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Laura A. Albert, Annunziata Esposito Amideo, Julia Bennell, Sally Brailsford, Paula Carroll, Ruth Kaufman, Katherine Kent, Kathy Kotiadis, Martin Kunc, Anna Nagurney, Frances O’Brien, Graham Rand & M. Grazia Speranza

To cite this article: Laura A. Albert, Annunziata Esposito Amideo, Julia Bennell, Sally Brailsford, Paula Carroll, Ruth Kaufman, Katherine Kent, Kathy Kotiadis, Martin Kunc, Anna Nagurney, Frances O’Brien, Graham Rand & M. Grazia Speranza (2024) Commentary on Carroll & Esposito Amideo “Gender Equality: Opportunities and challenges for the OR community”, Journal of the Operational Research Society, 75:6, 1030-1042, DOI: [10.1080/01605682.2024.2344969](https://doi.org/10.1080/01605682.2024.2344969)

To link to this article: <https://doi.org/10.1080/01605682.2024.2344969>



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Published online: 15 May 2024.



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Commentary on Carroll & Esposito Amideo “Gender Equality: Opportunities and challenges for the OR community”

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ABSTRACT

This article comprises a set of commentaries for the paper written by Carroll and Esposito Amideo from different scholars and OR practitioners. The commentaries agree on the importance of documenting the gender situation across the OR community and the need to address it through multiple actions.

KEYWORDS

Gender Equality; Survey; WISDOM; WORAN

M. Grazia Speranza – Department of Economics and Management, University of Brescia, Italy



I read this paper with great interest and I am pleased to have the opportunity to share my thoughts about it. The paper has essentially two parts, one about the role of women in the history of Operational Research (OR), the other about the analysis of the 318 responses to a survey, of which 54% were from female and 46% from male researchers in OR. My first comment is that this paper was much needed.

I was not surprised to read that women do not appear in the history of OR. The authors justify the fact mainly with the military nature of the applications that are at the origin of OR. I believe there is a deeper reason that explains why only very few women appear in the history of OR and of all sciences. In general, it may happen that women do not appear because they did not receive recognition for their contributions but it most often happens because they were not allowed to express their potential, because they were not allowed to contribute. We should not forget that women have been discriminated until not long ago. Only at the end of the 19-th century several universities began to offer courses to women. However, those courses were aimed at training women in the humanities, mainly in theology and education, and for decades did not lead to degrees. As

an example, only in 1920 women could for the first time take a degree at Oxford. As another example, the Harvard Graduate School of Education admitted women in 1920, whereas the Harvard Medical School accepted its first female enrollees in 1945. The society is very slow in adapting to cultural changes. It is not hard to imagine how the families and the society discouraged girls from doing something that was unusual and believed to be inappropriate. And, although to a much lesser extent, this happens still today.

The second part of the paper, that is the careful analysis of the responses to the survey shows, among other facts, that females move less than males, that caregiving responsibilities are an issue for females much more than for males. While this kind of output was expected, the differences between females and males are less strong than in other surveys I have seen. I wonder whether there is a bias in the sample represented by the 318 researchers who decided to fill the survey. Their sensitivity towards the gender issues is probably higher than the average.

In conclusion, I would have liked to see the analysis of a larger number of responses to the survey, with some control over the sample that should ideally represent the entire OR community. In any case, I wish to praise the authors for doing this work and the journal for publishing it. Even though no norm discriminates women nowadays, still

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women's careers are slowed down by the fact that most of the burden of having a family is on their shoulders, that stereotypes are still dominant in our society, that there are biases in the minds of men and women. The consequences are that females have less time to work, are more constrained in many ways, face more intense scrutiny, are less self-confident than men. Their careers are slower or do not progress at all. I hope that initiatives like WISDOM, WORAN and WOR/MS will inspire the world and that this paper will be followed by others to keep our community aware that there is still work to do to attract more women to OR and to allow females express their full potential.

Kathy Kotiadis – Kent Business School, University of Kent, UK

Frances O'Brien – Warwick Business School, University of Warwick

The article on gender equality by Carroll and Esposito-Amideo (2024) is the first of its kind in OR by talking about controversial issues such as why are there such few women in the documented history of OR and do women spend more of their time on childcare responsibilities which prevent them from progressing in their career. To truly appreciate the motivation for the article it is worth understanding the authors background which is not captured in the narrative of the paper. One of the authors, Esposito Amideo, participated in the very first Women in OR and Analytics networking (WORAN) meeting in 2018 at the OR61 conference held at Kent. She played a pivotal role in supporting the WORAN social media efforts and raising awareness of WORAN and later put the same drive and enthusiasm in developing EURO Women in Society Doing Operational research and Management science (WISDOM). Similarly, the other author, Carroll, has played a significant role in founding and subsequent chairing of the EURO WISDOM committee and its various initiatives. These issues described in the paper have all been covered in WORAN events and hence both authors' background research and expertise are arguably more extensive than the paper might indicate. Such provenance should also be captured because it is part of the history of women in OR and Analytics and moving forward these authors must be acknowledged in their role.

This research previously presented at EURO22 conference in Finland, received both praise and surprising questions such as "Are you sure women want to be promoted?". Was the question just provocative or indicating a lack of awareness or belief of such challenges. If it is the latter, the literature review makes the

research gap on women in OR clear and the survey puts forward some initial evidence about how women fare when compared to men in OR and Analytics.

The article surveys men and women across a number of themes, finds clear evidence of additional challenges for women. We will focus on one core challenge discussed in the article: that of additional caring responsibilities. The survey conducted only finds a strong statistical significance for the association of care responsibilities and gender in the 35-44 age bracket compared to other ages where it is reported as weaker. However it is worth noting that the survey was conducted during the EURO2021 hybrid conference electronically which was also during the Covid-19 pandemic. Childcare responsibilities in combination with Covid-19 may have affected women's attendance to the conference even if it were hybrid. It is worth considering if these circumstances had an impact on the findings. A UK survey published in the same year of 2021 (Parenting in lockdown: Coronavirus and the effects on work-life balance - Office for National Statistics (ons.gov.uk)) reports that in "households with children aged under 18 years, women were carrying out on average two-thirds more of the childcare duties per day than men. Women were delivering an average of 3 h and 18 min of childcare, which includes time spent supervising children, while men contributed 2 h." Although this ONS is a UK wide survey it corroborates the authors finding for the 35-44 age bracket.

The UK OR society should consider working with the authors to replicate the study to gain UK insights for the field. The authors explain that 90% of survey respondents were affiliated with an institution in Europe. However the participation of those working in the UK would have been less than 4% and arguably fewer than that as the UK contribution to the survey is not explicitly reported like other countries. Without evidence it is hard to form policies to mitigate the challenges at a local level.

In summary the authors should be commended for this study. This work alongside other initiatives will pave the way for women in OR and Analytics to be acknowledged for their contribution, supported to meet their potential and promoted so they can help shape the field for forthcoming generations of academics and practitioners.

Katherine Kent – Chair of Women in OR and Analytics Network (WORAN), Office for National Statistics, UK

As Chair of The OR society's Women in OR and Analytics Network (WORAN) I welcome research into

women in OR and it is important to highlight how far we have to go in the pursuit of gender equality.

I agree with the authors that there is a lack of research in this area of women in OR. As chair of WORAN I can see the benefit for further research into the impact of WOR/MS. WISDOM, WORAN the latter two only being established in recent years.

I'm pleased to say WORAN has covered many of these topics in our events, for example career breaks and leadership. In July we held a panel discussion with women working for the coal board, an opportunity to hear these missing voices on working in OR. The paper also mentions that Alisa Land is recognised by OR society and indeed we now hold an annual Land lecture.

To our members an important issue are barriers to progression to senior roles, impacting retention and promotion - these are covered in the authors survey.

Although the sample was over 300 responses, with good coverage of men and women, as it was taken from those attending EURO conference, it is targeted at those still in OR and crucially able to attend such an event. For example, those able to attend a face-to-face event likely to have fewer caring responsibilities.

On the specific response "too soon since appointed"—I think this is an area which could be explored further—was this a personal reflection or what they have been told? This should be also compared with the facts of how long since they have been appointed, to do a comparison between men and women.

On the literature study, the authors found limited literature where sex is considered as an explanatory variable. This is important, and I'd like to see journal reviewers highlighting/asking explicitly on this in future.

This analysis was on published journals, what about those papers that never were accepted and that could be part of the problem, if these are not considered relevant/"OR" enough. Alternatives could be widening out to conference papers or dissertation topics and see if same trends emerge.

Although mentioned in the paper, the current developments in AI were not explored in detail, either from the opportunities they offer OR academics/practitioners or as a risk of automation for roles of men or women. This is a topic I am interested reading more about.

Also, I would be interested in future research into the increasing online collaboration, and whether that has increased opportunities for women to author academic papers and impact job mobility.

In summary, I would recommend all read this very enlightening and digestible paper and think about the synergies with their experiences and their institutions. As a reminder, WORAN is open to all

and these issues shouldn't be seen as a for women to solve.

Sally Brailsford – Southampton Business School, University of Southampton, UK

While I welcome this paper, and I congratulate the editors of JORS on publishing it, I have a few reservations about the methodology and the novelty of the conclusions. For understandable reasons the authors have focused on academia, but these are broad societal issues and it would have been useful to have had greater representation among survey participants from business, industry and public sector organisations. All the (extensive) prior sociological and demographic evidence suggests that academia is no different from any other sector, and that STEM disciplines do not differ greatly from the arts or humanities, but quantitative data for OR in particular across all sectors would be interesting. The authors recognise this is a limitation of their study but I wonder whether, had the survey been conducted at a UK OR Society annual conference (which typically attract more practitioners than EURO-k conferences) a better balance would have been achieved, albeit at the expense of the international aspect.

Regarding the literature survey on the "gender/OR nexus," most of the 17 cited papers describe modelling studies on medical or sociological topics. Given the fuzzy boundary between statistics, analytics and OR it is not surprising to find that gender is often mentioned in these application areas. In my own field of health OR, gender is very often a key variable, for example in modelling attendance for appointments, length of stay, and health outcomes (including survival). However there is nothing special about gender in such models and other variables such as age and socio-economic status can be equally important. More relevant insights might have been obtained by reviewing the literature in gender studies, demography or sociology to see whether any papers focusing specifically on gender issues used methods that could be classed as OR. Of course, this would have been very time-consuming; and it would have been necessary to define OR!

My third point is a more general one. While it is useful (although depressing) to have up-to-date quantitative data on this topic, the career challenges faced by women in all disciplines and in all sectors are well known and are not unique to OR. The analysis of the survey data did not reveal any surprising findings.

My own academic career began in my late 30s when I did the MSc in OR at Southampton. My original aim was to work for the NHS as an OR analyst,

but my MSc turned into a PhD and eventually a lectureship. I have remained at Southampton ever since, and in 2007 became the first woman in the Business School to be promoted to Professor. Since then many other female Professors have joined me, including Julia Bennell, now Executive Dean at Leeds Business School. Julia and I have both served as Head of the Management Science Department. Southampton now has a relatively high number of women in leadership roles, including several Deans and Heads of School, but this was not always the case in the past. Ruth Davies had an outstanding research reputation by the late 1990s, but was never promoted to Professor. In the early 2000s she was offered a Chair at Warwick and became Head of the OR Group there. Southampton's loss was definitely Warwick's gain!

Hence in all honesty I cannot say that my own career has been hindered by my gender, other than having to sit on a disproportionate number of appointment and promotion panels. However, I had already had my children; I also had a very supportive husband. Over a 35-year academic career I have seen the difficulties faced by female colleagues and have been involved in many initiatives to overcome them. I fully agree with the comment in the final paragraph of this paper that more research is needed, especially into which interventions work (and not only for women but for all under-represented groups). I am just not convinced that OR is the right discipline to conduct such research.

Julia Bennell - Leeds University Business School, University of Leeds

The paper seeks to demonstrate the historical low participation and recognition of women in OR and the perceived current barriers in career progression for women. The acknowledgement of the disparity in gender balance in our field was given a more formal platform in EURO conferences since Valencia in 2018 (in my memory) and this paper provides empirical evidence to support the observations articulated in the discussion forums and plenary sessions since then.

As a faculty Dean and a member of the steering group of a University EDI committee in a large University, I can say with confidence that the challenges identified in this paper are commonly held across most disciplines. In general women are more likely to be time poor due to caring and domestic responsibilities, and within work, more likely to take on much needed pastoral and administration work that gains little recognition or reward—often referred to as academic housework. I don't believe these issues can be solved by a single discipline, but

require institution wide interventions to level the field for academic progression.

While the paper provides evidence of the historic and existing gender imbalance, I'm keen to focus more on how we remove unconscious and systemic bias. As a discipline, we can take action by looking at everything we do through a gender equality lens. To illustrate this I need to make a confession. As co-ordinator of the European Working Group in Cutting and Packing (ESICUP), some years ago I planned the programme for our annual meeting. Following the convention of allocating a session chair from the list of speakers in the session, I picked the academics I recognised as well known in the field. Only after the conference had I spotted that almost all of the session chairs were men. I had applied a heuristic that reinforced gender bias.

Through the efforts of all members of the OR community, we can take action. For example, always ensure gender parity on committees, session and stream chairs, keynote speaker, journal editor boards—if possible, go one better, and appoint more women. When citing work, where you have a choice of papers that support your discussion point, be aware of gender bias and try to cite papers with female authors. Networks are critical for academic success and one of the hardest aspects of academic life for women to engage with when they have children. When deciding who will gain the esteem of a certain role, take time to evaluate researchers in the field—how will this appointment benefit a diverse and inclusive community as well as who will do a good job.

I have been fortunate in my academic career to have some excellent mentors; men and women, who have worked with me and introduced me to their networks. OR, in all its rich diversity, is an ideal environment to embrace true diversity in perspective and personal attributes be that gender, race, disability, or sexual orientation. Our roots are a pluralistic research field that requires the full engagement of a pluralistic community.

Laura A. Albert – Department of Industrial & Systems Engineering, University of Wisconsin-Madison, USA

I was thrilled to read “Gender Equality: Opportunities and challenges for the OR community” by Paula Carroll and Annunziata Esposito Amideo, since there is a knowledge gap on the status of women in operational research (OR). The paper performs a literature review of scholarly works that document the role of women in OR and finds that women are largely invisible in the recorded history of OR. The paper also

reports the results of a survey conducted at the EURO conference in 2021 that sheds light into career progressions in OR by gender. The paper contributes new information regarding the participation and recognition of women in OR, and it motivates the need to continue to discover barriers to women's participation, productivity, and recognition in OR.

I hope this is not the last paper on the topic of women in OR. I outline three important directions for future study.

The paper focuses on gender identity in European OR communities and on European OR society boards of directors. Performing a similar analysis of OR societies across the globe, including those in the Americas, Asia, Africa, and the Middle East, may provide additional insights. Similarly, an analysis of overall membership rates by gender identity in these OR societies, and breaking the numbers down further by career stage (e.g., student, academic, industry professional, and retired), could reveal national trends and practices that have encouraged or discouraged women's participation in OR in some quarters of the world. Such an analysis could include other groups that have been historically marginalized by gender, including non-binary and transgender individuals, as well as other demographic groups.

It is well-documented that the intersection of gender with other identities is important for explaining women's participation, productivity, and recognition in academia (e.g., Ford et al., 2019). The authors include one aspect of intersectionality in their paper when they analyze the impact of care duties on women's participation in OR. Expanding the analysis to explicitly study gender as it intersects with race, sexual orientation, disability status, and caregiver status may uncover new insights. Other research has discovered that the intersection of gender identity and parenthood status is a major factor in explaining different rates in participation, achievements, and recognition in academia (Perna, 2005, Lutter & Schröder, 2020, Morgan et al., 2021). This issue was accentuated after the onset of the COVID-19 pandemic (Myers et al., 2020).

The productivity and recognition of women in OR are as important to understand as women's participation in OR. It was disheartening to learn from the paper that there is only one woman in the top 100 cited OR authors in Google Scholar and how few women have been recognized by major society awards. These patterns exist in other scientific disciplines (Meho, 2021), suggesting that women face barriers once they have joined the profession. Forms of recognition such as editorial board composition (Brandeau 2021), publication citations (Teich et al., 2022), tenure rates (Astegiano et al., 2019), and colloquium

invitations (Nittrouer et al., 2018) could be included in such an analysis in addition to major society awards. Identifying barriers could help to explain reduced recognition rates for women and lead to efforts to remove them by inspiring new structures and policies.

This paper has taken an important step forward in addressing a critical need for the OR community, and I hope more scholarly works follow to build on the momentum. Doing so would enable a broader cross section of society to fully participate and excel in OR, which will take OR to even greater heights.

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Ruth Kaufman – Past President of The Operational Research Society, UK

Gender inequality, inequity and exclusion in OR has long been an issue hiding in plain sight and this paper provides a significant opportunity to bring it into the spotlight. The paper touches only briefly on why inequity is important, and I want to discuss this in more detail.

Inequity matters in its own right: “fairness” is a legitimate, if hard-to-define, objective for any enterprise, and one that is increasingly being used in OR modelling. But it also matters because of its impact on the OR profession’s own effectiveness and efficiency. These two objectives have been at the heart of OR’s contribution to enterprise since its inception, so it should come naturally to OR professionals to ask how inequity affects the profession’s own ability to deliver impact. There are at least two considerations.

The first is that good OR people, and good OR outcomes, are scarce resources. It is sheer wastefulness to make it harder for some to participate effectively. Moreover it is wastefulness that ripples down the generations, as newcomers lose out on role models, and on the confidence that they “belong” and are welcome. We have a profession that aims to improve efficiency across the economy, yet fails to apply its skills to improving the efficient conversion of its own pipeline material into effective members of the community; a profession that aims to solve problems but is stymied by everyday problems such as integrating part-time working into a leadership position. We have the tools—let us apply them.

The second is the consequences of a male-dominated, gender-blind profession on the quality of OR impact. As the paper rightly identifies, there are few OR solutions in the literature that take a gender-lens. Maybe there are not many OR solutions that require one—a question which is in itself worth further exploration. But one area would definitely benefit from a gender-lens: the impact of gender in the consulting environment.

Many large organisations in business, industry and government are trying to attract and retain women, reflected in female-friendly Human Resources policies. But OR people are advisers and consultants. Their effectiveness is crucially determined, not by their own line management chain, but by the culture and behaviours of the people they advise, and the people with whom they must collaborate; it is those individuals who will dictate the dynamics and outcome of the consultancy engagement.

The OR consultancy environment varies across sectors, business types and geographies, but in

male-dominated industries especially, female experiences of being patronised, obstructed or conversely being treated with kid gloves as an exotic charmer, are anecdotally common and unresearched. Management may provide support such as workarounds, adjustments, possibly tailored training for the female consultant; or it may be left for the woman herself to struggle with. In either case, such responses are local and hidden. Research bringing this centre-stage as a potential factor in the success of OR consulting would be greatly welcomed.

Anna Nagurney – Isenberg School of Management, University of Massachusetts, USA

First, I would like to thank the Editors of the Journal of the Operational Research Society for establishing the initiative of “Discussion Papers” and accompanying “Commentaries.” It is inspiring to have, as the first published discussion paper, the paper by Paula Carroll and Annunziata Esposito Amideo on Gender Equality. The paper provides a panoramic, multifaceted perspective, focusing on the history of OR and OR and gender equality, followed by a systemic literature review with the goal of uncovering gender perspectives on the history of OR, and an analysis of the latter as well as that of an online survey during the EURO 2021 hybrid conference on the gender dimension of OR careers. Each of these topics could merit an individual paper.

In terms of OR and gender equality, the authors focus on WISDOM (Women in Society: Doing Operational research and Management science), founded in 2022. It is a EURO Forum (general interest group) with aims to “support, empower and encourage the participation of ALL genders in OR within EURO” through certain actions. Other gender initiatives related to OR professional societies include WOMMS (Women in Operations Research and the Management Sciences) of INFORMS, founded in 1995, and the UK Women in OR & Analytics Network (WORAN), established in 2020. Carroll and Esposito Amideo, with coauthors, earlier produced a white paper in 2020 (cf. Carroll et al. (2020)) emphasizing the gathering of data on gender and OR, since the number of women in OR “may be low.” They identify the percentages of board members of EURO national OR societies and reveal that 73% are male with 27% being female.

In addition, Carroll and Esposito Amideo note that another gender perspective on the OR community is the percentage breakdown of prize winners and that many more males have received awards in various EURO categories than females. They also

highlight some awards of the UK OR Society and of INFORMS and the first female recipients of them. I expand and add to the discussion by noting the following. INFORMS, with over 11,000 members now, started its Fellows program in 2002. 25% of its members identify as female (INFORMS (2024)). As of 2023, there were over 400 elected INFORMS Fellows, with approximately 10% of them being female. IFORS started its Fellows program in 2021 and there have been 5 females out of 36 thus recognized <https://www.ifors.org/ifors-fellows/> with Grazia Speranza, the first female, inducted in 2021. 7 out of the 58 IFORS (International Federation of Operational Research Societies) Distinguished Lecturers have been female <https://www.ifors.org/ifors-distinguished-lectures/>, with this award being initiated in 1999 and with the first female (Brenda Dietrich) receiving it in 2012. There have been 5 female (out of 45 total) Omega Rho Distinguished Lecturers <https://connect.informs.org/omegarho/distinguished-lectures/distinguished-lecture-series>, since 1983, with this lecture given at the annual INFORMS Meeting. Judith Liebman was the first female to receive this award in 2003, followed by Karla Hoffman, Margaret Brandeau, Anna Nagurney, and Laura Albert, the immediate Past-President of INFORMS. The Harold Larnder Prize, which requires a lecture, has been given annually since 1986 by the Canadian Operational Research Society, and, as of 2023, there have been 3 female recipients (Ailsa Land in 1994, Anna Nagurney in 2020, and Sophie D'Amours in 2023) out of a total of 37 awardees. [https://www.cors.ca/?q=content/harold-larnder-prize-0#:~:text=The Harold Larnder Prize is,at the CORS Annual Conference Clearly, as noted by Carroll and Esposito Amideo, more recently, females in OR have been increasingly recognized with awards; however, the percentages are still quite low.](https://www.cors.ca/?q=content/harold-larnder-prize-0#:~:text=The%20Harold%20Larnder%20Prize%20is,at%20the%20CORS%20Annual%20Conference%20Clearly,as%20noted%20by%20Carroll%20and%20Esposito%20Amideo,more%20recently,more%20females%20in%20OR%20have%20been%20increasingly%20recognized%20with%20awards;however,the%20percentages%20are%20still%20quite%20low.)

The WORMS Award has been given out annually since 2005 and according to its website: “celebrates and recognizes a person who has contributed significantly to the advancement and recognition of women in the field of Operations Research and the Management Sciences (OR/MS).” <https://www.informs.org/Recognizing-Excellence/Community-Prizes/Women-in-OR-MS/WORMS-Award-for-the-Advancement-of-Women-in-OR-MS#:~:text=The%20WORMS%20Award%20celebrates%20and,during%20the%20INFORMS%20annual%20meeting>. All recipients of the WORMS Award have been females.

In 2006, I chaired an ad hoc committee on diversity, having been invited by the then INFORMS President Mark S. Daskin. The report (cf. Nagurney (2006)) was quite eye-opening and revealed not only the number of INFORMS Fellows to that date that were female (about 5%) but also the number of major INFORMS award recipients that were female.

The data revealed that the recognition of females in OR for their scientific accomplishments, through 2006, was miniscule, and many recommendations were made, including the collection of gender-specific data. Slides to the accompanying presentation can be found here: <https://supernet.isenberg.umass.edu/Informs-diversity/DiversityPresentation112006.pdf> Since then, multiple females have been elected President of INFORMS, a welcoming fact. But, still, as mentioned earlier, only about 10% of the elected INFORMS Fellows are females. As for another type of board, and the composition of its membership, Newhouse & Brandeau (2021) published an illuminating study on the diversity of INFORMS journal editorial boards, the “gatekeepers,” of a total of 16 journals. They found not only that the editorial boards have low levels of diversity with women comprising just under 20% of the editorial board members and with fewer than 1% of editorial board members being underrepresented minorities, but 10 institutions (less than 5% of the total) are the home bases for more than 25% of the editors. Furthermore, Newhouse & Brandeau (2021) discovered a high level of connectivity between editorial board members (as measured by coauthor relationship) for some of the INFORMS journals. The latter, they noted, may give the appearance of an “in crowd” being influential. Specific recommendations were also made.

In their discussion paper, Carroll and Esposito Amideo recognize not only a gender imbalance on EURO society boards and in terms of awards, but also an imbalance in visibility. I believe that, in this dimension, professional OR societies can play a much greater role. For example, I served on the INFORMS History and Traditions Committee from 2016 and 2018 and I advocated for the inclusion of additional oral histories of females in OR. Despite my efforts, the website; see: <https://www.informs.org/Explore/History-of-O.R.-Excellence/Oral-Histories>, to-date, only includes 2 interviews (of Ailsa Land and Margaret Wright) and links to external interviews with Judith Liebman and Christine Shoemaker. The present History and Traditions committee of INFORMS is all male and, perhaps, that is playing a role. A remarkable initiative, in contrast, is one by Anand Subramanian, the conceiver of the outstanding Subject to (s.t.) podcast. According to Subramanian (2023), writing in the IFORS December newsletter, “The goal of the s.t. podcast is to inspire the next generation of operation researchers by means of informal yet in-depth conversations with great names in the field of OR in the form of oral history.” This series can be viewed both on YouTube and on various podcast platforms. As of January 2024 (Subramanian (2024)), Anand has conducted 80 interviews with 30 of them being female

guests (all have been operations researchers except for Anand's Mother, who has a PhD in the STEM field of chemistry), with nationalities associated with 16 countries. The Subject to YouTube channel currently has approximately 2,740 subscribers and nearly 70,000 views.

Furthermore, after mentioning several female prize winners in OR over time, the discussion paper authors highlight that only two females are among the top 100 cited in OR according to their h-index. Here, I believe, there may lie some confusion as to the identity of OR, which Carroll and Esposito Amideo call attention to early in their discussion paper. Not only do we have "operational research" but also "operations research" and I found that many highly cited scholars, including INFORMS Fellows, may list as their specialty on Google Scholar a methodology (optimization, for example) or application (transportation, supply chains, energy, healthcare) but not "Operations Research." This may also be an issue in their systemic literature review, which I comment on subsequently.

Carroll and Esposito Amideo, in their analysis of their systemic literature review, note the small number of papers at the gender/OR nexus. However, the INFORMS journal *Management Science* in 2022 published a virtual special issue of papers that had appeared in the journal in the past few years on Diversity, Equity and Inclusion <https://pubsonline.informs.org/page/mnsc/papers-on-diversity-equity-inclusion>. In this collection of 30 papers, I found 12 with "gender" in the title and topics investigated such as: "gender profit gap," "gender diversity in organizations," "gender quotas," "executive search and gender inequality," to name just a few. As I had mentioned earlier, this discussion paper, with its topics, could have yielded several papers. And, here, perhaps in the literature search, the confusion over the identity of OR may have arisen, with "Management Science" not considered. The discussion paper authors, in their finding a small number of papers, then expanded their search to analyze 38 History of OR papers, and applied a gender lens to this set of papers. They state that it is not surprising, given the military origins and history of OR, that this literature is male dominated. Nevertheless, it is quite troubling that this literature is "largely silent on the contributions of individual women on the role women have played in the founding and developing the OR discipline." The authors, in addressing their first research question: Is there a gender dimension to the history of OR?, report that, according to their findings, the OR history literature strikingly recognizes and honours individual males for their contributions. I personally learned a tremendous amount from my PhD advisor at Brown University, Stella Dafermos, who, in 1968, was the

second female to receive a PhD in OR in the United States. Sadly, she passed away at age 49 in 1990, and was honoured with an obituary in the journal *Operations Research* (Nagurney (1991)). I believe that, to date, Stella is the only female thus recognized. Her 1980 paper (cf. Dafermos (1980)) on traffic equilibrium and variational inequalities, published in the INFORMS journal *Transportation Science*, was chosen as one of the twelve most impactful ones in that journal in its 50th year history at that time; see <https://pubsonline.informs.org/page/trsc/classics>. Stella was a contemporary of Judith Liebman in their PhD studies at Johns Hopkins University and a true trailblazer.

The discussion paper's second research question, on whether there are gender differences in OR careers, based on the authors' survey, reveals that women in OR do "perceive barriers to career progression to a greater extent than their male colleagues." Interestingly, they find that a lower percentage of the females who responded have changed their affiliated institute. My recommendation in this dimension, which I have availed myself of, is to take shorter leaves from one's home institutions to engage in, for example, a Fulbright program or a Visiting Fellows program. Enhancing one's networks in this manner and the knowledge exchanges garnered can be incredibly rewarding both professionally and personally. A significant portion of the respondents to their survey, of over 78%, noted no gender-specific barriers to participating in OR and this is very good news. Further surveys and studies in this area are warranted. In a recent article in *Science Advances* (cf. Spoon et al. (2023)), based on a census of 245,270 tenure-track and tenured professors at United States-based PhD-granting departments, women were found to leave academia at higher rates than men at every career age. The researchers found that a harsh workplace climate, which can include feelings of not belonging as well as actual harassment, was the most common reason women left academia (Ye (2023)). In this dimension, professional societies and fora such as WISDOM, WORAN, and WORMS can and are providing valuable communities for females with accompanying encouragement.

There is much that can be done to increase the visibility of female operations researchers as well as to provide support for them. For example, INFORMS, in 2019, published an article by Kara Tucker, "Powerful, pragmatic pioneers," in *ORMS Today*. The article, as Women's History Month was approaching, was to spotlight 10 women—longtime, influential members of INFORMS and to also profile one "rising star." Having females keynote major conferences is also an important way of generating inclusiveness and enhancing visibility as is having

females represented on important panels. Recognition of excellent scientific work through best paper awards can also provide enhanced visibility and valuable support. Documenting the contributions of females in articles, and I would advocate also in books, as well as through oral histories and interviews expands their visibility and adds to outreach and education. Doing so, also helps to promote the historical contributions of females in OR and, in addition, strengthens the foundations for present and future generations of Operations Researchers. Articles such as the one by Amorosi et al. (2021) in a journal, also cited by Carroll and Esposito Amideo, can further record the achievements of female researchers and their journeys and inspire others. And, having female representation on prize committees can further expand inclusiveness and the diversity of award recipients.

Research on the gender and OR nexus, in turn, can be further stimulated through best paper prize competitions, such as the INFORMS DEI Best Paper Student Prize competition, initiated in 2022. A finalist paper in the 2023 competition, which I served on the selection committee of, was on the gender/OR nexus, and was entitled, “Gender inequality in research productivity during the COVID-19 pandemic.” It has now been published in *Manufacturing & Service Operations Management* (see Cui et al. (2021)).

Many thanks to the authors of this discussion paper for bringing out many issues that our OR profession should be and can be addressing. By working together, we can provide more innovative and creative solutions to problems that we are faced with now on our planet, including gender inequality. Gender equality, according to UNICEF (2017), as the authors state, means “that women and men, girls and boys, have equal conditions, treatment and opportunities for realising their full potential, human rights and dignity, and for contributing to (and benefiting from) economic, social, cultural and political development.” Gender equality is an essential component to the success of OR as a discipline and as a profession.

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Graham Rand – Lancaster University, UK

Carroll and Esposito Amideo’s survey shows that women are largely invisible in the recorded history of OR. Whilst I’m not in a position to comment from a sociological perspective as to why this may be, I can add further data to aid the understanding of the participation of women in the history of OR.

The authors’ examination of the board representation of European OR societies and the winners of various awards reveals the underrepresentation of female operational researchers. Two projects looking at the founder figures of operational research in which I was involved give the same picture, even more dramatically. The International Federation of Operational Research Societies’ (IFORS) Hall of Fame, published between 2003 and 2006, recognises 23 of the most significant contributors to OR (Rand, 2006). All are male. Profiles in Operations Research: Pioneers and Innovators describes the lives and contributions of 43 OR pioneers (Assad & Gass, 2011). All are male.

Consider, further, the editors-in-chief of several major journals. There have been no female editors-in-chief of the Journal of the Operational Research Society (17 males), Management Science (11 males) and the European Journal of Operational Research (15 males). Operations Research bucks the pattern: after 13 male editors, the first female editor-in-chief, Amy Ward, took office this year.

The authors analyse the board representation of European OR societies. An even greater underrepresentation of females is revealed when considering the gender of presidents of two national societies, the UK’s ORS and USA’s INFORMS and its’ predecessors, Operations Research Society of America (ORSA) and The Institute of Management Science (TIMS), and two international groups, IFORS and EURO. Table 1 has the figures.

It will be noticed that INFORMS and EURO have larger proportions of female presidents. The international groups were created later than the national societies: EURO in 1975 and INFORMS in 1995. In common with the ORS and IFORS, they experienced a higher proportion of female presidents in the twenty first century. The figures can be seen in Table 2. The OR Society lags behind!

As can be deduced, there were only two female presidents of these societies in the twentieth century: ORSA’s Judith Liebman, in 1987, and INFORMS’ Karla Hoffman in 1998.

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Table 1 Gender distribution of society presidents.

Gender	USA					
	ORS	ORSA	TIMS	INFORMS	IFORS	EURO
Male	32	42	41	20	20	19
Female	3	1	0	10	3	5
Femal proportion	8.6%	2.3%	0%	33.3%	13%	20.8%

Table 2 Gender distribution of society presidents in the twenty first century.

Gender	ORS	INFORMS	IFORS	EURO
Male	9	16	5	7
Female	3	9	3	5
Female proportion	25%	36%	37.5%	41.7%

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This is a welcome contribution to the journal on an important debate that has been going on across the society for some time: gender equality. JORS is the first journal to publish a study of the situation across the OR community. We are glad to have this opportunity to contribute the efforts done by different OR Society through the different initiatives, e.g., WISDOM, WORAN, etc.

Definitively, there is always room for additional research such as surveys comprising more OR societies either individually or globally, discussion of the barriers to participation using methods like Problem Structuring Methods or Systems Thinking. Clearly, any actions taken now will only be realised after few years given the delays and “leaks” in the profession pipeline. Modelling can support policies, look at scenarios and understand the delays (Willis et al., 2018).

In terms of practical actions, other commentaries suggest few of them. I can mention one that has happened a while ago. One of my MSc students, Sukrity Chapagain, did a project on “Profiles of Women in Operational Research on Wikipedia” with the support of Frances O’Brien from Warwick Business School. The project undertook research to follow on from a WORAN event that had explored Wikipedia profiles from the field of OR which highlighted that there were many more male compared to female OR-related profiles. Sukrity found that since the internet has a significant impact on the recognition of key personalities, e.g., acknowledging their achievements and contributions, the online

presence of a personality plays an important role in the career development of students and the younger generation. Through an online survey, few prominent females working in Operational Research were identified. Then, a framework based on highly nominated personalities in Wikipedia was employed to develop few profiles on Wikipedia. I invite to look at a sample of the profiles created, e.g., Maria Grazia Speranza, Valerie Belton, and replicate them to increase the visibility of female academics in OR.

A study performed few years ago by Taylor & Francis JORS manager, Richard Goodman, obtained statistics about the distribution of accepted/rejected papers in terms of gender. Unfortunately, one of the important findings was the lack of gender information from authors, more than 50% of the authors don’t provide gender information. Without this information, we can’t know the situation in detail. From the articles with gender information, 25% of the articles have female authors in 2020 and 29% in 2021. It will be useful to compare with other journals to have a wider picture of the OR community. Another interesting study can be the formation of networks between authors, is there a propensity to have mixed teams or are mostly differentiate by gender?

In terms of the gender distribution in JORS, the percentage of women in the editorial board (editors, associate editors, and international advisory board) is 26%. Definitively, there is room for improvement, and we are actively trying to balance it.

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Response to commentaries

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Firstly, a sincere thank you to JORS for being the first journal to publish a study on gender equality across the OR community. The new Discussion format is an ideal way to bring visibility, and to promote a discussion on issues such as gender equality. Such issues are cross-cutting and intersectional with the core work of operational researchers. We are aware that speaking about gender equality is an emotive issue, and are very pleased with this opportunity to participate in rational discourse with members of the OR community.

Secondly, a sincere thank you to the anonymous reviewers, and to the commentators for taking time from their busy schedules to share their impressions of our work, and for sharing their own insights on gender equality. The commentators are senior members of the OR community who, whether they intend it or not, are visible role models for the OR community.

It is particularly fitting that our work coincides with the 75th anniversary of the UK Operational Research Society, an opportune time to reflect on where we have come from, where we are, and where we want to go. We summarise the main themes in the commentaries and look forward to further discourse on gender equality within the OR community, and within OR research.

Theme 1: Research gap and contribution

Several commentators noted that the study is much needed and addresses an interesting research gap. They also note that the results are not surprising. The insights from the work of recent Nobel Prize winner Claudia Goldin that gender pay gaps largely occur after women start to have children is not surprising to many either, but is an important acknowledgement and evidence that women do not compete on a level playing field. The results in our paper might not be surprising, but provide documentary evidence of the past and current situation of women in OR.

The commentators note that men and women are impacted by stereotypes and biases at a societal level. We are often unaware of systematic biases.

Systemic issues have blocked women's progress and recognition in the past and lead to missed opportunities. As noted, this is a huge loss and waste both for the individual women, for OR, and for society as a whole.

Our study analyses the literature, the survey results, and some additional data such as OR prizes. Our work points to evidence of progress in OR but that the rate of change is slow. The commentators note that the study was at a EURO level which provides an overview of the broad EURO community.

Theme 2: Study limitations and further research

Every problem can be seen as an opportunity. The same is true of the limitations of our study. The commentators point to several ideas for further research.

The survey sample is small. We acknowledge the limitations of the survey instrument used. We too were disappointed with the relatively low response rate and agree that localised research would be useful to understand local/regional cultural and intersectional issues.

Our data gathering is limited, and as noted by the commentators could be broadened. The commentators suggest several other data sources to measure and track, and to help understand gender equality progress within OR. The AI and machine learning communities are alert to the need to de-bias their training data so that they do not reinforce existing biases. We may also need to take a leaf from the AI and ML communities and evaluate our data for any systematic biases. A gender data gap exists in many sectors. Gender data has not historically been collected, (e.g., author names). Such data is expensive to gather and creates privacy concerns about how the data will be used. It is an interesting question whether gender specific data in our OR models could address the differential needs of men and women.

Our Systematic Literature Review is limited in scope. We restricted ourselves to just one search string and papers published in specific academic journals. As the commentators note, there are multiple alternative search strings that could unearth further evidence of the historic participation and contribution of women in OR, or of latent gender dimensions in OR applications and methodologies. In addition to journal articles, conference papers and the archives of the learned societies could be a rich resource for further research.

Some of the papers we identified consider gender/sex as an explanatory variable. As the commentators note, this is not unusual in sectors such as healthcare, where sex and other intersectional

factors such as age, race and socio-demographic factors are often considered. We wonder if this is where we have an opportunity to stress test our OR techniques which may allocate (healthcare) resources, or assign workload without first evaluating the data/test instances, or explicitly include fairness constraints or objective function components?

As noted by the commentators, insights from gender studies and other disciplines could help inform the OR community about our lack of awareness and understanding of what we should be asking during problem formulation of our OR models, and what kind of sensitivity analysis we should conduct to assess the impact of our models' recommendations on gender equality.

The identity of OR is touched on briefly. We used the terms "Operational" and "Operations" Research, but not "Management Science", nor "Business Analytics". We leave further discussion on the identity and definition of OR to another day.

Lastly, the OR community cannot address all societal "wicked problems", but can address what

we have agency over. We can aim to stop any leaky pipeline and retain female talent in OR including through existing initiatives such as WISDOM/WORAN/WORMS.

Conclusion

Our study is just a first step. It acts as a call to the OR community to consider the insights from our study, and to take the next steps. As the commentators note, gender equality should not be seen as a problem for women to solve, but is a challenge for everyone. Everyone can act as a role model, champion and mentor. We invite all members of the OR community to explore the gaps and limitations of our study. We hope our article creates visibility of gender equality issues and prompts further research and discussion on gender dimensions both of the OR community members, and in OR research. As one commentator says: "We have the tools":- let us consider how we apply them. We end our response, not with a full stop, but withto be continued.