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In-Person or Virtual? What Will Operations Management/Research Conferences Look Like?

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Problem Definition: The Covid-19 pandemic allowed the Operations Management/Research (OM/OR) community to experiment with virtual conference formats, which are expected to provide substantial environmental benefits. It is unclear, however, how such format change affects the value conferences provide to our community. Academic/practical relevance: Our community is eager to contribute to the climate change response and emissions reduction momentum and act responsibly. In turn, we analyze the environmental footprint of our conferences and explore ways to reduce the same while preserving their value for our community. Methodology: We leverage a series of Covid-19-induced natural experiments to determine the environmental footprint and societal value difference between different conference formats via Life Cycle Assessment and survey techniques, respectively. Specifically, we focus on INFORMS, POMS, and EurOMA conferences that were conducted in in-person and virtual formats between 2019 and 2021. Results: The environmental impact assessment reveals a substantial impact reduction from a virtual switch, on average from 941.9 kg CO2eq per person for in-person formats to 1.0 for virtual. The value assessment analysis, however, identifies a major utility loss, with the overall perceived value derived from conference attendance going down from 7.9 to 4.0 (on a scale of 10). Not surprisingly, virtual formats do show some merit, such as lower perceived costs, attendance flexibility and inclusion. The preference for in-person formats is clear though, justified by socialization and networking benefits, the two most important value drivers identified by our analysis. Societal implications: There is a clear trade-off in our choice between virtual and in-person conferences. It is therefore a good time for our research community to rigorously study how we can reduce our societal environmental footprints while maintaining interactions that facilitate knowledge creation and dissemination.

Keywords: Academic Conferences; Carbon Footprint; Perceived Value; Virtualization; Environmental Operations; Survey Research; Technology Management and Process Design

1. Introduction

As the climate change response momentum is growing stronger with more companies adopting Science-Based Targets and the US Congress making the largest-ever investment into tackling climate change under the recently passed Inflation Reduction Act, the Operations Management/Research (OM/OR) community is also in search of ways to help contribute to the Greenhouse Gas (GHG) emissions reduction debate and act responsibly. In addition to the climate change-related research we conduct (e.g., Blanco 2022, Chandy et al. 2019, Han et al. 2022), we strive to set an example by understanding and shaping the environmental footprint of our societal activities. The objective of this article, accordingly, is to analyze one of our core societal activities – our conferences – and explore ways in which we can reduce their environmental footprints while preserving their true nature.

Conferences are widely used in the knowledge industry as a tool to disseminate new research, foster the exchange of ideas, and set the agendas of academic communities (Etzion et al. 2022). They further play a pivotal role in the professional development of researchers, allowing them to network with peers, receive feedback to improve their work, and find career-relevant information (Hauss 2021, Rowe 2018). Over decades, academic conferences have evolved towards an almost standard format, involving the gathering of hundreds or thousands of scholars in appealing locations for a few days of intense debate within technical sessions, via posters, and plenaries, combined with pleasant social events such as dinners and award ceremonies (Egri 1992).

In the last 20 years, however, this institutionalized format has come under increasing pressure for the environmental impact it generates, mostly due to the tons of CO_2 emitted by scientists flying long distances to reach conference locations (Lester 2007, Neugebauer et al. 2020). Klower et al. (2020), for instance, calculated the travel emissions associated with the 2019 Fall Meeting of the American Geophysical Union in San Francisco, obtaining around 3 tons of CO_{2eq}[1] per person – greater than what an average citizen in Brazil, Morocco, or Indonesia emits over a year (Our World in Data). Against this worrying evidence, some scholars have begun, even before the pandemic, to challenge the traditional format based on resource-intensive trips and made calls to exploit the progress in videoconferencing technologies to experiment with virtual formats (Fraser et al. 2017, Reay 2003). Before 2020, though, only a few academic societies had engaged in such experimentation and a comparison between formats was only possible based on anecdotal evidence (Sá et al. 2019).

The Covid-19 pandemic forced the transition to virtual formats to occur abruptly, prompting academics in all fields to rethink their long-standing conferencing model (Donlon 2021). By leveraging this sort of natural experiment, this article aims to carry out a factual comparison of in-person and virtual formats based on multiple dimensions, thus highlighting the advantages and disadvantages inherent in each. The ultimate objective is to spark a serious discussion within the OM/OR community about how we envision the future of our conferences and explore opportunities for OM/OR research in the same space. To attain this objective, we need to dig deep into the very reasons why we organize and attend conferences, a topic often overlooked in the scholarly literature and in the board meetings of the academic societies organizing those meetings. Using a comprehensive environmental assessment of 6 recent OM/OR conferences in in-person and virtual formats, this article begins by illustrating the drivers of variations across the environmental footprints of different conferences and their formats. It then provides the results of a recent survey with the members of three of the largest international OM/OR societies on how different format choices – i.e., in-person versus virtual – affect not only the environmental footprint but also their social and scientific value. Lastly, it concludes with a discussion on how best to

interpret these findings, both deriving a list of practical recommendations for our societies and drawing an agenda of crucial open questions for the OM/OR community to improve academic conferences.

2. Environmental footprint

Scholars in several fields have begun to account for the GHG emissions related to their conferences and evaluate potential mitigation opportunities – e.g., in architecture (Kuper 2019) and political science (Jäckle 2019). To the best of our knowledge, this has not yet occurred in the OM/OR field. Motivated by this void and the strong belief that the OM/OR community is well-positioned to contribute to the debate on the environmental footprint of global activities, we undertook a comprehensive assessment of the environmental impacts of our conferences and how they changed as a result of Covid-driven virtualizations. To this end, we partnered with three of the largest international OM/OR societies, who accepted to support us with data related to their conferences. These include the *Institute for Operations Research and the Management Sciences* (INFORMS) and its *Manufacturing and Service Operations Management Society* (MSOM), the *Production and Operations Management Society* (POMS), and the *European Operations Management Association* (EurOMA).

Most assessments from other fields are basic carbon footprint evaluations focused on the travel activities of delegates (e.g., van Ewijk and Hoekman 2021, Klöwer et al. 2020). Following the best practice in environmental sciences and engineering (see Neugebauer et al. 2020, Tao et al. 2021), we extended the scope and level of detail of our analysis by carrying out a full *Life Cycle Assessment* (LCA). This methodology evaluates the environmental impacts associated with the entire life cycle of a product or service, from raw material extraction to waste disposal (ISO 2006). For a conference, the LCA approach enables consideration of other processes than delegates' travel, such as catering and accommodation, and impact categories other than climate change, such as water consumption and human toxicity. *Hence, we carried out a comprehensive LCA of conferences organized by different OM/OR societies in different formats, thus providing a new and unique contribution to the literature*. Given the significant data requirements of LCA, we limited the analysis to the last in-person and virtual annual meetings organized by the supporting societies, for which more accurate data were available (see Table 1). For an in-depth description of the methodology, we refer to Cavallin Toscani et al. (2022), who provide a detailed account of this LCA analysis. Here, we only report the general modeling approach and main findings.

Table 1. Conferences under study, adapted from Cavallin Toscani et al. (2022)

Conference	Format	Period	Duration	Size	Venue
INFORMS 2019	In-person	October 2019	4 days	7,072	Seattle (US): Washington State Convention Center + Sheraton Grand Seattle.
INFORMS 2020	Virtual	November 2020	6 days	5,501	Online: in-house virtual platform + Zoom.
POMS 2019	In-person	May 2019	4 days	2,000	Washington DC (US): Washington Hilton.
POMS 2021	Virtual	April-May 2021	5 days	1,488	Online: in-house virtual platform + Zoom.
EurOMA 2019	In-person	June 2019	3 days	561	Helsinki (FI): Hanken School of Economics + Aalto University Business School.
EurOMA 2021	Virtual	July 2021	3 days	340	Online: Exordo virtual platform.

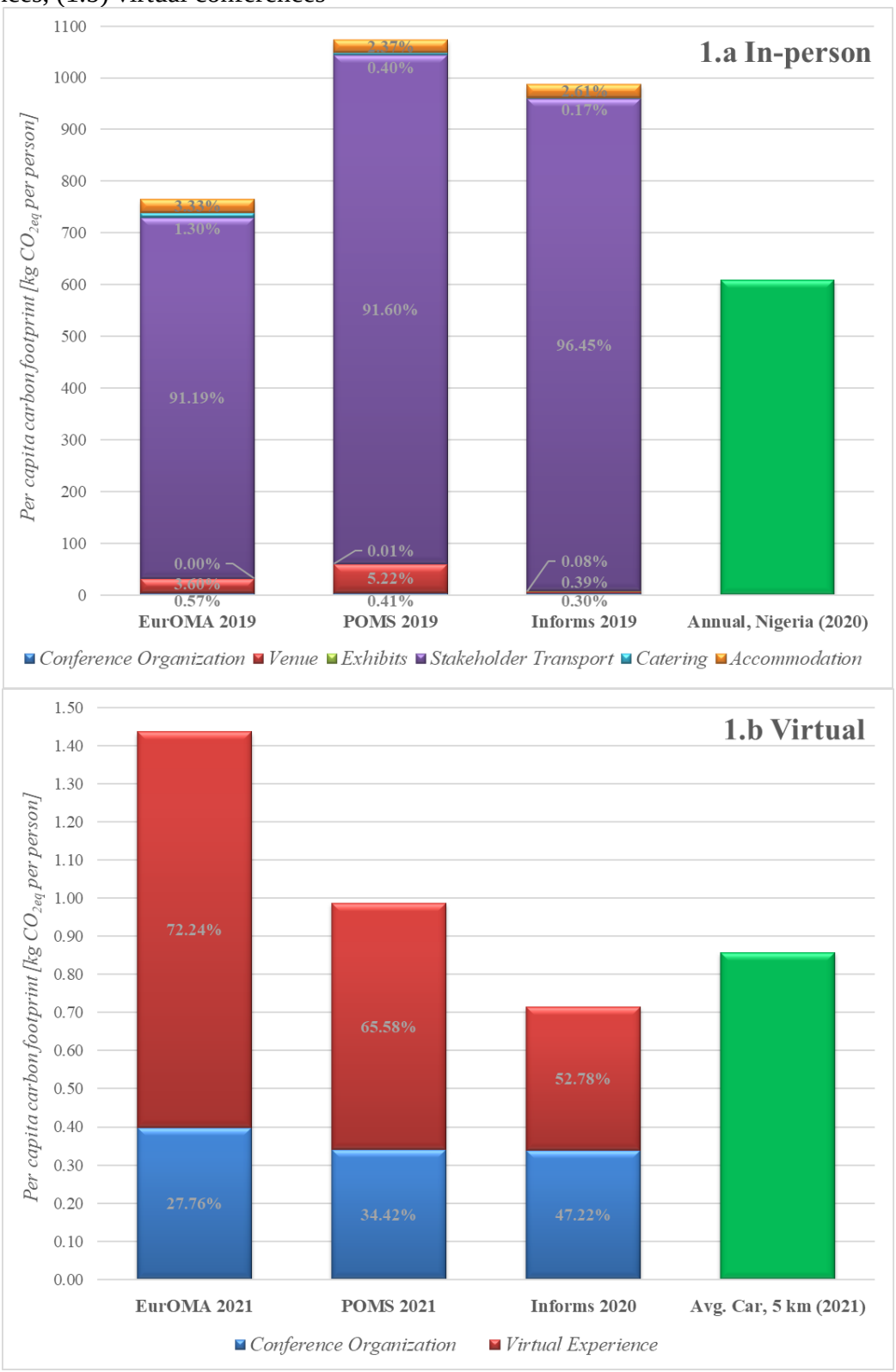
The impactful activities of the conference life cycle were clustered into a predefined set of stages. For in-person conferences, these include: *Conference Organization*, general planning activities like conference-related board meetings, venue inspection visits, organizing committee's activities, participants' registration, and production/disposal of conference materials; *Venue*, the use of venue buildings, mostly referring to their energy consumption; *Exhibits*, the production/disposal of exhibition and career fair materials; *Stakeholder Transport*, the transportation of delegates, exhibitors, and staff to the conference site; *Catering*, the production/transportation of food and beverages consumed at the conference venue; and *Accommodation*, the conference-related overnight stays of delegates and other stakeholders. For virtual conferences, instead, the impactful activities include: *Conference Organization*, with the same meaning as for in-person conferences, even if in this setting most activities are virtualized; and *Virtual Experience*, the life-cycle use of electronic devices to connect participants during and after the conference.

For each conference, data was collected for all the above stages from multiple sources – mostly primary data from organizers and secondary data from the literature. They were then implemented in *SimaPro*^{TM}, a renowned LCA software which allows converting process data into a desired set of environmental impact indicators and gauging the contribution of each life cycle stage, thus identifying the main ecological hotspots. Hence, we evaluated the overall conference impacts across many indicators (e.g., carbon and water footprints, emissions of toxic substances, land use, etc.) and the stage contributions within each. For synthesis, we focus here on the carbon footprint, the indicator that most people are familiar with. Carbon footprint was found to be a good proxy for the overall environmental impacts when the system is dominated by travel activities, as is the case with academic conferences (Astudillo and AzariJafari 2018).

Figure 1 reports the per-capita carbon footprint of the analyzed in-person (1.a) and virtual (1.b) conferences, displaying their breakdown by conference stage, and providing some benchmarks to help understand their magnitude. One thing that stands out is the scale of impact on the y-axis. For in-person conferences, the average emissions are 941.9 kgs CO_{2eq} per person, while for virtual conferences the same amounts to 1.0 kgs – almost three orders of magnitude of difference. As the benchmarks show, that is similar to the difference between driving an average-technology car for a few kilometers – say to go to the supermarket and buy some groceries – to the cumulative emissions that an average citizen in many developing countries emits over an entire year (Our World in Data, UK GOV 2022).

Looking at impact contributions within in-person conferences, *Stakeholder Transport* dominates GHG emissions (above 90% average share), followed by *Venue* and *Accommodation* (3.1% and 2.8% average shares, respectively). *Conference Organization*, *Exhibits*, and *Catering* are almost negligible, even though the wider set of indicator results shows that they are significant for other impact categories, such as water consumption and land use. In general, stakeholder travel drives the overall impact of in-person formats. For virtual formats, *Virtual Experience* is associated with the largest impact contribution (63.5% average share of GHG emissions), but *Conference Organization* also plays a significant role.

Figure 1. Per-capita carbon footprint breakdown by conference stage for (1.a) in-person conferences, (1.b) virtual conferences



When focusing on the different societies, some significant drivers of variation emerge. Within in-person conferences, POMS and INFORMS display a greater travel footprint than EurOMA, leading to greater overall emissions. The reason is the different average distance traveled by delegates, which in turn is a consequence of the interplay between the membership spatial distribution and the conference location. EurOMA typically has a predominant share of medium-haul air travelers from Europe (between 1500 km and 4000 km to the conference location), with an average distance of around 3410 km. POMS and INFORMS, instead, have a greater share of long-haul air travelers (>4000 km to the conference location), with average distances around 4750 and 4660 km, respectively. POMS has a greater share of inter-continental travelers than INFORMS, which explains the greater average value. Going beyond transportation, a significant difference can be spotted in the venue footprint (color red in Figure 1.a), which is much lower for INFORMS than other conferences – e.g., 2.9 kg CO_{2eq} per person versus 56 kg for POMS. This is related to the different energy sources and supply systems employed to generate the heat consumed at the venue. INFORMS 2019, indeed, was held in Seattle downtown, where most buildings are supplied by a district heating system fueled by wood waste. From a carbon perspective, this system has a lower impact than traditional gas boilers used in most convention centers, making this aspect a venue selection criterion worth considering. A final minor difference concerns the catering footprint, which is surprisingly greater for EurOMA despite its organizers having purposefully offered a vegetarian menu. This is related to the established norm in European conferences of including most meals within registration fees – 4 meals per registrant at EurOMA – as opposed to American conferences where just a few receptions/luncheons are provided – 1.5 and 0.5 meals per registrant at POMS and INFORMS, respectively. Incorporating the food consumed outside the event would likely reverse this outcome (Neugebauer et al. 2020).

As to virtual conferences, the main difference concerns the growing footprint of the virtual experience stage moving from INFORMS to EurOMA. Virtual platform analytics revealed this is due to the different time attendees spent online connected to the event platform and meeting apps used (e.g., Zoom). EurOMA attendees were connected on average for ~8.9 h per person, while INFORMS ones for ~2.8 h (granular data was not available for POMS). This may suggest reducing online activity to decrease impacts. However, as one of the primary objectives of a conference is to maximize the interaction, this would not make sense from a scientific point of view, especially given the inherent low impact of virtual conferences.

Considering the above results, the choice seems obvious enough from an environmental perspective. If we are serious about decarbonizing our activities and leading by example in the transition needed to reduce climate change impact, then virtual conferences seem to be the way to go. But is it really an obvious choice? What is the downside? Is there a utility loss associated with the savings on the environmental dimension? Motivated by these questions, we next set out to measure how a shift to virtual conference formats affects the value academic conferences provide to our societies.

3. The societal perceived value of conferences

Perceived value can be defined in many ways. One of the most cited definitions is that of Zeithaml (1988, p. 14), who defines it as "*the consumer's overall assessment of the utility of a product based on perceptions of what is received and what is given*". It thus represents a cognitive trade-off between *benefits* – what is received – and *costs* – what is given (Monroe 1990). This definition has been widely operationalized in the event management literature and the factors driving the

perceived value of several event types – such as festivals or sporting events – have already been studied (e.g., Akhoondnejad 2016, Aşan et al. 2020). In the context of academic conferences, a few studies have investigated the motivations that drive scholars to attend them (Fellermann et al. 2019, Hauss 2021, Rowe 2018), but a thorough empirical evaluation of the value of a conference and the factors driving it is not available to the best of our knowledge.

To assess how the perceived value of a conference changes when moving from in-person to virtual formats, we need to build a proper measurement instrument. To this end, and in line with the fragmented literature on academic conferences, we followed a mixed-methods approach (Tashakkori and Creswell 2007). For brevity, a detailed description of all methodological steps for this construction is provided in Appendix A, while an overview follows. In summary, we first ran multiple semi-structured interviews/focus groups to inductively identify the factors that affect the value of a conference (either in-person or virtual), for which the interview protocol is available in Appendix B. The content analysis of interview data allowed for the identification of many value factors, which, in accordance with the above definition, were clustered into *conference benefits* and *costs*. Then, we designed a questionnaire to measure the perceptions of the identified benefits and costs for both in-person and virtual conferences, together with a question on the overall perceived value of the two formats. The questionnaire further included questions to capture several demographic and other factors that emerged in the interviews as potentially relevant variables affecting the valuation of conference formats. After a pilot test of the questionnaire, the final instrument was administered to the members of supporting societies. A copy of the questionnaire is reported in Appendix C, while the resulting dataset is available from the authors (submitted in a Supplemental file linked to this article and will be made available for public use along with the article). The survey data was subject to multiple statistical analyses, including an exploratory data analysis, analyses of variance, and regression analyses, whose outcomes were interpreted together with the input coming from the interviews, literature, and comments written in the survey – we indeed let respondents provide their feedback through an open-ended question.

In the following, the findings are organized in three sections, addressing (1) the value factors that positively or negatively affect the value derived from attending in-person and virtual conferences (i.e., the conference benefits and costs), (2) the demographics and other antecedents that can influence conference format valuation, and (3) the overall value of the two formats, along with the identification of the most significant drivers among previous variables.

3.1 Benefits and costs of in-person and virtual conferences

To detect the benefits and costs of different conference formats, we interviewed 15 experienced officers and/or fellows of the supporting societies (details on the sample are provided in Table A.1). Table 2 lists the value factors which were inductively identified through the ‘open coding’ of their responses (Corbin and Strauss 2014). As can be observed, conferences provide a large set of benefits/services to attendees, ranging from career-related ones, such as research training and job market, to private benefits, such as tourism and leisure. To enjoy them, however, attendees incur several costs/sacrifices, ranging from tangible ones, such as economic and environmental costs, to intangible ones, such as the risk of intellectual property infringement. Table 2 further indicates potential items – also inductively derived – to measure the identified value factors (*Description/Operationalization*), the frequency with which they were mentioned in the interviews/focus groups (*Frequency Count*), and potential segments of the audience – e.g., junior scholars – for whom they are expected to be more relevant (*Expected Group Differences*).

Table 2. Conference benefits and costs

	Factor	Description/Operationalization	Frequency Count [a]	Expected Group Differences
Conference Benefits	*Networking* [b]	Establishing collaborations with scholars/ practitioners with similar interests	8	
	Flexibility [b] (only virtual)	Flexibility in attending where and when I want	7	More relevant for scholars from developing countries, with low budgets, care responsibilities, disabilities, or visa requirements
	Receiving Feedback [b]	Receiving feedback to improve my research/work	6	More relevant for junior scholars
	Socialization [b]	Socializing with new or old friends	6	
	Tourism & Leisure [b] (only in-person)	Visiting attractive places/cultures *or* Combining a business trip with a vacation	6	
	Getting Updated [b]	Discovering recent developments in the field *or* Getting ideas for my research	5	
	Job Market [b]	Interviewing/being interviewed for job positions *or* Exchanging career-relevant information	5	More relevant for scholars in the market
	Meeting The Top [b]	Meeting renowned people in the field	5	
	Research Training [b]	Learning about research methods and academic norms	4	More relevant for junior scholars
	Focus Panels	Having a platform to debate topics of interest	3	
	Visibility & Awards	Increasing my visibility in the community *or* Getting recognition/awards for my work	3	
	Collaborations Advancement	Meeting co-authors to work on current projects	2	
	Exhibits	Discovering new products for my work or private life	2	
	Extraordinary Experiences	Escaping/disconnecting from daily routines	2	
	Internationalization	Experiencing how academia and industry work in other parts of the world (e.g., company visits)	2	More relevant for junior scholars
	Mentoring	Supporting other scholars with their research	2	More relevant for senior scholars
	CV Enhancement	Adding conference attendance to my academic CV	0 [c]	More relevant for junior scholars
	Fundraising	Attracting funds from the private sector to finance my research activities	0 [c]	
	Publication	Publishing my research in the conference proceedings or special issues in affiliated journals	0 [c]	More relevant for junior scholars
Conference Costs	*Accessibility* [b]	Difficulty of traveling (in-person) or attending virtually (virtual)	8	More relevant for scholars from developing countries, with care responsibilities, disabilities, visa requirements, poor internet access, or unfamiliarity with new technologies
	Economic Cost [b]	Costs related to my attendance (registration, transport, accommodation, and meals)	8	More relevant for junior scholars, from developing countries, or with low budget
	IP Infringement [b]	Risk of people copying the ideas I present at the conference	6	
	Time Cost [b]	Time taken away from other activities/responsibilities	6	More relevant for senior scholars, or with care responsibilities
	Environmental Cost [b]	Environmental impact associated with conference attendance	4	
	Isolation	Sense of isolation from not being able to integrate into the community	3	More relevant for junior scholars, or introverted
	Physical Health Cost [b]	Risk of impaired health due to attendance (e.g., infections for in-person, online fatigue for virtual)	3	More relevant for scholars with disabilities
	Mental Health Cost	Anxiety associated with the conference experience	2	More relevant for introverted scholars, or not native speakers
	Discrimination & Harassment [b]	Risk of discrimination or harassment occurring during the conference	1	More relevant for female scholars, or from underrepresented groups

[a] number of interviews/focus groups in which the factors were mentioned (out of 9 interviews/focus groups).
[b] factors included in the survey.
[c] factors derived from the literature (Hauss 2021, Rowe 2018).

Interview findings served as the basis to craft the survey questionnaire, where we made respondents rate the identified value factors – operationalized through the reported items – for both in-person and virtual conference formats. Given the goal of maximizing the response rate and reducing fatigue bias, we included only some of the value factors in the questionnaire, selected based on the frequency count plus a few based on the judgment call of society leaders (highlighted in Table 2). The administration to societies' members lasted for around one month between January and February 2022, leading to 555 responses. As detailed in Appendix A, the followed mixed-method approach was opportunistic but sufficiently robust and reliable in line with the exploratory nature of the research. Table 3 reports the general information on the sample, offering a snapshot of the surveyed OM/OR community, while Figure 2 displays the mean values of the selected benefits and costs for in-person and virtual conferences, as measured in the survey on a scale from 1 to 5. These are ordered based on the growing gap between the two formats.

Table 3. General information of the sample

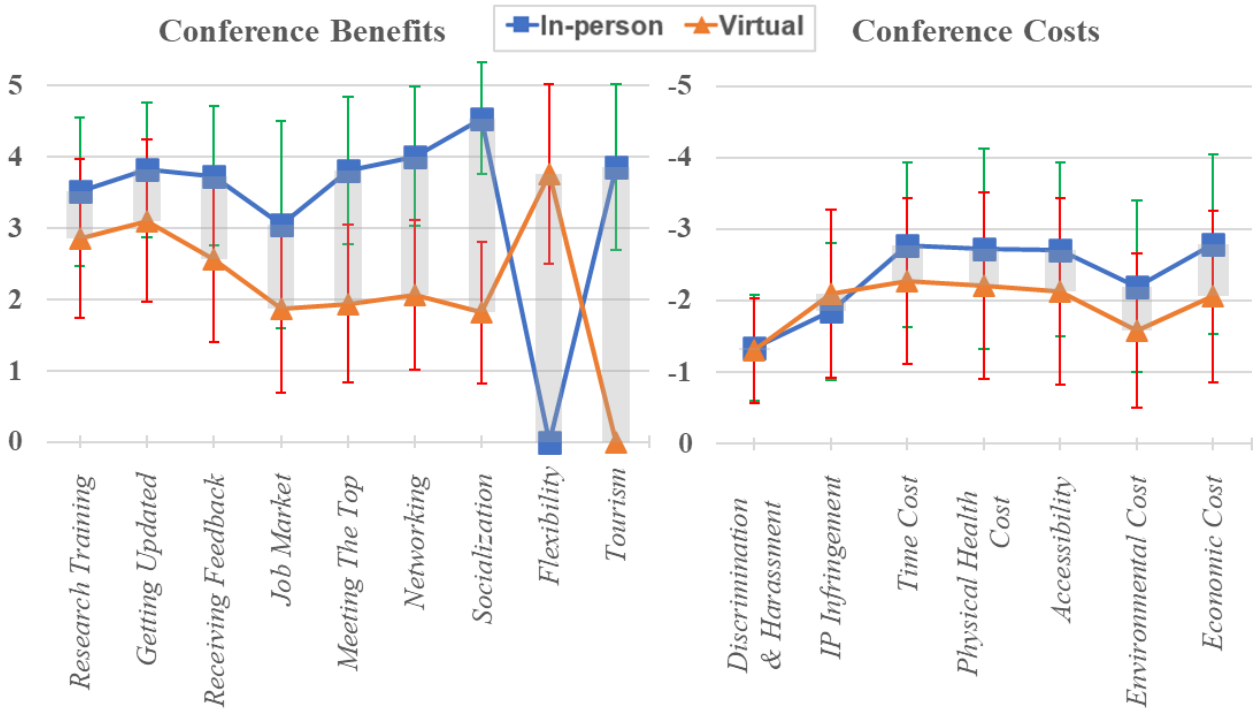
Variable		**(N=555)**	**%**	**Variable**		**(N=555)**	**%**
Age	*18-34*		28.8	Society Affiliation	*INFORMS*		72.1
	35-54		51.0		*MSOM*		55.0
	55+		19.6		*POMS*		60.5
Gender	*Female*		31.5		*EurOMA*		24.0
	Male		65.9	Format experience	*In-person*		93.9
	Prefer not to say		2.0		*Virtual*		90.8
Continent	*Asia*		8.8		*Hybrid (I-P attendance)*		23.6
	Europe		27.7		*Hybrid (V attendance)*		50.3
	North America		59.8	Limiting Conditions –	*Low Budget*		45.9
	Other		3.1	in-person attendance	*Care Responsibilities*		30.3
Professional	*PhD Student*		17.3		*Disabilities*		1.8
Status	*Post Doc*		3.1		*Bureaucratic Requirements*		28.6
	Tenure Track Professor		24.1	Limiting Conditions –	*Low Budget*		13.3
	Tenured Professor		49.2	virtual attendance	*Internet Access*		6.8
	Other Role in Academia		2.3		*Tech Unfamiliarity*		3.2
	Industry		3.1		*Poor Virtual Design*		62.9

In general, in-person conferences outperform the virtual ones when considering the benefits. Respondents rated *Socialization*, *Networking*, and *Tourism* as the greatest benefits of in-person conferences. These are also the factors for which the largest gap between in-person and virtual formats exists, with no surprise for tourism, while socialization and networking are likely the factors for which the in-person interaction is most needed and most difficult to replace in a virtual setting. For other benefits though, the gap between the two formats is smaller – e.g., *Research Training*, *Getting Updated*, and *Receiving Feedback* – indicating that virtual conferences work quite well in providing these values/services. The greatest benefit of virtual conferences, and the only factor with a mean value close to those of the above listed high-ranking in-person benefits, is *Flexibility* – i.e., the possibility of attending wherever and whenever you like – the true added value of virtual.

Looking at the costs, the situation is reversed. Here, in-person conferences perform much worse, presenting higher perceived costs than virtual conferences, even if the gaps are relatively small. There is only one cost factor that is greater for the virtual setting, i.e., *IP Infringement*. This reflects a concern that emerged in the interviews that virtual conferences may increase the possibility for malicious users to copy the ideas/work of other attendees (e.g., through the availability of recorded

presentations). In both formats, no other cost is significantly greater than the others, with multiple factors presenting similar mean values, such as *Economic Cost*, *Time Cost*, *Physical Health Cost*, and *Accessibility*.

Figure 2. Pattern for the perceived benefits and costs of in-person and virtual conferences (on a scale of 1-5)



3.2 Antecedents to conference valuation

The last column in Table 2 indicates several antecedents which we identified in the literature and interview data as potentially affecting the valuation of conference formats, namely age, gender, country/continent, professional status, society affiliation, previous experience with different formats, and the presence of some conditions limiting the ability to attend conferences [2]. For instance, it is well known that scholars in different career stages look for different values in conferences (Hauss 2021) and that people coming from different regions of the world incur different costs to attend them (Arend and Bruijns 2019). These variables are all attendee-related or individual antecedents, which we measured in the survey (Table 3). Interestingly, around one person out of two claimed to have low budget issues when it comes to attending in-person conferences, and around one out of three has care responsibilities or bureaucratic issues.

There are then conference-related or context antecedents, such as the conference size, time, location, thematic and geographic scope. For instance, the networking value may be different for a conference attracting an international audience compared to one with a national scope, or the perceived time cost may be different in the Fall when there are more teaching requirements as opposed to the Summer. On the one hand, our survey targeted only the members of partner societies, meaning that our findings are representative of international conferences in the OM/OR field. On the other hand, questions in the survey were framed with reference to generic in-person and virtual conferences, thus averaging the effect of other context antecedents.

The values of perceived benefits and costs reported in Figure 2 represent the average pattern across the whole sample. As visible from the large standard deviations, respondents were not monolithic in their perceptions. As predicted, some significant differences emerge when segmenting the sample based on the antecedents in Table 3. Appendix D includes a set of graphs displaying significant group differences in the benefits or costs of in-person and virtual conferences. Regarding ***Gender*** differences (Figure D.1), female attendees reported a greater *Time* and *Health Cost* for in-person than males and rated almost all virtual benefits as higher. Regarding ***Professional Status*** (Figure D.2), PhD students valued some benefits such as *Receiving Feedback* and *Meeting the Top* more than tenure track and tenured professors in both formats, but they also rated several costs as higher, particularly *Economic Cost* for in-person and *IP Infringement* for virtual. Tenured professors, instead, seem to prioritize the *Socialization* benefit of in-person and rated basically all the benefits of virtual as lower – the pattern for tenure track professors lies in-between. As to ***Continent*** differences (Figure D.3), members from Asia assigned greater values to the career-related benefits of in-person, such as *Receiving Feedback* and *Getting Updated*, but they also rated several in-person costs as higher. People from the southern hemisphere instead reported a greater *Economic Cost* for in-person and, quite surprisingly, rated all the costs of virtual as higher, especially *Accessibility* – likely for time zone issues or the lack of good internet access. Regarding ***Society Affiliation*** (Figure D.4), EurOMA members rated the *Job Market* benefit of both formats as significantly lower than the members of US societies. The academic market works indeed differently in Europe, and it is not common to organize large career fairs within conferences. They also rated the *Economic* and *Environmental Costs* of in-person as higher, probably due to the lower budget availability and greater environmental consciousness in Europe. Lastly, people with some ***Limiting Conditions*** affecting attendance displayed peculiar patterns (Figure D.5), such as people with disabilities and care responsibilities, who assigned greater scores to *Health Cost*, *Accessibility*, and *Time Cost* of in-person, or people not familiar with new technologies, who assigned a greater score to *Accessibility* of virtual, or people with low budget, who assigned a greater score to *Economic Cost* in both formats.

3.3 Overall value and main value drivers

The overall perceived value of the two formats, which we measured in the survey on a scale from 0 to 10, showed a mean value of 7.9 for in-person conferences and 4.0 for virtual ones. While respondents were largely in agreement with the value of in-person conferences (st. dev. $\approx$ 1.8), the answers for virtual conferences were more spread (st. dev. $\approx$ 2.5), indicating a relatively weaker consensus. It is nevertheless important to reiterate that significant differences can be found when segmenting the sample, with some groups valuing virtual conferences more – e.g., females, PhD students, people from Asia, EurOMA members, and people with disabilities and care responsibilities. In particular, the last two groups also assigned a significantly lower value to in-person conferences.

So far, we provided a long list of value factors and other antecedents potentially affecting the valuation of in-person and virtual conferences. However, arguably, not all are significant in explaining the overall perceived value of the two formats, as measured above. To identify the most significant value drivers, we conducted a multiple linear regression analysis linking the overall perceived value of a conference reported by the participants to these drivers. Table 4 reports the findings of two main effect models, one for in-person and one for virtual conferences, including the full list of main effects – value factors and antecedents/control variables. We chose these models via a rigorous selection process (detailed in Appendix E), considering also ease of

interpretation. Despite their simplicity, the findings proved to be robust to several statistical manipulations. For instance, we also specified models considering interaction effects, which we expected to be relevant based on the group differences highlighted above. Particularly, given the large interaction space, we ran different feature selection algorithms, including *Stability Selection with the Lasso* (Meinshausen and Bühlmann 2010, Tibshirani 1996) and *Revisiting Alpha-Investing* (Johnson and Stine 2019). Eventually, these procedures led to the selection of a few interaction effects which helped explain some variation in the data, but they did not alter the main findings from the main effect analyses reported here. More details on robustness checks are also provided in Appendix E.

These detailed statistical analyses suggest that the perceived value of in-person conferences is mostly driven by *Socialization*. Other significant benefits are *Networking* and *Receiving Feedback*, while on the costs side – among all factors with a negative coefficient – *Accessibility* plays the greatest role, along with the *Environmental Cost*. As to demographic and other control variables, an affiliation with *EurOMA* seems to exert a large positive effect on the valuation. The value of virtual conferences, instead, is mostly driven by *Flexibility*. Several other value factors play a significant role though, which include *Networking*, *Research Training*, and *Getting Updated* on the benefits side, and *Environmental Cost* and *Time Cost* on the costs side. *Environmental Cost*, particularly, is the only cost with a positive coefficient. A possible explanation is that people assigning higher scores to it are likely environmentally conscious people, who overall value the virtual format more due to its inherent low impact. As to control variables, the residence in Asia exerts a significant positive effect, while previous experience with in-person conferences and the perception of poor virtual design negatively impact virtual conference valuation.

4. Discussion

To the best of our knowledge, the results reported above offer the first comprehensive investigation into the trade-off inherent in current virtualization strategies between the environmental sustainability and societal perceived value of academic conferences. This is best visualized in Figure 3, which synthesizes the main findings from the environmental and value analyses through a two-dimensional chart, with on the x-axis the per-capita carbon footprint of the OM/OR conferences and on the y-axis the overall perceived value assigned by society members to the two formats. In the following, we outline several recommendations to help OM/OR societies move to the upper-left corner of the chart, which indicates conferences delivering high utility and causing low environmental impacts – current in-person and virtual formats are both far away from that target. Subsequently, we propose an ad-hoc research agenda for OM/OR scholars to support this task.

Table 4. Full linear models of main effects for the perceived value of in-person and virtual conferences

	Model for Perceived Value of In-person		**Model for Perceived Value of Virtual**	
Variable	*Estimate*	*St. Error*	*Estimate*	*St. Error*
(Intercept)	4.723***	0.690	0.655	0.660
Receiving Feedback	0.205*	0.080	0.177	0.091
Networking	0.233**	0.081	0.287**	0.107
Getting Updated	0.039	0.092	0.282**	0.108
Meeting The Top	0.128	0.076	0.203*	0.094
Research Training	0.116	0.082	0.294**	0.106
Job Market	0.008	0.047	-0.022	0.074
Socialization	0.327***	0.094	0.180	0.105
Tourism	0.096	0.061		
Flexibility			0.379***	0.077
Economic Cost	-0.078	0.067	0.003	0.073
Time Cost	-0.088	0.068	-0.222**	0.075
Accessibility	-0.201**	0.070	-0.171*	0.068
IP Infringement	-0.017	0.073	-0.109	0.070
Environmental Cost	-0.147*	0.062	0.240**	0.079
Physical Health Cost	-0.027	0.053	-0.014	0.064
Discrimination & Harassment	-0.113	0.096	0.140	0.120
Gender_Male	-0.048	0.136	-0.172	0.164
Gender_Prefer not to say	-0.049	0.425	-0.334	0.520
Continent_Asia	0.161	0.257	0.762*	0.301
Continent_North America	0.086	0.185	-0.054	0.214
Continent_Other	0.141	0.374	0.174	0.452
Prof. Status_Industry	-0.028	0.319	-0.131	0.387
Prof. Status_Academia Other	-0.179	0.382	0.325	0.458
Prof. Status_Tenured Prof.	-0.067	0.201	-0.317	0.237
Prof. Status_Tenure Track Prof.	-0.286	0.207	-0.060	0.250
Job seeker	0.023	0.203	-0.026	0.245
US Society	0.170	0.221	-0.033	0.266
EurOMA	0.632***	0.187	0.180	0.226
Other Society	0.054	0.193	0.576*	0.239
In-person	0.127	0.284	-0.998**	0.358
Virtual	0.042	0.227	0.312	0.276
Hybrid (I-P Attendance)	-0.002	0.150	-0.020	0.179
Hybrid (V Attendance)	0.070	0.129	0.391*	0.158
Low Budget	-0.276	0.143	-0.075	0.238
Care Responsibilities	-0.265	0.151		
Disabilities	-0.367	0.456		
Bureaucratic Requirements	0.098	0.145		
Internet Access			-0.149	0.309
Tech Unfamiliarity			0.166	0.457
Poor Virtual Design			-0.393*	0.168
Other Condition	-0.345	0.183	-0.595**	0.197
R^2	0.355		0.552	
F statistic	8.866 on 37 and 491 DF		18.61 on 37 and 491 DF	

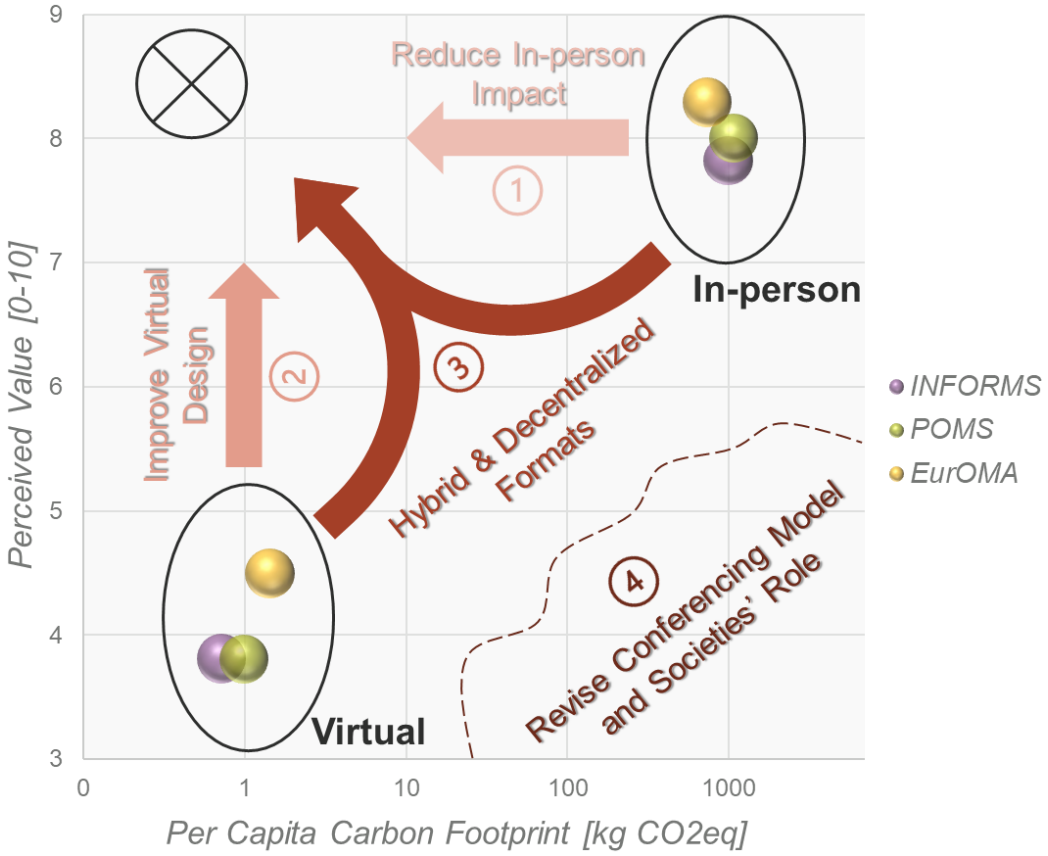
* Significant at the 0.05 level, ** Significant at the 0.01 level, *** Significant at the 0.001 level.

4.1 Recommendations for OM/OR Societies

Our analysis so far, allowed us to identify four main strategies to overcome the trade-off between the environmental impacts and perceived value of our conferences. These are indicated in Figure

3 and ordered based on the level of disruption to the established conferencing model. Strategy 1 (*Reduce In-person Impact*) concerns the mitigation of the environmental impacts of current in-person formats. To this end, many green practices have been suggested in the literature, such as the selection of a central location (Jäckle 2019) and green venue (Cavallin Toscani et al. 2022), the incentive to shift to landbound transportation for closer air travelers (van Ewijk and Hoekman 2021), the establishment of partnerships with green hotels and service providers (Neugebauer et al. 2020), the dematerialization and digitalization of conference materials (Hischier and Hilty 2002), the provision of vegetarian and local food (Astudillo and AzariJafari 2018), the reduction of food waste (Monteiro et al. 2020), and the offsetting of unavoidable carbon emissions (Lester 2007). Among these, only the first option has the potential to significantly reduce GHG emissions – up to 12% according to Klöwer et al. (2020). The others, though, despite leading to limited savings (less than 1-2% according to our data), have the potential to induce a pro-environmental behavior change in delegates and therefore attain a wider indirect environmental benefit (Mair 2014). Regarding carbon offsets, several studies have expressed skepticism about their use, indicating them as a last resort after the implementation of all possible mitigation options (Kuper 2019, Lester 2007).

Figure 3. Environmental impacts and perceived value of current in-person and virtual OM/OR conferences



Strategy 2 (*Improve Virtual Design*) involves the optimization of the utility/experience of current virtual formats. As opposed to in-person conferences that have existed for decades, virtual conferences have only recently been widely tested, and organizers have mostly designed them

directly translating the traditional format used for in-person to the virtual space. This may arguably not be the best way to design them and leverage their full potential – around 63% of respondents indicated poor design as a condition limiting virtual attendance. With the experience coming from Covid-driven experimentation, several guidelines have started to appear (e.g., Fulcher et al. 2020, Sarabipour et al. 2021). Some frequent suggestions include the accurate planning for time zone differences to avoid inconveniences for intercontinental attendees (Skiles et al. 2021); the relaxation of the schedule over longer periods to tackle online fatigue and mitigate distractions from other responsibilities (Etzion et al. 2022); the preference for synchronous over asynchronous modes of communication to keep a high engagement, still making the recordings available to facilitate people unable to attend (Klöwer et al. 2020); and the ex-ante planning of interactions and use of ad-hoc apps (e.g., Zoom breakout rooms, Gather, Slack) to replace/augment the serendipitous encounters happening in in-person formats (Fulcher et al. 2020). The relevance of these issues and the efficacy of associated solutions are confirmed by our data. For instance, EurOMA members assigned a significantly greater score to virtual formats than INFORMS and POMS members and stayed connected longer during the conference: ≈9 h per person at EurOMA versus ≈3 h at INFORMS, despite the conference lasting half as long (3 days versus 6). Comments provided by respondents suggest that this was due to the different modes of communication, as EurOMA was mostly based on live presentations (synchronous mode) and INFORMS and POMS on pre-recorded presentations (asynchronous mode), with the latter harshly criticized in the comments. Arguably, the size could also play a role, with larger-size conferences making the attendance feel more impersonal, but we believe that would apply to in-person formats too.

Beyond experience design, another issue for virtual conferences regards the choice of registration fees. Several respondents indicated a misalignment between the prices of the studied OM/OR conferences and their value proposition. That, combined with a general prejudice against virtual interactions (especially for higher age groups), likely explains the reduction in the number of delegates (see Table 1). Notably, for INFORMS and EurOMA, not only the overall audience decreased in the virtual setting (-20-40%), but also the share of delegates from other continents (-5% for both, while for POMS +2%). This contradicts the evidence from other fields, where significant increases in the number and diversity of attendees were achieved, leading to the celebration of the virtual format as a solution that fosters accessibility for underrepresented groups and tackles the lack of inclusion often criticized in in-person formats (Etzion et al. 2022, Skiles et al. 2021). Apparently, this outcome is achieved only when the price point is set low enough to match delegates' expectations and availabilities. As with PhD students, OM/OR societies may further differentiate prices or design ad-hoc incentives to facilitate attendance from underrepresented groups in virtual settings.

It is also important to note that even if we were able to implement all the solutions above, strategies 1 and 2 would hardly take us close to the target position in Figure 3. On one hand, current transportation technologies – especially air travel – lead to massive environmental impacts which are hard to abate. On the other hand, current videoconferencing technologies are unable to satisfactorily replace in-person interactions and provide those socialization and networking benefits that drive the value of academic conferences. New green transportation solutions and virtual/augmented reality technologies may disrupt the landscape in the coming decades. Notwithstanding, given the tight decarbonization path ahead, we cannot afford to wait for these innovations to come. A possible solution for the short-term, therefore, is represented by strategy 3 (*Hybrid & Decentralized Formats*). Hybrid conferences allow attendees to join in-person or remotely, thus leveraging the best of both formats (Langin 2021). Decentralized conferences

instead are run in interconnected hubs in multiple locations, with attendees traveling to the closest hub to reduce long-distance travel (Fraser et al. 2017). These solutions are not mutually exclusive but can be combined (Tao et al. 2021). They are shown to lead to significant environmental savings, up to 80% emission reduction in ideal scenarios (van Ewijk and Hoekman 2021). On the flip side, they present significant planning challenges (Fraser et al. 2017), as confirmed by some of our interviewees involved in the organization of the INFORMS 2021 hybrid conference. Furthermore, their value profile remains unknown, and they likely create different classes of attendees (in-person versus virtual, bigger-hub versus smaller-hub) who derive different values from attendance. OM/OR societies may collaborate to test these formats. For instance, instead of having every society running its decentralized event, societies with different geographic scopes may organize their usual conferences simultaneously and interconnect them to create a global OM/OR event (Klöwer et al. 2020).

All previous strategies share a common perspective adopted in conference literature, that involves the focus on and optimization of a single conference. A more radical type of strategy – i.e., strategy 4 (*Revise Conferencing Model and Societies' Role*) – asks the very question of whether we need a conference in the first place. After all, the core role of academic societies is not to organize conferences but to meet their members' needs, such as the need to socialize, network, and receive feedback. Conferences bundle a set of services together, including technical sessions, social gatherings, career fairs, etc., to meet many of those needs aggregately and efficiently. These services, however, could also be disaggregated and provided in more tailored combinations (e.g., seminar series, PhD summer schools) and in different formats of communication (i.e., in-person versus virtual), which, as shown in this research, meet various needs differently. Hence, the major question for our societies need not be what the best format for their annual conference(s) is, but what the real needs of their members are and, consequently, what the optimal number, format, size, and frequency of conferences or other activities are to meet those needs while minimizing the overall environmental impacts. This kind of portfolio perspective is in line with the very meaning of sustainability, which concerns the satisfaction of people's needs while remaining within ecological boundaries and calls for research by our community to leverage our operational expertise in addressing these questions.

4.2 Agenda for OM/OR Research

The analysis presented so far reveals many crucial open questions for researchers to help identify and implement different strategies, and we strongly believe that the OM/OR field is well-positioned to address those. To this end, we indicate three layers of questions for OM/OR research to tackle.

The first layer regards defining the *Objective Function* of an academic conference. As shown above, conferences are multidimensional phenomena. In this research, we considered the value for attendees and environmental impacts as two crucial dimensions to optimize, but many others may exist. Examples include the research advancement in the field, the financial return for academic societies [3], the image return for sponsoring universities/companies, or the spillover economic effect for local communities (Hansen and Pedersen 2018). Future research may direct efforts to map all possible objectives of an academic conference and find proper ways to assess them, through ad-hoc proxies and measurement protocols. As an example, bibliometric indicators are often used to measure the research impact of conferences (Bedogni et al. 2022). The next step would then be to aggregate selected indicators into a global objective function through multi-criteria kind of analyses. Well-established holistic frameworks, such as the triple bottom line

framework (Elkington 1997), may prove useful to reduce the large number of criteria into a condensed hierarchy of dimensions. Notably, this kind of inquiry may help investigate the trade-offs inherent in different conference typologies (small versus large, focused versus generalist, national versus international) and identify which works best with different sets of objectives.

The second layer descends from the former and regards *Location Selection* for in-person formats. A number of previous studies have proposed simple optimization models derived from the facility location literature to select conference locations to minimize the distances traveled by delegates and consequently GHG emissions (e.g., Tao et al. 2021). These models can be extended to include some of the objectives cited above and thus turn the problem into a multi-objective optimization one. On the same front, empirical analyses can also be conducted to analyze the effect of location attributes on some target dimensions. For instance, Bedogni et al. (2022) recently discovered a strong correlation between the "touristicity" of a location and the research impact of conferences held in that location. Such analyses would likely require the creation of geo-referenced datasets, which, in turn, could be useful for other sectors of the event industry and other research purposes.

The third layer regards *Conference (Re)design*, especially for virtual/hybrid formats. To support the design of future conferences, OM/OR researchers could investigate the preferences and behaviors of conference delegates and incorporate them into multi-dimensional optimization problems. Virtual conferences provide a suitable setting to run field experiments as well and this advantage has not been leveraged so far. A possible evolution of the value analysis included in this work may be a discrete choice analysis to predict the choice of whether or not to attend a conference (alternatively, a specific session/gathering) based on several attributes of the conference and the individual – we identified many relevant attributes. This would help forecast delegates' choices for different conference formats and configurations. Apart from choice modeling approaches, other response variables may be considered to optimize conference design, such as the level of engagement or the number of new connections established. Many proxies could be used to operationalize the value factors identified in this research in a more objective way. To this end, we suggest looking at studies that have tackled similar challenges related to virtualization strategies in other settings (e.g., smart working, virtual/hybrid learning, etc.). In addition, in other fields there may already be well-established operational definitions of constructs such as networking and socialization that could be adapted to the context of academic conferences (e.g., Forret and Dougherty 2001).

In closing, we note that there may be many other important research questions that we may have missed and we, therefore, invite all interested colleagues to delve into the topic and join the discussion. To support future research, and in line with our objective to leverage our community expertise in advancing sustainability research, the data we have collected during the project will be made public.

5. Conclusions

This article aims to initiate a serious debate and a research track within the OM/OR community about the future of our conferences. To this end, we leveraged the Covid-driven transition to virtual conferences to carry out a comparison of in-person and virtual formats based on multiple dimensions. We first assessed the environmental footprint of several international OM/OR conferences in their most recent in-person and virtual versions through a comprehensive LCA. We then evaluated the societal perceived value of the two formats through a global survey administered to the members of partner societies. The environmental analysis highlighted a massive impact

reduction moving from in-person to virtual formats – considering GHG emissions, from 941.9 to 1.0 kg CO_{2eq} per person on average. The value analysis revealed, instead, a significant utility loss, with the overall perceived value going from an average score of 7.9 for in-person to 4.0 for virtual (almost halved). When considering the benefits and costs that drive conference valuation, virtual formats display some merits, such as lower perceived costs (economic, environmental, health, and accessibility) and the added value of flexibility. These factors arguably explain why some sub-groups of the OM/OR community more affected by them assigned greater scores to virtual formats, including female attendees, younger generations, and people with care responsibilities or disabilities. Nevertheless, a majority of respondents were aligned on the greater value of in-person formats and assigned a significantly greater score to all benefits of in-person as compared to those of virtual, with a particularly large gap for the socialization and networking benefits. Detailed statistical analyses identified these as the most important value drivers for in-person conferences, while for virtual, flexibility emerged as the most important one.

We nevertheless note that care must be exercised when interpreting and generalizing the results above for several reasons. The first regards the limited number and variety of conferences analyzed, which were constrained by the resource requirements of LCA. Other events organized by supporting societies or conferences organized by other OM/OR societies may have a different environmental profile, even though this is unlikely to change our conclusions on the huge saving associated with virtual formats. On the value side as well, even if the EurOMA case allowed us to appreciate the variation related to conferences with a smaller size and different geographic scope, we did not capture the full spectrum of possible conferences in terms of size, seasonality, location, thematic and geographic scope. The effect of these factors on the value profile remains therefore to be investigated. Another limitation to the assessment of the perceived value of virtual conferences is the potential bias coming from the "lockdown effect". People may indeed value virtual formats differently in a scenario where they are not a forced option but can be chosen among other alternatives. That, combined with the expected improvements in virtual conference designs and technologies, would probably require a re-assessment in future years. In-person and virtual formats may turn out to appeal to different membership segments and, therefore, could be treated as complements instead of alternatives.

This consideration takes us back to the question cited in the title, whose answer, instead of either in-person or virtual, is likely in-person *and* virtual. This is in line with the agenda of improvement strategies that we elaborated for OM/OR societies. The first two strategies involve the separate optimization of current in-person and virtual formats, for which we drafted a list of best practices/recommendations. The third regards the testing of new formats, i.e., hybrid and decentralized conferences, that combine previous formats and thus allow leveraging their benefits and overcoming some of their limitations. Lastly, the fourth strategy involves the design of a global portfolio of conferences and other activities in multiple formats to meet the different needs of members – which remain to be assessed as a top priority – while minimizing the overall environmental impacts. To support these strategies, the need for a specific agenda for research is clear, possibly focused on three layers of questions addressing: (1) what the objective function of academic conferences is, (2) what the suitable criteria/methods for the optimal conference location selection are, and (3) what delegate preferences and behaviors imply for the (re)design of conference processes.

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Endnotes

[1] A CO_2 equivalent (CO_{2eq}) is a metric measure employed to compare the emissions from various GHGs (e.g., methane) based on their global-warming potential, by converting amounts of other gases to the equivalent amount of CO_2 with the same global warming potential (Eurostat).

[2] Limiting conditions for in-person attendance include low budget, care responsibilities, disabilities, and visa/bureaucratic requirements; limiting conditions for virtual attendance include low budget, lack of/poor internet access, unfamiliarity with new technologies, and poor virtual experience design.

[3] Many societies cover their running costs through conference revenues.

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Appendix

Appendix A details the methodology followed to measure the variation in the perceived value of the target international OM/OR conferences due to the Covid-driven shift from in-person to virtual formats. Appendices B and C detail the protocol used for the interviews and the questionnaire used for the surveys, respectively. Appendix D reports a set of figures illustrating significant group differences in the perceived benefits and costs of in-person and virtual conferences across sub-groups of the sample. Lastly, Appendix E provides details on the regression analyses conducted to identify the most significant drivers of the perceived value of the analyzed academic conferences in either in-person or virtual formats.

Appendix A: Methodology for the societal perceived value of conferences

As mentioned in the manuscript, perceived value is defined here as "*the consumer's overall assessment of the utility of a product based on perceptions of what is received and what is given*" (Zeithaml 1988, p.14). In this utilitarian definition, it thereby constitutes a trade-off between 'benefits' and 'costs' (Monroe 1990). Coherently with the limited and fragmented literature on the perceived value of academic conferences, we implemented a mixed-method approach (Bryman 2006, Tashakkori and Creswell 2007), with primarily a *development* purpose, i.e., "*to use the results from one method to help develop or inform the other method*" (Greene et al. 1989, p. 259). Particularly, we used qualitative methods (interviews plus content analysis) to inductively identify the main value factors that make up the value proposition of academic conferences. Next, we carried out a quantitative analysis (surveys plus statistical analyses), informed by qualitative findings and input from the literature, to (i) assess OM/OR scholars' perceptions of the identified value factors in in-person and virtual conferences, (ii) measure the overall perceived value of the two formats, and (iii) investigate – for both formats – which value factors are the most significant in explaining the overall perceived value. Data collection and analysis for the two methods are described in Sections A.1 and A.2, respectively.

A.1. Qualitative analysis

As to data collection for the qualitative analysis, we employed multiple semi-structured interviews and focus groups. Particularly, we drew a convenient sample of 15 leaders and/or fellows of the supporting OM/OR societies who have extensive experience in organizing and attending conferences (see Table A.1). These were interviewed either individually or, when possible, in focus groups, as shown in Table A.1. Focus groups turn particularly useful to provide insights into the sources of complex behaviors and motivations (Morgan 1996), as is the case with academic conferences. The interview protocol was the same for interviews and focus groups and comprised a few open-ended questions to detect the factors that affect the valuation of in-person and virtual conferences, either positively or negatively – the full protocol is reported in Appendix B. The interviews/focus groups were carried out via Zoom and typically lasted 1-1.5 h. They were all recorded and synthesized in ad-hoc interview reports following the structure of the protocol (Voss et al. 2002). Interview reports are available from the authors upon request.

As to data analysis, an 'open coding' process was used (Corbin and Strauss 2014) to break down interview data into the factors that drive the perceived value of academic conferences, both in in-person and virtual formats. In line with the adopted nominal definition of perceived value, the identified value factors were split into *conference benefits* and *costs*, that is, factors that either

positively or negatively affect the value derived from attending conferences. Within each group, the iterative comparison of emerging factors allowed for the revision/merging of overlapping ones – what is called 'axial coding' by Strauss and Corbin (2014). Also, for all factors, tentative items to operationalize them in a survey instrument were inductively derived and iteratively refined. The coding results were discussed among the authors and iteratively revisited until an agreement was reached, to guarantee a high degree of inter-rater reliability (Wang and Chugh 2014). The outcome of this process is Table 2 in the manuscript.

Table A.1. Sample for the interviews/focus groups

Respondent	Role	Interview or Focus Group ID
Feryal Erhun	Former MSOM President, POMS Board Member	Focus Group 1
Burak Kazaz	MSOM President	
Tim Kraft	Former MSOM Board Member	
Taco van der Vaart	Former EurOMA President, EurOMA Board Member	Focus Group 2
Constantin Blome	EurOMA Board Member	
Charles Corbett	MSOM Fellow, POMS Fellow	Interview 1
Steven Graves	Former INFORMS President, INFORMS Board Member, INFORMS Fellow, MSOM Fellow, POMS Fellow	Focus Group 3
Dan Guide	POMS Fellow	
Joe Blackburn	POMS Fellow	
Sushil Gupta	POMS Executive Director, POMS Fellow	Interview 2
Ann Vereecke	EurOMA Fellow	Focus Group 4
Chris Voss	EurOMA Board Member, POMS Fellow, EurOMA Fellow	
Marshall Fisher	INFORMS Fellow, MSOM Fellow, POMS Fellow	Interview 3
Jay Swaminathan	INFORMS Fellow, MSOM Fellow, POMS Fellow	Interview 4
Elena Gerstmann	INFORMS Executive Director	Interview 5

A.2 Quantitative analysis

Based on the qualitative findings, we next designed a questionnaire to measure attendees' perceptions of the identified benefits and costs for both the in-person and virtual formats of the target OM/OR conferences. This task presented us with a challenge since the large number of value factors (19 benefits and 9 costs), combined with the need to make respondents rate them twice (one for in-person and one for virtual conferences), would have involved a very long questionnaire, thus jeopardizing the response rate and reliability (Forza 2002). To keep the survey parsimonious, we performed a selection, keeping only the value factors that were mentioned in at least 4 interviews/focus groups. This inclusion criterion was agreed upon with society leaders, who, however, asked us to further include two value factors below the cut-off that they deemed important (i.e., *Physical Health Cost* and *Discrimination & Harassment*). In the end, 8 benefits and 7 costs were included in the survey. These, along with the single items through which they were operationalized, are indicated in Table 2. We measured them through a 5-point unipolar Likert scale, framing the questions as: "*Please rate the extent to which the following factors positively/negatively affect the value you personally derive from* [***in-person*** or ***virtual***] *conferences*" (1 – Not at all, 2 – To a small extent, 3 – To a moderate extent, 4 – To a large extent, 5 – To a very large extent).

In accordance with the overarching research objective, we further included two questions to measure the overall perceived value of the two conference formats. These were derived from an operationalization of Zeithaml's definition provided by Armbrecht (2021) in the event management literature. Particularly, we adopted an 11-point scale for the questions and framed

them as: "*Consider an average international annual conference you would typically attend. Weighing all the benefits and costs, what is the overall value you derive from that conference if it is* [***in-person*** or ***virtual***]*?*" (0 – Very low, 10 – Very high). The more granular scale was chosen to increase variance in the responses and to safely approximate the measured variables as continuous, as these were anticipated to be the response variables in subsequent regression analysis.

As indicated in the manuscript, we also added a few questions to measure some demographic and other attendee-related variables that we identified in the interviews or literature as potentially relevant antecedents influencing the perceived valuation of in-person and virtual conferences. Moreover, at the end of the questionnaire, we included an open-ended question to let respondents write any comment that would come to their minds.

Eventually, the questionnaire was made up of four sections (a copy is reported in Appendix C):

A. *General Information*, with questions to measure demographic/general antecedents;
B. *Conference Benefits & Costs*, with questions to make respondents rate the selected value factors for both in-person and virtual conferences (questions and items therein contained were randomized to tackle fatigue bias);
C. *Overall Perceived Value*, with questions to gauge the overall value of the two formats;
D. *Conclusive Feedback*, with a final space for respondents' comments.

Given the exploratory nature of the research, formal scale development for the measured constructs (conference benefits and costs, and overall perceived value) was out of the scope of the study – i.e., no multi-item scales, statistical validation with factor analyses, etc. (Forza 2002). Notwithstanding, to guarantee the construct validity and the overall reliability of the measurement instrument to an acceptable extent, we ran some content validity assessments – i.e., we made 'naïve respondents' assign the developed items to the value factors and checked the accuracy of the matches (Hinkin 1998) – and we also pilot-tested the questionnaire both with a sample of PhD students in our institution and later with a few OM/OR academics specialized in survey design. This allowed us to check the overall length and clarity of the questionnaire and avoid falling into common pitfalls and biases. Particularly, to tackle common method variance – which can be problematic when gathering data from single respondents in a cross-sectional study (Siemsen et al. 2009) – we guaranteed the anonymity of the respondents, asked them to provide truthful answers, and randomized several items/blocks of questions (Podsakoff et al. 2003).

The questionnaire was implemented in the online software Qualtrics XM^{TM} and administered to the members of the OM/OR societies for around one month between January and February 2022 through various channels (direct emails to members, societies' newsletters and blogs). After a couple of reminders, we obtained 555 responses.

As to quantitative data analysis, survey data was analyzed through multiple statistical techniques, including exploratory data analysis, analysis of variance, and regression analysis. Exploratory data analysis was used to obtain summary descriptive statistics for the measured constructs (mean, standard deviation), as shown in Figure 2 in the manuscript. Analysis of variance (ANOVA) was employed to detect potential group differences in the measured constructs across sub-groups of the sample identified by the demographic/general antecedents measured in the first section of the survey. The results of the multiple ANOVAs conducted are summarized graphically in Appendix D. Lastly, regression analysis was used to identify which value factors are statistically significant in predicting the overall perceived value of in-person and virtual conference formats while controlling for the effect of demographic/general antecedents. More information on regression analyses and associated robustness checks is provided in Appendix E.

Appendix B: Interview protocol

1. What values does an academic conference in the Operations Management/Research (OM/OR) field bring to the various stakeholders involved?
    - *Delegates*
    - *Academic societies*
    - *Local organizing committees*
    - *Suppliers*
    - *Sponsors & Exhibitors*
    - *Academic/research institutions*
    - *Others […]*
2. What are the main issues associated with the traditional model of conferencing?
3. How do virtual conference formats perform in delivering the identified values to stakeholders?
4. How do they perform in mitigating or exacerbating the identified issues? Do they create new issues?

Appendix C: Survey questionnaire

A. General Information

1. How old are you?

☐ Under 18
☐ 18-24 years old
☐ 25-34 years old
☐ 35-44 years old
☐ 45-54 years old
☐ 55-64 years old
☐ 65+ years old

2. In which country do you currently reside? Choose an item.

3. How do you describe yourself?

☐ Male
☐ Female
☐ Non-binary/third gender
☐ Prefer to self-describe Click or tap here to enter text.
☐ Prefer not to say

4. What best describes your professional status?

☐ Student
☐ PhD Student
☐ Post Doc
☐ Tenure Track Professor

☐ Tenured Professor
☐ Other role in academia Click or tap here to enter text.
☐ Industry
☐ Government
☐ Other, outside of academia Click or tap here to enter text.

5. Are you currently looking for a job?

☐ Yes
☐ No

6. Are you a member of or affiliated with one or more of the OM/OR societies listed below? (Please check all that apply)

☐ INFORMS
☐ MSOM
☐ POMS
☐ EurOMA
☐ Other: Click or tap here to enter text.

7. What conference formats have you experienced in your career? (Please check all that apply)

☐ *In-person*
☐ *Virtual*
☐ *Hybrid* (in-person attendance)
☐ *Hybrid* (virtual attendance)

B. Conference Benefits & Costs

8. Please rate the extent to which the following factors *positively affect* the value you personally derive from ***in-person*** conferences

	1 Not at all	2 To a small extent	3 To a moderate extent	4 To a large extent	5 To a very large extent
receiving feedback to improve my research/work					
establishing collaborations with scholars/practitioners with similar interests					
discovering recent developments in the field					
meeting renowned people in the field					
learning about research methods and academic norms					
interviewing or being interviewed for job positions					
socializing with new or old friends					
visiting attractive places/cultures *[only in-person]*					
flexibility in attending where and when I want *[only virtual]*					

9. Please rate the extent to which the following factors *negatively affect* the value you personally derive from ***in-person*** conferences

	1 Not at all	2 To a small extent	3 To a moderate extent	4 To a large extent	5 To a very large extent
costs related to my attendance (registration, transport, accommodation, and meals)					
the time taken away from other activities/responsibilities					
the difficulty of traveling *[only in-person]*					
the difficulty of attending virtually *[only virtual]*					
the risk of impaired health due to attendance (e.g. infections or zoom fatigue)					
the risk of people copying the ideas I present at the conference					
the risk of discrimination or harassment occurring during the conference					
the environmental impact associated with conference attendance					

10. In a non-pandemic situation, what conditions would currently limit your ability to travel to a large ***in-person*** conference in another country? (Please check all that apply)

☐ Low budget
☐ Care responsibilities
☐ Disabilities
☐ Visa/Bureaucratic requirements
☐ Other: Click or tap here to enter text.

11. Please rate the extent to which the following factors *positively affect* the value you personally derive from ***virtual*** conferences

[Same table as Q8]

12. Please rate the extent to which the following factors *negatively affect* the value you personally derive from ***virtual*** conferences

[Same table as Q9]

13. What conditions currently limit your ability to attend a large ***virtual*** conference? (Please check all that apply)

☐ Low budget
☐ Lack of/poor internet access
☐ Unfamiliarity with new technologies
☐ Poor virtual experience design
☐ Other: Click or tap here to enter text.

[Note 1: the items in Q8, Q9, Q11, and Q12 were randomized]
*[Note 2: the sequence of blocks Q8-Q9-Q10 and Q11-Q12-Q13 was randomized, with 50% of the respondents seeing the questions for **in-person** before, and the other 50% for **virtual**]*

C. Conference Overall Value

Consider an average international annual conference you would typically attend.

Weighting all the benefits and costs, what is the overall value you derive from that conference...

14. ...if it is ***in-person***?

Very low										Very high
0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

15. ...if it is ***virtual***?

Very low										Very high
0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

D. Conclusive Feedback

16. If you have anything else to add related to the above, please write below

Click or tap here to enter text.

Appendix D: Group differences in the perceived benefits and costs of in-person and virtual conferences

We report here some graphs showing the patterns for the perceived benefits and costs of in-person and virtual conferences across several sub-groups of the sample, segmented by ***Gender*** (Figure D.1), ***Professional Status*** (Figure D.2), ***Continent*** (Figure D.3), ***Society Affiliation*** (Figure D.4), and the presence of specific ***Limiting Conditions*** affecting attendance (Figure D.5). In the graphs, the value factors are ordered as in Figure 2 in the manuscript. The following abbreviations are used for sake of synthesis: Research Training – RT, Getting Updated – GU, Receiving Feedback – RF, Job Market – JM, Meeting the Top – MT, Networking – N, Socialization – S, Tourism – T – or Flexibility – F, Discrimination & Harassment – DH, IP Infringement – IP, Time Cost – TC, Physical Health Cost – HC, Accessibility – A, Environmental Cost – EnC, Economic Cost – EcC. The value factors for which statistically significant differences were spotted through ANOVA – at the 5% significance level – are highlighted with a star (*). Particularly, given the non-normality and sometimes heteroskedasticity in the data, non-parametric ANOVAs were run (i.e., Kruskal-Wallis tests).

In the graph for ***Professional Status*** (Figure D.2), only the categories with a frequency above 5% are displayed (i.e., *Post Doc*, *Other Role in Academia*, and *Industry* are omitted), even though the ANOVAs were run across the whole sample. The graphs for ***Society Affiliation*** (Figure D.4) and ***Limiting Conditions*** (Figure D.5) represent instead peculiar cases, as they do not show segmentations of the sample based on a single categorical variable, but they report the patterns for several non-mutually exclusive categories of the sample identified by ad-hoc dummies – as an example, a scholar can be both a member of EurOMA and US Societies (INFORMS, MSOM, and POMS were merged into a unique category given the large overlapping in their memberships) or can suffer from both disabilities and low budget conditions. For these cases, multiple non-parametric t-tests were conducted. Their results, along with the results of the post-hoc tests conducted in conjunction with the ANOVAs, are available from the authors upon request. In Figures D.4 and D.5 the average pattern across the whole sample is reported as a benchmark.

Figure D.1. Group differences in the perceived benefits and costs based on *Gender*

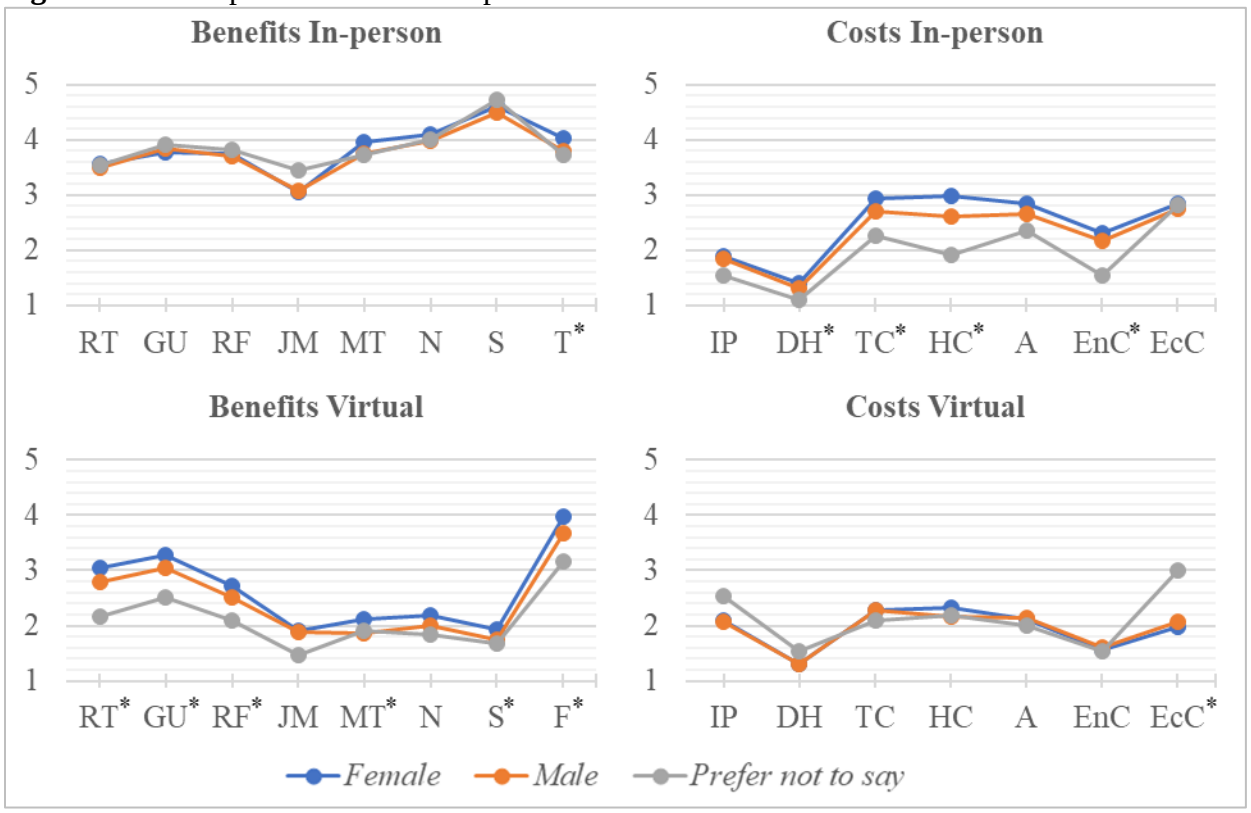


Figure D.2. Group differences in the perceived benefits and costs based on *Professional Status*

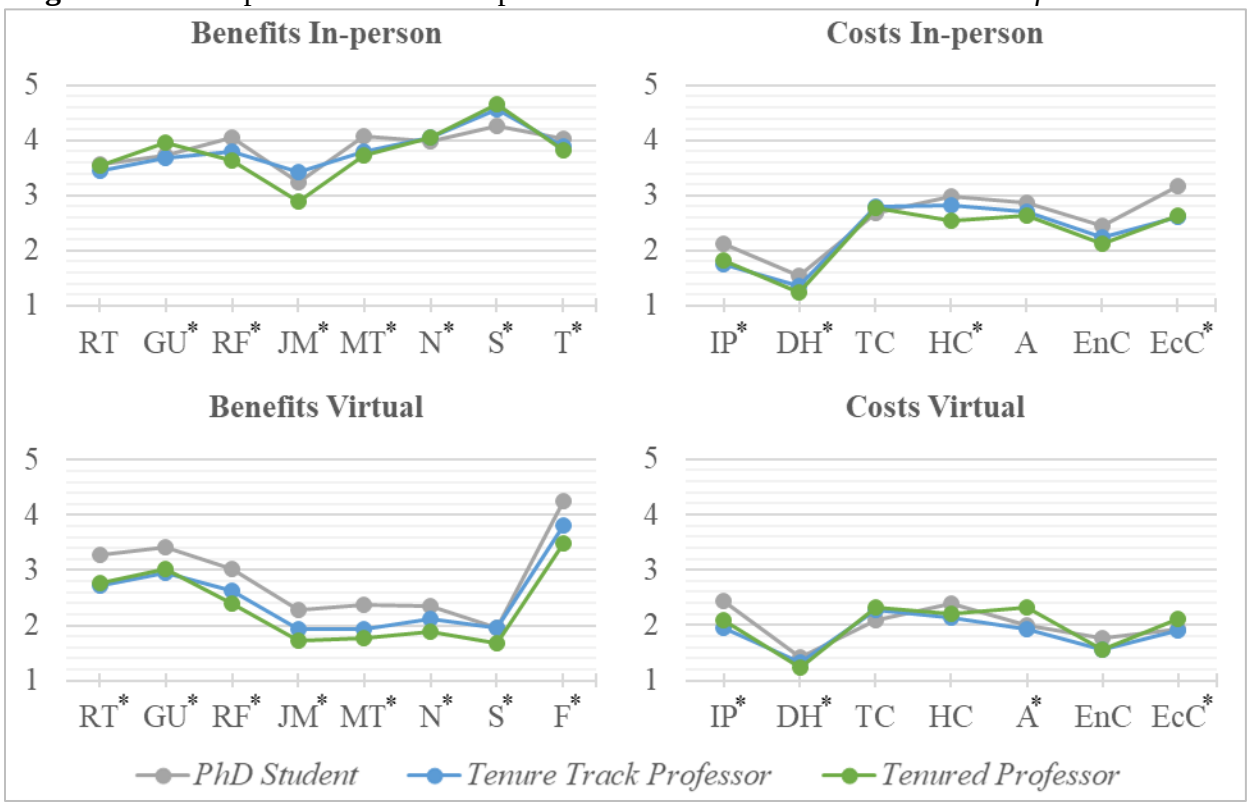


Figure D.3. Group differences in the perceived benefits and costs based on *Continent*

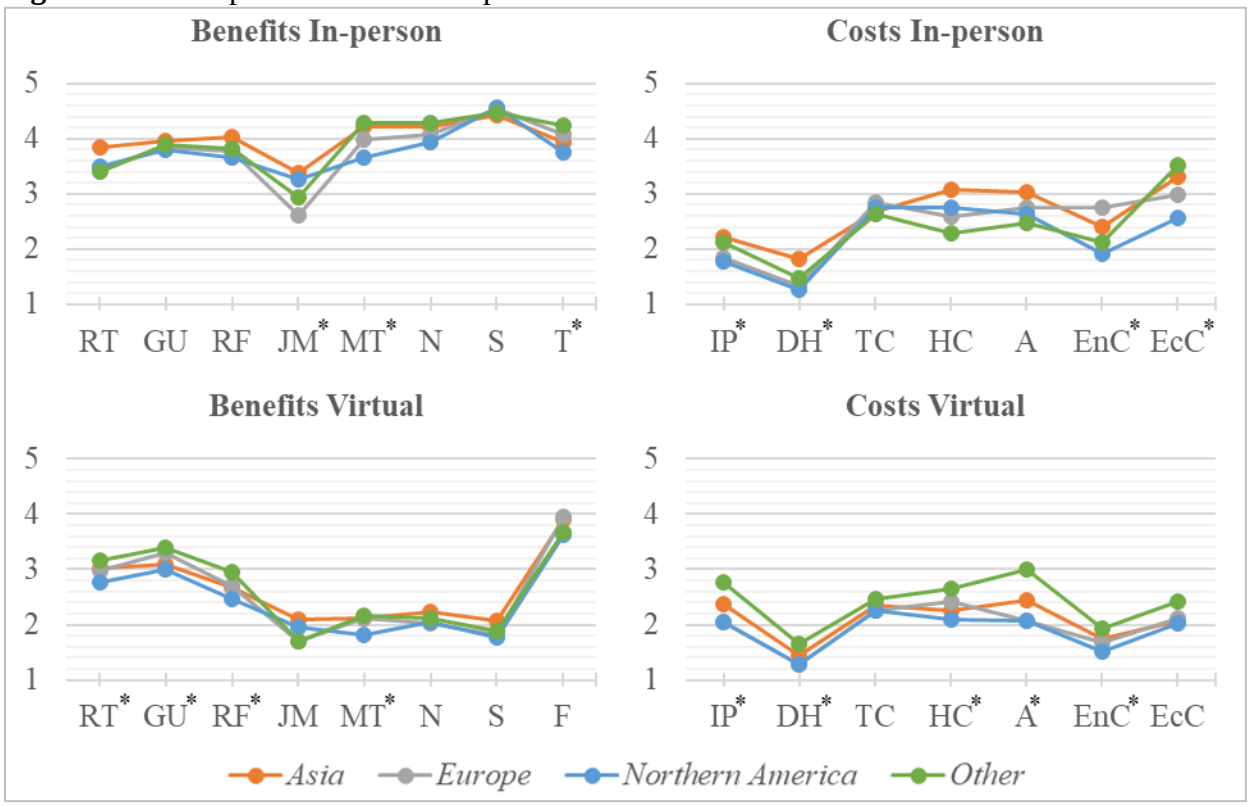


Figure D.4. Group differences in the perceived benefits and costs based on *Society Affiliation*

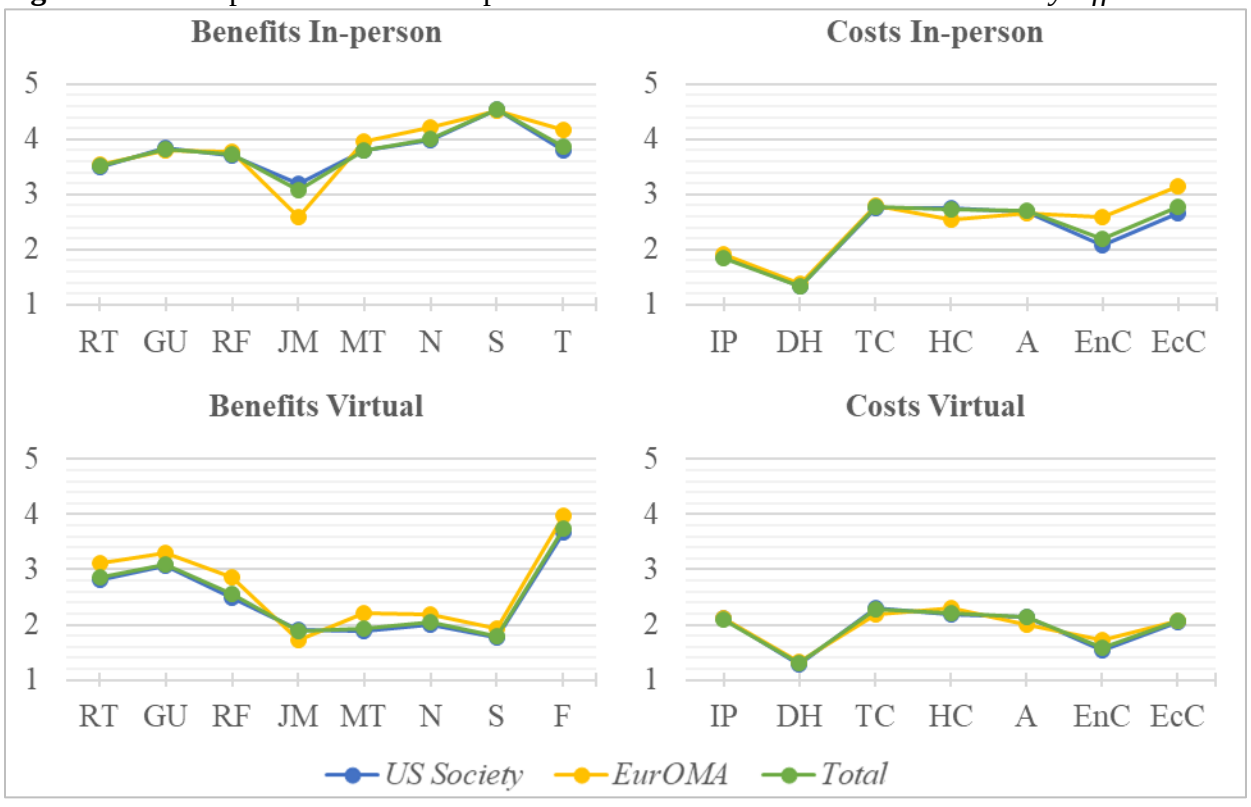
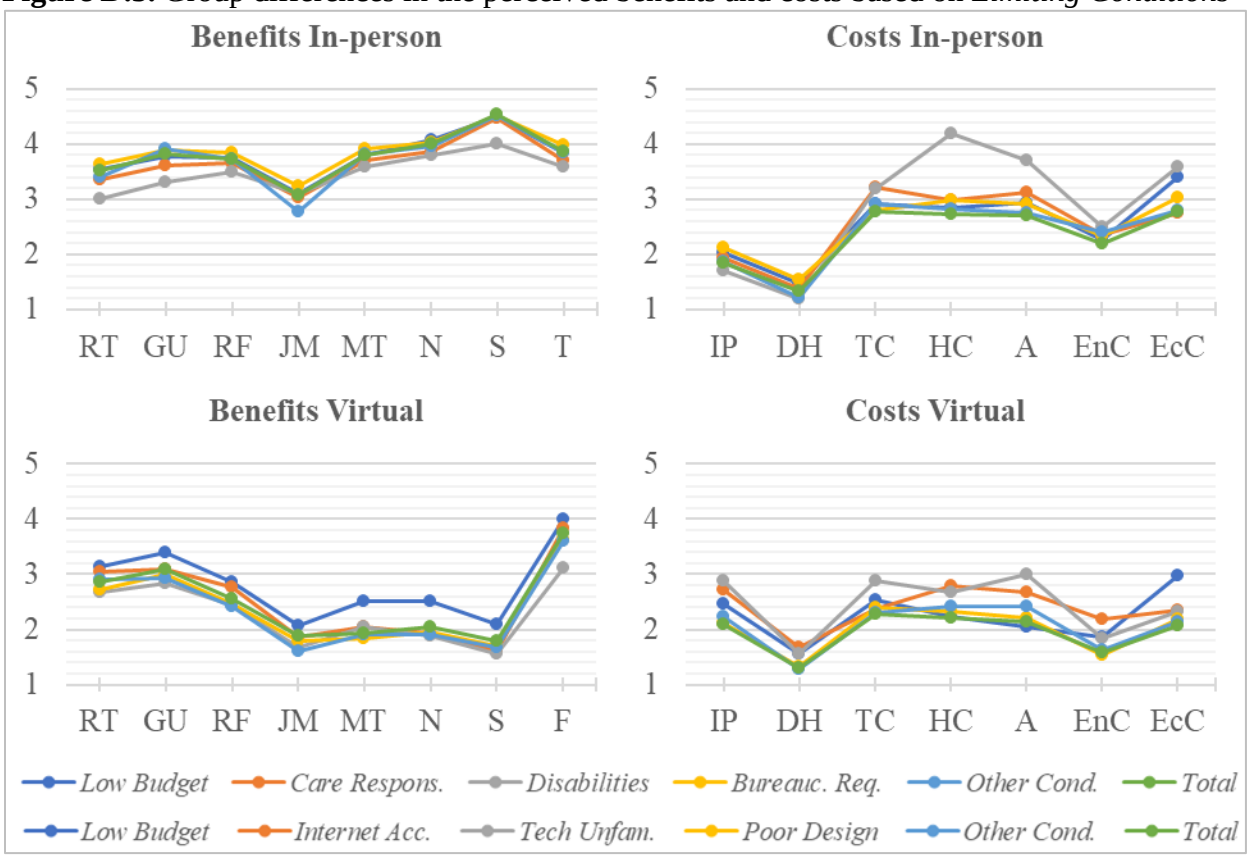


Figure D.5. Group differences in the perceived benefits and costs based on *Limiting Conditions*



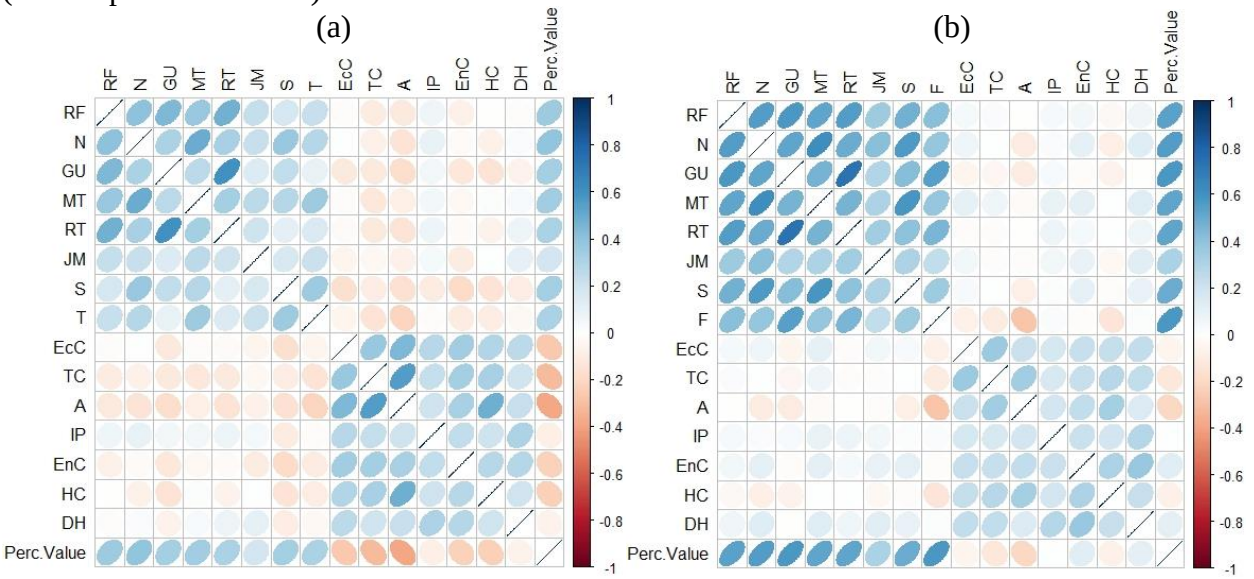
Appendix E: Multiple linear regression analysis and robustness checks

To identify the most significant drivers of the perceived value of in-person and virtual conferences, we conducted a multiple linear regression analysis. To this end, we first dropped from the dataset the observations containing missing data (25 for in-person conferences and 21 for virtual) – missing values are indicated with "N/A" in the accompanying dataset. We then specified several regression models having as response variables the overall perceived value of in-person and virtual conferences, and as covariates, for each format, the associated value factors (numeric independent variables) and the demographic/general antecedents (categorical control variables). For categorical variables, we refined the data in the following ways: (i) we omitted *Age* as it is highly related to *Professional Status*; (ii) we merged some low-frequency categories for two multi-level factors (for *Continent*, we merged *Latin America*, *Africa*, and *Oceania* into *Other*, and for *Professional Status*, we merged *Post Doc* and *Other Role in Academia* into *Academia Other*); (iii) we aggregated the dummies related to *INFORMS*, *MSOM*, and *POMS* affiliation into a unique dummy called *US Society* (as mentioned earlier, the memberships largely overlap).

In line with our exploratory aim, we started by specifying two full linear models of main effects, one for in-person and one for virtual conferences, including all related variables above. The results are shown in Table 4 in the manuscript. These models display an acceptable predictive power, especially the model for virtual conferences ($R^2 \approx 55\%$ as opposed to 36% for in-person). In general, there was more variation in the variables associated with virtual conferences and, relatedly, more signal in the models specified to predict their overall value. However, the relatively

high correlations between some of the value factors – especially positive value factors (see Figure E.1) – raised our attention to potential multicollinearity issues. After investigation, moderate issues as measured by variance inflation factors (VIF) were spotted, even though not worrisome: just 3-4 covariates in the two models displayed a VIF greater than 2.5 (heuristically considered a cause for concern without a strong signal) and most of these were multi-level categorical variables, for which, when adjusting for the degree of freedom, the VIF was below the threshold.

Figure E.1. Correlations among the numeric covariates (value factors) and response variables (overall perceived value)



Notes. (a) Variables for in-person conferences. (b) Variables for virtual conferences. The same abbreviations used in Appendix D for the value factors are used here.

Being aware of multicollinearity and the potentially large signal embedded into interaction effects – as suggested by the significant group differences highlighted in Appendix D – we next set out to identify both a subset of informative main effects as well as any interaction effects which would help reliably predict the perceived value of the two conference formats. To this end, we specified both reduced main effect models obtained through backward elimination and interaction effect models. For the latter, given the extremely large interaction space, we relied on feature selection procedures. Specifically, we considered two selection algorithms for identifying interactions: *Stability Selection with the Lasso* (Meinshausen and Bühlmann 2010) and *Revisiting Alpha-Investing* (RAI) (Johnson and Stine 2019). All interaction effect models considered were hierarchical by design, in that they respected the *principle of marginality*: an interaction between two explanatory variables was included only if the marginal terms were also included. Before running the selection algorithms, we centered the numeric independent variables to reduce the VIF of interaction effects – this was done for the reduced main effect models too. This means the model coefficients presented hereafter are not directly comparable to those of the full main effect models in Table 4 and the comparison is limited to check if the features that are selected by the procedures are significant also in the full models.

The *Lasso* (Tibshirani 1996) is a penalized regression model which minimizes the sum of squared residuals as well as a penalty term consisting of the sum of the absolute values of estimated coefficients. Given the high collinearity present in interaction spaces, the selection of individual

interactions by considering the entire set of possible interactions can be unstable. To overcome this, we used *Stability Selection* (Meinshausen and Bühlmann 2010), which repeatedly performs Lasso selection using a randomly chosen subset of the observations along with a perturbation of the penalty term. If a covariate is selected "sufficiently often" throughout this randomized procedure, then the selection is stable. Given the exploratory nature of the research which has no confirmatory purpose, we relaxed the threshold and accepted an interaction if it was included in at least 50% of the models created on subsampled data (typically 60%). Stability selection was solely used for the selection step. We then fitted linear models using least squares on the selected covariates with one important change: as anticipated, we enforced a hierarchical structure by including the main effects corresponding to any identified interaction. In our case, this often reduced the significance of interaction effects.

RAI is conceptually a variant of stepwise regression that enforces a hierarchical model structure by following the principle of marginality (Johnson and Stine 2019). The (initial) base model includes only an intercept term, and then covariates are added individually when a conservative variant of the corresponding hypothesis test passes a significance threshold. Once multiple (marginal) covariates are included, a test of their interaction is conducted. The rejection threshold is initially strict and is gradually relaxed, with a termination condition designed to control a measure of false rejections. Again, in line with the exploratory nature of the research, we relaxed the threshold for the error rate control of RAI, which we set to 0.25 as opposed to a more traditional level of 0.1.

The linear models resulting from previous procedures are displayed in Table E.1. Within all these models, the effect of multicollinearity as measured by VIF and their generalization for interaction effects is small (below 2.5). The reduced main effect models obtained through backward elimination show an improvement in the predictive power as compared to the full main effect models, but do not substantially change the value drivers identified as significant – their statistical significance mostly becomes more pronounced. As to interaction effect models, even with the relaxation of acceptance thresholds, the selection procedures led to stable inclusion of only a few interaction effects – not consistent between Lasso and RAI. Importantly, the inclusion of these features did not alter – except for a few minor exceptions – the significance of the main value drivers identified in the main effect analysis.

These findings provide evidence of the robustness of the models displayed in Table 4. Even if they suffer from some statistical weaknesses, we chose to display them as they are easier to interpret and allow us to highlight theoretical insights that are statistically robust.

[All steps above, along with other analyses performed on the dataset, were conducted in R. To foster transparency and replicability, the R code used for these analyses and the associated interim findings obtained are reported in three Supplemental Documents in HTML format. The first is named "*Exploratory Data Analysis of Conference Survey Data*" and details all the steps related to exploratory data analysis and data cleaning/preparation. The second and the third are named "*Regression Analyses for perceivedValueIP*" and "*Regression Analyses for perceivedValueV*", and detail all the steps related to the regression analyses for the overall perceived value of in-person and virtual conferences, including feature selection, stability/bootstrap analysis, model comparison and checking. These files are available from the authors upon request]

Table E.1. Alternative linear models for the perceived value of in-person and virtual conferences obtained through feature selection procedures

	Models for Perceived Value of In-person			**Models for Perceived Value of Virtual**		
	(1) BE	***(2) Lasso***	***(3) RAI***	***(4) BE***	***(5) Lasso***	***(6) RAI***
Variable	*Estimate*	*Estimate*	*Estimate*	*Estimate*	*Estimate*	*Estimate*
(Intercept)	6.637***	7.995***	7.894***	3.805***	4.342***	4.155***
Receiving Feedback	0.220***	0.118	0.351**	0.192**	0.177**	0.221**
Networking	0.225***	0.297***	0.334***	0.375***	0.421***	0.470***
Getting Updated				0.262**	0.085	0.299***
Meeting The Top	0.107			0.177*	0.163*	
Research Training	0.118*			0.281***	0.199*	0.256**
Socialization	0.397***	0.299**	0.283***	0.217**	-0.026	0.332***
Tourism	0.086					
Flexibility				0.402***	0.546***	0.463***
Time Cost	-0.153**	-0.241***	-0.190***	-0.243***		-0.246***
Accessibility	-0.197***	-0.225	-0.305***	-0.175***		-0.178***
Environmental Cost	-0.214***		-0.311***	0.272***		0.322**
Gender_Male					-0.115	
Continent_Asia				0.629**		
Continent_North America		-0.136		-0.156		
Continent_Other				0.029		
Prof. Status_Academia Other				-0.001		
Prof. Status_Tenured Prof.				-0.477**		-0.423***
Prof. Status_Tenure Track Prof.				-0.219		
US Society		0.010		-0.329		
EurOMA	0.483***		0.254***			
Hybrid (V attendance)				0.303**		
Low Budget	-0.379***					
Care Responsibilities	-0.291**					
Poor Virtual Design				-0.376**		
Other Condition	-0.497***			-0.406**		
Socialization x North America		0.300*				
Rec. Feedback x US Society		0.188				
Accessibility x US Society		-0.083				
Time Cost x Rec. Feedback			0.162***			
Socialization x Networking			-0.214***			
Env. Cost x EurOMA			0.296**			
Accessibility x EurOMA			0.340**			
Socialization x Male					0.469***	
Getting Updated x US Society					0.248	
Socialization x Accessibility						-0.240***
p	14	12	11	20	12	12
R^2	0.372	0.389	0.325	0.568	0.565	0.523
AIC	1890.84	1872.49	1923.08	2088.29	2075.93	2124.77

Notes. Only features that were selected in at least one of the models are displayed. Models (1) and (4) are the reduced main effect models obtained through backward elimination. Models (2) and (5) are the reduced interaction effect models obtained through stability selection with the Lasso. Models (3) and (6) are the reduced interaction effect models obtained through RAI. For model comparison, the last row also reports the Akaike Information Criterion (AIC) (Akaike 1974).

* Significant at the 0.05 level, ** Significant at the 0.01 level, *** Significant at the 0.001 level.

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