foreign labour to fill labour shortages. In 2018, the population effect reduced the impact of economic growth on poverty reduction by nearly half.

4 Conclusions

In this paper we present a detailed decomposition method to decipher changes in components using a shift-share simulation approach. The method attributes the changes to four different effects and helps interpret of poverty change when poverty line is calculated using the distribution of equivalised disposable income.

We provide empirical illustrations with Maltese EU-SILC data for 2005–2018. They show that while income growth has contributed to poverty change, so has the poverty threshold. We also separated the income distribution effect and showed that the distribution effect is actually a combination of the change in total population inequality. Changes in the total population suggest that the increase in migration inflows is likely to have contributed to increases in poverty.

In summary, our paper has methodological improvements that draws from Kakwani (2000) and Mishra (2015) and expands on the methodology of Günther (2007). To our knowledge, this is the first such attempt on Maltese data. Many studies fix the poverty line to study difference of poverty between two periods of time, but it comes at the cost of losing important information about the four components, including any interactions between them.

Another important contribution of this exercise from a policy perspective is that it allows social scientists to understand how earnings, income distribution, poverty line and demographics affect poverty outcomes and helps communicate the results to policy makers and the public. The proposed decomposition may provide a unique avenue for an improved analysis of taxes and benefits by integrating results from microsimulations with poverty change decomposition. This simplifies interpretation and avoids counter-intuitive results without the need to fix the poverty line. While growth remains vital, we must complement our efforts to increase growth with policies that make more resources available to the relatively poor. To some extent, this can be achieved by focusing on inclusion, specifically by helping people below the poverty line to move up the income ladder faster.

5 Disclaimer

Funding for this research was made possible by the Centre for Labour Studies at the University of Malta. The views expressed in this paper do not necessarily reflect the official views of the University of Malta. We thank Dr Anna Borg, Dr Luke Fiorini and Dr Manwel Debono and the two anonymous reviewers for their reading of our manuscript and their suggestions.

	Poverty Head- count ('000)	Poverty Ratio (%)	Poverty Change (p.p.)	Income Change (p.p)	Population Change (p.p.)	Inequality Change (p.p.)	Poverty Line Change (p.p.)
2005	57.1	14.4					
2006	56.2	14.1	-0.3	-1.9	0.1	-0.6	2.1
2007	60.3	15.1	1.0	-0.5	0.0	0.3	1.2
2008	62.2	15.5	0.4	-4.4	0.1	1.0	3.8
2009	59.9	14.8	-0.7	-3.2	0.1	-0.1	2.5
2010	63.4	15.6	0.8	0.3	0.1	0.8	-0.3
2011	63.2	15.5	-0.1	-1.3	0.0	-0.8	2.0
2012	62.5	15.3	-0.3	-2.2	0.1	-0.6	2.5
2013	66.0	15.9	0.7	-3.0	0.2	0.9	2.6
2014	66.7	15.9	-0.1	-3.1	0.2	-0.4	3.2
2015	71.5	16.5	0.7	-2.9	0.4	0.5	2.7
2016	72.3	16.4	-0.2	-1.1	0.3	0.3	0.3
2017	75.5	16.7	0.3	-2.9	0.3	-0.5	3.5
2018	79.0	16.9	0.2	-1.2	0.5	-0.2	1.1

Table 1: Quadruple-decomposition of poverty headcount ratio



Figure 6: Quadruple-decomposition of poverty headcount, thousands

The present document has been produced using the EU-SILC 2005–2018 Data—National Statistics Office, Malta. The calculations and conclusions within the document are the intellectual product of the undersigned.

References

- DG for Economic and Financial Affairs (ECFIN). (2019). 2019 European semester: Country report of Malta. *European Commission*.
- DG for Economic and Financial Affairs (ECFIN). (2020). 2020 European semester: Country report of Malta. *European Commission*.
- Günther, I. (2007). *Empirical analysis of poverty dynamics: With case studies from Sub-Saharan Africa.* Peter Lang International Academic Publishers.
- Kakwani, N. (2000). On measuring growth and inequality components of poverty with application to Thailand. *Journal of quantitative economics*, *16*(1), 67–80.
- Koutsampelas, C. (2014). The introduction of a GMI scheme in Cyprus: Family structure, equivalence

10.7423/XJENZA.2022.2.01

scales and policy challenges (no. EM10/14). EUR-OMOD Working Paper.

- Ministry for Finance (MFIN). (2019). National reform programme. *Government of Malta*.
- Mishra, S. (2015). Decomposing poverty change: Deciphering change in total population and beyond. *Review of Income and Wealth*, *61*(4), 799–811.
- Picos, F. & Schmitz, M. L. (2016). In-depth analysis of tax reforms using the EUROMOD microsimulation model (no. 06/2016). JRC Working Papers on Taxation and Structural Reforms.
- Sutherland, H. (2007). EUROMOD: The tax-benefit microsimulation model for the European Union. In A. Gupta & A. Harding (Eds.), *Modelling our future: Population ageing, health and aged care*. Elsevier.
- Vella, M. & Camilleri, G. (2021). Inequality dynamics in Malta: Cracks, blips and long-term trends. *International Journal of Economics and Finance*, 13(11), 1–20.

www.xjenza.org

Appendix

Stata code for a Quadruple Poverty Decomposition (2018 over 2017) **poor2111 poverty rate at mu2 and sigmal and zl and eta1 gen poor2111=0 replace poor2111=1 if (ehhydisp2017 * \$ymean2018 / \$ymean2017 < \$pl2017) sum poor2111 [aw = dhweight2017] return list gen poor2111=r(sum) **poor1111 poverty rate at mul and sigmal and zl and eta1 gen poor1111=0 replace poor1111=1 if (ehhydisp2017 < \$pl2017)</pre> sum poor1111 [aw = dhweight2017] return list gen poor1111=r(sum) **poor2211 poverty rate at mu2 and sigma2 and zl and eta1 gen poor2211=0 replace poor2211=1 * \$pop2017 / \$pop2018 if (ehhydisp2018 < \$pl2017) sum poor2211 [aw = dhweight2018] return list gen poor2211=r(sum) **poor1211 poverty rate at mul and sigma2 and zl and eta1 gen poor1211=0 replace poor1211=1 * \$pop2017 / \$pop2018 if (ehhydisp2018 * \$ymean2017 / \$ymean2018 < \$pl2017) sum poor1211 [aw = dhweight2018] return list gen poor1211=r(sum) **poor2121 poverty rate at mu2 and sigmal and z2 and eta1 gen poor2121=0 replace poor2121=1 if (ehhydisp2017 * \$ymean2018 / \$ymean2017 < \$pl2018) sum poor2121 [aw = dhweight2017] return list gen poor2121=r(sum) **poor1121 poverty rate at mul and sigmal and zl and eta1 gen poor1121=0 replace poor1121=1 if (ehhydisp2017 < \$pl2018)</pre> sum poor1121 [aw = dhweight2017] return list gen poor1121=r(sum) **poor2112 poverty rate at mu2 and sigma1 and zl and eta2 gen poor2112=0 replace poor2112=1 * \$pop2018 / \$pop2017 if (ehhydisp2017 * \$ymean2018/\$ymean2017 < \$pl2017) sum poor2112 [aw = dhweight2017] return list gen poor2112=r(sum) **poor1112 poverty rate at mul and sigmal and zl and eta2 gen poor1112=0 replace poor1112=1 * \$pop2018 / \$pop2017 if (ehhydisp2017 < \$pl2017)</pre> sum poor1112 [aw = dhweight2017] return list gen poor1112=r(sum) **poor2221 poverty rate at mu2 and sigma2 and z2 and eta1 gen poor2221=0 replace poor2221=1 * \$pop2017 / \$pop2018 if (ehhydisp2018 < \$pl2018) sum poor2221 [aw = dhweight2018] return list gen poor2221=r(sum)

10.7423/XJENZA.2022.2.01

www.xjenza.org

```
**poor1221 poverty rate at mul and sigma2 and z2 and eta1
gen poor1221=0
replace poor1221=1 * $pop2017 / $pop2018 if (ehhydisp2018 * $ymean2017/$ymean2018 < $pl2018)
sum poor1221 [aw = dhweight2018]
return list
gen poor1221=r(sum)
**poor1122 poverty rate at mul and sigmal and z2 and eta2
gen poor1122=0
replace poor1122=1 * $pop2018 / $pop2017 if (ehhydisp2017 < $pl2018)
sum poor1122 [aw = dhweight2017]
return list
gen poor1122=r(sum)
**poor2212 poverty rate at mu2 and sigma2 and zl and eta2
gen poor2212=0
replace poor2212=1 if (ehhydisp2018 < $pl2017)</pre>
sum poor2212 [aw = dhweight2018]
return list
gen poor2212=r(sum)
**poor1212 poverty rate at mul and sigma2 and zl and eta2
gen poor1212=0
replace poor1212=1 if (ehhydisp2018 * $ymean2017 / $ymean2018 < $pl2017)
sum poor1212 [aw = dhweight2018]
return list
gen poor1212=r(sum)
**poor2222 poverty rate at mu2 and sigma2 and z2 and eta2
gen poor2222=0
replace poor2222=1 if ehhydisp2018 < $pl2018</pre>
sum poor2222 [aw = dhweight2018]
return list
gen poor2222=r(sum)
**poor1222 poverty rate at mul and sigma2 and z2 and eta2
gen poor1222=0
replace poor1222=1 if ehhydisp2018 * $ymean2017 / $ymean2018 < $pl2018</pre>
sum poor1222 [aw = dhweight2018]
return list
gen poor1222=r(sum)
**poor2122 poverty rate at mu2 and sigmal and z2 and eta2
gen poor2122=0
replace poor2122=1 * $pop2018 / $pop2017 if (ehhydisp2017 * $ymean2018 / $ymean2017 < $pl2018)
sum poor2122 [aw = dhweight2017]
return list
gen poor2122=r(sum)
gen changep2018= poor2222 - poor1111
gen income1 = poor2111 - poor1111
gen income2a
              = poor2211 - poor1211
gen income2b = poor2121 - poor1121
gen income2c = poor2112 - poor1112
gen income2ab = poor2221 - poor1221
gen income2bc = poor2122 - poor1122
gen income2ac = poor2212 - poor1212
gen income2 = poor2222 - poor1222
gen dist1
             = poor1211 - poor1111
            = poor2211 - poor2111
gen dist2a
gen dist2b
              = poor1221 - poor1121
gen dist2c = poor1212 - poor1112
gen dist2ab = poor2221 - poor2121
gen dist2ac = poor2212 - poor2112
```

10.7423/XJENZA.2022.2.01

gen	dist2bc	=	poor1222 - poor1122
gen	dist2	=	poor2222 - poor2122
gen	povl1	=	poor1121 - poor1111
gen	povl2a	=	poor2121 - poor2111
gen	povl2b	=	poor1221 - poor1211
gen	povl2c	=	poor1122 - poor1112
gen	povl2ab	=	poor2221 - poor2211
gen	povl2ac	=	poor2122 - poor2112
gen	povl2bc	=	poor1222 - poor1212
gen	povl2	=	poor2222 - poor2212
gen	pop1	=	poor1112 - poor1111
gen	pop2a	=	poor2112 - poor2111
gen	pop2b	=	poor1212 - poor1211
gen	pop2c	=	poor1122 - poor1121
gen	pop2ab	=	poor2212 - poor2211
gen	pop2ac	=	poor2122 - poor2121
gen	pop2bc	=	poor1222 - poor1221
gen	pop2	=	poor2222 - poor2221
gen	res2018	=	<pre>changep2018-income1-dist2a-povl2ab-pop2</pre>
gen	incomeeffec	:t2	018 = (income1*6 + income2a*2 + income2b*2

```
gen incomeeffect2018 = (income1*6 + income2a*2 + income2b*2 + income2c*2 + income2ab*2 + income2ac*2 + income2ac*2 + income2b*2 + income2ac*2 + income2
```

Fabri S. et al. (2022). Xjenza Online, 10(2):74-85.

Xjenza Online: Science Journal of the Malta Chamber of Scientists www.xjenza.org DOI: 10.7423/XJENZA.2022.2.02

Review Article



Understanding the Economic and Sociodemographic Determinants of Early School Leaving: A Configurational Approach

S. Fabri^{*1}, V. Martinelli², J. Spiteri¹, V. Cassar¹

¹Faculty of Economics, Management and Accountancy, Old Humanities Building, University of Malta, Msida, Malta ²Faculty Of Education, Old Humanities Building, University of Malta, Msida, Malta

Abstract. Education is at the heart of any nation's social and economic development and certainly within the specific scope of the European Union's strategic development. As a result, early school leaving is a subject of inexorable importance because its effect reverberates in other social and economic realities. This paper examines the macroeconomic and socioeconomic determinants of ESL by adopting a multi-analytical strategy involving a linear regression method and a configurational approach. The outcomes highlight the complexity of ESL involving nonlinearity, equifinality, and asymmetric relations. Inequality and parental education emerge as key determinants of ESL; these relationships are more robust compared to the other determinants, namely Gross Domestic Product per capita, youth unemployment, and parental job status. The practical and theoretical aspects of these outcomes are explained throughout the discussion.

Keywords: Education, Early School Leaving, Configurational Approach, Fuzz-Set Qualitative Comparative Analysis

1 Introduction

Early School Leaving (ESL) is an indisputably important subject because it is a reality that has profound implications not only on the 'early school leaver' but also on societies and economies. Due to these consequential implications, one encounters a wide array of studies focusing on the individual motivators that cause young people to leave schooling early and on the educational circumstances that engender such courses of action (Humphrey et al., 2013; Lamb & Rice, 2008; Thrupp & Lupton, 2006). To a much lesser extent, other studies take a more macro approach to explain the broader context in which ESL happens (De Witte et al., 2013). Our study's contribution is twofold: First, we examine both macroeconomic (Gross Domestic Product (GDP), inequality, and youth unemployment) and socioeconomic (parents' professional and occupational status, and parents' educational background) features that account for the preponderance of ESL. Second, we adopt a multi-analytical strategy involving linear-based regressions and the configurational approach based on fuzzy-set gualitative comparative analysis (fsQCA). These high-level analyses allowed us to explore patterns invisible to similar previous inquiries and shed new light on how school leaving rates manifest themselves in more complex ways than we usually conceive. The rest of this article is planned as follows. We first present a critical review of the macroeconomic and socioeconomic determinants of ESL and highlight a few lacunae that require attention. Then, using EU-level data, we explain the method and present a series of analyses using both regression techniques and fuzzy-set analyses to establish whether socioeconomic patterns are in line with the general understanding of the wider literature or whether patterns require more attention. Finally, we provide an analysis of our results in the discussion section before concluding.

2 The Macroeconomic and Sociodemographic Determinants of ESL

Whilst various studies attempt to understand what causes early school leaving in developed countries, despite the opportunities available for young people, few studies focus on both the macro-economic and sociodemographic determinants.

2.1 GDP and ESL

There is both a hypothesised and an actual negative correlation between ESL and GDP (De Witte et al., 2013). This is posited at a theoretical level by Calero and Gil-Izquierdo (2014) using economic microsimulation to estimate the monetary costs of early school leaving in Spain. Over a 20-year period, starting in 2007, the recuperation of the wage losses attributable to ESL was estimated to account for anything from 4% to 17% with respect to the GDP of the country if ESL were eliminated. On the other hand, Andrei et al. (2011) established a clear relationship between increased expenditure on education as a share of the GDP and the improved quality of education. Using the EUROSTAT database, they concluded that this increase in education expenditure resulted in lowered ESL rates across the EU. Recent data corroborates this, with negative correlations between state investment in key areas, including education and ESL, across many central and east European countries (Vodă, 2020).

2.2 Inequality and ESL

The impact of socioeconomic backgrounds on school failure tends to move in the same direction as general school failure (Fernández-Mellizo & Martínez-García, 2017). From an economic perspective, unlike as predicted by human capital theory (Becker, 2009), equality of educational opportunity has not led consistently to increased social mobility. Despite improved educational opportunities for all, ESL continues to plague educational systems even in developed European countries, particularly south European ones such as Spain, Malta and Italy, with percentage rates of ESL well above the targeted 10% for 2020 (Eurostat, 2021). From a sociological inequality of educational opportunity perspective, there is an element of persistent inequality based on how sociodemographic and educational characteristics influence ESL and school engagement (Bayon-Calvo et al., 2020). International literature shows that students' socioeconomic background is strongly correlated with ESL (De Witte et al., 2013). Self-system level factors of feeling related, competent and in control in education impacts students' school engagement and students' ESL (Nouwen & Clycq, 2019). This suggests that to counteract ESL, one may consider the possible influence of policies based on equity and management of student diversity within a framework of inclusion and flexibility in educational pathways backed by public funding (Bayon-Calvo et al., 2020).

2.3 Youth Unemployment and ESL

The three concepts of ESL, NEET (not in education, employment or training), and youth unemployment are used to describe youth vulnerability. They are defined us-

10.7423/XJENZA.2022.2.02

ing different variables, and all highlight various aspects of problematic transitions from education to employment (Ryan & Lörinc, 2015). While it is understood that they share common characteristics, this section deals specifically with ESL. When one leaves school early, it is implied that the individual lacks the necessary skills for gainful employment. Indeed, it is not just literacy and numeracy that early school leavers lack but critical thinking skills, problem-solving, and knowledge of the STEM subjects. Furthermore, ESLs lack the entrepreneurial skills that broadly contribute to business creation and employability (Ross & Leathwood, 2013). Early school leavers experience a range of disadvantages in their adult life chances and cost society dearly in the form of social welfare expenditure, health services and imprisonment rates (C. R. Belfield & Levin, 2009; Smyth & McCoy, 2009). When economies are in decline, the labour market for young people, particularly for ESLs who typically have no or few qualifications, is unforgiving. These school leavers' employment prospects are bleak, often characterised by low-paid, low-security employment, dependence on government training schemes, and periods of being NEET (Ryan & Lörinc, 2015).

2.4 Adult educational background and ESL

Despite improved retention rates among working-class young people, ESL remains structured by social class background, and the degree of inequality in school completion between social strata has remained relatively stable (Byrne & Smyth, 2010). In terms of parental education, social capital is a significant factor in educational and occupational opportunities for youth (lannelli et al., 2002). One also needs to consider the primary (Boudon, 1974) and secondary (Breen et al., 2009) effects of social capital and parental educational background on ESL. Primary effects explain how children from different social backgrounds perform differently in school because lowereducated parents are less able to help their children with their school assignments. Additionally, parents' economic constraints may affect their children's educational prospects deleteriously (Lavrijsen & Nicaise, 2015). Secondary effects explain how even students of the same academic performance level make different educational decisions depending on their social background (Breen et al., 2009). Even if Breen et al. (2009) suggest that such inequality is diminishing, they posit that children of bettereducated parents are better guided to make more ambitious cost-benefit type decisions supporting higher social mobility and higher earnings in the longer term by virtue of their social capital and access to guidance that lower social background peers may not have. Ultimately individual lives are affected by extraneous circumstances best explained by reproduction theory (Bourdieu et al., 1977) on the one hand and rational action theory (Boudon, 1974) on the other.

2.5 Adult Professional Status and ESL

Lloyd and Mensch (1999) defined the successful transition to adulthood as a critically important aspect of human development through schooling. Conversely, premature exit from schooling affects other inter-related markers in the transition to adulthood (Utomo et al., 2014). Education is the primary mechanism through which opportunity and success are determined and is a vital predictor of a person's level of engagement in lifelong work and study. On the one hand, individuals with higher education levels enjoy higher-paying jobs, better general health, and a lower likelihood of engaging in crime (Lamb & Huo, 2017). On the other hand, being an ESL means disengagement from study and work, and the consequences are private, fiscal and social (C. Belfield, 2008; Psacharopoulos, 2007). One needs to consider the costs of families who are not economically independent, their reliance on resources from non-governmental agencies to support vulnerable individuals, and the intergenerational burdens transferred to their children. This is apart from the loss to society of lost revenue, cost of crime and incarceration, social welfare payments, and poor health (Lamb & Huo, 2017). Individuals who pursue their education through to tertiary level receive significant positive returns in the form of higher earnings and an increased likelihood of being employed full-time (Wilkins, 2015). This amounts to an earning differential of around 40 per cent for adults with a university degree (Forbes et al., 2010; Sinning, 2014). Indeed, all considered, most early school leavers can only look forward to a life on the fringes of society. As can be seen from the analysis in this section, the research available about the outlined determinants is limited and sometimes contradictory. Moreover, research focuses on linear regression methods, which assume the individual impact of these elements on the individual rather than concurrently. Individual analysis is not reflective of real-world settings. Thus, in the next section, we shall conduct a linear regression analysis to understand if the results are in line with previous studies. A configurational analysis will enhance this investigation to reflect real-world settings and analyse the impact of these elements in a concurrent rather than an individual manner.

3 Method and Analysis

3.1 Sample and Data Collection

In this article, we utilise data from 30 European countries, including all European Union (EU) member states (with the exception of Croatia due to lack of data) and Ice-

10.7423/XJENZA.2022.2.02

land, Norway and Switzerland, spanning the period 2010 to 2017.

3.2 Measures

Table 1 provides details regarding the measurement of each of the variables used in this article, including data sources. While the relationship between our economic variables and early school leaving has been explored at length in the literature (e.g. (Clark, 2011; De Witte et al., 2013; Lavrijsen & Nicaise, 2015), the sociodemographic variables require further unpacking and discussion. It is important to note that in the case of the socioeconomic variables, the age brackets reflect the expected age ranges of parents for youths aged between 18 and 24 within our sample period (i.e. 2010 to 2017). The inclusion of both parental education and professional status in our analysis follows directly from evidence linking these variables to early school leaving (e.g. Chevalier et al. (2013) and Traag and Van der Velden (2011).

3.3 Calibration

In order to be able to conduct the fuzzy-set analysis, all measures have to be calibrated and thus take on a value from 0 to 1 in order to conduct an analysis using fuzzysets. The calibration process used is known as the direct method of calibration, a method that is known to lead to precise results, as per previous application in social sciences literature (Ragin, 2000). The direct method of calibration involved identifying the value of full-membership, non-membership and the cross-over point (neither in nor out). The calibration values (table 2) are based on the researchers' theoretical knowledge and statistical distribution of the sample. Thus, following a thorough analysis of the distribution of the data for each variable, the researchers analysed the theoretical meaning of each construct to determine the high (score of 1), low (score of 0), and cross-over (score of 0.5) points (Schneider & Wagemann, 2010). Before identifying the values shown in table 2, different options for the calibration points have been considered to make sure that the calibration points are robust.

The sufficiency analysis involves the analysis of sufficient conditions. Such conditions show configurations relevant to producing an outcome, but they are not the only configurations possible associated with the outcome (Ragin, 2008). The first step of the sufficiency analysis involved the development of a truth table, with each row illustrating the different sufficient combinations. This table is made up of 2k rows, where k is the number of causal conditions used in the analysis (in total, five). The second step involved the analysis of the subset relation through the consistency value, which indicates the extent by which the individual or overall solution differs from being a perfect subset of the outcome. The third

Category	Variable Name	Description	Source
Dependant Variable	Rate of early school leavers	The proportion of the total population aged 18 to 24 who have completed at most a lower secondary level of education and are currently not involved in further education or training	Eurostat (2019)
Economic Explanat- ory Variable	GDP	Annual Gross Domestic Product (GDP) per person, measured at constant 2010 Euros (\in), millions	Eurostat (<mark>2019</mark>)
Economic Explanat- ory Variable	Inequality	Gini coefficient denoting the distribution of income in each country. The measure ranges from 0 to 1, with 0 denoting perfect equality and 1 denoting perfect in- equality	Eurostat (2019)
Economic Explanat- ory Variable	Youth unemploy- ment	The proportion of the active population aged 18 to 24 who is currently unemployed	Eurostat (<mark>2019</mark>)
Sociodemographic Explanatory Vari- able	Adult educational background	The proportion of population aged 35 to 44 with a level of education equal to or below ISCED level 2	Eurostat (2019)
Sociodemographic Explanatory Vari- able	Adult professional status	The proportion of active population aged 40 to 59 who are either managers, professionals or technician and associate professionals	Eurostat (<mark>2019</mark>)

 Table 1: Description of Variables and Sources

Variable	Statistical Distributions				Calibration			
Variable	Max.	ax. Mean Min. Std. Dev. Me		Full- Membership	Cross-Over	Non- Membership		
ESL	3.11	2.29	1.50	0.42	3.00	2.50	1.50	
GDP	11.28	10.04	8.62	0.66	11.28	10.10	8.62	
Inequality	3.58	3.38	3.16	0.13	3.58	3.40	3.10	
Youth Unemployment	3.86	2.93	2.06	0.46	3.80	3.80	2.00	
Parents' Education Level	3.95	2.75	1.50	0.56	3.90	2.80	1.50	
Parents' Job Status	-1.28	-1.60	-2.23	0.21	-1.28	-1.60	-2.20	

Table 2: Descriptive Statistics and Calibrations

step involves reducing the matrix rows to simplified conditions, which is done by implementing Quine-McCluskey algorithm whereby Boolean algebra is employed (Ragin, 2008). At this stage, the solutions are assessed through their coverage, which measures the extent by which an outcome is explained by a causal condition (Fiss, 2007). The fourth step involves the assessment of the complex solutions, given that the study is based on inductive reasoning. At this stage, the complex solution is used. Unless there is a theoretical justification that supports the use of logical remainders, the complex solution is deemed to be the best solution (Cooper & Glaesser, 2011). The fifth step of the sufficiency analysis involves the assessment of the causal conditions. The analysis consists of 32 (25) possible combinations. The frequency threshold for both high and low ESL outcomes was set at 1, which implies that there is at least one case per configuration. This allowed the analysis to perform on more than 90% of the sample for both outcomes, exceeding the 80% threshold (Ragin, 2008; Rihoux & Lobe, 2009). The consistency cut-off value was set at 0.854 for high ESL outcomes and 0.935 for low performing outcomes, higher than the 0.750 threshold (Campbell et al., 2016). Following the analysis of the sufficiency conditions, the analysis of necessary conditions is undertaken. The analysis is undertaken in order to assess whether the presence (or absence) of any of the variables alone is necessary (has to be present) for the two outcomes to take place. For a condition to be called necessary, there has to be a consistency of at least 0.9, and coverage of at least 0.8 (Ragin et al., 2006).

3.4 Data Analysis

The first part of the analysis includes traditional linear regression modelling using panel data estimation methods given that the sample consists of 30 countries over the period 2010 to 2017. Panel data methods are particularly useful given that they utilise both cross-country and timevarying factors in order to explain variations in ESL, thus resulting in more information being used within the estimation and therefore greater inference accuracy (Hsiao, 1985). The rate of ESL across our sample is expressed as a function of a number of economic and sociodemographic determinants, as identified in the vast empirical literature discussed earlier. Thus, we specify the following linear regression model:

$$ln(Early_{i}t) = \beta_{0} + \beta_{1} ln(GDP_{it}) + \beta_{2} ln(Inequality_{it}) + \beta_{3} ln(Youth_{it}) + \beta_{4} ln(Educ_{it})$$
(1)
+ \beta_{5} ln(Prof_{it}) + \alpha_{i} + u_{it}

Where:

 $\ln = \text{Natural logarithm}; \text{ Early}_i t = \text{Rate of early school}$

10.7423/XJENZA.2022.2.02

leavers in country *i* at time *t*;

 $GDP_{it} = Real GDP per capita;$

Inequality_{*it*} = Gini coefficient capturing income inequality; Youth_{*it*} = Youth unemployment;

 $Educ_{it}$ = Proportion of adults aged 35 to 44 with a level of education equal to or below ISCED level 2;

 $Prof_{it}$ = Proportion of the working population aged 40 to 59 who are either managers, professionals or technicians and associate professionals;

 α_i = Country-specific, time-invariant unobservable factors;

 u_{it} = Random disturbance term.

Equation (1) is estimated using three different specifications, namely a Random Effects model (REM), a Fixed Effects model (FEM), and a Panel Data Instrumental Variables model with Fixed Effects (IVFEM). This threepronged approach is adopted in order to ensure the robustness of our findings. Furthermore, all three methods allow us to control to some degree for a number of additional , time-invariant determinants of ESL that may be unique to each country but which may not be directly observable or measurable from the data. This is extremely important, since it leads to a more parsimonious econometric model with greater efficiency, while also minimising any risks of inconsistency or endogeneity bias. In the REM we account for unobservable country-specific effects across our panel but, for efficiency, assume that they are uncorrelated with our explanatory variables. This assumption of independence is relaxed under the FEM, where we explicitly account for unobservables and assume that they are correlated with our explanatory variables. Finally, the IVFEM expands on the FEM by accounting for potential reverse causality (endogeneity) between our dependent variable (early school leavers) and our economic variables, namely GDP per capita, inequality and youth unemployment, since there is some evidence that the rate of early school leaving is associated with various negative economic outcomes (e.g. Heckman (2011). Pairwise correlations across our explanatory variables indicate that there are moderate levels of correlation between youth unemployment and inequality (r = 0.5; p = 0.00) and inequality and GDP per capita (r = 0.5; p = 0.00), and high levels of correlation between professional status and GDP per capita (r = 0.8; p = 0.00), indicating only a limited potential presence of multicollinearity in our regression estimates. It is important to note that while the panel data analysis proposed above yields various important estimation benefits, it also has a number of shortcomings. Firstly, it does not account for potential nonlinearities, particularly between the unobserved countryspecific effects and ESL, which may affect the reliability of our parameter estimates (Hsiao, 2007). Secondly, there is the possibility of cross-sectional dependence, i.e. correlations across the unobserved effects across countries, which may result in inconsistent estimators, although the proper treatment of such dependencies is still unclear (Hsiao & Tahmiscioglu, 2008). Following the analysis using linear methods, we analysed the connections between the variables through configurational analysis. Fuzzy-set Qualitative Comparative Analysis (fsQCA) 2.0 is used to conduct this analysis (Ragin et al., 2006). This analysis involves the calibration of each variable as explained in the previous section followed by a sufficiency and necessity analysis (Schneider & Wagemann, 2012). These two forms of analysis have been conducted for both high and low ESL outcomes.

4 Results

4.1 Regression Results

Results from the regression analysis estimate equation (1)under three different specifications (table 3). Each column shows the results for each specification in turn. In each specification, robust standard errors are used, clustered at the country level to account for within-panel serial correlation and heteroscedasticity across panels.¹ The results obtained are somewhat mixed across the three specifications, particularly when it comes to the economic variables. For example, although GDP per capita is negatively-related to early school leaving, it only emerges as marginally significant (at the 10% level) in the FEM. Similarly, income inequality is negatively correlated with ESL, although in this case the coefficients are statistically significant (at the 10% level) in both the REM and FEM specifications. In turn, the coefficients on youth unemployment are not statistically significant across all specifications. Thus, it appears that the relationship between our economic variables and ESL is somewhat unclear across our three specifications. This may be due to several factors, including endogeneity issues between our independent and dependent variables, which may explain the lack of statistically significant coefficients in our IVFEM specification. It is also possible that these results reflect the shortcomings of the methods used, which assume a log-linearised relationship between each economic variable and ESL, which may not reflect reality as captured in the data. Matters are somewhat different when it comes to

our sociodemographic determinants of ESL. This is because adult education is positively and significantly correlated with ESL across all three specifications and is the only significant coefficient in the IVFEM specification. In fact, the results indicate that a 1% increase in the proportion of adults aged 35 to 44 with an education level of ISCED level 2 or lower is associated with an increase in the proportion of ESL by around 0.4–0.5%. Thus, it is clear that parental education is an important determinant of ESL, with youths more likely to leave formal schooling or training if parents (and indeed other adults) have low levels of education. Along similar lines, adults' professional status is positively-correlated with ESL, albeit only in the REM and FEM specifications, which tallies somewhat with the previous results on educational background, since the findings suggest that adults in high-level jobs are more likely to be associated with lower levels of ESL. Nonetheless, it is important to note that professional status is not significant in the third IVFEM specification. The results from our regression analysis indicate that while the relationship between our economic variables and ESL is mixed, there is a clear association with sociodemographic variables, with parental education and (to a lesser extent) adult professional status emerging as key determinants of ESL rates.

4.2 Fuzzy-Set Analysis and Results

In essence, the above analysis demonstrates the limitations of using an additive-based method. This form of analysis fails to show whether there is complementarity between practices in reaching the outcome. It also fails to provide potential equifinal solutions. It would be interesting to assess the combinations that are effective in different situations. Regression analysis also has limitations when it comes to analysing higher-order interactions and, therefore, such questions are answered through fsQCA, which provides a more refined insight of the connection between the variables (Fiss, 2011). To this effect, the rest of this section is divided in two parts consistent with other presentations of Qualitative Comparative Analysis (QCA) results (Schneider & Wagemann, 2010).

4.3 Necessity Conditions Results

The results of the necessity analysis for high and low (\sim) ESL (log) outcomes are illustrated in table 4. A condition is necessary if the consistency and coverage are at least 0.9 and 0.8, respectively. None of the conditions tested meet these criteria, thus none of the conditions is necessary for any of the outcomes. The analysis will now proceed with the examination of the sufficiency conditions.

¹In addition to testing for serial correlation and heteroscedasticity, we also conducted unit root tests on each of the variables used in the regression models, utilizing the Harris-Tzavalis test (Harris & Tzavalis, 1999) for panel data variables where the number of panels exceeds the number of time periods. For each variable, we reject the null hypothesis for the existence of a unit root, implying that our variables are stationary.

Coefficients	POLS	REM	FEM	IVFEM
	(1)	(2)	(3)	(4)
Log GDP per capita	-0.2222***	-0.1767	-0.7204*	-0.4057
	(0.0572)	(0.1080)	(0.4143)	(1.5782)
Log Inequality	-0.4193*	-0.8367*	-0.9345*	-1.4734
	(0.2145)	(0.4473)	(0.5059)	(1.9006)
Log Youth Unem- ployment	-0.0851**	-0.0328	-0.1662	-0.1076
	(0.0405)	(0.0974)	(0.1065)	(0.3505)
Log Adult Educa- tion	0.6715***	0.5448***	0.3817*	0.4923**
	(0.0336)	(0.1244)	(0.2100)	(0.2463)
Log Professional Status	-0.0478	-0.4798*	-0.6822**	-0.4454
	(0.1359)	(0.2509)	(0.3101)	(0.4587)
Constant	4.2630***	4.7193**	11.0260**	9.5803
	(1.1939)	(2.2236)	(4.9196)	(15.8607)
Ν	240	240	240	240
R-Squared	0.6417	0.5925	0.1759	0.4207
F-Statistic	118.48***		6.92***	
Wald Statistic		42.62***		8.86

Table 3: Regression Results

	High E	SL	Low ESL		
Condition tested	Consistency	Coverage	Consistency	Coverage	
High GDP	0.645	0.523	0.674	0.791	
Low GDP	0.742	0.612	0.593	0.708	
High Inequality	0.782	0.640	0.561	0.663	
Low Inequality	0.588	0.481	0.696	0.822	
High Youth Unemployment	0.734	0.627	0.606	0.748	
Low Youth Unemployment	0.705	0.553	0.698	0.792	
High Parents' Education	0.887	0.748	0.548	0.667	
Low Parents' Education	0.604	0.481	0.801	0.920	
High Parents' Job Status	0.702	0.509	0.734	0.770	
Low Parents' Job Status	0.683	0.640	0.531	0.720	

Table 4: Necessity Analysis

	High School Leaving Rate			е	Low School Leaving Rate			
Permutation	1	2	3	4	5	6	7	8
Macroeconomic Conditions								
GDP	\oplus	\oplus	\oplus	•	•	•	\oplus	•
Inequality	\oplus	•	•	•	\oplus	\oplus	\oplus	•
Youth Unemployemnt	\oplus	•	•	•		•	\oplus	•
Socio-Economic Conditions								
(Low) Parents Education Level	•	•	\oplus	•	\oplus		\oplus	\oplus
(High) Parents' Professional Status	\oplus	\oplus	•	•	•	•	\oplus	\oplus
Consistency	0.929	0.898	0.855	0.868	0.945	0.945	0.980	0.698
Raw Coverage	0.354	0.526	0.388	0.430	0.471	0.350	0.283	0.241
Unique Coverage	0.073	0.112	0.020	0.031	0.122	0.022	0.051	0.036
Overall Solution Consistency	0.789				0.936			
Overall Solution Coverage	0.687				0.583			

Table 5: Configurations of Macro and Socioeconomic Factors with respect to High and Low ESL Rates across the EU.

10.7423/XJENZA.2022.2.02

4.4 Sufficiency Conditions Results

Table 5 shows the solutions for high and low ESL outcomes among the different EU countries used in the The table includes two symbols under each sample. configuration—"•" illustrates the high presence of a condition, and $``\oplus"$ illustrates the low presence. The blank spaces indicate that the specific variable is ineffective within the specific configuration. The analysis shows four configurations for high ESL, and four configurations for low ESL. The overall and individual consistency levels for the two outcomes exceed the 75% threshold, implying that the configurations outlined are strongly associated with the respective outcomes (Campbell et al., 2013). The solution also indicates acceptable overall and individual raw and unique coverage, in line with previous studies (Fiss, 2007; Meuer, 2016). Raw coverage shows the number of cases that are fully part of the conditions of a solution. Unique coverage represents the proportion of cases that are not covered by other solution terms (Schneider & Wagemann, 2012). The results for each configuration are explained in table 6. To examine the robustness of the sufficiency analysis outcomes, further analysis was conducted. First, the calibration points were varied by $\pm 0.5\%$. Second, the analysis was conducted for the periods 2010–2013 and 2014–2017, separately. The interpretation of the findings with these changes remains unchanged in all of these analyses. Thus, it can be deduced that the results are robust. The sufficiency analysis results show that there are clear signs of complex relations among ESL, macroeconomic conditions, and socioeconomic conditions. These complexities involve nonlinearity, equifinality, and asymmetric relation. Nonlinearity is illustrated through different relations among variables. For example, parents' educational level and job status could have a positive association (configuration 3), or a negative one (configuration 4). Equifinality is shown through the fact that there are alternative configurations of socioeconomic conditions occurring within the same macroeconomic context and outcome (configurations 2 and 3). The results also indicate clear signs of asymmetric relations whereby the factors that lead to low ESL are not the exact inverse of the factors that lead to high ESL. For example, despite the different outcomes, configurations 4 and 8 have the same macroeconomic factors, while configurations 3 and 5 have the same socioeconomic factors.

5 Discussion and Conclusion

This article has sought to understand the relationship between ESL rates and various macroeconomic and social factors. The results from both the panel data regression and fuzzy-set analysis point towards a complex relationship between ESL and the various economic and

10.7423/XJENZA.2022.2.02

social determinants specified in the literature. Considering the macroeconomic conditions, inequality emerges as a key correlate of ESL rates under both estimation methods, with the fuzzy-set analysis indicating that high levels of inequality are generally associated with high levels of ESL, although the opposite scenario of low inequality and ESL is somewhat less evident. These findings are broadly consistent with the results of Kearney and Levine (2016), who find that youth from low-income backgrounds may perceive the returns to further schooling and human capital accumulation to be low, thus resulting in higher levels of ESL among these cohorts. Therefore, a key implication of this result is the importance of social and redistributive policy mechanisms to minimise income disparities and promote higher levels of social mobility. This has been explicitly identified by the EU as a priority area in the medium term, with 'Fairness' a key pillar of its 2021 Annual Sustainable Growth Strategy, particularly in light of the economic crisis precipitated by the COVID-19 pandemic (EC, 2020a) In addition, GDP per capita also emerged as an important determinant of ESL, particularly in the fuzzy-set analysis where high GDP levels were associated with low levels of ESL, underscoring the importance of economic prosperity in boosting returns to education via improved job conditions and opportunities (Jensen, 2010). These results further emphasise the need to pursue macroeconomic policies that encourage sustainable economic growth in the post-COVID recovery phase, with mechanisms like Next Generation EU aimed at re-energising growth and investment among EU member states (EC, 2020b). In addition, the fuzzy-set analysis identifies low youth unemployment as a potential correlate of ESL, with high youth unemployment associated with high ESL rates. Although the direction of causality is somewhat of a moot point, the finding underscores the need to ensure growth and investment to create job opportunities across all strata of society, and in particular young people. When it comes to the social factors, low parental education is closely associated with high levels of ESL, across both methods employed in this article. This finding is consistent with the literature on intergenerational educational mobility and, in particular the fact that attainment is highly persistent across parents and children, thus perpetuating inequality and hampering mobility (Checchi et al., 2013). Within this scope, educational policies should be aimed at breaking this cycle of low attainment through widespread reforms and improved learning resources for all students irrespective of background from a young age (Chetty et al., 2011). Against the background of the results obtained, one needs to consider which aspects of the problem to address and the critical time to act. When low parental education co-occurs with

Configuration	ESL Level	Macroeconomic Context	Socio-Economic Context
1		Low GDP, Inequality, Youth Un- employment	Low Parents' Education and Pro- fessional Status
2	High ESL	Low GDP, High Inequality and Youth Unemployment	Low Parents' Education and Pro- fessional Status
3		Low GDP, High Inequality and Youth Unemployment	High Parents' Education and Pro- fessional Status
4		High GDP, Inequality, Youth Un- employment	Low Parents' Education and High Professional Status
5		High GDP, and Low Inequality	High Parents' Education and Pro- fessional Status
6	Low ESL	High GDP, Low Inequality, and High Youth Unemployment	High Parents' Professional Status
7		Low GDP, Inequality, Youth Un- employment	High Parents' Education and Low Professional Status
8		High GDP, Inequality, Youth Un- employment	High Parents' Education and Low Professional Status

Table 6: Description of the Configurations

high inequality and high youth unemployment, this creates deficit and necessitousness, associated with intergenerational stability perpetuating inequality and youth unemployment. This calls for supporting families 360-degrees, literally from the moment parents make first contact with hospital at the beginning of the mother's pregnancy, right through early toddlerhood, childcare, early schooling and throughout the child's school life. Such parents may benefit from familial support in preparation for their parenting roles. They would benefit from training to support their children's learning in a proactively participative manner rather than just reactively, or not at all, assisted by family support workers. The diametric opposite has also been indicated in our study where. High professional status is associated with lower levels of ESL, further highlighting the impact of parental attainment on children's educational choices, which in turn influences their future job and earning prospects (Lee & Solon, 2009).

Therefore, the main findings from this article indicate that early school leaving among European youths is a complex and multi-faceted problem that requires a variety of economic and social policy interventions in order to keep it in check. Further research should seek to analyse each individual determinant, in turn, to further understand the underlying relationship in greater detail, with a particular emphasis on teasing out causal linkages, which would further aid the development of effective policies.

References

- Andrei, T., Teodorescu, D., & Oancea, B. (2011). Characteristics and causes of school dropout in the countries of the European Union. *Procedia-Social and Behavioral Sciences*, 28, 328–332.
- Bayon-Calvo, S., Corrales-Herrero, H., & De Witte, K. (2020). Assessing regional performance against early school leaving in Spain. *International Journal of Educational Research*, 99(10151), 5.
- Becker, G. S. (2009). *Human capital: A theoretical and empirical analysis.* University of Chicago press.
- Belfield, C. (2008). *The cost of early school-leaving and school failure*. World Bank.
- Belfield, C. R., & Levin, H. M. (2009). High school dropouts and the economic losses from juvenile crime in California. *Center for Benefit-Cost Studies of Education, 26*.
- Boudon, R. (1974). *Education, opportunity, and social inequality: Changing prospects in western society.*

- Bourdieu, P., Passeron, J. C., & Nice, R. (1977). *Education, society and culture.* SAGE Pub.
- Breen, R., Luijkx, R., Müller, W., & Pollak, R. (2009). Nonpersistent inequality in educational attainment: Evidence from eight European countries. *American journal of sociology*, *114*(5), 1475–1521.
- Byrne, D., & Smyth, E. (2010). No way back? the dynamics of early school leaving.
- Calero, J., & Gil-Izquierdo, M. (2014). Too much to pay: An estimation through microsimulation techniques of the monetary costs of early school leaving in Spain. *Journal of Simulation*, 8(4), 314–324.
- Campbell, J. T., Sirmon, D., & Schijven, M. (2013). *The good, the bad, and the fuzzy: A configura tional approach to acquisitions.* Paper presented at the Academy of Management Proceedings.
- Campbell, J. T., Sirmon, D. G., & Schijven, M. (2016). Fuzzy logic and the market: A configurational approach to investor perceptions of acquisition announcements. *Academy of Management Journal*, 59(1), 163–187.
- Checchi, D., Fiorio, C. V., & Leonardi, M. (2013). Intergenerational persistence of educational attainment in Italy. *Economics letters*, 118(1), 229–232.
- Chetty, R., Friedman, J. N., Hilger, N., Saez, E., Schanzenbach, D. W., & Yagan, D. (2011). How does your kindergarten classroom affect your earnings? evidence from project STAR. *The Quarterly journal of economics*, 126(4), 1593–1660.
- Chevalier, A., Harmon, C., O'Sullivan, V., & Walker, I. (2013). The impact of parental income and education on the schooling of their children. *IZA Journal* of Labor Economics, 2(1), 1–22.
- Clark, D. (2011). Do recessions keep students in school? the impact of youth unemployment on enrolment in post-compulsory education in England. *Economica*, 78(311), 523–545.
- Cooper, B., & Glaesser, J. (2011). Paradoxes and pitfalls in using fuzzy set QCA: Illustrations from a critical review of a study of educational inequality. *Sociological Research Online*, 16(3), 106–119.
- De Witte, K., Nicaise, I., Lavrijsen, J., Van Landeghem, G., Lamote, C., & Van Damme, J. (2013). The impact of institutional context, education and labour market policies on early school leaving: A comparative analysis of EU countries. *European Journal of Education*, 48(3), 331–345.
- EC. (2020a). Annual sustainable growth strategy 2021. european commission COM(2020) 575.
- EC. (2020b). Europe's moment: Repair and prepare for the next generation. european commission COM(2020) 456.

- Eurostat. (2019). *Eurostat statistics explained*. http:// ec.europa.eu/eurostat/statistics-explained/index. php/Main Page
- Eurostat. (2021). Early leavers from education and training aged 18–24 by sex and labour status, 2021 (% of population aged 18–24). https://ec.europa.eu/ eurostat/statistics-explained/index.php?title=File: Early_leavers_from_education_and_training_ aged_18-24_by_sex_and_labour_status, 2021 (%25_of_population_aged_18-24).png
- Fernández-Mellizo, M., & Martínez-García, J. S. (2017). Inequality of educational opportunities: School failure trends in Spain (1977–2012). *International Studies in Sociology of Education*, 26(3), 267–287.
- Fiss, P. C. (2007). A set-theoretic approach to organizational configurations. *Academy of management review*, *32*(4), 1180–1198.
- Fiss, P. C. (2011). Building better causal theories: A fuzzy set approach to typologies in organization research. *Academy of Management Journal*, *54*(2), 393–420.
- Forbes, M., Barker, A., & Turner, S. A. (2010). *The effects of education and health on wages and pro-ductivity.*
- Harris, R. D., & Tzavalis, E. (1999). Inference for unit roots in dynamic panels where the time dimension is fixed. *Journal of econometrics*, *91*(2), 201–226.
- Heckman, J. J. (2011). The economics of inequality: The value of early childhood education. *American Educator*, *35*(1), 31.
- Hsiao, C. (1985). Benefits and limitations of panel data. *Econometric Reviews*, 4(1), 121–174.
- Hsiao, C. (2007). Panel data analysis—advantages and challenges. *Test*, *16*(1), 1–22.
- Hsiao, C., & Tahmiscioglu, A. K. (2008). Estimation of dynamic panel data models with both individual and time-specific effects. *Journal of Statistical Planning and Inference*, *138*(9), 2698–2721.
- Humphrey, N., Wigelsworth, M., Barlow, A., & Squires, G. (2013). The role of school and individual differences in the academic attainment of learners with special educational needs and disabilities: A multilevel analysis. *International Journal of Inclusive Education*, 17(9), 909–931.
- Iannelli, C., Zentrum, M., Sozialforschung, E., & Cristina, I. (2002). Parental education and young people's educational and labour market outcomes: A comparison across europe (tech. rep.). Paper presented at the MZES Working Papers 45, MZES.
- Jensen, R. (2010). The (perceived) returns to education and the demand for schooling. *The Quarterly journal of economics*, *125*(2), 515–548.

10.7423/XJENZA.2022.2.02

- Kearney, M. S., & Levine, P. B. (2016). *Income inequality,* social mobility, and the decision to drop out of high school.
- Lamb, S., & Huo, S. (2017). Counting the costs of lost opportunity in Australian education.
- Lamb, S., & Rice, S. (2008). *Effective intervention strategies for students at risk of early leaving*. Centre for Post-compulsory Education; Life Long Learning. The university of Melbourne.
- Lavrijsen, J., & Nicaise, I. (2015). Social inequalities in early school leaving: The role of educational institutions and the socioeconomic context. *European Education*, 47(4), 295–310.
- Lee, C.-I., & Solon, G. (2009). Trends in intergenerational income mobility. *The Review of Economics and Statistics*, 91(4), 766–772.
- Lloyd, C. B., & Mensch, B. (1999). Implications of formal schooling for girls' transitions to adulthood in developing countries. *Critical perspectives on schooling and fertility in the developing world*, 80–104.
- Meuer, J. (2016). Exploring the complementarities within high-performance work systems: A set-theoretic analysis of UK firms. *Human Resource Management*, 56(4), 651–672.
- Nouwen, W., & Clycq, N. (2019). The role of social support in fostering school engagement in urban schools characterised by high risk of early leaving from education and training. *Social Psychology of Education*, 22(5), 1215–1238.
- Psacharopoulos, G. (2007). *The costs of school failure: A feasibility study.* EENEE Brussels.
- Ragin, C. C. (2000). *Fuzzy-set social science*. University of Chicago Press.
- Ragin, C. C. (2008). Qualitative comparative analysis using fuzzy sets (FsQCA). In B. Rihoux & C. C. Ragin (Eds.), Configurational comparative methods. qualitative comparative analysis (qca) and related techniques. (pp. 87–122). Sage.
- Ragin, C. C., Drass, K. A., & Davey, S. (2006). Fuzzyset/qualitative comparative analysis 2.0. Tucson, Arizona: Department of Sociology, University of Arizona, 23(6), 1949–1955.

- Rihoux, B., & Lobe, B. (2009). The case for qualitative comparative analysis (QCA): Adding leverage for thick cross-case comparison. *The Sage handbook of case-based methods*, 222–242.
- Ross, A., & Leathwood, C. (2013). Problematising early school leaving. *European Journal of Education*, 48(3), 405–418.
- Ryan, L., & Lörinc, M. (2015). Interrogating early school leaving, youth unemployment and NEETs: Understanding local contexts in two English regions. *Educação, Sociedade & Culturas, 45*, 33–54.
- Schneider, C. Q., & Wagemann, C. (2010). Standards of good practice in qualitative comparative analysis (QCA) and fuzzy-sets. *Comparative Sociology*, 9(3), 397–418.
- Schneider, C. Q., & Wagemann, C. (2012). Set-theoretic methods for the social sciences: A guide to qualitative comparative analysis. Cambridge University Press.
- Sinning, M. (2014). *How much is it worth? new estimates* of private returns to university education in Australia (F. Report, Ed.).
- Smyth, E., & McCoy, S. (2009). *Investing in education: Combating educational disadvantage* (ESRI).
- Thrupp, M., & Lupton, R. (2006). Taking school contexts more seriously: The social justice challenge. *British journal of educational studies*, *54*(3), 308–328.
- Traag, T., & Van der Velden, R. K. (2011). Early schoolleaving in the netherlands: The role of family resources, school composition and background characteristics in early school-leaving in lower secondary education. *Irish Educational Studies*, 30(1), 45–62.
- Utomo, A., Reimondos, A., Utomo, I., McDonald, P., & Hull, T. H. (2014). What happens after you drop out? transition to adulthood among early schoolleavers in urban Indonesia. *Demographic Research*, *30*, 1189–1218.
- Vodă, I.-M. (2020). Correlation between school dropout and gross domestic product in the emerging countries of central and Eastern Europe. *Educatia*, 21(19), 66–72.
- Wilkins, R. (2015). Measuring income inequality in Australia. *Australian Economic Review*, 48(1), 93–102.

Xjenza Online: Science Journal of the Malta Chamber of Scientists www.xjenza.org DOI: 10.7423/XJENZA.2022.2.03

Review Article



Designing an evaluation strategy for a large-scale science and arts festival using Science in the City, Malta as a case study

S. Cutajar¹, S. Seligova², E. Duca^{*3}

¹Institute of Earth Systems, University of Malta, Msida, Malta ²DLHA38, Stupava, Slovakia ³Department of Mathematics and Science Education, Faculty of Education, University of Malta, Msida, Malta

Abstract. In this work, we analyse and present a stepby-step guide on how to set up a valuable and informative mixed method evaluation strategy of large-scale science festivals and events. A literature analysis helped identify the best technique to set up a multi-approach methodology (multiple-choice questionnaire and silent observers). Questionnaire data was to be collected using systematic sampling. The approach was applied to a local case study to develop best practice. Its implementation was analysed and assessed to provide festival organisers with useful recommendations to enhance the evaluation strategy, and improve festival quality and researcher engagement in subsequent editions. Combining a mixed-method approach to collect both qualitative and quantitative data helped gather a good and comprehensive overview of the festival. It set a baseline for future editions to improve upon. All the evaluation efforts carried out in this work were very dependent on volunteers, therefore an effective and appropriate volunteer recruitment, training and retainment strategy was essential. This work has developed a baseline assessment of the festival establishing a professional evaluation strategy with limited funds and experience. It is a step-by-step guide for large science festival organisers who want to set up effective evaluation of their efforts.

Keywords: Public engagement with science and technology, Informal learning, Science festival, Evaluation strategy, Qualitative data, Quantitative data

1 Introduction

The phenomenon of large public science communication events such as science festivals has spread throughout Europe and the world (Bultitude et al., 2011) with a dramatic increase in the last few decades (Cassidy, 2006).

Science festivals are time-limited and recurring celebrations of science that engage non-specialists with scientific content using activities with common themes and branding (Bultitude et al., 2011). They include a large variety of events showcasing STEM subjects through lively and entertaining events including hands-on activities, live experiment demonstrations, exhibitions, workshops, and lectures. European Researchers' Nights, supported by the European Commission's Research and Innovation Framework Programme Horizon 2020 (H2020, 2014-2020) by the Marie Skłodowska-Curie actions, are public events dedicated to bringing researchers closer to various publics. Under the criteria set by Bultitude et al. (2011), European Researchers' Nights are considered science festivals and will be treated as such in this work. Science communication researchers argue that science festivals are ways to communicate science between scientists and different publics (Burns et al., 2003; Jensen, 2014; Jensen & Buckley, 2011, 2014). Only a few, however, have systematically and consistently examined the effect of science festivals on learning, practicing and inspiring science, improving attitudes towards science or enhancing scientific literacy (Burns et al., 2003; Jensen & Buckley, 2011). Similarly, there is little published research available on the evaluation of European Researchers' Night, with Dimitrova (2010), Roche et al. (2017) and Sardo (2016) being rare examples. In fact, science festivals have long been criticised for their lack of rigour when evaluating (Bultitude et al., 2011) and consideration of long-term research towards their impact (Jensen & Buckley, 2014), both of which require methodological expertise and resources by the event organisers that are not necessarily available (Jensen, 2015; King et al., 2015). Jensen (2014) and Jensen and Buckley (2014) pointed out that the methodologies of some studies related to science festivals are problematic. They are heavily dependent on close-ended and simple survey data, so that complex and insightful feedback is often lacking. Consequently, analysing and evaluating the multitude of dynamic events happening during a science festival is often seen by organisers as a burden and a box-ticking exercise undertaken for funders. Effective science communication can empower research and innovation systems to address global challenges and put public interests at the heart of how knowledge is produced, shared and applied. However, for science communication to play this mediating role effectively, there needs to be a more integrated and 'evidence-based' approach (Jensen & Gerber, 2020). As such, practical guides on evaluation strategies of science festivals are useful tools for organisers to start evaluating their impact in an appropriate way. This paper is a step towards evidence-based science communication practice. It offers a step-by-step guide to support science communicators and organisers with little or no experience in evaluation. It outlines the process of evaluating large festivals that involve a variety of activities by using a mix of qualitative and quantitative data.

2 Context

2.1 Case Study: Science in the City, Malta

This paper highlights a science and arts festival on the Maltese Islands, Science in the City (SitC), as a case study for designing and conducting an evaluation strategy of a large-scale science festival. Science in the City, set up in 2012 partakes in the EU-wide European Researchers' Night, and is the Maltese Islands' most high profile annual science activity. The festival is supported by the European Commission's Research and Innovation Framework Programme Horizon 2020 (H2020, 2014–2020) by the Marie Skłodowska-Curie actions. At its sixth edition, the festival was estimated to have attracted more than 20,000 people to Valletta, the Maltese Island's capital city (over 5% of the Islands' population). Led by the University of Malta, the primary aim of the festival is to engage with and involve local people within a variety of science themed activities. The festival marries research, mostly undertaken in Malta, with theatre and dance performances, stand up comedy, art exhibitions, art installations, hands-on activities, music and science experiments. In its sixth edition, the festival showcased six main science and arts-based activities and opportunities, varying from jazz music, interactive artistic installations, music, theatre and dance. Science in the City (SitC) has established itself as the leading exemplar of best-practice in arts-science engagement in Malta. Utilising SitC, a best practice strategy to evaluate a science festival was tested and documented. Current literature on science festival evaluation and large touristic events was reviewed and

used to develop a comprehensive strategy. The multimethod evaluation strategy developed and tested in this research was intended to serve as a basis for adaptation by other event evaluators. An implementation plan is outlined, including step-by-step methodology and management of human resources.

2.2 Evaluation Strategy

An evaluation plan to explore the strengths and weaknesses of SitC as a public engagement event was designed. A number of research methods were considered for the evaluation, such as participant interviews, visitor tests, archival document review and case studies (Shaw et al., 2006). These methods were considered unsuitable or impractical for a public engagement event on the scale of SitC. For example, participant interviews during the event would distract from the fun, entertainment value of visitors, while archival document reviews were impossible as previous evaluation data was not of sufficient quality. The goal was to capture as much information as possible across the breadth of events within a tight time-frame. A mixed-method evaluation approach consisting of surveys collected using systematic sampling (every fifth person observed by the trained surveyor in specific age groups) and independent observations by silent observers was chosen.

3 Evaluation objectives

The specific objectives of the festival's evaluation were identified following the 'SMART' principle, i.e. specific to the event, measurable, achievable (or attainable), realistic (or result-oriented), and time bound around the event schedule. The objectives were targeted for this case study of an annual large science and arts festival that is attended by tens of thousands of people. As this was the first attempted systematic evaluation exercise of this festival, efforts were limited to the following objectives which were identified as baseline information that an organiser of a science festival would want to understand as an initial exercise:

- Demographics: Audience demographics profile, including gender, ethnicity, income, country/town of origin and level of education (Questions 1–5, Appendix A).
- 2. Profile of visiting group: Visiting group characteristics, including group size and makeup (eg. are people visiting with other adults or children? Questions 6–9, Appendix A).
- Motivation for attending: Understanding the attendee's reasons in visiting a science and arts festival (Question 10, Appendix A).
- 4. Quality of experience: Several questions were asked about the nature and quality of experiences at the

festival, including whether they enjoyed the festival or not (Question 11, Appendix A). Further questions assessed how comfortable attendees were with the interactions with researchers and their level of participation, to understand if researchers were engaging with visitors in an effective way (Questions 12–16, Appendix A).

4 Methods

4.1 Mixed-method evaluation

A mixed-method approach (Seaton, 1997) was chosen to be the most suitable for a large festival with activities ranging from artistic expressions to science experiments, outdoor to indoor locations, and professional performers to university student volunteers. The mixed-method approach adopted consisted of:

- A 16-item multiple-choice questionnaire (see Appendix A). Questions were adapted from the literature to ensure validity and reliability. It included questions on visitor profiles (demographics, accompanying group size and composition, education level, and place of residency), motivations for participation, reception of the festival, and interactions with researchers/volunteers. The questionnaire was administered through personal interviews by trained volunteer interviewers who sampled the population in a systematic manner. Both online and paper versions of the questionnaire were provided to interviewees according to their preference.
- Silent Observers (see Appendix B): three trained volunteers were instructed to experience the festival from a visitor's perspective. These observations were noted in a structured manner. Each silent observer was given a list of activities and events to attend and different starting points and places to be throughout the night.

4.2 Respondents of the questionnaire

The quantitative evaluation was conducted on the night of SitC on 30th September 2016. A total of 392 entries were recorded over the course of five hours. This number was limited to audience members. The questionnaire was printed on A4 paper in English or on an online platform.

4.3 Volunteers recruitment, training, and management

Bussell and Forbes (2002) highlighted the importance of understanding the target audience in order to successfully recruit and retain volunteers. The evaluation volunteers were undergraduate and postgraduate students from the University of Malta and employees of a pharmaceutical company (as part of their Corporate Social Responsibility) that had shown interest to help out with the festival. In this way, it was ensured that there was a diverse sample of students and professionals participating in data collection. When recruiting students for the evaluation strategy, preference was given to those who were unaffiliated with an organisation since it was expected that students that form part of student organisations would prefer volunteering with their peers. Students were specifically sought out in a dedicated call for volunteers that was advertised through the main channels used by students (such as Facebook). Finally, for the silent observers, volunteers who the organising team personally knew were relied upon due to the level of trust required for the task. The importance of understanding what motivates people to volunteer for the festival's evaluation was acknowledged in order to offer better support and guidance (Hyejin & Ross, 2009). This was achieved by meeting every volunteer a few weeks before the festival. A two-hour workshop introduced volunteers to the festival's evaluation practice, the importance of good data collection and unbiased sampling, and the event details and logistics. Volunteers had the freedom to select which age category they would survey during the festival, ensuring they would feel most comfortable when talking to interviewees. Management ensured that an equal number of volunteers covered each age category. Suggestions on how to select respondents were illustrated and practiced: volunteers were instructed to first look down at their feet, look up for people in their selected age category, count five such people, interview the fifth person, and, if the selected person would not agree to take the survey, start counting again—a systematic sampling approach. During the workshop the online survey was installed and tested on their smartphones (see Logistics). Interviewers received a free festival t-shirt and an 'Evaluation staff' name tag to associate them with the festival to aid approaching festival attendees. Free water and snacks were provided. Additionally a symbolic reward $(\in 10 \text{ vouchers from a local book shop})$ was given to the participants at the end of the night's work. The reward was only mentioned after they had undertaken the necessary training and showed up on the day. This was done to incentivise future participation and to thank them for their work during the night. The volunteers were all given basic training on approaching citizens. Sample scripts were provided to help them introduce themselves as evaluation volunteers with SitC, give details of the research project and invite festival attendees to take part in the survey. Science in the City lasted for approximately six hours and the volunteers worked individually for nearly five hours of the event (one hour after the event started till half an hour before its end). They were also advised on how to choose

89

participants randomly to reduce sampling bias based on an individual's gender, age or ethnicity. The volunteers used paper-based versions of the survey or digital version on tablets or other smart devices, depending on their and the interviewee's preferences. The volunteers were also located in strategic locations in the festival such as 'rest areas', 'meeting points', 'entrances' and 'exits' in order to observe public reaction and participation in the events.

4.4 Quantitative data collection

4.4.1 Questionnaire design

The questionnaire was designed in English with the intention of capturing a diverse range of responses in 10 minutes or less per survey participant. Following published guidelines on designing questionnaires for evaluations (Boynton & Greenhalgh, 2004; Spicer, 2012) the survey relied on a mixture of several closed-end multiple choice questions and limited open-end questions (Reja et al., 2003). The survey questions were adopted from reports and guidance on evaluation of public engagement activities that investigated similar ideas at different public engagement events. Apart from demographic and general questions (Questions 1-5), the questionnaire consisted of questions related to motivation of attending SitC (Question 10), level of participation (Questions 12, 16), knowledge and interest in science (Question 9) and impression of the festival (Question 11). The draft questionnaire underwent pilot testing amongst the SitC committee and volunteers to resolve the issues of ambiguity and incomprehensibility until it achieved a form that gathered responses on the most pertinent points of the evaluation.

4.4.2 Questionnaire platform

Although volunteers were recruited to interview people and gather data in person, a system to collect entries was still necessary. An electronic data collection methodology was opted by the research team for three main reasons. First, the technology provided a reusable system for future festival editions allowing for on-going evaluation. Second, the collected data did not need to be converted into an electronic format for analysis avoiding extra labour costs and reducing risks of introducing additional errors. Third, the ease of data entry and logistics: volunteers could access the survey at any moment from their smartphones without any limits on the number of interviewees. The software package ZohoForms was identified as the best online survey tool after a gap analysis. The analysis looked for affordable and robust software with both online and offline data collection, and with the option to be installed on multiple smartphones and operating systems. Only a few volunteers expressed a strong preference towards collecting data in a paper format, which

was accommodated.

4.4.3 Data management and analysis

All collected data were collected in a digital or paper format. Data was entered into a Microsoft Excel database, formatted and homogenised through the use of the Comma Separated Values (CVS) format and analysed using R programming. The descriptive analyses included descriptive statistics such as frequency, mean and percentage. Inferential analyses were made to calculate the total median score on their overall ratings using a Likert scale on the following variables (Questions 9, 11, 12): 1. How do you rate your general level of interest in science **outside** of the Science in the City festival? (score range 0-4); 2. What is the overall impression of the 2016 Science in the City? (0-4); 3a. To what extent do you agree or disagree with the following statements? (0-4)3b. I am likely to further investigate some of the scientific topics I encountered at the SitC festival (0-4). The calculated overall score derived from the Likert scale questions was treated as a dependent variable. This was termed as interviewee score. Median values of interviewee score were compared between various categories of participants, treated as independent variables, for example age groups, gender, and 'yes' or 'no' responses to questions. Mann Whitney U and Kurskal Wallis tests were used to test the differences in median scores. The difference in mean and median scores were statistically considered significant if *p*-value was less than 0.05.

4.5 Qualitative data collection

4.5.1 Silent observers

Following Seaton (1997), an unobtrusive observation method was adopted to record and study the events. The three silent observers were instructed to dress normally and to show minimal signs of their role at the festival in order to reduce possible positive or negative biases. Each volunteer was given a notepad, a pen, a map of the festival and the full programme. To ensure that the organisers could have an overview of the entire festival, a suggested schedule of events to attend and places to visit was provided. However, silent observers were instructed to move freely, observe and experience the festival. They were specifically asked to keep notes on: logistics, audience, and the behaviour of other volunteers and researchers (see Appendix B).

4.5.2 Crowd estimates

The most challenging aspect of the study was estimating the number of people attending the festival. Management discussed and researched multiple methods of crowd counting but did not find an optimal solution as it was

10.7423/XJENZA.2022.2.03
either too human resources dependent, using clickers at entry points; or too expensive/technical, using algorithms and images of the crowd (Cariveau, 2014; Streich et al., 2003). Management decided to use crowd estimates given by the local council and police. However, due to the high mobility of people and gatherings in front of shows, exhibitions and activities happening throughout the night it was very difficult to estimate the density of people along the streets and in indoor spaces.

4.5.3 Minimum number of volunteers

From previous editions of the festival, a minimum of 20,000 people were roughly estimated to attend the event throughout the night. A statistically significant sample at 95% confidence level (with 5% confidence interval) requires about 377 responses from the questionnaire. We needed a minimum of 8 volunteers collecting approximately 10 surveys an hour for the five hour long surveying period (or 50 surveys per volunteer over the night). In order to limit biases and to make sure that all age categories were well represented, the population of festival goers was divided into four age categories: 0–17, 18–29, 30–49, and above 50 years old. Each volunteer was instructed to gather data of people in one age category only. An equal number of volunteers was assigned to each age group.

4.5.4 Logistics

On the night of the festival all volunteers met with the evaluation manager half an hour before the start of the festival. At this point all materials were distributed and last minute directions were given. Data was gathered from about one hour after the event started till half an hour before its end. Half an hour before the closing of the festival a debriefing meeting took place: all interviewers and silent observers gathered and discussed with the evaluation manager their impression of the festival, the data collection methodology and other feedback.

5 Results

5.1 Results from the case study

Nineteen volunteers collected 392 survey responses during the festival. The sample was smaller than the study's initial objective. The reason is due to an overestimation of the working capacity of volunteers.

5.2 Demographics

Despite the sample's small size, the data collected is wellsampled: results show an almost equal number of males and females were surveyed (48.7% female; 51.3% male); and respondents are also equally split across age ranges as shown in figure 1 (blue represents direct sampling, 392

10.7423/XJENZA.2022.2.03

responses). figure 1 also illustrates how the group demographics data gives a qualitative idea of the real population present at the festival (orange represents group sampling, 1,237 indirect responses). From such data emerges that the bulk of participants are below 15 years old, and between 16–25 years old.

Figure 2 shows two important survey results: (1) mostly families (more than 50% of surveyed people) visit the festival, and (2) there is a considerable portion of young adults (16–25 years old) attending the festival with friends. Independently, silent observers reported a lack of activities and experiments targets towards young adults, but plenty of experiments for children. Due to the large attendance from young teenagers, future editions of the festival should try to specifically target such an audience.

5.3 Reception of the festival

Forty-two percent of the people surveyed were going to the festival for the first time. 83% of respondents liked the festival. Two of the silent observers had previously experienced the festival. Their comparison with past editions could identify practices that improved (or not) and gave feedback on possible improvements. The point of view of the other silent observer that never participated in the event was also relevant to point out what a newcomer notices, appreciates, and dislikes.

5.4 Reason for attending

Of the sampled population 76.5% have an interest in science and 59% of them would investigate science further after the festival. Reasons for attending are mainly to have fun (39%), to spend time with the family (26%), and to find out more about University of Malta research (21%).

5.5 Interactions

While 88% of survey respondents felt that researchers or volunteers at stands were enthusiastic when communicating to attendees, only 54.6% approached them to engage in conversation with them, and 14.6% felt that they were using difficult jargon. As the night progressed volunteers engaged less with visitors.

5.6 Internal feedback

The three silent observers collected qualitative data on the festival with special attention to one-off events, performances, and indoor activities. From their notes, it emerged that the composition of festival attendees changed throughout the night. Their feedback turned out to be an important internal feedback mechanism that gave insight on logistics, hard places to find, scheduled events not run on time, low attendance in certain events, and practical information. Table 1 summarises the multi-



Figure 1: Age spread of all surveyed people (1629 in total), both directly (total of 392 people in blue, bottom) and indirectly through group demographic questions (total of 1237 in orange, top).



Figure 2: Age spread of directly surveyed people (392 in total) with indication of their company (Family, Friend or Other).

strategy evaluation and its utility according to the dimension that was researched and analysed.

6 Discussion

Overall, setting up a mixed method evaluation strategy was not as challenging as anticipated. Good results were achieved in both methodology and information gathered. However, a few issues need further investigation. In terms of methodology, more attention must be paid on volunteer recruitment and management in order to optimise efforts from the organisers.

6.1 Setting up the evaluation

The time needed to create the evaluation strategy was considerably less than expected due to two main factors:

- extensive research has already been carried out on large touristic events (Langen & Garcia, 2009; Wood, 2005) which provided adaptable guidelines for science communication practice (del Carmen Sánchez-Mora, 2016; Koolstra, 2008);
- 2. case studies and examples of survey questionnaires from similar events were publicly available and easily adaptable. Instead the time of the research team was mostly invested in recruiting, training, and managing volunteers.

6.2 Volunteer strategy

An appropriate and effective volunteer recruitment and management strategy is essential for the success of a large-scale evaluation strategy. The volunteer recruitment process had its challenges. Although the organising team started contacting organisations two months in advance, potential volunteers only started responding three weeks before the festival. The main contribution of volunteers came from a medical research company that had an interest in helping out with the festival. Only when the organising team successfully identified a key contact person did all the communications occur efficiently: a training session was organised in less than one week, and further volunteers were encouraged to participate. The rest of the volunteers were recruited through social media and mailshots through University channels. Since most student organisations were actively involved in the festival, we specifically targeted students not belonging to any organisation but that wished to take part in it. A good volunteer recruitment and management strategy is essential for the success of such efforts. Overall there was a very positive response from volunteers: all the 19 recruited volunteers attended the training session held the weeks before the festival and showed up on the night of the festival. During the debriefing with evaluation volunteers at the end of the festival it seemed clear that

training sessions were helpful as most of them reported trying some of the approach methods discussed during the training session and adopting the most suitable for them. They also acknowledged the difficulty in collecting randomly sampled data as they would either receive rejections or acceptance from an entire group. An unexpected positive side effect of the training sessions was that although not all volunteers knew each other, throughout the festival a cohesive group formed that encouraged cooperation. The name tag and t-shirt that were handed at the event also helped create a shared identity. During the debriefing at the end of the event some volunteers reported stories of some problems and how they solved them thanks to the others' help.

6.3 One-to-one training for silent observers

The three silent observers were recruited from personal acquaintances of the organisers. They were chosen based on reliability and previous festival experience (as a visitor, as an active participant and never been before). Each one of them could give a different perspective on the festival while trying to be objective. Their diverse backgrounds and experiences helped develop a more complete picture of the festival. Before the festival, the evaluation manager met with each silent observer in a one-to-one session. Their role was explained and discussed and some basic concepts of non-verbal indicators of individual and collective audience reactions were elucidated. The silent observer experience was overall very formative for the festival organisers. Having an external and objective view on the quality of the festival helped analyse mistakes and realise successes better.

6.4 Data Collected

The data collection procedure turned out to be an exhausting experience for the volunteers. This was identified in the debriefing logistics meeting. The volunteers also gave informal feedback that supported the silent observer feedback received. This reason is the most likely explanation for the lower than anticipated number of collected surveys. All interviewers reported being fatigued and inefficient after two hours. This resulted in the final meeting and debriefing session to occur half an hour earlier than planned. This problem could be overcome by splitting the team into two groups and requiring them to collect data for only two hours. This might also improve the quality of the data since visitors would interact with rested and enthusiastic people. By the end of the night, 392 people were directly surveyed through the questionnaire. Information on another 1,237 people was gathered indirectly through group demographic questions administered through the survey (Questions 6 and 7). The data collected was almost three times higher than any previ-

Aim	Survey utility	Silent observer utility
Demographics	Quantitative - Well-sampled data with additional group demographic informa- tion gives qualitative insights of the real population.	Qualitative - the majority of the popula- tion attending the festival is families.
Reception of the festival	Quantitative - 42% of the people surveyed were going to the festival for the first time. 83% of respondents liked the festival.	Qualitative - impression on the festival and comparison with past editions indic- ates a decrease in activity quality.
Reason for attending	Quantitative - 76.5% of the sampled people have an interest in science and 59% of them would investigate science further after the festival. Reasons for attending are mainly to have fun (39%), to spend time with the family (26%), and to find out more about University research (21%).	No information.
Interactions	Quantitative - information on interac- tions of researchers with visitors. While 88% of respondents felt that researchers were enthusiastic, only 54.6% engaged in conversation with them, and 14.6% felt that they were using difficult jargon.	Qualitative - as the night progressed vo- lunteers engaged less with visitors.
Internal feedback	No info on logistics	Qualitative - Organisers received import- ant info on logistics and how/what to improve, for example more clear sig- nage and training stand volunteers to ap- proach audiences.

 Table 1: Summary of the multi-strategy evaluation.

Conclusions

7

ous attempts. Furthermore, notes and comments from the silent observers helped complete the picture of the outcome of the festival. Very constructive feedback was collected for use for future years. For the future of organizing a survey, it is also necessary to collect data regarding how many people were contacted and how many people refused to provide answers. As the data was evaluated, it was evident that the age group between 40-64 prevailed in participating in the responses. Which can lead to skewed overall results. We have no further information as to why this age group formed most of the answers.

6.5 **Recommendations for festival organisers**

Combining the survey with the information gathered from the silent observers helped gather a good and comprehensive overview of the festival. It set a baseline for future editions on which to build on and keep on improving. All the evaluation efforts carried out in this work were very dependent on volunteers, therefore an effective and appropriate volunteer recruitment, training and retainment strategy was essential. Passive data collection is recommended: any type of data that visitors leave behind naturally such as time spent at a particular location/activity; questions asked; level of engagement through body language; amount of food or drinks sold; number of samples/leaflets handed out; online activity on the website and social media interactions. Once set up, passive data collection is a cheap way of gathering complementary information on an event. Another possibility would be to build-in evaluations in interactive activities carried out throughout the night, such as boards where people can pin their reactions to the event. In SitC, NGOs, government institutions, industry partners and student organisations plan and perform numerous experiments and interactive activities with the guidance of the organisers. With minimal extra effort, a simple and creative way of collecting information on the effectiveness of the experiment or activity could be integrated into the evaluation. Additionally the evaluation team realised the lack of qualitative data. Short informal interviews and/or long focus groups can be conducted with event organisers and visitors to gather impressions and comments to improve future festival editions. A few evaluation volunteers reported that some of the interviewees wished to say more and comment on activities and the festival. Unfortunately there was no time to collect such valuable contributions. The evaluation can also consider the impact on the organising team and external stakeholders: festivals have been proven to help stimulate and maintain partnerships (Bevc et al., 2016). A good understanding of collaborations can help improve and develop them over the years to maximise impact.

based, can result in fewer citizens being interested in science or taking a scientific career, which results in the development of greater misconceptions (Gascoigne & Metcalf, 2001; Jensen & Gerber, 2020). Doubtlessly, evaluation of science communication activities are not easy to perform: they depend on the subtle interplay of the audiences, objectives (del Carmen Sánchez-Mora, 2016), communication medium (Cooke et al., 2017; Grand & Sardo, 2017) and interpretations of results which might be misleading (Jensen, 2014). This work has developed a baseline assessment of the festival developing a professional evaluation strategy with limited funds and experience. It is a step-by-step guide for large science festival organisers who want to set up effective evaluation of their efforts. This study used a case study festival to test this approach and managed to identify successes and challenges that helped the organisers improve the festival in subsequent years. Future work will see the iterative evaluation of the festival over a multi-year time span to assess the progression and incorporation of evaluation data by the festival management. Collecting more case studies and tested questions will help improve evaluation for effective implementation.

When considering science communication programmes,

practitioners must pay more attention to evaluate their

work to assess effectiveness and improve their practices.

Ineffective science communication, which is not evidence

Acknowledgements 8

The paper's authors thank all the organisations, volunteers, interns and personnel that made this study possible. The Science in the City-European Researchers' Night festival, is organised by the University of Malta and the Malta Chamber of Scientists together with a large number of partners. Funded by the European Commission's Research and Innovation Framework Programme H2020 (2014–2020) by the Marie Skłodowska-Curie actions (grant number: 722824). It is recognized as a Festival by Europe for Festivals and Festivals for Europe (EFFE). It is supported by the Parliamentary Secretariat for Financial Services and Digital Economy and a number of corporate sponsors. The authors would like to thank Ms Silvia Verdolini and Mr Benji Fenech Salerno for providing their expertise and contributions.

9 Privacy and consent statement

9.1 Consent statement

The purpose of the survey was to analyse and present a step-by-step guide on how to set up a valuable and informative mixed method evaluation strategy of large-scale

science festivals and events. The survey was being conducted by the University of Malta. The participation in this survey was voluntary. The participants in this research survey may withdraw at any time. The responses of participants were confidential and we kept it this way for the whole time. When collecting information from participants, consent and permission were explicit, informed, voluntary and re-negotiable. We provided participants with enough information about the data collection that they can make an informed decision about whether they want to participate or not. Everyone had the right to refuse to participate. That meant that if they did not feel like answering the questions, they did not have to, and if they felt like stopping part way through, they could stop at any time.

9.2 Data protection

All data is stored in protected format. To help protect participant confidentiality, the survey didn't contain information that would personally identify a participant. The data are used as a group for statistical purposes and will not be pointed to a single person. We make all data anonymous when analysing it—this means that participants will not be identified.

References

- Bevc, C. A., Young, D., & Peterman, K. (2016). Using social network analysis to document science festival partnerships. *JCOM*, *15*(05), A04.
- Boynton, P. M., & Greenhalgh, T. (2004). Selecting, designing, and developing your questionnaire. *BMJ*, 328(7451), 1312–1315.
- Bultitude, K., McDonald, D., & Custead, S. (2011). The rise and rise of science festivals: An international review of organised events to celebrate science. *International Journal of Science Education, Part B: Communication and Public Engagement*, 1(2), 165–168.
- Burns, T. W., O'Connor, D. J., & Stocklmayer, S. M. (2003). Science communication: A contemporary definition. *Public Understanding of Science*, 12(2), 183–202.
- Bussell, H., & Forbes, D. (2002). Understanding the volunteer market: The what, where, who and why of volunteering. *Int. J. Nonprofit Volunt. Sect. Mark*, 7, 244–257.
- Cariveau, D. (2014). Crowd size estimation. *Tratto da course*, *1*.
- Cassidy, A. (2006). Evolutionary psychology as public science and boundary work. *Public Understanding of Science*, 15(2), 175–205.

- Cooke, S. J., Gallagher, A. J., Sopinka, N. M., Nguyen, V. M., Skubel, R. A., Hammerschlag, N., & Danylchuk, A. J. (2017). Considerations for effective science communication. *Facets*, *2*, 233–248.
- del Carmen Sánchez-Mora, M. (2016). Towards a taxonomy for public communication of science activities. *JCOM*, 15(2).
- Dimitrova, K. (2010). Impact assessment of researcher's night 2010. *Report by ATA48*.
- Gascoigne, T., & Metcalf, J. (2001). Report: The evaluation of national programs of science awareness. *Science Communication*, 23, 66–76.
- Grand, A., & Sardo, A. M. (2017). What works in the field? evaluating informal science events. *Frontiers in Communication*, 22(2).
- Hyejin, B., & Ross, S. (2009). Volunteer motivation and satisfaction. *Journal of Venue and Event Management*, 1(1), 61–77.
- Jensen, E. (2014). The problems with science communication evaluation. *Journal of Science Communication*, 1(C04), 2014.
- Jensen, E. (2015). Highlighting the value of impact evaluation: Enhancing informal science learning and public engagement theory and practice. *JCOM*, *14*(3), Y05.
- Jensen, E., & Buckley, N. (2011). The role of university student volunteers in festival-based public engagement. NCCPE.
- Jensen, E., & Buckley, N. (2014). Why people attend science festivals: Interests, motivations and self-reported benefits of public engagement with research. *Public Understanding of Science*, 23(5), 557–573.
- Jensen, E., & Gerber, A. (2020). Evidence-based science communication. *Frontiers in Communication*, *4*, 78.
- Jensen, E., & Laurie, C. (2016). Doing real research: A practical guide to social research SAGE publications.
- King, H., Steiner, K., Hobson, M., & Clipson, H. (2015).
 Highlighting the value of evidence-based evaluation:
 Pushing back on demands for 'impact'. *JCOM*, 14(2), A02.
- Koolstra, C. M. (2008). An example of a science communication evaluation study: Discovery07, a Dutch science party. *JCOM*, 7(2), A03.
- Langen, F., & Garcia, B. (2009). Measuring the impacts of large scale cultural events: A literature review. *Liverpool: Impacts, 8.*
- Reja, U., Manfreda, K., Hlebec, V., & Vehovar, V. (2003). Open-ended vs. close-ended questions in web questionnaires. Adv Methodol Stats, 19.

- Roche, J., Davis, N., O'Boyle, S., Courtney, C., & O'Farrelly, C. (2017). Public perception of European research: An evaluation of European researchers' night in Ireland. *International Journal of Science Education, Part B Communication and Public Engagement*, 7(4), 371–391.
- Sardo, M. (2016). Evaluation of the Bristol Bright Night 2015 (BBN15). *University of the West of England*, *31*, 2017.
- Seaton, A. (1997). Unobtrusive observational measures as a qualitative extension of visitor surveys at festivals and events, mass observation revisited. *Journal of Travel Research*, *35*(4), 25–30.
- Shaw, I. F., Greene, J. C., & Mark, M. M. (2006). *The SAGE handbook of evaluation SAGE publications Ltd.*
- Spicer, S. (2012). *Evaluating your engagement activities. developing an evaluation plan*. The University of Manchester.
- Streich, A., Marx, D., Stafford, J., Rodie, S., & Todd, K. (2003). Estimation of attendance at a large outdoor event. *Journal of Extension*, 41, 5.
- Wood, E. (2005). Measuring the economic and social impacts of local authority events. *International Journal of Public Sector Management*, *18*(1), 37–53.

A Appendix – Science in the City, Malta Survey

- 1. Sex [Female/Male]
- 2. What is your year of birth? [Year]
- 3. Where do you live in Malta? Please indicate the letters of your postcode. [Postcode list]
- 4. Do you have a Maltese nationality? [Yes/No]
- What is your highest (completed) level of education? [Less than secondary; Secondary; Post secondary; Bachelor; Master; PhD or Professional]
- Who did you come to the festival with? [Alone; With family; With friends/ Significant other; With colleagues; Other]
- If not alone, please also indicate the ages and number of people in the group you attended the festival with: [Number of people age 0–15; Number of people age 16–25; Number of people age 26–39; Number of people age 40–64; Number of people above 65]
- 8. How many year/s have you attended SITC festival before 2016? [Number]
- 9. How do you rate your general level of interest in science OUTSIDE of the Science in the City festival? [Strongly interested; Interested; Neutral; Not interested; Strongly not interested; No opinion]
- 10. What are the reasons for attending the Science in the City? [Entertainment; Family time; Fun day out; Learn more about University of Malta research; Meet new people; Other]
- 11. What is the overall impression of the 2016 Science in the City? [Very good; Good; Neutral; Poor; Very poor; No opinion]
- 12. To what extent do you agree or disagree to the following statements?

I felt I was able to participate actively in the Science in the City festival. [Strongly agree; Agree; Neutral;

Disagree; Strongly disagree; No opinion]

I am likely to further investigate some of the scientific topics I encountered at the SITC festival. [Strongly agree; Agree; Neutral; Disagree; Strongly disagree; No opinion]

- 13. Did the volunteers/researchers at the stands greet you? [Yes/Sometimes/No]
- 14. Were volunteers/researchers enthusiastic about their research? [Yes/Sometimes/No]
- 15. Did volunteers/researchers use difficult scientific language? [Yes/Sometimes/No]
- 16. Did you engage in more (than 5 minutes) conversation with any volunteers/researchers? [Yes/Sometimes/No]

B Appendix – Silent observers instructions

General instructions

- Move around.
- Observe the audience.
- Record information that indicates an event's success (or failure) and the reasons for it.

Keep notes on:

- Logistics
 - The organisation and scheduling of each event.

Was it easy to find?

How are people moving around? Are there points where it is difficult to pass?

Are people using info points?

• Audience

Make estimates of audience numbers.

Are people enjoying themselves? Record descriptions of audiences based on non-verbal indicators of individual

and collective audience reactions to each event.

Audience comments: engage in casual conversation, listen to and record spontaneous audience comments.

• Festival volunteers/researchers

Are volunteers/researchers friendly?

Are they engaging people in conversation? Or are they simply explaining things?

Do they talk to children? To grown ups? Both?

Are they organised / neat? Do they give a good impression?

Were they knowledgeable? Were they understandable?

Your opinion

Did you enjoy it / find it interesting?

Suggestions for improvement?

C Appendix - Survey Results

392 survey responses were collected on the night. The statistical relationship between a number of categorical variables were evaluated. Chi-square tests of independence were carried out using IMB SPSS statistics software. For each test, a contingency table was created and the resulting calculations yielded the chi-square value, degree of freedom, *p*-value and Cramer's V. Where open-ended questions were explored, the qualitative data assessment used was pattern analysis (Jensen & Laurie, 2016) with reliability and objectivity addressed through independent coding.

Interactions wi Greetings	th researchers/volunteers	5
Greetings	Number of responses	Percentage
Yes	313	79.8%
Sometimes	35	8.9%
No	27	6.9%
N/A	17	4.3%
Jargon		
Jargon	Number of responses	Percentage
No	245	62.5%
Sometimes	68	17.3%
Yes	57	14.5%
N/a	22	5.6%
Enthusiasm		
Enthusiasm	Number of responses	Percentage
Yes	346	88.3%
Sometimes	28	7.1%
No	2	0.5%
N/A	16	4.1%
Conversation		
Conversation	Number of responses	Percentage
Yes	214	54.6%
No	104	26.5%
Sometimes	54	13.8%
N/A	20	5.1%

Table 2

Demographics

Total number of people surveyed 392 Female 48.7%; Male 51.3%

Age (by category)

Age	Number of people	Percentage
0–15	88	22.4%
16–25	95	24.2%
26–39	48	12.2%
40-64	118	30.2%
65+	43	11.0%
Min = 6 years old; Max 96 years o	bld	
Education		
Highest Education	Number of people	Percentage
Post Secondary	102	26.0%
Bachelor	93	23.7%
Secondary	69	17.6%
Less Secondary	85	21.7%
Master	30	7.7%
PhD/Professional	11	2.8%
NA	2	0.5%
Where they live in Malta		
Place	Number of people	Percentages
Place "ATD"	Number of people 35	Percentages 8.9%
Place "ATD" "BKR"	Number of people 35 24	Percentages 8.9% 6.1%
Place "ATD" "BKR" "NXR"	Number of people 35 24 21	Percentages 8.9% 6.1% 5.4%
Place "ATD" "BKR" "NXR" "SGN"	Number of people 35 24 21 21	Percentages 8.9% 6.1% 5.4% 5.4%
Place "ATD" "BKR" "NXR" "SGN" "NA"	Number of people 35 24 21 21 16	Percentages 8.9% 6.1% 5.4% 5.4% 4.1%
Place "ATD" "BKR" "NXR" "SGN" "NA" "MST"	Number of people 35 24 21 21 16 16	Percentages 8.9% 6.1% 5.4% 5.4% 4.1% 4.1%
Place "ATD" "BKR" "NXR" "SGN" "NA" "MST" "SLM"	Number of people 35 24 21 21 16 16 12	Percentages 8.9% 6.1% 5.4% 5.4% 4.1% 4.1% 3.1%
Place "ATD" "BKR" "NXR" "SGN" "NA" "MST" "SLM" "ZBG"	Number of people 35 24 21 21 16 16 12 12	Percentages 8.9% 6.1% 5.4% 5.4% 4.1% 4.1% 3.1% 3.1%
Place "ATD" "BKR" "NXR" "SGN" "NA" "MST" "SLM" "ZBG" "SPB"	Number of people 35 24 21 21 16 16 12 12 11	Percentages 8.9% 6.1% 5.4% 5.4% 4.1% 4.1% 3.1% 3.1% 2.8%
Place "ATD" "BKR" "NXR" "SGN" "NA" "MST" "SLM" "ZBG" "SPB" "Not Malta"	Number of people 35 24 21 21 16 16 12 12 11 11 11	Percentages 8.9% 6.1% 5.4% 5.4% 4.1% 4.1% 3.1% 3.1% 2.8%
Place "ATD" "BKR" "NXR" "SGN" "NA" "MST" "SLM" "ZBG" "SPB" "Not Malta" "ZRQ"	Number of people 35 24 21 21 16 16 12 12 11 11 11 10	Percentages 8.9% 6.1% 5.4% 5.4% 4.1% 4.1% 3.1% 3.1% 2.8% 2.8% 2.8% 2.6%
Place "ATD" "BKR" "NXR" "SGN" "NA" "MST" "SLM" "ZBG" "SPB" "Not Malta" "ZRQ" "BBG"	Number of people 35 24 21 21 16 16 12 12 11 11 10 9	Percentages 8.9% 6.1% 5.4% 5.4% 4.1% 3.1% 3.1% 3.1% 2.8% 2.8% 2.6% 2.3%
Place "ATD" "BKR" "NXR" "SGN" "NA" "MST" "SLM" "ZBG" "SPB" "Not Malta" "ZRQ" "BBG" "FGR"	Number of people 35 24 21 26 16 16 12 12 11 10 9 9	Percentages 8.9% 6.1% 5.4% 5.4% 4.1% 4.1% 3.1% 3.1% 2.8% 2.8% 2.6% 2.3%
Place "ATD" "BKR" "NXR" "SGN" "NA" "MST" "SLM" "ZBG" "SPB" "Not Malta" "ZRQ" "BBG" "FGR" "MSD"	Number of people 35 24 21 26 16 16 12 12 11 10 9	Percentages 8.9% 6.1% 5.4% 5.4% 4.1% 4.1% 3.1% 3.1% 2.8% 2.8% 2.8% 2.8% 2.6% 2.3% 2.3%
Place "ATD" "BKR" "NXR" "SGN" "NA" "MST" "SLM" "ZBG" "SPB" "Not Malta" "ZRQ" "BBG" "FGR" "MSD" "ZBR"	Number of people 35 24 21 21 16 16 12 12 12 11 11 10 9 9 9 9 9	Percentages 8.9% 6.1% 5.4% 5.4% 4.1% 4.1% 3.1% 3.1% 2.8% 2.8% 2.8% 2.6% 2.3% 2.3% 2.3%

Disclaimer: Postal addresses below a frequency of 8 are not included.

Table 3

Gr	oup	demo	ograp	hics
-	-			-

Age range	Number of people	Percentage	
0-15	436	35.2%	
16-25	355	28.7%	
26-39	195	15.8%	
40-64	220	17.8%	
65+	31	2.5%	
Total number of peop	le: 1237		
Estimate total numb	per of people by category, which	age category is the largest population at th	e festiv
Estimate total numb Age range	per of people by category, which Number of people	age category is the largest population at th Percentage	e festiv
Estimate total numb Age range 0-15	per of people by category, which Number of people 524	age category is the largest population at the Percentage 32.2%	e festiv
Estimate total numb Age range 0-15 16-25	per of people by category, which Number of people 524 450	age category is the largest population at the Percentage 32.2% 27.6%	ie festiv
Estimate total numb Age range 0-15 16-25 26-39	ber of people by category, which Number of people 524 450 243	age category is the largest population at the Percentage 32.2% 27.6% 14.9%	ie festiv
Age range 0-15 16-25 26-39 40-64	ber of people by category, which Number of people 524 450 243 338	age category is the largest population at the Percentage 32.2% 27.6% 14.9% 20.7%	e festiv

Total number of people: 1629 (direct + indirect)

Type of accompanying people – Who did you come to the festival with?

Туре	Number of responses	Percentage
With family	224	57.1%
With friends/ Significant other	134	34.2%
Alone	20	5.1%
With Colleagues	9	2.3%
Other	3	0.8%
N/A	2	0.6%

Table 4

Reception of the fe Returning audience [% of	stival the people that has been there	e before; % that came more than once]
Frequency	Number of people	Percentage
0	162	41.3%
1	85	21.7%
2	70	17.9%
3	44	11.2%
4	14	3.6%
5	5	1.3%
6	7	1.8%
N/A	5	1.3%
Did they like it?		
Impression	Number of people	Percentage
Good (G)	168	42 9%
Very good (VG)	157	40.1%
Neutral	137	11 2%
	7	1 00/
FOOI (F)	i F	1.0/0
	5	1.3%
Very poor (VP)	3	0.8%
	8	2.0%
VG + G = 83%		
VP + P = 2.7%		
Reason	Number of people	Percentage
Family time	102	26.0%
Research in Malta	85	21.7%
Entertainment	84	21.4%
Fun day out	69	17.6%
Other – learn more	13	3.3%
Other – by chance	10	2.6%
Other	7	1.8%
Other – curiosity	5	1.3%
Other – participation	4	1.0%
Meet new people	3	0.8%
Other – particular exhibit	2	0.5%
N/A	8	2.1%
Interest in science		
Level of interest	Number of people	Percentage
Interested	162	41.3%
Strongly interested	138	35.2%
Neutral	62	15.6%
Not interested	16	4 1%
Strongly not interested	4	1%
No opinion	2	0.5%
N/A	9	2.3%
$SI \pm I = 76.5\%$	5	2.570
SNI + NI = 5.1%		
Follow up on science		
Oninion	Number of respondents	Dereentage
	Number of respondents	
Agree (A)	109	4U.070
Strongly agree (SA)	12	
Neutral	80	20.6%
Disagree (D)	48	12.2%
No opinion	12	3.1%
Strongly Disagree (SD)	7	1.8%
N/A	13	3.3%
SA + A = 59%		
D + SD = 14%		

Xjenza Online: Science Journal of the Malta Chamber of Scientists www.xjenza.org DOI: 10.7423/XJENZA.2022.2.04

Research Article



Public opinion and protest efficacy: A study on the proposed yacht marina in Marsaskala, Malta

V. Visanich*

Old Humanities, Faculty Of Arts, University Of Malta, Msida, Malta

Abstract. Public opinion data regarding environmental concerns are central to a better understanding of the effects of social movements in sensitising environmental issues, and at times changing political decisions. In August 2021, Transport Malta issued an expression of interest for the design, construction and operation of a 700-berth yacht marina in the bay of Marsaskala, a fast-growing locality in the south east of the Maltese Islands. A social movement made up of residents, non-residents, an environmental NGO and local stakeholders organised a number of protests following the publication of the marina plans. The aim of this article is to identify underlying factors causing individuals' concerns on the proposed development. It explores the environmental movement surrounding this concern and analyses survey data on public opinion. It does so to better understand the extent of specific areas of impact that the proposed marina would have on the community of Marsaskala. Specifically, it focuses on how this would impinge on the everyday life of citizens. Results point to the social, environmental and economic impacts that this development would have, particularly on the community infrastructure of the locality of Marsaskala. Discussion focuses on how the ongoing impact on public opinion and protest, not only on mobilising public opinion but impacting political decisions.

Keywords: Social movement, environmental movement, yacht marina, protest, Marsaskala, Malta

1 Introduction

Studies on the impact of social movements have predominantly focused on protest efficacy, public opinion, or both (Agnone, 2007). Some scholars have theorized on the effects of these movements, particularly environmental movements, on public policy, referring to the impact of sensitising issues and changing political decisions (Rootes, 1999). It has been argued that dramatic events like protests can at times affect policy changes by leveraging elite concessions (Barkan, 1984; Morris, 1993).

Malta, a small island state in the Mediterranean Sea, has seen a fluctuating salience of environmental issues in recent years. During the last decade, Malta has been experiencing a very rapid fate of economic growth. Significant job creation and foreign revenue have followed in the wake of various projects, and new economic niches. This interest has accelerated pressure on the finite natural environment to 'give way' to progress and modernisation. This economic expansion has also been accompanied by a growing environmental concern, as citizens try to resist and fight back against the erosion of their quality of life.

Lately, the locality of Marsaskala in Malta has been the centre of debate, with a number of organised protests by civil society, strongly opposing the proposed development of a yacht marina. 'No to marina' banners hanging from residents' balconies demonstrate how forcefully the opposition is to the proposed call for expression, issued by Transport Malta for the design, construction and operation of a 700-berth yacht marina proposed for Marsaskala Bay.

The objective of this article is to shed light on the environmental movement, spawned and organized by civil society, on the proposed yacht marina in Marsaskala. The aim of this research is to identify underlying factors causing individuals' concerns on the proposed development. This article draws from sociological research to develop a baseline of the current situation and profiles the affected citizens, by conducting an online survey with residents of Marsaskala as well as non-residents, between the 14 to 21 November 2021. The survey steered around the issues of awareness and opinion on the expression of interest for a yacht marina as well as its presumed impact on the urban, environment and social fabric of the Marsaskala community. Additionally, this survey aimed at obtain-

ing knowledge on the implications on the everyday life of non/residents including in terms of community, well-being and personal lives.

This article raises some concerns emphasised by respondents on how the proposed development would obliterate the fundamental characteristics of this fishing village. They referred to how it would compromise spaces and areas that are currently used by the public for relaxation, as well as threaten the livelihood of fishers whose boats navigate in the Bay. It was also argued that it would increase vehicular traffic into the area and compound an already serious traffic and parking situation. Additionally, it would destroy the locality's current aesthetic and cultural appeal to tourists and visitors as well as eliminate a unique public good for the benefit of the few who could afford making use of the marina.

1.1 The impact of environmental movement and public opinion in Malta

Various studies examine the political impact of social movements by focusing on protest efficacy (Barkan, 1984; Morris, 1993), particularly the importance of protest accompanied by social movement advocacy and a favourable political context (Andrews, 2001). While many social movement scholars stress the importance in influencing public policy, however some claim that this is not sufficient because scholars of social movements do not take public opinion into account in their modelling (Burstein, 2003; Burstein & Linton, 2002). Burstein (2003) considers the impact of public opinion on public policy by referring to its impact and the extent to which such an impact may be negated or diluted by interest groups, social movement organizations, political parties and elites (Burstein, 2003). In the analysis of the outcome of social movement actions, discussion dwells not only to establish whether movements create social change, but also how such movements generate political change (Andrews, 2001).

Malta's environmental movement, ranging from environmental NGOs to grass-roots activists, has a direct or indirect outcome usually by mobilizing public opinion. This can result in a significant impact on local society, including procedural (increased democratisation such as access to decision making structures), substantive (impact of the material result), structural (changes in political structures and institutions) and sensitisation effects (changes in the political agenda and in public attitudes) (Briguglio, 2015; Carter, 2001; Giugni, 1995; Rootes, 1999, 2007; Van der Heijden, 1999). Such impacts can raise consciousness amongst the public and/or policy elites. Malta's environmental movement has resulted in a number of partial or full victories of various environmental issues, including the valid contribution of civil society in Malta in the 'bird hunting in spring' national referendum held in 2015 (Briguglio, 2015; Veríssimo & Campbell, 2015). Another case in point was the withdrawal of plans for a private hotel complex at Munxar, St Thomas Bay, also in Marsaskala, following social and political mobilisation (Boissevain, 2001).

Additionally, an exemplary case of the impact of environmental social movements is the activism of Front Harsien ODZ, a Maltese citizens' environmental movement working actively to protect an Outside Development Zone (ODZ) land in Zongor in Marsaskala. This land was to be utilised as a site for a private American University of Malta (AUM) (Briguglio, 2018). This plan was followed by various press conferences and protests, with one such event attended by thousands of citizens in Valletta, Malta's capital city. Consequently, this activism (both physical and digital) resulted in a partial victory in August 2015, when the Malta Prime Minister at that time announced revisions in the planned development, reducing the area of impact by 80 per cent to eighteen thousand square metres (Briguglio, 2018). Moreover, taking also into account the failures to meet contractual demands by the developer, the current Prime Minister announced in mid-February 2022-during the run-up to a general election—that the government was renegotiating a land concession concerning the AUM and that the Żongor land would be returned to the people (Arena & Xuereb, 2022). This would result in a complete victory for environmental NGOs and residents who protested tirelessly against the development. This case illustrates how protests against land concessions concerning the AUM and the Zongor land would appear to have proved useful in view of the political decision in mid-February 2022 to renegotiate the land and return it to public use.

1.2 The locality of Marsaskala

The locality of Marsaskala (Figure 1), also known as Wied il-Ghajn, is situated in the south east of Malta and very close to the towns of Żejtun (2.5km away) and Żabbar (2.2km away). This settlement, with a long narrow inlet known as Marsaskala Creek, was originally a fishing village but it is now more regarded as a tourist destination (Hop-kins, 2014; Young, 1983). Marsaskala bay is sheltered to the north by Ras iż-Żonqor and to the south by the headland of Ras il-Gżira. Marsaskala is largely bordered by a promenade, with low shelving rock ledges cut with salt pans.

In this settlement, there has been substantial population growth in the last two decades: from 5,419 in 2001 (National Statistics Office, 2001) to 13,726 in 2018 (Camilleri, 2018).

The population influx has resulted in physical expansion

of the urban footprint in multiple zonal locations in the settlement (Johnston, R. J. et al., 2000), resulting in four zonal areas in Marsaskala: Bellavista, Żonqor, Siberia and St Thomas Bay zones (Seychell, 2010). In it worth noting that in this model of zonal locations in Marsaskala there are missing references to the old part of the town. One reason for this is because this part of the town is relatively small and has become completely subsumed by the other areas.

1.3 Proposal for a yacht marina

The 2006 local plan for Marsaskala shows that the bay has already been earmarked for a yacht marina or a maritimerelated development, and thus planning policy groundwork for the project is already in place (Galea, 2021).

It warrants to mention that in 1997, a study commissioned by the MMA (Malta Maritime Authority) and MEPA (Malta Environment and Planning Authority) entitled 'Yachting Development in Malta' did not recommend Marsaskala as one of the potential sites for the development of a yacht marina in view of the considerable breakwater costs and being an exposed site (Deloitte and Touche, 1997). This report recommended that Marsaskala should be "ruled out" as a possible site for developing a marina and ranked it at the 11th place amongst the various locations considered. Additionally, this report has been useful in the preparation of a more recent document entitled the 'Development of Yachting Facilities in Malta' (Malta Maritime Authority, 2009), with the scope of identifying potential sites suitable for all weather marinas and others that could be considered for establishing temporary and seasonal marinas.

In August 2021, Transport Malta issued an expression for interest for the design, construction, financing, operation and maintenance of a yacht marina in Marsaskala with an estimated procurement value of around \in 183 million across 50 years (Galea, 2021). According to the project brief in Transport Malta's questionnaire, the concession to develop a yachting centre would make Marsaskala and the southern region area '...more appealing to the tourist industry' (ibid.).

Preliminary designs of the marina by Transport Malta show land reclamation in three areas, amounting to 16,000 square metres across parts of the Marsaskala bay as well as the bay completely dotted with berth spots (Figure 2). The plan also shows the required dredging; a construction practice which would result in substantial damage to the bay's underwater habitat, as well as an adjoining saline marsh (a Natura 2000 site).

The designed layout of the yacht marina shows a substantial increase in the current berthing capacity to a minimum of at least 700 berths in the marina pertaining to the project, while the concessionaire would also be expected to host and provide for a re-organisation of the current 567 berth holders. With the exclusion of these current berth holders, the marina would be organised with 20% dedicated to vessels between 1 and 12 metres in length, 50% dedicated to vessels of between 13 and 23 metres in length, 25% to vessels of 24 to 36 metres in length, and the remaining 5% to vessels larger than 36 metres in length (ibid.).

A number of protests were organised and attended by various residents, fishers, festa enthusiasts, local organisations and environmental NGOs. Predominantly the protests were organised by Marsaskala residents and Moviment Graffitti, a local left-wing NGO active against exploitation of people and the environment (movimentgraffiti.org). Moviment Graffitti activist Andre Callus confirmed that a total of six press conferences and protests were organised in relation to the yacht marina. In the most recent activity, on Saturday 12 February 2022, protesters demanded electoral candidates for the imminent general election to unequivocally state their position on the proposed development. Meanwhile, and again in view of the coming election, Marsaskala residents have started placing yellow notices on their doorbells, warning party politicians to stay away unless they planned to oppose the marina proposal development (Figure 3).

In this context, Deputy Prime Minister Chris Fearne declared that he opposes the proposed Marsaskala marina project. He told the Times of Malta:

I believe that the part of Marsaskala which is underdeveloped and where residents can enjoy swimming, recreation and fishing should remain undeveloped and residents should continue enjoying Marsaskala Bay as is.(Arena & Xuereb, 2022)

In addition, on 22 February, Prime Minister Robert Abela announced the 'instant dismissal' of the proposed marina project, stating:

The locality deserves better. We heard the concerns of the people. We listened, and we learned. (Barbara, 2022)

2 Methodology

The research methodology for this study was designed to identify the social implications of the development in question. A quantitative research design was used to use statistical data and conduct a systematic investigation study (Watson, 2015). In essence, this research method was used due to its ability to acquire a larger sample size, and thus increasing the likelihood of achieving statistical



Figure 1: Local Plan, Marsaskala, 2006, MEPA. Source: The Malta Independent



Figure 2: Preliminary design of Yacht Marina in Marsaskala, Transport Malta Expression for Interest. Source: The Malta Independent



Figure 3: Affixed notices to doors of private residents advising electoral candidates not to knock on their door if they are in favour of the marina plans (Photo source: Moviment Graffitti)

generalisation. The research population of the study was generally Marsaskala residents (67%) or citizens who have close links with the town, either as part-time/summer residents (7%) or as visitors (23%) (Figure 1).

The survey questionnaire, designed and distributed in both English and Maltese versions, was exported from Google Forms onto Microsoft Excel, to conduct the quantitative data analysis. The survey questionnaire was composed of closed-ended questions but also presented respondents the possibility to write their opinion in the comment section. The questions asked in the survey were purposely written to obtain information on the factors causing individuals' concerns of the proposed development. Reference to literature and reports outlining the effects of yacht marinas on surrounding environments and communities was done to inform the design of the questionnaire. Additionally, an exploration of speeches during protests as well as actions by the environmental movements, including the 'no to marina' banners, helped to further inform the survey design.

The recruitment of respondents, sourcing participants aged 18+ irrespective of nationality, was done by posting the survey on the social media platforms of various groups and organisations related to Marsaskala, and including the Marsaskala Local Council Facebook page.

With the total resident population of Marsaskala standing at 13,726 in 2018, the sample of 733 full-time residents who responded to the survey within seven days, yielded an overall margin of error 1 of $\pm 3.55\%.$ The total research population stood at 1,105.

To ensure that each respondent's right to confidentiality and autonomy was respected, ethical guidelines were followed and implemented during the construction and dissemination of the survey.

3 Perceptions on impact

In general, the popular concern was of both disappointment and anger about the marina proposal. This partly explains the strong respondent turnout in such a short time, as well as the willingness with which no less than 319 respondents took the opportunity to submit comments in the survey.

3.1 Demographics

More females (54%) than males answered the online survey (Figure 4). The majority of respondents were within the age bracket of 30-59 years (61%). Despite the general tendency of an older age cohort not being technologically proficient to answer online surveys, in this survey the 60+ age group (25%) were more keen and willing to fill in the survey compared to young adults (18-29 age cohort) (14%).

It is worth noting that a high percentage (67%) of survey respondents had tertiary level of education, thus the sampling contained an over-representation of highly

 $^{^1 \}mbox{The Margin of Error (MOE)}$ is calculated according to the formula:

MOE = $z * \sqrt{p * (1-p)} / \sqrt{(N-1) * n/(N-n)};$

Where: z = 1.96 for a confidence level (α) of 95%, p = proportion (expressed as a decimal).

educated participants. Thus, the sample in terms of level of education, does not represent the general population in Marsaskala. An explanation of this overrepresentativeness is that persons with higher level of education had greater interest in the proposed project and/or they were more technologically proficient compared to persons with lower level of education.

Out of the total research population who were full-time residents, 56% have been living in Marsaskala for over 20 years, 15% has been living there for 1–5 years, 12% for 6–10 years, 14% for 11–15 years and 3% for 16–20 years (Figure 5).

An overwhelming majority of 93% (N=1,023) were against the proposed yacht marina in Marsaskala Bay, with only 5% stating that they are in favour of this proposal (Table 1). The majority of respondents felt a sense of belonging to Marsaskala, including those who were not full-time residents but frequent visitors. They strongly agreed (82%) that the proposed development would spoil the characteristics of Marsaskala and would have adverse effects on their wellbeing. In effect, some respondents expressed feelings of anger for proposing to ruin 'their' public/private space while expressing a sense of belonging to their hometown. Typical remarks in the comment section refer to this feeling of intrusion:

Leave my home town alone! Leave us continue to enjoy swimming in clean (minus the fish farm slime) sea water (30–59 years-old female, fulltime resident for 20+ years).

Please leave our beautiful bay alone, its natural beauty should be preserved for future generations. Residents are entitled to use the bay for recreation, not just rich visitors (60+ years-old female, full-time resident for 11–15 years).

Respondents were asked on their degree of agreement or disagreement of the effects of the proposed project on specific areas. The strongest concern was expressed in relation to environmental issues, with 86% strongly agreeing that it would lead to lower water quality, worsen levels of pollution, and negatively impact on swimming, diving and other aquatic sports in the Bay (Table 1).

3.2 Environmental Impact

Negative environmental impacts were amongst the greatest concerns for respondents. 82% strongly agreed that it would spoil the locality's character; 80% strongly agreed that the proposed project would result in more land and sea traffic; and 77% strongly agreed that it would have an undesirable visible impact.

Respondents referred to how the proposed project would lead to adverse environmental effects in Marsaskala,

including at il-Maghluq saline marshland. Some respondents (N=3) commented on this:

A Marina would strangle Marsaskala Creek: the bay and its marine life, the Saline Ecosystem of il- Magħluq, and the quality of life of all Marsaskala residents. Shame to those who seek to foist this monster on us citizens! (60+ yearsold male, full-time resident for 20+ years).

If this is done, Marsaskala would not exist apart from peripherally. The place where activities for locals are held won't be able to take place because the land would be taken up. It would have an environmental impact especially at II-Magħluq [saline ponds] and the unique species of fish at this place...[Original in Maltese] (30– 59 years-old male, full-time resident for the last 11–15 years).

Additionally, respondents felt that the proposed development would stifle and throttle the only significant open space left in this fast-growing locality. It is worth noting that the population of Marsaskala grew by 12% between 2015 and 2018 (Camilleri, 2018). For some respondents, the remaining quaint and picturesque characteristics of Marsaskala would be lost with the completion of this proposed project.

Marsaskala is one of the last remaining picturesque villages in Malta... Let's not ruin it for the sake of the greed of a few wealthy people (30–59 years-old female, full-time resident for the last 6–10 years).

It will seriously reduce the level of peace, tranquillity and enjoyment that all residents and visitors presently enjoy, when visiting the waterfront all around this beautiful bay... (60+ years-old, male, full-time resident for the last 6–10 years).

...Marsaskala is up till now a more authentic place, bringing more valuable tourists than the central area as they usually regularly come back, are attached to the place. Building a marina would make of Marsaskala yet another neighbourhood for rich people, with no soul and no seaside opportunities for locals and tourists looking for peaceful experiences (30–59 years-old, female, full-time resident for the last 1–5 years).

Another environmental concern mentioned was related to traffic congestion and lack of parking spaces. The locality is already congested and the proposed project would contribute to the existing gridlock:



Figure 4: Demographics



Figure 5: Number of years living in Marsaskala for full-time residents

How, in your opinion, would this proposed yacht marina development impact the locality of Marsaskala?	Strongly Agree	Agree	Indifferent/ Neutral	Disagree	Strongly Disagree
Spoil the character	82%	7%	5%	4%	2%
Improve economic activity	7%	15%	25%	24%	29%
Increase in high-end tourism	5%	10%	23%	27%	35%
Negative visible impact	77%	11%	4%	4%	4%
Negative environment impact (pollution)	86%	5%	4%	2%	3%
More land & sea traffic problems	80%	11%	5%	3%	1%
Loss and deterioration in the quality of life	78%	12%	5%	2%	3%
Lower water quality in Marsaskala Bay	86%	7%	3%	3%	1%
No impact at all	3%	3%	13%	8%	73%
Direct impact to me, my family and/or my friends	62%	18%	11%	4%	5%

Table 1: Impact on specific areas



Figure 6: Strong agreement to specific areas

_

Another negative impact to the residents is the traffic and the parking issues which already exist and which will surely increase with this project (30–59 years-old, female, full-time resident for 20+ years).

Such environmental concerns flagged out by participants emphasise the need for detailed scientific reports in such proposals, including assessment on pollution resulting from the construction and operation of the proposed development, as well as its general environmental impact both on/in the sea and land. An assessment of the impact on protected and/or sensitive habitats and species in the sea by means of a benthic survey is required in such applications, as well as an assessment of archaeological investigations or discoveries made within the last ten years in the effected area.

While a number of respondents simply wrote 'No to marina' (13%) in the comment section, others had harsher comments related to greed and capitalist voracity. Some respondents elaborated on their disapproval and referred to fears on how the proposed development would impact, not just the bay, but directly their way of life as residents and visitors. Others claimed that it would directly impact their mental health.

3.3 Impact on wellbeing and everyday life

Respondents expressed their views on how the environmental consequences of the proposed project would have a direct impact on their own wellbeing. A majority of 78% strongly agreed that the proposed development would lead to an overall loss and deterioration in the quality of life of Marsaskala residents. Respondents felt that this development would have a direct impact on them or their family and/or friends (62% strongly agreed and 18% agreed).

The most prominent open-space in Marsaskala is the promenade utilised for recreational walking, swimming and fishing. In general, respondents feared that the marina would have adverse effects on their general well-being and physical activity, particularly impacting on their recreational swimming and walking activities. This was elaborated in the comment section, with a number of respondents, not all full-time residents of Marsaskala, emphasising their fears of adverse impacts to their physical activity:

It will totally destroy our beautiful bay, and will stop us from swimming as the sea will be polluted with oil & fuel spills and sewage from the yachts (60+ years-old, female, visitor to Marsaskala).

The bay should remain intact. No marinas and no breakwaters. The bay in Marsaskala is our

piazza and so many things revolve around it. From a simple walk, to a swim, to fishing, to business, to feast enthusiasts, etc... (18–29 years-old female, full time resident for the last 1–5 years).

What we really need is for Marsaskala to remain the quiet place it is great for a lovely jog along the promenade and a lovely swim. We are already shrinking bays everywhere else. Stop this development (30–59 years-old, female, full-time resident for the last 6–10 years).

3.4 Impact on local fishers

Some respondents (N=5) commented on the way the proposed development would directly impact the livelihood of some fishers who moor their small boats in the bay but cannot afford the fees of a marina:

The project is out of keeping and environmentally unfriendly to the Sea and the ocean life in the bay and its immediate environs. The rubbish that was disturbed in the bay during the last few weeks of storms illustrates the amount of debris and detritus that has been churned up from the seabed. It will harm the fishermen and their catches and also prevent swimming, water polo etc., Being available to the local population. It is money driven to satisfy a few (60+ years-old, female, part-time resident).

My father had a small boat moored in the port, which he used on Sundays just to relax and go fishing in peace since I remember. I thank God he passed away before he witnessed this. But I know there are other locals like him, and once you are a pensioner, you cannot afford the exorbitant fees of a private marina (30–59 years-old, female, full-time resident for 20+ years).

3.5 Economic Impacts

Some of the respondents (5%) who agreed with the Marina development spoke of the economic spinoffs that may accrue to the locality. Others admitted that they have a marine craft which they would like to berth in the Bay.

One respondent noted the economic spin offs as beneficial to local restaurants, however others commented that this would lead to an inflation in restaurant prices.

Property in Marsaskala will be upgraded (60+ years-old, female, full-time resident for 11–15 years).



Figure 7: Perceptions on specific areas.

It will decrease the value of property, cause more stress on the infrastructure, and increase population causing the village to decline to a substandard area (30–59 years-old, male, full-time resident for 20+ years).

I know friends of mine are leaving Marsaskala believing that their property will devalue if the marina gets built. One said property prices would increase (60+ years-old, male, full-time resident for 11–15 years).

3.6 Required improvements

During protests, reference was made on the need for embellishment of the promenade. Comments of some participants were more directed on the current state of Marsaskala bay, which is occupied with a haphazard and unquantified arrangement of moorings, consisting of various anchoring arrangements, mooring lines and buoys. While the total majority of respondents disagreed with the proposed development, some respondents commented on the need for a reorganisation of the disorganised mooring area for small boats:

The idea of a marina is good, but the size is too big; if it was downsized, you'd still have a marina and people can still swim (30–59 years-old, female, full-time resident for 20+ years).

I disagree with the project as proposed taking up almost the entire bay. However, a smaller marina which may take up only the inner part of the bay may bring good organisation in the bay and a good visual impact (60+ years-old, female, full-time resident for 20+ years).

Did required improvements in the bay only focus on the moorings... as many 'Skalin' also include the surrounding promenade when making reference to the bay. In various protests, protestors made reference to embellishment of the area, especially the promenade. Was any of this mentioned by the survey respondents?

4 Discussion

Protest can influence public policy and decisions. The Marsaskala marina plan is an example of how civil society mobilised and actively worked to voice its opposition to the marina plan. Salient findings of the survey were that an absolute majority of 93% (N=1,023) are against the proposed yacht marina in Marsaskala Bay. Also, the proposed yacht marina would have a direct negative impact on physical activity of residents, disrupting walking and swimming activities. This will lead to an overall loss and deterioration in the quality of life of residents and non-residents. Participants also outlined the adverse effects on the characteristics and environment of Marsaskala as well as the inflation in prices; for both catering establishments and residential property.

This paper outlined how residents, non-residents and environmental NGOs, forcefully protesting against the proposed yacht marina, aimed at having a sensitising impact by changing the political agenda on the development of a yacht marina in Marsaskala Bay. It is not only for

the 'no to marina' banners, hanging over in balconies of residential houses, and the numerous protestors attending the organised protests in Marsaskala, but also the high response rate to the survey in a relatively short period of time, which collectively highlight how strongly citizens felt about the proposed development.

In line with Rootes (1999) model on the impact of environmental movements, it is worth noting the direct impact of protests and voicing public opinion on political agenda. Equally relevant is the fact that amongst protesters were party-political figures such as one local councillor, who actively protested and a Members of Parliament who declared themselves to be against the project. The two-party system, dominated by the current party in government—the Labour Party, and the Nationalist Party, has its implications on the degree of involvement in protests as part of their political agenda to 'listen' to citizens. Also, protests happened during the run-up to a general election, and thus this intense political climate accentuated the need for politicians to be 'closer' to citizens and in touch with their concerns.

In the analysis of the outcome of social movements, discussion is steered not only towards establishing whether movements create change, but how movements generate political change (Andrews, 2001). The expressed public opinion survey referred to in this article, in which results were published on national media sources, coupled with the various numbers of protests organised to date, were successful in steering discussion amongst political elites against the marina plans. It can be argued that the survey results have served to strengthen the environmental movement itself by increasing the protesters' confidence in their fight against the proposed project.

With an imminent general election, protesters demanded electoral candidates to voice their opinion on the marina plan. In response to this, the Deputy Prime Minister voiced his opposition to the marina plans. Following this, the Prime Minister announced plans to 'listen to the people' and abolish the marina plan. This demonstrates the substantive effective impact these protests have had on decisive political decisions.

4.1 Conclusion

This sociological research raises concerns, both on social and environmental aspects, emphasised forcefully by the majority of respondents. A number of objections were raised by respondents, especially for and by full-time residents, on the disruption in the social fabric of the locality.

Based on the survey, it is worth noting the power of civil society and their protest efficacy against the proposed development. This article outlined the essence of careful consideration for sustainable community development that must remain central when assessing the implications of major infrastructure projects, rather than being given marginal consideration. The joint actions, through physical and digital protesting of civil society, proved to be effective in changing political decisions, particularly contextualised in the favourable political context of a general election.

References

- Agnone, J. (2007). Amplifying public opinion: The policy impact of the U.S. environmental movement. *Social Forces*, *85*(4), 1593–1620.
- Andrews, K. (2001). Social movements and policy implementation: The Mississippi civil rights movement and the war on poverty, 1965 to 1971. *American Sociological Review*, *66*(1), 71–95.
- Arena, J., & Xuereb, M. (2022). Chris Fearne says he opposes Marsascala marina project. *Times of Malta*, *15*, 2022.
- Barbara, G. (2022). We listened and we learned: PM Abela announces plan to scrap Marsaskala Marina project'. *Malta Today*, *22*, 2022.
- Barkan, S. (1984). Legal control of the Southern civil rights movement. *American Sociological Review*, 49, 552–565.
- Boissevain, J. (2001). Contesting Maltese landscapes. journal of Mediterranean studies. *11*(2), 277–296.
- Briguglio, M. (2015). The bird hunting referendum in malta. *Environmental Politics*, 24(5), 835–839.
- Briguglio, M. (2018). Digital activism, physical activism: Malta's front harsien ODZ. *Contention: The Multidisciplinary Journal of Social Protest*, 6(1), 49.
- Burstein, P. (2003). The impact of public opinion on public policy: A review and an agenda. *Political Research Quarterly*, *56*(1), 29–40.
- Burstein, P., & Linton, A. (2002). The impact of political parties, interest groups, and social movement organizations on public policy: Some recent evidence and theoretical concerns. *Social Forces*, *81*(2), 381–408.
- Camilleri, I. (2018). *Double-digit growth in population in northern part of Malta*. Times of Malta.
- Carter, N. (2001). *The politics of the environment: Ideas, activism, policy.* Cambridge University Press.
- Deloitte and Touche. (1997). Yachting development in Malta.
- Galea, A. (2021). Proposed Marsaskala yacht marina concession could have a value of €183 million. Malta Independent.
- Giugni, M. (1995). Outcomes of new social movements. In H. Kriesi, R. Koopmans, J. Dvendak & M. Giugni (Eds.), New social movements in Western Europe (pp. 207–237). London UCL Press.

- Hopkins, J. (2014). The tourism impact on Marsaskala over the past 50 years: The locals' perspective. *University of Malta: Institute of Tourism, Travel and Culture (Unpublished dissertation).*
- Johnston, R. J. et al. (2000). *The dictionary of human geography*. London: Blackwell.
- Malta Maritime Authority. (2009). Development of yachting facilities in Malta.
- Morris, A. (1993). Birmingham confrontation reconsidered. *American Sociological Review*, 58, 621–36.
- National Statistics Office. (2001). *Demographic review* 2001.
- Rootes, C. (1999). *Environmental movements: Local, national and global*. Frank Cass.
- Rootes, C. (2007). Environmental movements (D. Snow, S. Soule & H. Kriesi, Eds.). *The Blackwell companion to social movements*, 608–640.

- Seychell, A. (2010). Community sentiment in Marsaskala Malta. Unpublished Masters Dissertation, MA Geography of Cities. University of Malta.
- Van der Heijden, H. (1999). Environmental movements, ecological modernisation and political opportunity structures. in rootes, c. (ed.) In *Environmental movements: Local, national and global* (pp. 199– 221).
- Veríssimo, D., & Campbell, B. (2015). Understanding stakeholder conflict between conservation and hunting in Malta. *Biological Conservation*, 191, 812–818.
- Watson, R. (2015). Quantitative research. *Nursing Standard*, *29*(31), 44–48.
- Young, B. (1983). Touristization of traditional Maltese fishing-farming villages: A general model. *Tourism Management*, 4(1), 35–41.

Borg Muscat C. et al. (2022) Xjenza Online, 10(2):115-126.

Xjenza Online: Science Journal of the Malta Chamber of Scientists www.xjenza.org DOI: 10.7423/XJENZA.2022.2.05

Research Article



Factors influencing the abundance and distribution of feral pigeons (*Columba livia*) in urban environments in Malta

C. Borg Muscat^{*1}, F. Sammut², P. J. Schembri³

¹ Department of Biology, Faculty of Science, University of Malta, Msida, Malta

² Department of Statistics & Operations Research, Faculty of Science, University of Malta, Msida, Malta

³ Department of Biology, Faculty of Science, University of Malta, Msida, Malta

Abstract. This study aimed at identifying factors that influence the abundance and distribution of feral pigeons (Columba livia) in urban environments in Malta, making it the first study of its kind locally. Feral pigeons were censused using transect surveys in different types of urban environments, which were categorised as in proximity of an agricultural area, main road, park, side street and suburb. The cluster density and the cluster abundance were then estimated using distance sampling analysis. The number of pigeons in clusters was two or three. The cluster density of feral pigeons was estimated to be $6.51 \times 10^{-5} \pm 1.57 \times 10^{-5} (1.44 \times 10^{-5} \text{ km}^{-2})$ in a total area of 4.52 km², with the highest estimate corresponding to the 'Park', followed by the 'Mainroad', 'Agricultural area', 'Sidestreet' and 'Suburb', in this order. The cluster abundance in the same area was estimated to be 293.89 ± 70.87 , with the highest estimate corresponding to the 'Mainroad', followed by 'Park', 'Sidestreet', 'Agricultural area' and 'Suburb' in this order. Negative binomial regression was used to study the possible influence of environmental factors on feral pigeon abundance. The results of statistical analysis showed that the abundance of feral pigeons is mostly affected by architecture: abundance was low where there was a preponderance of modern buildings. This study may contribute to a tailormade and economical scientific management plan for controlling feral pigeons in urban settings.

Keywords: Distance sampling, generalized linear models, Urban environmental variables, density, synanthropic species

1 Introduction

Feral Columba livia is a major synanthropic species worldwide (Amoruso et al., 2014) which occurs both in urban and semi-natural habitats. The wild counterpart of the feral pigeon originally prevailed in Mediterranean bordering countries, as well as in parts of Europe, Northern Africa and Western Asia. The pigeon was introduced and subsequently proliferated in North, Central and South America, as well as in all of Europe (Baptista et al., 1997). The domestication of feral pigeons in the Mediterranean region is thought to have occurred around 3,000 BCE (Driscoll et al., 2009; Johnston et al., 1995; Murton et al., 1972a; Murton et al., 1972b). Concomitantly, artificial selection favoured certain traits, including an annual high reproductive success, docile behaviour, and non-aggressiveness between males (Magnino et al., 2009). Initially, pigeons were bred as a source of food (Driscoll et al., 2009; Stringham et al., 2012; Tchernov, 1984); however, they were later used as carrier pigeons and/or racing pigeons, as well as for the decorative value of fancy breeds. With artificial selection, humans unintentionally contributed to behavioural and morphological advantages that have enabled C.livia to successfully exploit urban habitats (Bowman, 2009).

Wild *Columba livia* is a medium sized compact bird with a length between 29 to 35 cm and a wing span of between 60 and 68 cm. It has a small head, rounded breasts to support its strong wing muscles, and short legs covered with scale-like skin. In its typical coloration, it has pale grey plumage on the back and upper wings and its head, neck and breast are darker in colour, while the underwings and rump are a contrasting white; it also exhibits two distinguishable black wing bars. In flight, it moves in straight paths with clipped wing beats. When on the ground, it walks with bobbing head movements. The wild form feeds on plant material such as grains and seeds. It has reddish eyes, as well as a dark bill, which, unlike most other birds, has partly covered nostrils, hence the pigeon can drink with the bill lowered in the water. Its preferred nesting sites include holes in trees, rock faces and cliffs (Svensson et al., 2010). The feral counterpart is identical in shape; however, it may exhibit many plumage variants. Such variants include variegated white and grey, all dark grey, dark pink-buff or dark piebald. They can also look like the wild counterpart, without the white rump, or may retain odd white remiges (Svensson et al., 2010).

The wild counterpart of the feral pigeon originated from rocky cliff habitats. As vertical-sided urban buildings provide similar environmental characteristics to the natural environment, the abundance of the feral pigeon in urban areas might be attributed to an innate preference for cliff-like habitats. However, their abundance in urban areas can also be attributed to the easily obtainable food supplied both intentionally and unintentionally by humans. Studies indicate that the densest populations of feral pigeons occur in historic town centres, as the old buildings provide ample nesting sites, while the high human population density of both locals and tourists in historic towns results in constant food sources (Buijs et al., 2001; Johnston et al., 1995; Sacchi et al., 2002). Other factors that lead to high population densities revolve around the reduction of selective action from natural factors such as predation and severe weather, and therefore less stress (Dobeic et al., 2011). The distribution and abundance of feral pigeons in urban environments therefore depends on a number of interacting variables, which may vary in importance depending on location.

In the past, interspecific interaction between pigeons and humans induced reciprocal benefits (Humphries, 2008; Johnston et al., 1995). However, in recent times feral pigeons are mostly viewed as a threat and nuisance. Research suggests that the birds may carry various pathogens including viruses, bacteria, fungi, protozoa and other parasites, and are therefore often associated with causing health problems for both humans and domestic animals (Haag-Wackernagel et al., 2004; Straff et al., 2001). They are also perceived as a threat to cultural heritage as they tend to foul and damage buildings and monuments with their excreta (Johnston et al., 1995). Indeed, many cities worldwide have been facing difficulties in managing oversized populations of feral pigeons (Haag-Wackernagel, 2005; Haag-Wackernagel et al., 2008; Magnino et al., 2009).

The most recent pigeon survey in Malta, carried out between 1998 and 2000, estimated about 1500 to 2500 pairs in the Maltese islands, whereby the majority of the population was found to be concentrated in the Valletta harbours urban areas. There is evidence to suggest that with increasing development, the feral pigeon population is expanding to the surrounding localities (figure 1), including Marsa, Hamrun, Blata il-Bajda, Gżira & Sliema; feral pigeons have colonised the St Vincent De Paul (Luqa) and St Luke's (Gwardamanġa) hospital complexes (Sultana et al., 2011). Moreover, substantial separate populations was also noted at Balzan and on the island of Comino; however, in the rest of the Maltese islands, including Gozo, the bird is only sparsely distributed (Sultana et al., 2011).

The present study assesses the abundance and distribution of feral pigeons in different types of urban environments on Malta island, using distance sampling. This is the first time that this statistical technique was used in a study on wild animal species in Malta The study also aims to determine which urban environmental characteristics most influence feral pigeon abundance.

2 Method

2.1 General methodology

The study consisted of two stages. The first stage involved distance sampling, a technique used for the estimation of abundance and/or density of biological populations (Thomas et al., 2010). The method, described by Giunchi et al. (2007) was followed.

In distance sampling a detection function models the probability of detection of the animal of interest given its perpendicular distance from the observer (surveying line or transect). A key concept is that as the animal's distance from the observer increases, the probability of detecting it decreases. Therefore, since in distance sampling the area in m^2 surveyed in the study is incorporated in the calculations, modelling allows the estimation of the total number of animals present in the area, including those that are undetected by the observer, hence, the density and abundance in the whole study region can then be estimated (Buckland et al., 2015). Distance sampling was preferred over other sampling methods as apart from being non-intrusive, easily carried out and inexpensive, it gives more representive results as the estimation process of this technique utilizes data beyond the line transect (Richardnson, 2007).

Distance sampling has four key assumptions (Miller et al., 2017; Thomas et al., 2010):

- all the animals of interest occurring on the line or point are detected and recorded;
- ii. the individuals and their perpendicular distance are detected and recorded before the animal is disturbed;
- iii. transects are randomly positioned with respect to the

- distribution of the study animal;
- iv. the measurements are precise.

This last can be achieved by using a rangefinder. The second stage of the study tested the relationship between the predictor variables, i.e. the environmental characteristics, and the response variable, i.e. pigeon abundance. This was achieved using generalized linear models (GLM), specifically the negative binomial regression model.

2.2 Study regions and locations

Although more complex structures exist, the survey design employed was organised using four main layers:

- i. the global layer which accounts for the entire study area;
- ii. the stratum layer that includes individual survey strata;
- iii. the sample layer that accounts for data of individual survey lines;
- iv. the observation layer which represents the data that relates to single observations (Thomas et al., 2010)

Through a desk cartographic review, three towns from each of the five districts in Malta were selected on the basis feral pigeons are known to occur within their confines (figure 1). These towns constituted the global layer. Five different types of urban environment were identified and these represented the stratum layer.

These were:

- i. town centre (labelled 'Mainroad');
- ii. residential areas off the town centre (labelled 'Sidestreet');
- iii. residential areas on periphery of town (labelled 'Suburb');
- iv. public open spaces within town (labelled 'Park');
- v. open spaces at periphery of town and adjacent to agricultural areas (labelled 'Agricultural').

Within each stratum, 300 m-long transects were allocated along randomly selected roads. These transects constituted the sample layer. The counts of feral pigeon along each transect constituted the observation layer.

2.3 Data Collection

Prior to data collection, a pilot study was carried out in Msida from December 2019 to the end of February 2020 to test the data collection protocol, which was adjusted to take into account particular field circumstances. The actual study was conducted between May 2020 and August 2020 inclusive. The two months hiatus between the pilot study and the actual data collection was as a result of the COVID-19 pandemic lockdown. Data collection was made during weekdays, from 8:00 until 12:00, excluding weekends and public holidays, to ensure consistency. Each transect of 300 m was walked, first in one direction on one side of the road, and then in the opposite one, on the other side; this took total time of about 10 minutes in total. During these walking sessions, data on the urban environment were recorded, consisting of counts of the following variables: People; Parked vehicles; Moving vehicles; Old buildings; Modern buildings; Abandoned buildings; Construction sites; Trees; Food sources; Water sources; Bins.

If pigeons were noted at any point along the transect, the transect was then walked again using the same procedure, this time counting pigeons on one side of the road and then on the other. When a feral pigeon was detected, the observer stopped and recorded the perpendicular distance of the animal to the transect line using a Tacklife MLR01 800 m Laser Rangefinder. If the pigeons occurred in a cluster, the number of birds in the group was also recorded.

3 Results

3.1 Distance sampling analysis

Three key functions with different formulations of adjustment series were used. Table 1 shows the models, their key functions plus adjustment, as well as the Akaike information criterion (AIC) computed using the R package 'Distance Sampling'. All the AIC values of the three computed models were nearly the same, hence, the best model cannot be chosen based on this measure alone.

Goodness-of-fit of the models was then checked using Q-Q plots, as well as the Cramer-Von Mises's test. Figure 2 shows the Q-Q plots obtained when the data is modelled using the (D) Half-normal key function with cosine (2) adjustment, (E) Hazard-rate key function, and (F) Uniform key function with cosine (1,2) adjustment, respectively. In this case all plots of the models had a similar structure and values close to the line y = x, making them 'good' models (Miller et al., 2017).

Table 1 also shows the Cramer-Von Mises test goodness-of-fit results for each model. The models have p-values larger than 0.05, so the null hypothesis is not rejected in all cases. This means that each model fits the data well (Miller et al., 2017).

Other measures that were used to determine the most adequate model included looking at the shoulder of the plot, the Standard Error (SE) and Coefficient of Variation (CV). The 'shoulder' refers to the detection function being flat near the sampling line transect and taking a shoulder-like shape in the fitted detection function overlaid on the histogram of observed distances. The shoulder is created because observers, apart from detecting the objects near them, must also detect the objects directly in front of them. Figure 2 shows the fitted detection func-



Figure 1: Map of the Maltese islands indicating the localities in the five districts i.e. Southern Harbour (SH); Northern Harbour (NH); South Eastern (SE); Western (W); Northern (N), that were sampled and other towns mentioned in the text, known to also be inhabited be feral pigeons.

tions overlaid on the histogram of observed distances for the feral pigeon data using (A) Half-normal key function with cosine (2) adjustment, (B) Hazard-rate key function, and (C) Uniform key function with cosine (1,2) adjustment, respectively. From these plots Model 3 shows the most pronounced shoulder supporting choosing this model to continue the analysis, and subsequently estimate the abundance and density of feral pigeons.

The SE and CV for detectability, given in table 1, show that the model with the smallest SE and CV is Model 3, with the Hazard-rate key function. This is yet another property that makes Model 3 the most suitable model for estimating the abundance of feral pigeons.

3.2 GLM analysis

Negative binomial regression was the GLM used to study the relationship between feral pigeon abundance and different urban environmental variables. To acquire a parsimonious model, any predictor variable whose coefficient had a corresponding *p*-value greater than 0.05 was omitted. At each step, the AIC and the Bayesian Information Criterion (BIC) of the fitted model were obtained. The AIC and BIC values decreased at a steady rate from the fit of the first model, which included all the predictors, to the fit of the model with only Old Buildings and Modern Buildings as predictors. The AIC and BIC gave slightly contradictory results when comparing the fit of the final model, a model with only Modern Buildings as predictor (i.e. 283.300 and 292.332 respectively), with the model which also included Old buildings as predictor (i.e. 283.3196 and 295.238 respectively). However, the difference in the values for the criteria for the two models is marginal and since the aim of the negative binomial regression analyses in this study is to identify the predictor variables (urban environmental characteristics) that influence the response variable (pigeon abundance), the model without Old Buildings was preferred as according to literature, the BIC is described as being the better model selection criterion for explanatory purposes (University, 2019).

3.3 Abundance of feral pigeons

The mean number of feral pigeons in the Districts, Localities within districts and urban environment (table 2) indicate that feral pigeons tend to occur in groups and sparingly within a given area.

The highest abundance of feral pigeons according to district, was for "Northern Harbour", followed by "Southern Harbour", "South Eastern", "Western" and "Northern" in this order. The abundance of feral pigeons in the localities within districts varied, with some towns not having any pigeons recorded at all. Feral pigeons were most abundant in "Park", followed by "Mainroad", "Agricultural area", "Sidestreet" and "Suburb".

To analyse whether the differences in feral pigeon count among districts and urban environments were significant, the Shapiro-Wilk test was first used to test the null hypothesis of univariate normal distribution for the different groups. Since the *p*-value in each district and transect resulted to be less than 0.05, the null hypothesis of normality was rejected and therefore the Kruskal-Wallis test was used. The test showed that there was no statistically significant difference among feral pigeon abundance in relation to districts ($X^2(2)=0.938$, p=0.649), however when considering the abundance of feral pigeons in relation to, a statistically significant difference, ($X^2(2)=6.697$, p=0.001) was found.

To identify which urban environment was responsible for the difference, the Mann-Whitney pair-wise test with the Bonferroni correction was carried out (table 3).

A significant difference in pigeon abundance was found in the majority of urban environment pairings with the exception of two: Suburb and Agricultural area, and Park and Mainroad. This shows that the urban environments pairs categorised as 'Suburb' and 'Agricultural area' and as 'Mainroad' and 'Park' share features that are unattractive and attractive, respectively, to feral pigeons. Model 3, consisting of the Hazard-rate key function, was used to estimate the cluster abundance and density of feral pigeons. The highest abundance was found in 'main road' followed by 'park', 'side street', 'agricultural area' and 'suburb' in this order (figure 3). The highest density of feral pigeons was found in 'park' followed by 'main road', 'agricultural area', 'side street' and 'suburb' in this order (figure 4).

4 Discussion

This study represents the first attempt to investigate the abundance and distribution of feral pigeons in Malta using the distance sampling technique and to associate these with urban environmental characteristics. Five districts in Malta were surveyed for feral pigeons between May 2020 and August 2020, hence during the Covid-19 restrictions.

Although feral pigeons were sparsely distributed, they were observed in all five districts, indicating that the species is ubiquitous to urban environments in all parts of mainland Malta. The mean abundance was low, but this was not due to insufficient sampling, but because feral pigeons occur sporadically within urban habitats, mostly in aggregates. This was the case at all spatial scales (strata): districts, towns and urban environment types.

As shown in table 2, the highest abundance found in this study, when considering localities, was in towns that surround Valletta, i.e. Msida and St Julians, hence towns that appertain to the Northern Harbour (NH) district. Al-



Figure 2: Key functions used for the estimation of abundance of feral pigeons (*Columba livia*) from transect data. Key functions fitted in distance sampling analysis (A) Half-normal key function with cosine (2) adjustment, (B) Hazard-rate key function, and (C) Uniform key function with cosine (1,2) adjustment. Quantile-quantile plot (D) Half-normal key function with cosine (2) adjustment, (E) Hazard-rate key function, and (F) Uniform key function with cosine (1,2) adjustment.

	Model 1	Model 2	Model 3
Key function	Uniform key function with cosine (1,2) adjustment	Half-normal key function with cosine (2) adjustment	Hazard-rate key function
AIC	1596.393	1597.352	1596.371
Test statistic	0.343619	0.304083	0.316579
<i>p</i> -value	0.102339	0.131644	0.121476
Formula	<na></na>	~ 1	~ 1
Cramer-von Mises test <i>p</i> -value	0.12148	0.10234	0.13164
Average detectability (Pa)	0.6622	0.63553	0.65755
Standard error i.e., SE (Pa)	0.06691	0.0781	0.03901
Coefficient of variation i.e., CV (Pa)	0.10104	0.12288	0.05932
Change in AIC	0	0.02174	0.98124

 Table 1: Summary for the detection function models fitted to the feral pigeon data.



Figure 3: Estimate of cluster density of feral pigeons per sampled urban environment type in m^2 using Model 3 (error bars are \pm one standard error).

Stratum	Area within stratum	Mean number of feral pigeons	Standard deviation
	Southern Harbour	2.2	4.93
	Northern Harbour	3.47	8.98
District	South Eastern	2.13	7.08
	Western	1.56	3.89
	Northern	0.73	2.80
	Paola	2.4	5.40
	Kalkara	4.1	6.30
	Fgura	0	0
	Msida	5.7	9.37
	Swieqi	0	0
	St. Julians	4.7	12.31
	Birzebbugia	2.3	4.90
Locality	Marsaskala	0	0
	Marsaxlokk	4.1	11.32
	Iklin	0	0
	Mtarfa	1.1	2.60
	Rabat	3.6	5.87
	Mellieha	0	0
	Mgarr	1.2	3.79
	St. Paul's Bay	1	3.16
	Agricultural area	1.2	6.57
	Mainroad	2.67	5.20
Urban environment	Park	5.33	9.38
	Sidestreet	0.6	2.04
	Suburb	0.26	1.46

Table 2: The mean number of feral pigeons counted per 300m transect in each stratum: District, Locality, Urban environment. There were 30 transects per district, 10 transects per locality, and 30 transects per urban environment.

Urban environment pairing	p-value	Urban environment pairing	p-value
Suburb & Sidestreet	0.0321	Sidestreet & Mainroad	0.0121
Suburb & Park	0.0002	Sidestreet & Agricultural area	0.0338
Suburb & Mainroad	0.0021	Park & Mainroad	0.2098
Suburb and Agricultural area	0.1	Park & Agricultural area	0.0004
Sidestreet & Park	0.0016	Agricultural areas & Mainroad	0.0031

Table 3: The results of the Mann-Whitney pairwise test with the Bonferroni correction applied to all combinations of the different urban environment. (H_0 : There is no significant difference in feral pigeons count among urban environments; H_A : There is a significant difference in feral pigeons count among urban environments.)



Figure 4: Estimate of cluster density of feral pigeons per sampled urban environment type in m^2 using Model 3 (error bars are \pm one standard error).

though there was no statistically significant difference in the total number of feral pigeons counted in the different districts, the high count in NH is congruent with previous studies (Sultana et al., 2011) which found that Valletta had the largest population of feral pigeons in Malta. It has also been suggested that the Valletta population was spreading to surrounding localities (Sultana et al., 2011) within the NH district.

The present study was designed to survey different localities that were as similar as possible in their urban environmental characteristics. Through distance sampling, apart from the abundance of feral pigeons in the total area sampled by transects (4.52 km^2) , an estimate of the abundance of the pigeons within each urban environment identified was also acquired. This indicated where the feral pigeons prefer to inhabit and hence enables identification of the urban characteristics they prefer, in this case, local centres and public open spaces located in the town centres, thus implying that these urban environment habitats share features that promote the feral pigeon's survival and proliferation (figure 3).

Studies have shown that the occurrence of feral pigeon in urban settings is greatly influenced by resource distribution, principally food, water, and shelter (Haag-Wackernagel, 1995; Murton et al., 1972a; Murton et al., 1972b). The 'Mainroad' was located in the historic centres of the towns surveyed, which represented the oldest part of a town (Hughes, 1956). Old buildings provide ample roosting places through their more elaborate design, with high physical complexity (Haag-Wackernagel et al., 2008). Main roads also tend to be lined with numerous restaurants and kiosks satisfying yet another of the birds' basic needs, that of food. Feral pigeons prefer to eat protein-rich food such as crop grain when possible (Johnston et al., 1995) however this is not always seasonally available. Hence, the feral pigeon has adapted to scavenge in urban environments where spillage of food is common and available in proximity of their roosting sites, thereby the birds expend less energy in foraging (Johnston et al., 1995). In fact, a study by Ryan (2011) showed that feral pigeons adapted to human foods since the birds preferred areas close to pigeon feeder sites, public spaces, and to landscape types with a high human density (Ryan, 2011). Water is another essential resource; feral pigeons satisfy their need for water from moisture in the food they forage or by drinking from whatever water is available, including rainwater puddles (Johnston et al., 1995). Town or village centres in Malta may have the occasional decorative water fountain, often found in parks. In fact, most parks are located in the same town or village centres or at a small distance from them, either way, easily reachable by feral pigeons.

Public open spaces are usually situated in the vicinity of a parish church or chapel, whose architecture offers many opportunities for the pigeons to roost. Apart from this, people enjoy eating in parks, providing another indirect food source for the birds, or even a direct one when people feed pigeons. Hence, both 'Mainroad' and 'Park' satisfy all the basic needs of feral pigeons.

The negative binomial regression analysis was used to study possible relationship between feral pigeon abundance and urban environmental variables. The urban environmental characteristics which were initially included in the GLM were 'Moving vehicles', 'Bins', 'Foodsource', 'Watersource', 'Old buildings' and 'Modern buildings', with the latter two having the strongest correlation with feral pigeon abundance. The predictors included in the GLM were not multicollinear and significantly influenced abundance when testing was carried out univariately.

The model with the best fit retained only one predictor variable: 'Modern buildings'. Therefore, according to the negative binomial regression, the abundance of feral pigeons is mostly affected by the presence of modern buildings and the relationship is a negative one, i.e., abundance is low where there is a preponderance of modern buildings. A study by (Sacchi et al., 2002) reached similar conclusions. The fact that the presence of modern buildings had a negative influence on pigeon numbers might lead one to expect to find the opposite effect from old buildings, which was not the case in this study. In the present investigation, the 'Old buildings' predictor variable was not retained in the model with the best fit; the amount of transects carried out could be a contribution to this result, as an insufficient number of transects may have been used. These types of relationships might, however, be influenced by other factors that have not been considered in the present study.

The higher density of feral pigeons in the 'Park' rather than in the 'Mainroad' might be attributed to the fact that, in this investigation, from a total study area of 4.52 km^2 only 0.30 km^2 represents public open spaces ('Park') within towns, whilst the local centres ('Mainroad') are represented by 1.24 km^2 . The preference for public open spaces within towns rather than local centres is very likely a result of the calmer ambiance present in a park. Hence, in the 'Park' there are more feeding opportunities and less stress.

The data gathered in the present study can be used as a starting point to investigate the ecology of feral pigeons in the urban environment of Malta. Repeating the study at time intervals will show whether the trends identified here change with time, including after the effects of COVIDrelated restrictions on human activities are no longer felt. Abundance estimation using distance sampling can be implemented throughout the Maltese islands, thereby identifying hotspots of feral pigeon occurrence and numbers. This study lays the ground for further research on feral pigeon populations and their ecology in urban environments as well as contributing information for management programmes that are tailormade to the local situation and circumstances. Periodical censuses of feral pigeons could also be useful for urban management of these birds.

References

- Amoruso, I., Fabbris, L., Mazza, M. & Caravello, G. (2014). Estimation of feral pigeon (*Columba livia*) population size using a novel superimposed urban strata (SUS) method. *Urban Ecosystems*, 17(2), 597–612.
- Baptista, L. F., Trail, P. W. & Horblit, H. M. (1997). Family Columbidae (Sandgrouse to Cuckoos) [published location: Lyns Edicions, Barcelona]. *Handbook* of birds of the world, 60, 243.
- Bowman, R. (2009). Superdove? how humans facilitated the success of the Rock Pigeon [review of Superdove: How the pigeon took Manhattan and the world, by C. Humphries]. *Ecology*, *90*(7).
- Buckland, S. T., Rexstad, E. A., Marques, T. A. & Oedekoven, C. S. (2015). Modelling detection functions.
 In S. T. Buckland, E. A. Rexstad, T. A. Marques & C. S. Oedekoven (Eds.), *In distance sampling: Methods and applications* (pp. 53–103). Springer.
- Buijs, J. A. & Van Wijnen, J. H. (2001). Survey of feral rock doves (columba livia) in amsterdam, a birdhuman association. *Urban Ecosystems*, 5(4), 235– 241.
- Dobeic, M., Pintarič, Š., Vlahović, K. & Dovč, A. (2011). Feral pigeon (columba livia) population management in Ljubljana. Veterinarski Arhiv, 81(2), 285–298.
- Driscoll, C. A., Macdonald, D. W. & O'Brien, S. J. (2009). From wild animals to domestic pets, an evolutionary view of domestication. *Proceedings of the National Academy of Sciences*, *106*, 9971–9978.
- Giunchi, D., Gaggini, V. & Baldaccini, N. E. (2007). Distance sampling as an effective method for monitoring feral pigeon (columba livia f. domestica) urban populations. *Urban Ecosystems*, *10*(4), 397–412.
- Haag-Wackernagel, D. (1995). Regulation of the street pigeon in Basel. *Wildlife Society Bulletin*, 256–260.
- Haag-Wackernagel, D. (2005). Parasites from feral pigeons as a health hazard for humans. *Annals of Applied Biology*, *147*(2), 203–210.
- Haag-Wackernagel, D. & Geigenfeind, I. (2008). Protecting buildings against feral pigeons. *European Journal* of Wildlife Research, 54(4), 715–721.

- Haag-Wackernagel, D. & Spiewak, R. (2004). Human infestation by pigeon fleas (ceratophyllus columbae) from feral pigeons. *Annals of Agricultural and Environmental Medicine*, *11*(2), 343–346.
- Hughes, J. Q. (1956). The building of Malta during the period of the Knights of st. John of Jerusalem, 1530-1795. Alec Tiranti Ltd., London.
- Humphries, C. (2008). *Superdove: How the pigeon took manhattan... and the world*. Smithsonian Books.
- Johnston, R. F. & Janiga, M. (1995). *Feral pigeons (vol.* 4). Oxford University Press on Demand.
- Magnino, S., Haag-Wackernagel, D., Geigenfeind, I., Helmecke, S., Dovč, A., Prukner-Radovčić, E., Residbegović, V., Ilieski, K., Laroucau, M., Donati, S., Martinov, E. & Kaleta. (2009). Chlamydial infections in feral pigeons in europe: Review of data and focus on public health implications. *Veterinary Microbiology*, 135(1–2), 54–67.
- Miller, D. L., Rexstad, E., Thomas, L., Marshall, L. & Laake, J. L. (2017). *Distance sampling in R BioRxiv*.
- Murton, R. K., Coombs, C. F. B. & Thearle, R. J. P. (1972a). Ecological studies of the feral pigeon Columba livia var. II. flock behaviour and social organization. *Journal of Applied Ecology*, 875–889.
- Murton, R. K., Thearle, R. J. P. & Thompson, J. (1972b). Ecological studies of the feral pigeon columba livia var. i. population, breeding biology and methods of control. *Journal of Applied Ecology*, 835–874.
- Richardnson, A. (2007). An active tutorial on distance sampling. *Journal of Statistics Education*, 15, 1.
- Ryan, A. C. (2011). The distribution, density and movements of feral pigeons Columba livia and their relationship with people. [master's thesis, victoria universtity of wellington]. ResearchArchive.
- Sacchi, R., Gentilli, A., Razzetti, E. & Barbieri, F. (2002). Effects of building features on density and flock distribution of feral pigeons Columba livia var. domestica in an urban environment. *Canadian Journal of Zoology*, 80(1), 48–54.
- Straff, W., Spiewak, R., Poblete, P. & Frank, J. (2001). Zoophilic Onychomykose durch Trichophyton gallinae. Z. Hautkr, 76(12), 749–750.
- Stringham, S. A., Mulroy, E. E., Xing, J., Record, D., Guernsey, M. W., Aldenhoven, J. T., Osborne, E. J. & Shapiro, M. D. (2012). Divergence, convergence, and the ancestry of feral populations in the domestic rock pigeon. *Current Biology*, 22(4), 302–308.
- Sultana, J., Borg, J. J., Gauci, C. & Falzon, V. (2011). *The breeding birds of malta*. BirdLife.
- Svensson, L., Mullarney, K. & Zetterström, D. (2010). *Collins bird guide (2nd ed.)* HarperCollins Publishers.
- Tchernov, E. (1984). Commensal animals and human sedentism in the Middle East. *Animals and archaeology*, *3*, 91–115.

10.7423/XJENZA.2022.2.05

125
Thomas, L., Buckland, S. T., Rexstad, E. A., Laake, J. L., Strindberg, S., Hedley, S. L., Bishop, J. R. B., Marques, T. A. & Burnham, K. P. (2010). Distance software: Design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology*, 47(1), 5–14.

University, T. P. S. (2019). AIC VS BIC. The methodology center, 8, 2021.



Table of Contents

ARTICLES

61 The Future of Scholarly Publishing is Open Access

Editorial

Cristiana Sebu

62 A Decomposition of Poverty Headcount: Income and Population Dynamics **Research Article**

M. Vella and G. Camilleri

74 Understanding the Economic and Sociodemographic Determinants of Early School Leaving: A Configurational Approach **Review Article**

S. Fabri, V. Martinelli, J. Spiteri, V. Cassar

86 Designing an evaluation strategy for a largescale science and arts festival using Science in the City, Malta as a case study

Research Article

S. Cutajar, S. Seligova, E. Duca

103 Public opinion and protest efficacy: A study on the proposed yacht marina in Marsaskala, Malta

Research Article

V. Visanich

115 Factors influencing the abundance and distribution of feral pigeons (Columba livia) in urban environments in Malta

Research Article

C. Borg Muscat, F. Sammut, P. J. Schembri