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She Must Be Seeing Things! Gender disparity in camera department networks

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ABSTRACT

This paper reports on a network-based investigation of the gendered nature of work in the screen sector. Using nine years of Australian film and television production data, we explore how the networks of project-based collaboration might explain the disparities in the career trajectories of men and women. Our analysis finds that projects with men as directors tend to reproduce familiar teams to the exclusion of women, while projects led by women in key creative roles tend to make more space for women. Moreover, we find that there is a significant number of men who only work with men (regardless of whether they have worked with them before), but no corresponding group of women who only work with women. Our findings bear on proposed equity interventions, especially government policies designed to encourage women to enter the industry. Ultimately, even accounting for the statistical domination of men in the network, we argue that inequities in the organisation of the screen sector appear to be driven much more by the closed network behaviours of men than they are by the positioning or behaviour of women.

Introduction

This article offers a novel empirical investigation of the relational factors underpinning the dominance of men in Australian screen sector camera departments. The importance of social networks for the formation and development of screen sector careers is well-evidenced and understood in the academic literature (Faulkner, 1983; Jones, 1996; Antcliff, Saundry and Stuart, 2007; Grugulis and Stoyanova, 2012). However, there has been very little attention paid to questions of social inequities and how these are rooted in the interpersonal relationships between professionals in the industry. Among industry bodies and policymakers, there is much more attention paid to tackling social inequities, though there is very little recognition of the importance of social networks for addressing this. In this paper, we aim to bridge these two gaps by explicitly and empirically exploring the question of gender-based inequities in screen sector careers through a relational lens using network data. In doing so, we provide an empirical demonstration of what have to date been anecdotal or assumed aspects of gendered behaviour in these industries.

Skewed camera department employment statistics are as universal as they are dispiriting. Camera departments globally exhibit a huge gender imbalance: men substantially outnumber women and gender minorities in camera-related roles in the vast majority of projects (e.g. Goldschmidt, 2021; Lauzen, 2021, 2022; Simone, 2021; Coles et al., 2022). This gender imbalance is particularly stark at the highest levels of the camera department hierarchy, where "the number of women DPs [directors of photography] in national cinema guilds around the world generally hovers around 2–6 %" (Margolis et al., 2015, p. 81). While this imbalance is well-documented, the available evidence is almost exclusively at the level of headcounts of the number of women employed in these roles in a given industry. This has the effect of creating an understanding of men's dominance in these industries as a matter of prevalence, the answer to which is more women. However, this overlooks the ways in which work in the reputation-driven screen sector is based on relationships, and thus takes place through networks of collaboration (Faulkner and Anderson, 1987; Jones and Walsh, 1997; Antcliff et al., 2007).

We use nine years of Australian film and television production data to analyse the gendered nature of screen sector work in a country where the situation has improved little over time. Our data offer a rare opportunity to study the key roles of producer, director, and writer alongside the comparatively under-researched creative and technical

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roles of the camera department. These camera departments demonstrate the clear challenges that women face in progressing in this industry. We find that the gender imbalance increases as crew members rise through the camera department hierarchy; men are well-represented at all levels while women's careers appear to stall after employment as 2nd Assistant Cameras (2nd ACs), a mid-level role in this segment of the film industry workforce. In addition, we draw on qualitative responses to a survey of Australian camera workers to complement our understanding of the relational factors at play in this industry. Survey respondents repeatedly highlighted the importance of personal connections and networks in the hiring practices of the industry, as well as how these practices contribute to a feeling that the camera department in Australia is a "boys club" that presents significant progression barriers for women.

We explore how the industry's networks of project-based collaboration might illuminate the observed gendered career trajectories, analysing how men and women appear to deploy different strategies in their project selection and working relationships. We argue that a shift towards understanding screen sector inequities as a relational question is essential in light of "the recalcitrance of the sector to deal with notions of *power*, and more specifically, with the fact that power operates through subjugation, silencing and oppression" (emphasis in original, Hadley et al., 2022, p. 5). Our focus on power is delivered through detailed consideration of the uneven gendered relationships that occur within camera departments and between these departments and the key creative teams that employ them.

We contend that in order for the relational behaviours that help sustain men's dominance in the industry to be redressed, they first must be evidenced and understood. To this end, we explore the problem of persistent male domination through a relational lens by focusing on network mechanisms that the existing scholarship suggests drive (gendered) collaboration behaviours. In particular, we focus on two key drivers of team selection in the largely project-based screen industries: the tendency towards team familiarity in project collaboration, which offers a measure of how closed a project is when it comes to allowing new voices and people; and the tendency towards working with people of the same gender. We explore how these drivers intersect with gendered patterns of structural power and leadership in the networks and discuss how they might contribute to the systemic resilience of male dominance in the industry.

Our study presents evidence that men's dominance in these industries is in part a relational phenomenon occurring through gendered mechanisms and behaviours that drive the patterns of collaboration and team selection. Our analysis finds that projects with men in positions of power tend to reproduce familiar teams to the exclusion of women, while projects led by women in key creative roles tend to make more space for women. Moreover, we find that there are a significant number of men who only work with men, but no corresponding group of women who only work with women. On this basis, we argue that discussions of equity in the industry must focus on redressing the behaviour of men in sustaining inequities, rather than on how the women disadvantaged and excluded by these behaviours can improve their prospects. We also argue that gendered inequality can only be fully addressed by policies that acknowledge, target and disrupt the uneven relationships we observe. By connecting a network-based analysis to current approaches to equity, diversity and inclusion, we contribute critical insights to ongoing debates about how policy can better address the consistently and sharply biased employment patterns in the cultural industries. While our focus is on the case of Australia, we hope the findings of our study could open avenues for remediation in other jurisdictions.

Background

Gender in the Australian screen sector

The observation of male domination in the creative sector is not new and is repeatedly observed in both academic and non-academic studies (O'Brien, 2019; Verhoeven et al., 2019; Jansson and Wallenberg, 2020; Conor, 2021). Typically, this observation has taken the form of statistical "headcounts", which simply count the people in the industry by gender. As a result, many of the strategies developed to remediate the poor statistical standing of women and gender minorities have focussed on aspirations for numerical equilibrium such as the multitude of 50/50 by 2020 initiatives that proliferated in global screen industries between 2016 and 2018 (e.g. Roxborough, 2016; Screen Australia, 2016; Telefilm, 2016; Reuters, 2019). Policies informed by this perspective tend to be characterised by attention to "pipeline problems" (getting more women qualified for merit-based entry), recruitment practices (providing incentives to employers to hire more women on crews) or skills development (improving women's networking ability to ensure more women stay in the system). In each of these approaches, women are constituted as a "deficit" for which the answer is to simply add "more". And yet despite many years of policy interventions on this basis, the available data indicate there has been little substantive change.

This lack of change is especially stark in the camera department. For example, using data from the national census, Screen Australia reports that men consistently occupied between 94 % and 96 % of all Director of Photography (DOP) positions reported in the census years of 1996, 2001, 2006, 2011 and 2016 (Australian Bureau of Statistics, 2021). This is reiterated by a 2021 industry snapshot that reports only 4 % of Australian films employed a woman as DOP (Screen Australia, 2021). These depressing proportions have held despite an overall increase in the number of DOP positions throughout this time, rising from 211 in 1996 to 339 in the 2016 census year, including therefore a rise in the number of women occupying these roles. The question remains, however, would a greater proportion of women necessarily mean they held more power or influence in the industry? In this regard, previous studies suggest that even a proportional decrease in the predominance of men in an industry may have minimal impact on their relative power. A recent study of board networks has shown that simply increasing the number of women in a network does not necessarily decrease the influence of men (Verhoeven et al., 2022). In other words, perhaps statistical gains do not always produce more substantive equity outcomes. Current equity policy design does not include relational analysis and relies almost entirely on statistical head-counting. As such, it largely overlooks questions relating to relations of power, and how change might be brought about by redressing the imbalances in those relations of power (Hadley et al., 2022).

This study offers alternative possibilities for insights that could inform strategic change, by way of a social network analysis of the gendering of screen industry careers. Our research seeks to understand the obstinate and widespread success of male domination in screen industries from a structural, network perspective as the outcome of uneven, gendered social relations. We propose that analysing relationships formed in film and television crews can unlock key mechanisms which produce unequal gendered outcomes in the industry.

Film production networks and gender

Employment networks in the Australian screen industries, as around the world, are typically (but not exclusively) project-driven (Blair, 2001; Bechky, 2006; Wing-Fai, Gill and Randle, 2015; Wreyford, 2015). Project success is dependent on many variables and there is considerable risk-aversion built into decision-making frameworks, from financing to recruitment to production and so on (Coles and Eikhof, 2021; Franklin, 2022). Consequently, there is a high attrition rate of personnel across the industry with many participants working only once or twice in the period we analyse. More nuanced distinctions in employment practices can be made between sectors; for example, film is more likely to be project-driven than television. Role type is also important; "above--the-line" roles (key creatives such as producer, writer or director) in television, for example, tend to operate more in the form of "lumpy employment" than "below-the-line" roles (the day-to-day crew).

There are a number of studies which have used the film and/or TV industries as a basis for network research. Early network-driven research focused on providing an account of the relational factors shaping how individuals navigate careers in project-based labour markets. A seminal study by Faulkner (1983) describes in detail how Hollywood composers use their networks to survive in a highly reputation-driven industry. Faulkner and Anderson (1987) broaden the perspective from only composers, and argue that the system of cultural production can be thought of as a social structure based on the ties formed through moving from project to project. Using fifteen years of Hollywood film production data, they find an assortativity among the key roles on productions based on the number of past credits, suggesting that those able to carve out success in the industry tend to partner with others who already have similar track records. This further entrenches reputation-based dynamics and makes it harder for newcomers to establish themselves in the industry.

These studies are complemented by Jones' account of the importance of the interpersonal dynamics of navigating a career in the film industry, where "[t]he key to getting more projects is building and maintaining a network with people who make movies" (Jones, 1996, p. 65). Drawing on qualitative interviews with film professionals and data on employment patterns over a three-year period, Jones observes how reputation-building and interpersonal skills are crucial to finding success in the demanding and constantly shifting project-based film industry. Networks, built through one's experiences working on projects, are the means by which these skills are gained. Jones notes that "[b]ecause insiders select and train newcomers with similar goals and values, the project network is replicated and maintained", thus cementing industry norms and culture (Jones, 1996, p. 66). This positions those professionals who integrate newcomers into the industry as gatekeepers, and rewards those newcomers who are most able to appeal to these gatekeepers. Jones' work on careers in the film industry illustrates how "the industry's structure is defined by the patterns of recurrent and nonrecurrent interactions" (1996, p. 69) among film workers, and how these patterns ultimately separate a handful of powerful people from the rest (1996, p. 69).

Subsequent empirical studies of film industry networks have largely focused on researching screen sector collaborations to assess their creativity or success, typically measured in terms of the popularity, recognition and awards received by the project (e.g. Perretti and Negro, 2007; Cattani and Ferriani, 2008, 2013; Cattani et al., 2008; Rossman et al., 2010; Meiseberg and Ehrmann, 2013; Cattani et al., 2014; Soda et al., 2021). While this body of work is valuable for building understanding of the ways in which creative team constellations intersect with cultural consecration (and thus further career prospects), it does not address questions of social inequities such as gender discrimination in screen sector careers.

One of the few studies to explicitly concern itself with the gendered nature of careers in the screen sector comes from Lutter (2015), who explores the gendered relationship between network openness and career longevity in film production teams. Using data from the Internet Movie Database (IMDb) on Hollywood movies and their cast and crew, Lutter estimates survival models for career longevity, exploring the relationship between each person's patterns of collaboration and their career length. Lutter finds that if "women pursue their careers in open and diverse network architectures, they can reduce their disadvantaged position and the risk of dropping out of the business to a level that is statistically indistinguishable from the risk men run" (Lutter, 2015, p. 346). In arriving at this conclusion, Lutter observes that cohesive, powerful male collaboration networks impose on women a "closure penalty". Lutter's investigation provides key framing for our analysis in this paper, as it leads us to consider whether mechanisms related to network closure/openness and collaborative diversity might explain the apparent differences in men and women's camera department career trajectories in Australia.

Other relational work on gender and film also informs our approach in this paper. Verhoeven et al. (2020) build on Lutter's work by using a simulation framework to project network evolution in three national film collaboration networks based on a number of policy-oriented "what-if" scenarios. The study finds that headcount-based approaches such as adding women and removing men do little to change the network structures, whereas encouraging central men to work with more women may in fact do more to open up the networks (*ibid.*). As such, it encourages us to think about collaboration networks explicitly as sites of power in which network interventions might be developed that seek to redistribute that power more equitably. In addition, it provides the basis for thinking not just of how experience-based creative team constellations differentially impact individual men and women's careers, but how important the pattern of men working with men is in sustaining the network structure.

Taking a different approach, Fanchi and Tarantino (2020) use 13 years of data (from 2004 to 2016) on applications for funding in the Italian film industry to explore the extent to which the digital transformation of Italian cinema has resulted in more equitable experiences for women in the collaboration networks. By focusing on the film funding application process, the authors are able to shed light on the selection mechanisms that go on to produce collaboration network structures and shape career trajectories. They find a number of unequal and gendered selection mechanisms that, together, work to "ossify" the creative scene in ways that make addressing gender imbalances more difficult (Fanchi and Tarantino, 2020, p. 170). In the resulting collaboration networks, they find that "films directed by women engage more women" (p. 171), with women directors most notably hiring women as screenwriters at a vastly higher rate than male directors do, a finding which chimes with results from a study of German film production teams (Loist and Prommer, 2019). Crucially, they identify that projects led by men tend to replicate themselves through repeat collaboration of the creative teams, while teams led by women tend to only appear once. Thus, closed collaboration networks are seen to work to the advantage of men and the disadvantage of women. Ultimately, they find that there is little evidence that men and women's participation became more equitable over the data period, as women remain excluded from centres of power and influence in the network structure overall (Fanchi and Tarantino, 2020, p. 179). Again, the authors highlight the value of going beyond counting heads, arguing that the "small number of women in creative networks is a problem, but so is the limited range of positions they hold within them" (p. 180). Fanchi and Tarantino's contribution helps provide further evidence of how patterns of repeat collaboration, as well as gendered project leadership behaviours, can shape the experiences of women in the industry. It also highlights the importance of paying attention to access to positions of structural importance when evaluating gendered participation outcomes in the screen industries.

Research questions

These studies suggest a number of ways in which relational mechanisms drive the gendered nature of screen sector careers. We express these as the following research questions:

RQ1: To what extent do men and women demonstrate a tendency towards working with people of the same gender, controlling for the overall gender imbalance?

RQ2: To what extent do men and women demonstrate a tendency towards working with people they have worked with before and reproducing familiar teams?

RQ3: Do women's overall prevalence rates align with their access to structurally important positions within the network?

RQ4: How do the mechanisms of familiarity and homophily intersect with questions of gendered project leadership?

These research questions inform our analytical strategy and where we aim to contribute to this emerging body of scholarship on gendered mechanisms of (dis)advantage in film production networks. In the next section, we explain our dataset and how we used it to explore these

questions.

Data and methods

In this study we use data on nine years of Australian film and television productions and the people who worked on them to answer our research questions. The broader research project from which this network analysis is drawn also involved an online survey which was administered to 582 camera department workers in Australia invited to participate through ACS member communication channels, industry press and social media. Detailed description of this survey and analysis of its results is presented in Coate et al. (2023) and the project's industry report (Coles et al., 2022). Before describing our network data and analytical approach, we first draw on the anonymised free-text responses to two open questions in the survey. The responses to these questions help provide a qualitative reference point for our network analysis as well as to contextualise our understanding of the experiences of camera department workers in terms of gendered network behaviours.

Qualitative supplementary evidence

The two questions for which survey respondents could provide free-text responses are as follows: 'Q36: Based on your personal experience, please provide any additional comments about hiring practices in the camera department', and 'Q53: I have experienced or witnessed other forms of bullying, harassment or discrimination while working in film & TV that I would like to specify and explain'. Respondents repeatedly used these questions to highlight what they saw as a "boys club" in Australian camera departments. In fact, the "boys club" sentiment was identified in 40 answers, emerging as a key theme in the responses (see Coate et al., 2023). These comments describe a link between familiarity and historical male dominance that has resulted in an employment barrier that is difficult for women to breach. As one respondent says,

> It can be very hard at the time to break into the 'boys club' or 'cool crowd'. Thats [sic] generally what I see as being the main thing people struggle with. Not so much direct discrimination as such, but more so it can be a very clique-y industry.

One respondent also highlighted not only the barriers faced as a woman in the sector, but also how women attempt to build relational solutions:

> As a female DP [director of photography] I have felt that my career progression has at times been slower, but can't give a specific incident of discrimination. I just know it has an impact in that producers and directors and networks are less likely to "take a chance" on a woman, in the way they will with a man. Especially when you are younger. Now that I am very established I try to pass work to other female DPs that I know and I see the resistance from producers. If they don't have the credits then it's "too hard". In terms of hiring practises [sic] I think women are generally more likely to hire other women in their camera teams.

These comments suggest that progression is slower not because of outright instances of obvious discrimination, but because of a more general workplace culture driven by biased hiring practices that are circuitously "based in part on levels and experience of skill but are also heavily reliant on personal networks", as one respondent wrote. It should be noted that the primacy of personal connections for employment success is recognised as a factor even by those who feel that white men are victims of discrimination in the industry rather than beneficiaries:

> With diversity hiring it is acceptable even encouraged to discriminate against older white males, of which I fall into the category of [sic]. I have never gotten work nor have I experienced an advantage being a white male in this industry, although I believe the white male stereotype who gets all the work does so because of their industry connections or nepotism and not just because they tick a box of being white and male. My industry connections are not enough to sustain a career based solely on my age, gender, or race. I believe I have had the same struggles getting work as any other person regardless of race or gender.

From this respondent's perspective, the normative dominance of men in the industry is purely about "industry connections", and gender only becomes salient when men perceive themselves to be discriminated against in favour of someone who will increase the diversity of the project team (something which the available workforce statistics suggest is not a widespread practice). Nevertheless, by privileging industry connections, which has been shown to disadvantage women in other national screen sectors (Grugulis and Stoyanova, 2012; Lutter, 2015; Margolis et al., 2015), the effect is a workplace culture which is ultimately inhospitable to women:

> It is a rich white boys club where groups of male friends hire their other friends, despite their level of skills, interest, talent and equipment. This means that film and the camera department particularly are exclusive and create a toxic environment for women, women of colour and young practicioners [sic]. I am often the only woman and woman of colour on set.

These statements provide anecdotal evidence of the perceived importance as well as the gendered (and racialised) nature of networks in structuring opportunities for Australian camera department workers. Moreover, they chime with the experiences described in Margolis, Krasilovsky and Stein's book *Shooting Women* (2015), which contains interviews with women who have worked behind the camera in film industries around the world. These interviews provide extensive qualitative evidence of historical and ongoing challenges women face in men-dominated camera departments. Interviewees for this book echo the Australian survey respondents, highlighting a range of discriminatory practices, from male gatekeepers deliberately failing to pass on hiring requests for camerawomen, to being fired by more senior men to make room for their male friends on projects, to outright harassment and professional sabotage. In addition, interviewees described how men's behaviour on set and women's frequent positioning as the only woman on a project lead to a toxic working culture. In combination, the Australian survey and the published interviews with camera personnel help contextualise how the boys club characteristics of the camera department establish an environment that sustains male domination in the industry. We now turn to exploring these aspects of the industry quantitatively with network data.

Project-role dataset

The dataset employed in our analysis is a database of all feature fiction films and scripted television series filmed in Australia between 2011 and 2019 inclusive. The dataset is unique in describing both above- and select below-the-line personnel in the Australian screen sector. The roles included all producers, writers, directors, cinematographers (in Australia known as Directors of Photography) and the remaining camera department made up of camera attachments, assistants, and operators, as well as data wranglers and video-split operators. Academic studies and policy interventions of gender inequality in screen industries frequently focus on above-the-line or key creative roles, rather than the work of the "craft" professions such as camera crew (a point made by Caldwell, 2008; Banks, 2009, 2018; Mayer, 2011; Jones and Pringle, 2015). This study attempts to understand the extreme gender inequality in camera departments by examining the gendered interactions between the high-status marquee roles of the key creatives and the camera crews they work with.

The majority of this data is based on Screen Australia production

lists. These initial lists, however, were missing some information about camera departments, some creative roles, some non-government funded productions, and the gender of personnel. To fill these gaps a variety of research techniques were undertaken. The Australian Cinematographers Society (ACS) provided information about additional production titles. Self-identified gender data from ACS membership lists were added. The ACS project steering committee and the project research team manually located additional information about camera department crews and gender attributions using a wide range of public online sources, including IMDb, production and personal websites, analysis of end credits, personal networks, news reports and other media including social media accounts.

The dataset was then cleaned. All documentary films (which are much more likely to have solipsistic or minimal employment patterns) and animations (which do not typically have a DOP) were removed from the dataset. All people in Still Photographer roles were also excluded from the dataset because there is a completely different employment process for them. A small number of TV productions (n = 5) with no traceable DOP were excluded. Although coding was not restricted to a binary definition of gender and we expected to capture the presence of non-binary people in the data, we found that out of these 3023 people, 3018 were identified by ACS sources as either a man or a woman. Coders were unable to identify a gender for the remaining five people, and these are recorded as missing and excluded from the analysis. The survey of camera workers in Australia from which the qualitative baseline evidence described earlier in this section was drawn found a small number of self-identified non-binary camera workers (n = 4). Their absence from the project-role data analysed here could either reflect an unwillingness to disclose their self-perceived gender identity in the employment setting, a misidentification by coders, or simply a non-overlapping population for the two datasets. They could also be among the five missing cases.

The final dataset contains one row for each role filled on a production; in our case, a role can be one of: producer, writer, director, or a range of camera department roles of various levels of seniority from Camera Attachment to DOP (as described above). This project-role dataset thus describes the names, genders and job titles of 3023 unique people working in 9445 roles on 774 productions made during the data period.

Description of the project-role data

Before proceeding to the creation of the network data, we first explored the project-role dataset itself. Table 1 presents some descriptives for the data. Overall, our dataset includes more TV projects than film projects, though the number of unique people is roughly equal between both types of production. We also note that we have more projects of both production types in our dataset from recent years than we do from the earlier years in the collection period. The TV projects generally have a higher proportion of roles filled by women, but across both production types women remain vastly outnumbered by men. The distribution of roles in the data also differs according to production type. For example, writers are much more common on TV projects (n = 1480) than film projects (n = 428), as are directors. This is explained by the two different production models, as television shows often have different episodes within a series written and directed by different people, allowing for more writers and directors overall when the crew is captured at the project level. Films, on the other hand, only have a single screenplay which results in fewer writing credits, and typically only have a single director. Overall, 36.7 % of the roles on film projects are above-the-line roles (writer/producer/director), and all other roles in our data are camera department roles. For TV projects, 51.6 % of the roles are above-the-line. Only 1.6 % of people (n = 47) in the data worked in both above-the-line and camera department roles, which includes a group of people (n = 16) who only worked on one project and occupied most or all of the roles on that project. Of the 3023 unique people in the dataset, 552 worked on at least one project in both film and TV, which is the reason that the number of unique people working on each type of production exceeds the total number of unique people when summed.

Table 1
Summary of project-role data.

	Film	TV	Total
Number of projects	325	449	774
Number of roles	3642	5803	9445
Number of unique people	1798	1777	3023
Mean number of roles per project	11.2	12.9	12.2
Percentage of roles filled by men	80.2 %	68.7 %	73.2 %

Before analysing the data as networks, there are a number of interesting things that we can learn about the (gendered) organisation of work in film and television projects from the role data. First, the gender balance is notably more uneven in film than in television, with men outnumbering women around 4 to 1 across all roles in the film projects and around 2 to 1 on TV projects. This is related to the greater number of writers in the TV data, as 43 % of writing roles on TV projects are occupied by women (compared with just 21.5 % of writing roles on film projects), more than the average for other roles. Second, there is little year-on-year change in the overall gender balance across all projects, with the ratio of unique men to women remaining strikingly stable in each industry across the nine-year period covered in the data (Fig. 1). Third, when measuring the proportion of men and women across all roles on each project for film and TV, we see that only a very small proportion of projects achieve a gender-balanced crew; 6.5 % of film productions and 13.4 % of TV productions employ at least as many women as men. When we restrict the data to only camera department roles, the situation is even starker, as only 2.4 % of film productions and 10.8 % of television productions employ at least as many women as men in these roles.

Finally, one particularly striking feature we see in the data is that the disparity between men and women's employment remains stable in the camera department hierarchy until the level of Second Assistant Camera, after which the gap between men and women widens among the more prestigious and senior roles in the camera department. Women occupy 38 % of Camera Attachment roles, 33.1 % of Video Split Operator roles, and 36.9 % of 2nd Assistant Camera roles. However, once women move up the camera department hierarchy to the level of 1st Assistant Camera, they occupy only 20.2 % of roles, and further up the chain this percentage falls to just 7.1 % of Camera Operator and Steadicam Operator roles, 10.8 % of 2nd Unit DOP roles, and 8.7 % of DOP and Underwater DOP roles. Fig. 2 shows that this pattern is present in both film and TV productions.

These aspects of the data suggest that work in this industry is organised in ways that appear to be inhospitable to women, and that women's careers in camera departments appear to stall at the 2nd AC level while men's do not. This supports the picture painted anecdotally by survey respondents of a sector where progression is harder for women, who are disadvantaged by the male-dominated workplace culture. Our research questions are designed to help us uncover the relational mechanisms that might help us explain why this is the case. To answer them, we represent our data as network data, as we detail next.

Collaboration network data

We derive our network data from the project-role data by first creating a person-by-project affiliation matrix M in which the cell $M[i, j]$ takes the value 1 if person i worked in any role on project j, and zero otherwise. We then obtain the one-mode row projection of this matrix by multiplying M by its transpose M', giving us the undirected person-to-person adjacency matrix A, in which the value of the cell $A[i, j]$ is equal to the number of projects that persons i and j worked on together. Our network analyses are based on this person-to-person collaboration network. We explain when and how we use the values of ties in the

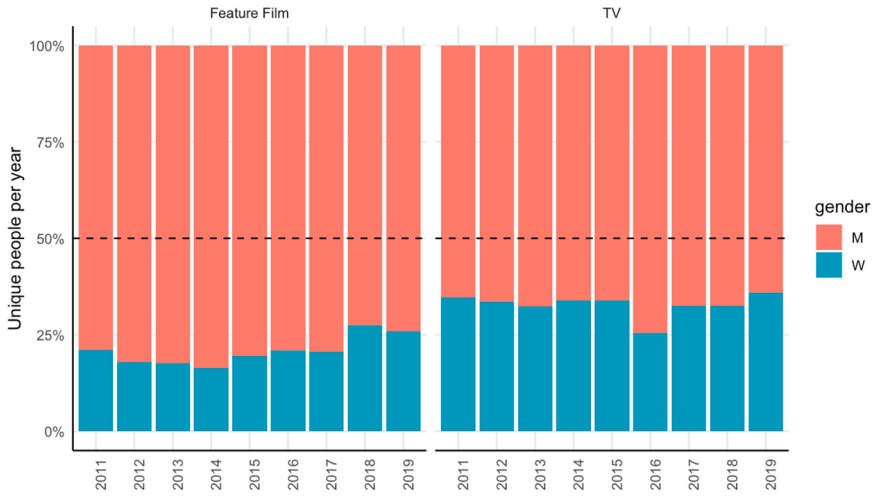

Fig. 1. Percentage of unique people in data per year by gender and type of production (all roles included).

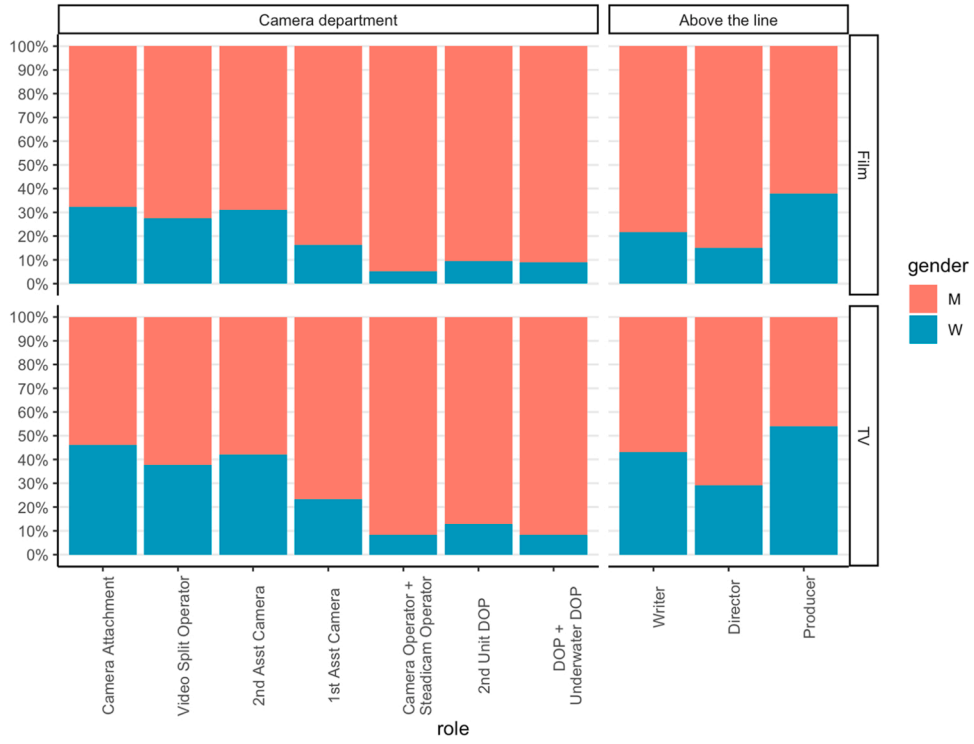

Fig. 2. Percentage of people in each role by gender. Camera department roles are organised hierarchically, increasing in seniority from left to right.

network below when outlining our analytical approach.

It is clear from our descriptive analysis of the project-role dataset that the nature of our data varies according to the type of production (feature film or TV), and we know from the data that most people (2471 out of 3023 people) only work on one type of production. Moreover, we know that some production roles are more relevant to the relational processes we are interested in than others. For example, writers do not typically have any interaction with camera department workers and are not really expected to play a role in some of the network processes that organise the experiences camera workers have in the industry. As such, before projecting from the two-mode person-to-project network to the one-mode person-to-person network, we considered a number of nodeset restrictions in order to ensure the network representations were appropriate for our research questions. It is worth explaining this stage in some detail, as the decision of which nodeset criteria to use can significantly alter the structure and interpretation of the resulting collaboration network. For example, leaving both TV and film projects in the data before projection may obscure key figures in the film industry if the TV-oriented part of the network dominates certain network measures.

Specifically, we explored three conditions for the project-level nodeset: 1) feature films were removed from the data prior to network projection, resulting in a TV collaboration network; 2) TV productions were removed from the data prior to network projection, resulting in a film collaboration network; 3) all types of productions were left in the data, resulting in a full collaboration network. For the person-level nodeset, we also explored three conditions: 1) writers are removed from the data prior to network projection, resulting in a collaboration network containing only camera department workers, producers and directors; 2) writers, producers and directors were all removed from the

data prior to network projection, resulting in a collaboration network containing only camera department workers; 3) all roles were left in the data. Through combination, these nodeset restrictions yield nine options for the collaboration networks, depending on which people and projects are included. We explored all nine networks in our analyses, though we aimed to let our substantive research questions guide which networks were most appropriate to focus on in which instance. Throughout the paper, we carefully label our results and figures (e.g. "film, all roles included", or "TV, camera departments only") to identify which nodesets underpin the networks.

Overall, when comparing the networks for film and TV projects, including all roles, the TV network is slightly denser (density = 0.03) and more well connected (average path length = 2.92) than the film network (density = 0.012, average path length = 3.06). In the full network containing both types of projects, the density is 0.014 and the average path length is 3.06. However, it should be noted that measures such as these are strongly linked to the size of a production's crew (in this case, its writers, producers, directors and camera workers) due to the projected co-affiliation nature of the data, and these crews tend to be larger in television series than in films.

It is important to note that a significant number of people work on only one project in the film and TV networks over the data period. For film projects, around 70 % of the people in the data only work on one project, and for TV projects around 50 % of people only work on one project, thus limiting the extent to which patterns of repeated collaboration can be analysed in this industry. In exploring whether working on only a single project is itself a gendered phenomenon, we found that in the film network, 71 % of men and 74 % of women work on only one film project; in the TV network, 51 % of men and 49 % of women work on only one TV project. Overall, 57.9 % (n = 1749) of the 3023 unique people in the dataset only work on one project over the whole data period, a phenomenon known colloquially as "one and done" in the industry.

Analytical approach

In order to answer our first research question, we need to know not only the gendered profile of teams and collaboration histories, but also whether there is an assortativity that cannot be explained by the difference in prevalence alone (i.e. gender homophily). Our second research question calls for a measure which captures the extent to which teams are composed of people who have worked together before, and a sense of each person's tendency to work with familiar collaborators. For our third research question, we need to define measures of structural importance within the network, which is generally expressed through the concept of centrality. In this section we explain precisely how we defined measures that capture these network mechanisms, as well as how we used the available information about the roles on each project to investigate our fourth research question about how these mechanisms intersect with project leadership.

RQ1 – The tendency to work with people of the same gender.

To answer RQ1 we first observe the gendered composition of project teams and individuals' collaboration histories. At the project level, we define this simply as the proportion of unique individuals working on the project that are men. In order to explore how individuals experience the gendered composition of teams across multiple projects, we define this at the individual level as the proportion of people that person i has worked with across all projects that are men.

To explore homophily as a mechanism for producing gender imbalance in collaboration networks, we calculated Yule's Q coefficients (Yule, 1912) for each person. When considering "*is connected with i/is not connected with i*" and "*shares i's gender/does not share i's gender*" as the two dichotomous attributes to compare, Yule's Q offers a measure of homophily which takes into account not only the ties that exist in each group, but the possible ties that could exist in each group but do not (Crossley et al., 2015). This is particularly appropriate for data such as ours in which women are vastly outnumbered by men. Following Bellotti et al. (2022), we calculated the coefficients for each year that a given person was active, such that for each person i and year $y \in Y$ in which i worked:

$$Q_{iy} = \frac{IM - EL}{IM + EL} \tag{1}$$

where I is the number of people i worked with in year y who have the same gender as i; E is the number of people i worked with in year y who do not have the same gender as i; L is the number of people who worked in year y and have the same gender as i but did not work with i; and M is the number of people who worked in year y and neither have the same gender as i nor worked with i. The final Yule's Q value for i is the mean of these coefficients:

$$Q_i = \frac{1}{N_{y \ni i}} \sum\nolimits_{y \ni i}^{y} Q_{iy} \tag{2}$$

This gives us an index between −1 and 1, where a value of −1 represents perfect heterophily, a value of 0 represents neither homophily nor heterophily, and a value of 1 represents perfect homophily.

RQ2 – The tendency towards familiarity.

To explore the extent to which people work with people they have worked with before, and what role this might play in the gendered experiences of the industry, we use two measures of familiarity. At the project level, we adopt Lutter's measure of team familiarity exactly (Lutter, 2015). According to Lutter's measure, the strength of collaboration between i and j is defined as:

$$w_{ij} = \sum_{f} \frac{\delta_i^f \delta_j^f}{n_f - 1} \tag{3}$$

where the deltas for i and j are 1 if i and j respectively were part of film f and zero otherwise, and n_f is the number of crew members on film f. The denominator gives greater weight to collaborations in smaller productions, assuming that two people working together in a small five-person crew will breed more familiarity than working together in a large fifty-person crew. The overall project-level team familiarity is then defined as:

$$\textit{team familiarity}_c = \frac{1}{n_c} \sum_{i>j} w_{ij} \tag{4}$$

which is simply the sum of the collaboration scores w_{ij} for each unique pair of collaborators in crew c, adjusted by the crew size n_c. By this definition, crews made up of people who have worked together before will have higher team familiarity scores as the w_{ij} values will be greater, and prior collaboration will count for more in smaller crews than in larger crews. We note that the team familiarity measure is distributed quite differently for TV and film projects, as Fig. 3 shows.[1] Team familiarity scores for TV projects are generally higher and more varied than is seen for film projects, indicating that it is more common for TV projects to use combinations of people that have worked together before. This is another example of why it is helpful to consider the film and TV networks separately, as they are characterised by different patterns of relationality.

In order to explore individuals' tendencies to work with people they have worked with before (thus allowing us to explore how this intersects with gender), we also defined an individual familiarity measure. This measure looks at each project i has worked on after their first project in the data, and classifies each unique person on that project as either "familiar" (i has worked with them before) or "new" (i has never worked

[1] All distribution curve plots used in this paper are produced using the kernel density estimation method for creating smoothed versions of histograms implemented by the *geom_density()* function in the R package *ggplot2* version 3.3.3 (Wickham, 2016).

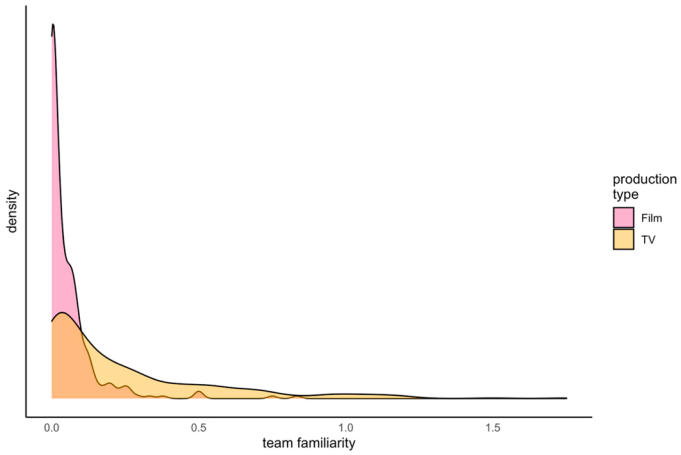

Fig. 3. Smoothed density estimates for the distribution of the computed team familiarity measure by production type. A small number of values above 2 on the x-axis have been removed from the visualisation to aid readability.

with them before). We then divide *i*'s total number of familiar people by *i*'s total number of people worked with to give a number between 0 and 1, which represents *i*'s propensity to work with people they have worked with before (a value of 1 means that *i* exclusively works with people they have worked with before; a value of 0 means that *i* has never worked with the same person more than once). This measure can only be defined for people who have worked on more than one project, and thus analyses based on this measure cover only that subset of the data.

RQ3 - Centrality as a measure of access to structurally important positions.

To capture gendered access to structurally important positions in our networks, we calculated three centrality measures which offer different ways of thinking about power in the industry. First, to explore who are the most well-connected people in the collaboration networks, we calculated the nodes' degree, giving us the total number of unique people each individual has worked with across all projects. We note that due to the projected nature of our network, this is strongly linked to the number and size of projects *i* has worked on. However, degree captures an important additional nuance: if A and B both work on 8 projects which each have 10 people, but A's projects always have at least 8 people in common while B's projects each only have 1 or 2 people in common, B will have a higher degree than A. Given that success in this industry is largely reputation-driven, with repeat working being itself a signal of trustworthiness (Faulkner and Anderson, 1987), we consider degree to be a useful indicator of an individual's ability to communicate this to their peers. Lutter (2015) makes a similar point in relation to film actors' careers, noting that an actor that works a lot with a given director but only with that director may be less successful overall than an equally active actor who works with that same director but also with other directors. We generalise this point to the other roles in a screen sector project team, supposing that a node with high degree not only works multiple times, but raises their profile among different sets of individuals. This also chimes with Jones' observation that, in film industry careers, "[b]uilding a reputation and developing a network evolve simultaneously – a reputation is established by performing quality work involving a variety of circumstances and people" (Jones, 1996, p. 64). We thus ignore edge weights when calculating degree, as the number of unique collaborators better captures what we are interested in.

Second, we calculated the eigenvector centrality scores for each node, in order to take into account not just the number of people worked with, but how well connected those people themselves are. A node with high eigenvector centrality is a collaborator of people who themselves have higher reputational status within the industry, possibly making their collaboration worth more in the eyes of peers. In line with our motivation for degree, we ignore edge weights in the eigenvector calculations. Finally, we also calculated the betweenness centrality scores, which tell us how often each individual lies on the shortest path between any two other individuals in the network. This provides a measure of brokerage power in the networks, seen as particularly important in creative networks wherein the "vision advantage" granted by occupying bridging positions can provide the broker with the capacity and flexibility to foster creativity and innovation, which are valuable traits in project-based labour markets (Soda et al., 2021). On the other hand, this structural property could position people as gatekeepers (Jones, 1996). We calculate both unweighted and weighted betweennes scores, to account for the idea that resources such as information and knowledge flow more quickly between people who collaborate often. In the weighted version, edge weights are treated as distances when calculating shortest paths, so we take the inverse of the weights such that edges between more frequent collaborators are considered shorter distances. We normalise these betweenness scores according to $B_{norm} = \frac{2*B}{n*n-3*n+2}$ (where B is the raw betweenness score and n is the number of nodes in the network); this is the default normalisation in the R package *igraph* (Csárdi and Nepusz, 2006) which we used to calculate each of the centrality measures.

RQ4 – Project leadership.

In order to explore how gendered project leadership is related to the relational mechanisms of homophily and familiarity, we looked at the roles that are most likely to have agency in selecting collaboration partners: directors, producers and DOPs. To explain why, it is important to note that agency is not distributed equally in collaboration networks such as the ones we analyse. Most people in these networks do not choose their collaboration partners – they are hired to work on projects, and their ties are with other people also hired onto that project. For these people, measures such as the tendency to work in familiar teams and the tendency to work with same-gender collaborators thus tell us about their *experiences* in the industry, but not necessarily about their *choices*. By focusing on people in these three key roles, however, we are able to capture more agency, as these roles are most likely to have hiring power over the project team. In the project-based organisation of the film industry, the key decision-making responsibility for employment typically rests with the producer and (to a lesser extent) the director. Producers are responsible for defining the scale and shape of the project and organising its financing, contracting and administration. They are usually responsible for the initial employment of above-the-line key creatives (for example the director and writer) and the heads of the different departments (which will vary according to the size and complexity of the production but may include camera, art, sound, make-up, hair, wardrobe, lighting, post-production and special effects). Employment practices will vary slightly from project to project with directors often playing a role in the selection of the DOP, editor or production designer, while heads of department will typically be responsible for appointing their own teams. However, ultimately it is the producer who is responsible for hiring and managing the entire cast and crew (Ebbers et al., 2013). Thus, to explore our fourth research question, we consider our project-level measures for those productions which have a man as a director against those which have a woman as a director, and do the same for producer and DOP. This allows us to focus more directly on the level of homophily and familiarity seen when men and women are making decisions about team selection.

Findings

Gendered composition of teams and homophily

Looking at gender balance not only as a headcount but as a relational phenomenon, we find that on film projects (considering all roles), the average percentage of people worked with that are men is 80.5 % for men, compared with an average of 77.6 % for women. On TV projects, the average for men is 70.2 %, and is 65.5 % for women. For both film

and TV, we conducted a two-sided t-test on the difference in means for men and women. This t-test (see Table 2) tells us how likely it is that we would find a difference in means of this size if the data were drawn from an underlying distribution where the "true" difference in means were 0. The t-tests for both the film and TV networks suggest that we can reject this null hypothesis, as the p-value is very small in both cases ($p < 0.001$). Besides confirming the dominance of men in this sector, these results suggest that there is a degree of gender-based assortativity in the project participation patterns of the industry, with men being less likely to work with women than are women. This difference persists even when we restrict the data to include only roles within the male-dominated camera departments. In film, the average percentage of men among people worked with is 84.5 % for men, compared with 83.1 % for women, though the t-test finds this difference not to be statistically significant ($p = 0.245$). In TV, the average is 81.2 % for men, compared with 75.6 % for women (t-test $p < 0.001$).

Exploring the question of homophily directly in relation to RQ1, the Yule's Q coefficients (which take into account the imbalance between the numbers of men and women who work in each year) reveal an interesting pattern. As Fig. 4a shows, most people don't show much of a strong tendency for homophilous or heterophilous collaboration, and the predominance of men among their collaboration partners can be more or less explained by the underlying numerical imbalance between men and women. However, we also see a clear group of men in the film industry who only or almost exclusively work with other men. There is no equivalent group of women who only work with women, but there is a group of women who only work with men. Given our earlier points about the distribution of agency in the networks, we cannot say that all of the men who only work with men are expressing a preference for doing so – only some of them have influence over the team selection. Similarly, it may be that the women only working with men are predominantly women who were simply hired onto projects on which no other women were present. Questions of agency are explored later in this section when we take project leadership into account. Fig. 4b shows that the pattern is less pronounced in TV, but still observed. Overall, in the film network, 178 men demonstrate perfect homophily in their collaboration patterns, while no women do. In the TV network, 39 men show perfect homophily, as do 11 women. In both film and TV, many people in the data do not show a strong tendency against working with potential collaborators of a different gender from themselves. However, there are also a large number of men who show a disproportionate tendency towards working with the available men rather than the available women.

Table 2
Comparison of means across men and women for measures used to explore RQ1 and RQ2.

Measure	Network	Mean for men	Mean for women	t-statistic	p-value
Percentage of people worked with that are men	Films, all roles	80.5	77.6	3.601	<0.001
	TV projects, all roles	70.2	65.5	5.539	<0.001
	Films, no writers	80.7	78.1	3.069	0.002
	TV projects, no writers	73.6	70.1	3.301	0.001
	Films, camera department only	84.5	83.1	1.162	0.245
	TV projects, camera department only	81.2	75.6	3.778	<0.001
Percentage of people worked with that are familiar	Films, all roles	10.5	8.3	2.075	0.039
	TV projects, all roles	33.3	32.4	0.472	0.637
	Films, no writers	11.1	8.9	2.05	0.042
	TV projects, no writers	33.3	27.8	2.5	0.013
	Films, camera department only	11.9	10.2	1.105	0.271
	TV projects, camera department only	31.8	28.9	0.968	0.336

Familiarity

In both film and TV, we found that it is more common for women to work with people they have not worked with before, while men show a stronger tendency to work with familiar people. Fig. 5a and b illustrate that this pattern is more pronounced in TV, where familiarity scores are higher in general. The difference between men and women is statistically significant in both film and TV when writers are excluded from the networks (see Table 2). However, the differences between men and women are not statistically significant in the networks containing only camera department workers (recall that we can only calculate this measure for people who work more than once, which reduces our *n*, especially for women). Nevertheless, we observe that in both film and TV, women are more concentrated at the lower end of the individual familiarity index distribution than men, and vice versa.

The observed tendency towards familiarity among men could work hand-in-hand with the fact that men also work with more men to produce a mechanism of gendered exclusion by familiarity. If men prefer to work with people they have worked with before, and we know that a) most of the people in the network are men, b) a lot of men show a disproportionate tendency towards working with other men, and c) women have been historically under-represented in the sector, then this is likely to result in men working with *men* they have worked with before. To explore this, we considered the correlation between the Yule's Q coefficients and the individual familiarity measure for those people who worked on more than one project in the networks. In the film network, the Pearson's correlation coefficient for these two variables is 0.12, though when split by gender the coefficient for men is 0.13 and for women is −0.06. In the TV network, the overall coefficient is 0.05, while the coefficient for men is −0.04 and for women is 0.21. Thus, there is only evidence of a weak relationship between homophily and familiarity, suggesting that the pattern of men working in overwhelmingly male-dominant teams is driven by a tendency among men to work with other men regardless of whether they have worked together before. The correlations do suggest that there is a tendency among some men in the film industry to work in teams that are male-dominant and familiar, and for some women in the television industry to work in teams that are familiar but less male-dominant.

Centrality

We now turn attention to the question of whether there is a gendered pattern of access to structurally important positions in the network, beyond the underlying gendered overall prevalence rates. Looking at the distributions of our three centrality measures, we found that centrality was not distributed much differently overall for men and women. In film and TV, a slightly higher proportion of men are able to achieve high degree scores, but the overall distributions are otherwise similar. When all roles are included in the network, women actually have higher scores generally for degree and eigenvector centrality in the TV network, though this pattern disappears when writers are excluded from the network. The overall distributions suggest that, despite being vastly outnumbered by men, women are generally able to accrue similar numbers of connections in the industry; these connections are similarly well-connected themselves; and most women have very similar capacity to exercise bridging or brokering power in the network structure compared with men. This is in itself interesting given the rhetorical focus of much gender policy discourse on what women can do differently and how they can be helped to network as well as men. In our data it seems that, in general, women get into similar network positions to

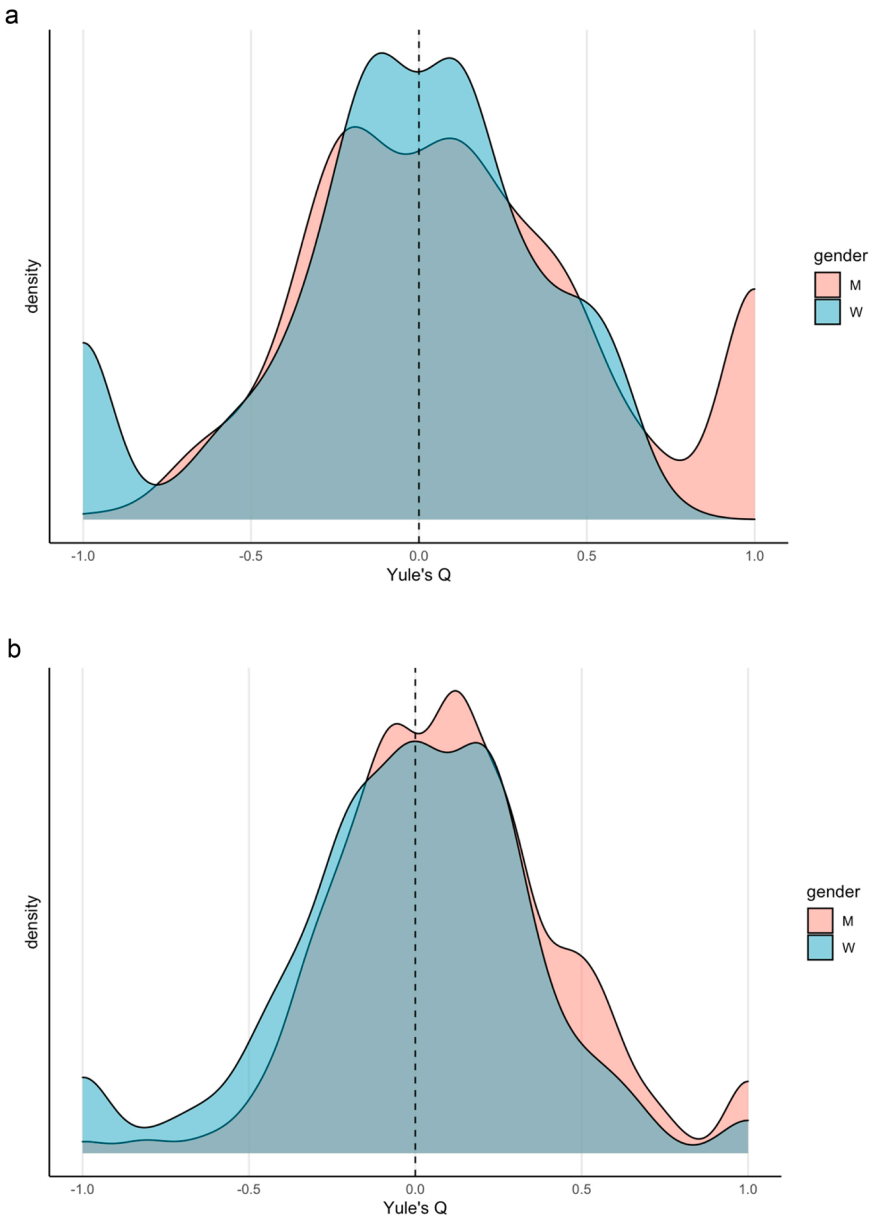

Fig. 4. a. Smoothed density estimates of Yule's Q coefficient distribution by gender. Film projects only, all roles included. Values of 1 on the x-axis indicate perfect homophily, values of −1 on the x-axis indicate perfect heterophily. b. Smoothed density estimates of Yule's Q coefficient distribution by gender. TV projects only, all roles included. Values of 1 on the x-axis indicate perfect homophily, values of −1 on the x-axis indicate perfect heterophily.

men.

Given that these centrality measures are heavily skewed, with most people having very low scores and only a few people having high centrality scores, we zoom in on the top 10 ranked individuals for each of the 3 measures for the TV and film networks to try and find the sites of power in the network structure. As Table 3 shows, camera department workers (here, a camera department worker is someone who has not also worked as a writer, producer or director in the data period) occupy all of the highest ranks for each of the centrality measures in the film network. Given this, it is perhaps unsurprising that the highest-ranked individuals for these measures are also almost entirely men. In the TV network, however, three people from above-the-line roles are among the most highly ranked people by degree, and women are more represented among the highly ranked individuals, especially for eigenvector centrality.

Notably, the profile of the top 10 ranked people by betweenness centrality reveals the structural importance of the camera department in the film and TV networks. Here, in both film and TV, the individuals in our data who most often lie on the shortest paths in the networks are entirely those working in camera departments. This suggests that camera departments are very important for connecting otherwise poorly-integrated parts of the industry together, with the people working in them acting as bridges between different regions of the creative network.

Project leadership

Comparing the profile of projects where men and women occupy the key roles of producer, director and DOP allows us to explore how project compositions differ relationally when men and women are in positions of power on productions. Fig. 6 presents the results of this comparison for our project-level measures. Among both film and TV projects, we find that projects with women in each leadership role employ a lower proportion of men and thus have a more equitable crew composition than their male-led counterparts. In addition, two-sided t-tests find that each

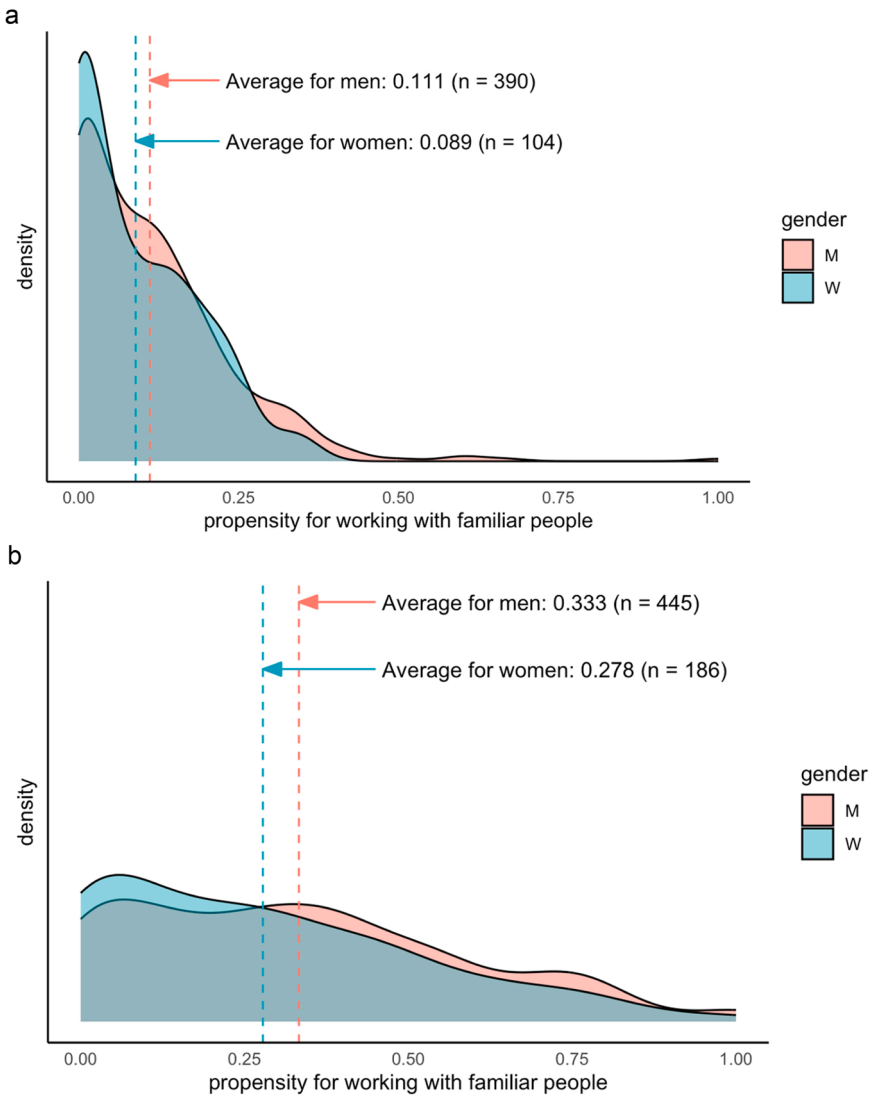

Fig. 5. a. Smoothed density estimates of individual familiarity distributions by gender. Film projects only, writers filtered out of the data prior to computing individual familiarity propensities. Fig. 5b. Smoothed density estimates of individual familiarity distributions by gender. TV projects only, writers filtered out of the data prior to computing individual familiarity propensities.

Table 3
Number of camera department workers and number of men among the top 10 ranked people for each centrality measure (film network vs TV network, all roles included).

	Film		TV	
Centrality measure	Number of camera department workers in top 10	Number of men in top 10	Number of camera department workers in top 10	Number of men in top 10
Degree	10	9	7	7
Eigenvector	10	9	10	5
Betweenness (binary edges)	10	9	10	8
Betweenness (weighted edges)	10	8	10	7

of the comparisons of the mean proportion of people that are men is statistically significant at the 95 % level. This provides an important nuance to our earlier findings relating to homophily, as it suggests that where team selection agency exists, both men and women demonstrate an apparent preference for working with more people of the same gender. The finding that projects with women in these roles are less dominated by men is therefore quite revealing - the reproduction of male dominance seems to be a problem which is most pronounced on projects in which men exercise hiring power (which is the majority of projects).

Looking at the mean team familiarity scores on men- and women-led projects suggests that familiarity may indeed be a mechanism by which women are disadvantaged in certain parts of the industry. In film, familiarity scores are low across the board, making it difficult to discern any distinct pattern. Moreover, t-tests found none of the comparisons for mean team familiarity to be statistically significant at the 95 % level for film projects. There is, however, a clearer and more pronounced pattern in the TV network, where projects with men in any of the three key roles all show notably higher team familiarity scores and levels of male dominance on average. For TV projects, t-tests found that the comparison of mean team familiarity scores based on the gender of the director and DOP were statistically significant at the 95 % level, while the comparison based on the gender of the producer was only marginally significant ($p = 0.07$). This suggests that the tendency towards familiarity among men with hiring power may be a mechanism of exclusion for women in the television industry specifically.

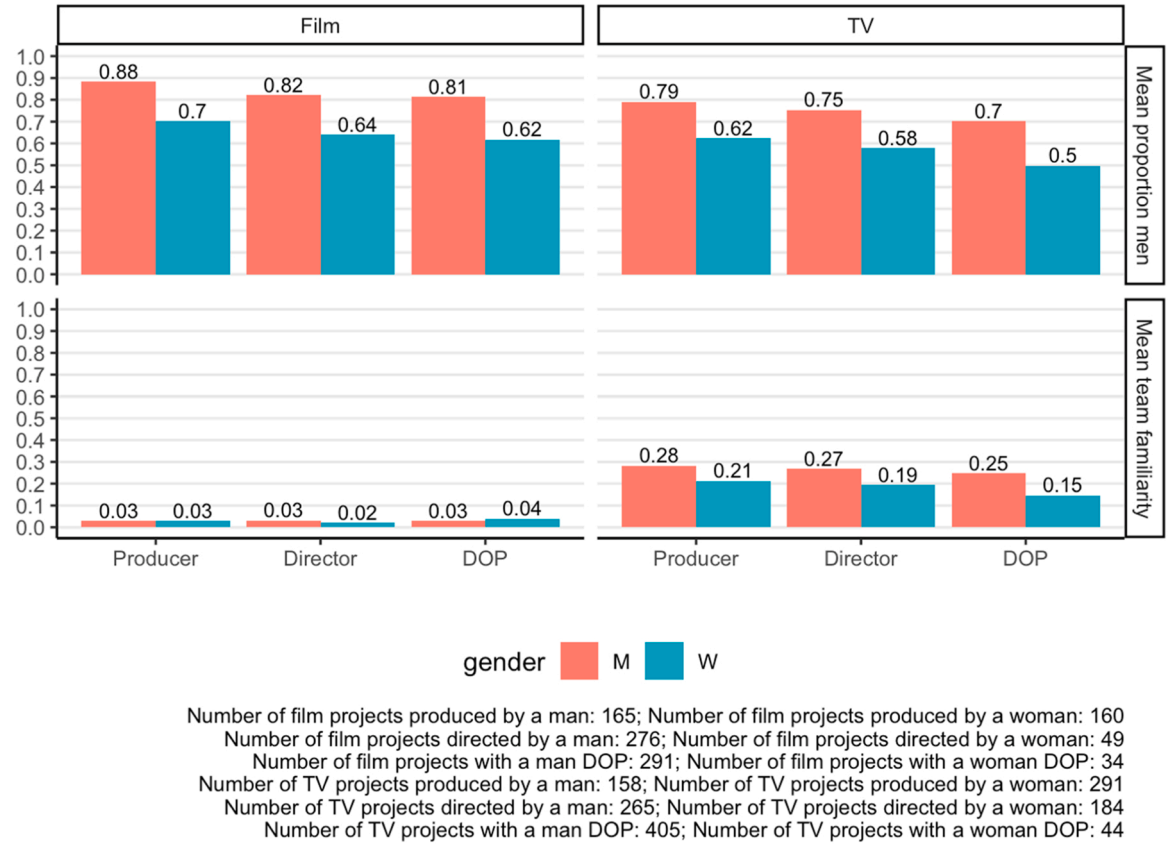

Fig. 6. Comparison of projects with men and women in the roles of producer, director and DOP in the film and TV networks, all roles included. Projects are compared based on the mean percentage of people working on them that are men as well as the mean team familiarity scores.

Discussion

Our findings provide interesting answers to our four research questions. First, we asked to what extent men and women show a tendency towards working with people of the same gender, accounting for the overall gender imbalance. In both film and TV, the mean proportion of people worked with that are men is higher for men than for women, though the differences are small. However, when we look at Yule's Q coefficients which capture the tendency to work with people of the same gender after accounting for the number of people in each group, we see a clear group of men in the film industry who disproportionately work with men rather than women, and a clear group of women who disproportionately work with men rather than women.

Second, we asked to what extent men and women demonstrate a tendency towards working with people they have worked with before. Team familiarity scores are low in general in the film network, but men's individual collaboration histories show a higher tendency towards familiarity than women's do. Team familiarity is higher in the TV network, but the observed gender pattern is the same. The higher mean familiarity scores for men compared with women are only statistically significant in the networks consisting of key creatives and camera department workers. Individual tendency towards familiarity is weakly correlated with homophily overall, but the link is strongest among men in the film industry and women in the TV industry.

Third, we asked whether overall prevalence rates for women align with their access to structurally important network positions. The overall distributions of centrality scores for each measure suggest that women in general get into similar network positions to men despite being so vastly outnumbered. However, zooming in on the top-ranked individuals for each measure shows that, when compared against the overall gender imbalance, women are less able to access the strongest positions, especially in the film industry. In both film and TV, betweenness scores suggest that the male-dominated camera department is critical to connecting different regions of the collaboration network.

Finally, we asked how the mechanisms of homophily and familiarity intersect with patterns of gendered project leadership. On TV productions, men-led projects have higher team familiarity scores on average than women-led projects. On both film and TV productions, when men are in positions of power on a project, those projects have much higher proportions of men working on them than projects with women in positions of power. This suggests that when men and women get into positions where they have more control over selection of their collaboration partners, both show a preference for working with more people of the same gender. The rationale for this behaviour may not be the same in both cases. For women, this may be a deliberate strategy to reduce the dominance of men in the industry, representing a kind of solidarity in the face of historical systemic exclusion. For men, it is less clear what the reason may be. It could be claimed (as several of our survey respondents do) that the gender imbalance is not a deliberate discrimination against women, but rather a preference for working with people one trusts from previous experiences. However, we saw that individual familiarity was only weakly correlated with homophily. Moreover, the significant number of men who show complete homophily in their collaboration partners suggests that familiar claims such as "I would hire more women, but there just aren't any to work with" offer insufficient explanation, as men's tendency towards working with other men persists even after taking into account the under-representation of women in the industry. Conversely, when women are in positions of power, they are much more able to find women to work on their projects despite there being so many fewer women overall.

Our analysis here shows that there is more to understanding gender

inequities in the screen industries than counting heads. By taking a relational approach, we can see that collaboration is a gendered process, with the patterns of co-working in the Australian screen sector unfolding in unequal and potentially exclusionary ways. Moreover, these processes appear to intersect with power, as women tend to oversee projects that make more space for women and new people, especially in television, while men tend to oversee projects that reproduce male-dominated creative collaborations. Given that there are so many more men than women in positions of power, this implies that the issue of gendered inequities in the screen sector is more an issue of male collaboration behaviour, rather than women's deficiencies in technical skills or networking abilities. These collaboration behaviours help us understand why women's careers appear to stall in Australian camera departments: the network presents them with systemic disadvantages that collectively paint the picture of a "boys club" which makes little space for women to progress, especially in the film industry. For scholars interested in inequities in other industries than the one we analyse here, we hope these findings can suggest possible mechanisms that could be further investigated beyond the Australian screen industries.

Our paper contributes by providing further evidence of how gender operates in the Australian screen sector. It is important to emphasise that we contribute not only by adding *more* evidence, but by adding *relational* evidence, which is uniquely capable of illuminating the underlying interpersonal behaviours in the industry. By taking a network approach to empirically investigating the problem of men's dominance in the Australian screen sector, we are able to address questions of relational behaviour which receive little empirical attention in this area. Rather than focus on whether there are "enough" women, or what women could do differently to be more successful, our approach to exploring gendered collaborations highlights the ways in which experiences of these project-based creative industries are driven by closed, exclusive network structures among men, especially men in positions of power. The evidence we find for homophily and familiarity-based collaborations, especially when gendered project leadership is taken into account, suggests that men's relational strategies and behaviours hurt women's participation a lot more than do women's. Conventional approaches which equate participation in the cultural sector with simply counting women (as a basis for gender equity policies) cannot provide this kind of insight into the processes which guide the assembly of creative teams. We suggest that it is at best unclear how policies aimed at "increasing women's participation" will disrupt the relational mechanisms that sustain men's dominance in the industry, given that they are not designed to change men's behaviour in any way. This is a key way in which relational data and network analysis can provide the evidence and basis for a more mechanistic and change-oriented conversation around gender inequities in project-based labour markets.

We close the paper with reflection on some limitations of the research we report on here, which also identify opportunities for future work to build on the analyses in this study. Our analysis is based on the one-mode projection of the person-to-project affiliation data. We pursued this strategy in order to analyse the way that collaboration creates gendered relational structures and patterns *between* creative professionals in this industry. However, there are some issues with the resulting networks obtained via this approach. First, as is common for secondary collaboration data, we use co-working on projects as a proxy for collaborative ties. This tells us little about the nature of the ties and the experiences of those involved. Our qualitative baseline evidence provides some context to interpret the patterns we see in the network data, but more qualitative work (such as interviews) exploring the gendered nature of collaboration from the perspective of those involved would help enrich further research in this area. This could, for example, help further clarify some of our discussion about possible asymmetries in the rationale for homophilous collaboration for men and women.

Secondly, the degree of the nodes in the column nodeset of the affiliation matrix has an oversized influence on the row-based degrees in the ensuing one-mode projection. Each film or TV project creates a complete subgraph among the people that worked on it, and so projects with larger crews create larger cliques in the projected network. These cliques have the effect of creating an overabundance of triangles in the projection, making investigation of extradyadic network mechanisms such as transitivity difficult. Moreover, as each member of these cliques has a highly overlapping neighbourhood, differentiation of nodes based on degree- and neighbourhood-based measures becomes closely linked to the number and size of projects worked on, which is a restrictive sense of a node's importance. A more bespoke approach to considering and measuring node importance in creative collaboration networks projected from affiliation data would help us gain a better sense of how power is distributed through these networks. However, the goal of this paper was not to introduce or trial a new method for measuring centrality in such networks.

There are a few options for addressing the clique problem, and here we wish to highlight two possible ways forward. The first is to use the fractional approach to affiliation network projection (Batagelj, 2020, 2022). This approach constrains each column in the affiliation matrix to provide the same normalised contribution (one point) to the projected network, with this point being split among the participants affiliated with that column-node. The normalised projection obtained this way is expected to offer a "fairer" reflection of the original affiliation network (*ibid.*). The second option is to use backbone extraction methods designed for bipartite networks (Neal, 2014) to select only the most significant edges to include in the final network. This approach would likely reduce the overabundance of cliques and highly overlapping neighbourhoods by filtering out those collaborations which are more likely to have happened in alternative scenarios wherein the same people worked on approximately the same number of projects and the projects had approximately the same size crews (*ibid.*). Further research into screen sector collaboration networks might consider exploring what the implications of these approaches to network representation might be for this particular kind of co-affiliation network data and its ability to inform equity policy discussions. We believe that the job of thinking through these implications warrants more time and space than we could afford to give it here, but we wish to acknowledge this as an area ripe for further exploration.

Finally, our adoption of Lutter's team familiarity measure highlighted the value of considering the temporal aspects of collaboration, and suggests that this might be a fruitful avenue for further investigation into the gendered mechanisms in this type of collaboration network. However, there are some limitations that should be noted when taking a temporal approach to data representing film and television productions. In our data, as is typical for production data, time is captured in a single variable corresponding to the year of release for the production. However, different production types have different release mechanisms - broadcast TV series, for instance, may be released episodically over the course of multiple years. This makes harmonisation with film data awkward. Moreover, when we study collaboration networks from a sociological perspective, we are often interested in the production process itself rather than the final project's release (indeed, an unreleased film is still a collaboration and would still be expected to contribute to the network mechanisms at work). How long a team works together prior to release can vary from project to project, and it is these timings that are more relevant to the relational processes that familiarity-based metrics are designed to measure, not the release timings. It may be that by ordering the dataset by release year, we inaccurately identify cases where people do (and do not) work with people they have chronologically worked with before. There is no simple solution to this problem, but future research on collaboration networks might explore how temporal measures can be developed which are less affected by this aspect of the screen industry's organisation model.

CRediT authorship contribution statement

Pete Jones: Writing, Methodology, Formal analysis, Programming,

Visualisation. Deb Verhoeven: Writing, Conceptualisation, Supervision. Aresh Dadlani: Formal analysis, Validation. Vejune Zemaityte: Data Curation, Writing - Review & Editing.

Declaration of Competing Interest

None.

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References

Antcliff, V., Saundry, R., Stuart, M., 2007. Networks and social capital in the UK television industry: the weakness of weak ties (Available at:). Hum. Relat. 60 (2), 371–393. https://doi.org/10.1177/0018726707075880.

Australian Bureau of Statistics, 2021. Characteristics of Employment. Australian Bureau of Statistics, Australia. Available at: ⟨https://www.abs.gov.au/statistics/labour/earnings-and-working-conditions/characteristics-employment-australia/latest-release⟩.

Banks, M., 2018. Production Studies. Fem. Media Hist. 4 (2), 157–161. https://doi.org/10.1525/fmh.2018.4.2.157.

Banks, M.J., 2009. Gender below-the-line: defining feminist production. In: Mayer, V., Banks, M.J., Caldwell, J.T. (Eds.), Production Studies. Routledge, pp. 87–98.

Batagelj, V., 2020. On fractional approach to analysis of linked networks. Scientometrics 123 (2), 621–633. https://doi.org/10.1007/s11192-020-03383-y.

Batagelj, V., 2022. Analysis of the Southern women network using fractional approach. Soc. Netw. 68, 229–236. https://doi.org/10.1016/j.socnet.2021.08.001.

Bechky, B.A., 2006. Gaffers, gofers, and grips: role-based coordination in temporary organizations. Organ. Sci. 17 (1), 3–21. https://doi.org/10.1287/orsc.1050.0149.

Bellotti, E., et al., 2022. Gender inequalities in research funding: Unequal network configurations, or unequal network returns? Soc. Netw. 70, 138–151. https://doi.org/10.1016/j.socnet.2021.12.007.

Blair, H., 2001. You're only as good as your last job: the labour process and labour market in the British Film Industry. Work, Employ. Soc. 15 (1), 149–169. https://doi.org/10.1177/09500170122118814.

Caldwell, J.T., 2008. Production Culture: Industrial Reflexivity and Critical Practice in Film and Television. Duke University Press. https://doi.org/10.1215/9780822388968.

Cattani, G., et al., 2008. The structure of consensus: network ties, legitimation, and exit rates of U.S. Feature Film Producer Organizations. Adm. Sci. Q. 53 (1), 145–182.

Cattani, G., Ferriani, S., 2008. A core/periphery perspective on individual creative performance: social networks and cinematic achievements in the Hollywood Film Industry. Organ. Sci. 19 (6), 824–844. https://doi.org/10.1287/orsc.1070.0350.

Cattani, G., Ferriani, S., 2013. Networks and rewards among hollywood artists: evidence for a social structural ordering of creativity. In: Kaufman, J.C., Simonton, D.K. (Eds.), The Social Science of Cinema. Oxford University Press, pp. 185–206. https://doi.org/10.1093/acprof:oso/9780199797813.001.0001.

Cattani, G., Ferriani, S., Allison, P.D., 2014. Insiders, outsiders, and the struggle for consecration in cultural fields: a core-periphery perspective. Am. Sociol. Rev. 79 (2), 258–281. https://doi.org/10.1177/0003122414520960.

Coate, B., Eltham, B., Verhoeven, D., 2023. By a long shot: Addressing Power, Devaluation and Discrimination in a Toxic Cultural Workforce. Australian Journal of Management. https://doi.org/10.1177/03128962231179379.

Coles, A., Eikhof, D.R., 2021. On the basis of risk: How screen executives' risk perceptions and practices drive gender inequality in directing. Gend., Work Organ. 28 (6), 2040–2057. https://doi.org/10.1111/gwao.12701.

Coles, A., Ferrer, J., Zemaityte, V., 2022. A Wider Lens: Australian Camera Workforce Development and Diversity 90. Available at: ⟨https://cinematographer.org.au/wp-content/uploads/2022/07/A-Wider-Lens-report-final.pdf⟩.

Conor, B., 2021. Gender & Creativity: Progress on the Precipice, Special Edition. UNESCO (2005 Convention Global Report series), Paris.

Crossley, N., et al., 2015. Social Network Analysis for Ego-Nets. SAGE Publications Ltd, London. https://doi.org/10.4135/9781473911871.

Csárdi, G., Nepusz, T., 2006. The igraph software package for complex network research. InterJ. Complex Syst. (Available at: ⟨https://igraph.org⟩).

Ebbers, J.J., Wijnberg, N.M., Bhansing, P.V., 2013. The producer–director dyad: managing the faultline between art and commerce. In: Kaufman, J.C., Simonton, D. K. (Eds.), The Social Science of Cinema. Oxford University Press, p. 0. Available at: ⟨https://doi.org/10.1093/acprof:oso/9780199797813.003.0007⟩.

Fanchi, M., Tarantino, M., 2020. 'Has digital transformation impacted gender imbalance in Italian cinema? A data analysis of creative clusters 2004–2016'. In: Massi, M., Vecco, M., Lin, Y. (Eds.), Digital Transformation in the Cultural And Creative Industries: Production, Consumption and Entrepreneurship in the Digital and Sharing Economy. Routledge/Taylor & Francis Group (Routledge research in the creative & cultural industries), London; New York, pp. 162–184.

Faulkner, R.R., 1983. Music on Demand: Composers and Careers in the Hollywood Film Industry. Transaction Books, New Brunswick.

Faulkner, R.R., Anderson, A.B., 1987. Short-Term projects and emergent careers: evidence from Hollywood. Am. J. Sociol. 92 (4), 879–909. https://doi.org/10.1086/228586.

Franklin, M., 2022. Risk in the Film Business: Known Unknowns. 1st edn. Routledge, London. https://doi.org/10.4324/9781003131670.

Goldschmidt, C. (2021) Levelling the Playing Field. Special Report. British Cinematographer. Available at: ⟨https://britishcinematographer.co.uk/gender-diversity/⟩ (Accessed: 6 December 2022).

Grugulis, I., Stoyanova, D., 2012. Social capital and networks in film and TV: jobs for the boys? Organ. Stud. 33 (10), 1311–1331. https://doi.org/10.1177/0170840612453525.

Hadley, S., Heidelberg, B., Belfiore, E., 2022. Reflexivity and the perpetuation of inequality in the cultural sector: half awake in a fake empire? J. Cult. Res. 0 (0), 1–22. https://doi.org/10.1080/14797585.2022.2111220.

Jansson, M., Wallenberg, L., 2020. Experiencing male dominance in swedish film production. In: Liddy, S. (Ed.), Women in the International Film Industry. Springer International Publishing, Cham, pp. 163–178. https://doi.org/10.1007/978-3-030-39070-9_10.

Jones, C., 1996. Careers in project networks: the case of the film industry. In: Arthur, M. B., Rousseau, D.M. (Eds.), The Boundaryless Career: A New Employment Principle for a New Organizational Era. Oxford University Press, Oxford, pp. 58–75.

Jones, C., Walsh, K., 1997. Boundaryless careers in the US film industry: Understanding labor market dynamics of network organizations. Ind. Bezieh. 4.

Jones, D., Pringle, J.K., 2015. Unmanageable inequalities: sexism in the film industry. Sociol. Rev. 63 (1_suppl), 37–49. https://doi.org/10.1111/1467-954X.12239.

Lauzen, M.M., 2021. Boxed. Women on Screen and Behind the Scenes on Broadcast and Streaming Television in 2020-21. The Center for the Study of Women in Television and Film, San Diego State University, p. 35. Available at: ⟨https://womenintvfilm.sdsu.edu/wp-content/uploads/2021/09/2020-21_Boxed_In_Report.pdf⟩.

Lauzen, M.M., 2022. The Celluloid Ceiling in a Pandemic Year: Employment of Women on the Top U.S. Films of 2021. The Center for the Study of Women in Television and Film, San Diego State University, p. 13 (Available at:). ⟨https://womenintvfilm.sdsu.edu/wp-content/uploads/2022/01/2021-Celluloid-Ceiling-Report.pdf⟩.

Loist, S., Prommer, E., 2019. Gendered production culture in the German film industry. Media Ind. J. 6 (1) https://doi.org/10.3998/mij.15031809.0006.106.

Lutter, M., 2015. Do women suffer from network closure? The moderating effect of social capital on gender inequality in a project-based labor market, 1929 to 2010. Am. Sociol. Rev. 80 (2), 329–358. https://doi.org/10.1177/0003122414568788.

Margolis, H., Krasilovsky, A., Stein, J., 2015. Shooting Women: Behind the Camera, Around the World. 1. publ. Intellect, Bristol.

Mayer, V., 2011. Below the Line: Producers and Production Studies in the New Television Economy. Duke University Press. https://doi.org/10.2307/j.ctv11g95zp.

Meiseberg, B., Ehrmann, T., 2013. Diversity in teams and the success of cultural products. J. Cult. Econ. 37 (1), 61–86. https://doi.org/10.1007/s10824-012-9173-7.

Neal, Z., 2014. The backbone of bipartite projections: inferring relationships from co-authorship, co-sponsorship, co-attendance and other co-behaviors. Soc. Netw. 39, 84–97. https://doi.org/10.1016/j.socnet.2014.06.001.

O'Brien, A., 2019. Women, Inequality and Media Work, 1st edition. Routledge, London. Available at: ⟨https://www.routledge.com/Women-Inequality-and-Media-Work/OBrien/p/book/9781138352315⟩.

Perretti, F., Negro, G., 2007. Mixing genres and matching people: a study in innovation and team composition in Hollywood. J. Organ. Behav. 28 (5), 563–586. https://doi.org/10.1002/job.464.

Reuters (2019) Berlin festival aims for gender equality with half of films by women, *Reuters*, 9 February. Available at: ⟨https://www.reuters.com/article/us-filmfestival-berlin-women-idUSKCN1PY09W⟩ (Accessed: 15 November 2022).

Rossman, G., Esparza, N., Bonacich, P., 2010. I'd like to thank the academy, team Spillovers, and network centrality. Am. Sociol. Rev. 75 (1), 31–51. https://doi.org/10.1177/0003122409359164.

Roxborough, S. (2016) Cannes: U.K. Industry Targets Gender Equality in Film Funding by 2020, The Hollywood Reporter, 15 May. Available at: ⟨https://www.hollywoodreporter.com/movies/movie-news/cannes-uk-industry-targets-gender-894246/⟩ (Accessed: 15 November 2022).

Screen Australia (2016) Gender Matters: Final stages revealed, Screen Australia. Available at: ⟨https://www.screenaustralia.gov.au/sa/media-centre/news/2016/07–29-gender-matters-better-deals⟩ (Accessed: 15 November 2022).

Screen Australia (2021) 2021 Snapshot: Cinema, Screen Australia. Available at: ⟨https://www.screenaustralia.gov.au/fact-finders/cinema/industry-trends/2021-snapshot⟩ (Accessed: 15 November 2022).

Simone, P. (2021) Female professionals in European film production. European Audiovisual Observatory, p. 67. Available at: ⟨https://rm.coe.int/female-professionals-in-european-film-production-december-2021/1680a4d30a⟩ (Accessed: 6 December 2022).

Soda, G., Mannucci, P.V., Burt, R.S., 2021. Networks, creativity, and time: staying creative through brokerage and network rejuvenation. Acad. Manag. J. 64 (4), 1164–1190. https://doi.org/10.5465/amj.2019.1209.

Telefilm (2016) Telefilm Canada announces, in partnership with the industry, gender parity measures for feature film production financing, Telefilm Canada. Available at: ⟨https://telefilm.ca/en/telefilm-canada-announces-partnership-industry-gender-parity-measures-feature-film-production-financing⟩ (Accessed: 15 November 2022).

Verhoeven, D., et al., 2020. Controlling for openness in the male-dominated collaborative networks of the global film industry. PLoS One 15 (6), e0234460. https://doi.org/10.1371/journal.pone.0234460.

Verhoeven, D., et al., 2022. Net effects: examining strategies for women's inclusion and influence in ASX200 company boards. Appl. Netw. Sci. 7 (1), 1–26. https://doi.org/10.1007/s41109-022-00490-y.

Verhoeven, D., Coate, B., Zemaityte, V., 2019. Re-distributing gender in the global film industry: beyond #MeToo and #MeThree. Media Ind. J. 6 (1) https://doi.org/10.3998/mij.15031809.0006.108.

Wickham, H., 2016. ggplot2: Elegant Graphics for Data Analysis, 2nd ed. Springer International Publishing: Imprint: Springer (Use R!), Cham. https://doi.org/10.1007/978-3-319-24277-4.

Wing-Fai, L., Gill, R., Randle, K., 2015. Getting in, getting on, getting out? women as career scramblers in the UK film and television industries. Sociol. Rev. 63 (1_suppl), 50–65. https://doi.org/10.1111/1467-954X.12240.

Wreyford, N., 2015. Birds of a feather: informal recruitment practices and gendered outcomes for screenwriting work in the UK film industry. Sociol. Rev. 63 (1_suppl), 84–96. https://doi.org/10.1111/1467-954X.12242.

Yule, G.U., 1912. On the Methods of Measuring Association Between Two Attributes. https://doi.org/10.2307/2340126.