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Gender diversity and publication activity—an analysis of STEM in the UK

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Outline

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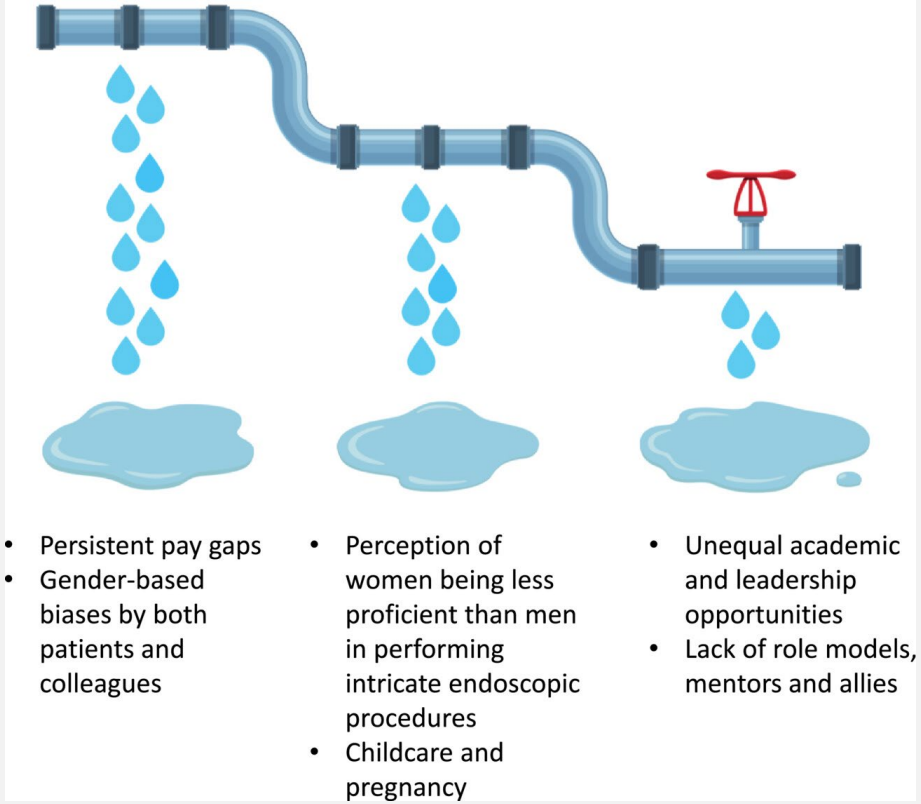
- Research Questions
- Data & Context
  - ❖ Gateway to Research
- Methods
  - ❖ Social Network Analysis
- Findings
- Concluding comments

Background

- Underrepresentation of women in academia remains a salient issue, one which is particularly prominent in science, technology, engineering, and mathematics (STEM).
- The existing literature attributes the disadvantages of women in academia (especially STEM) to a number of factors:
  - ❖ disproportionate pressure to balance educational plans with non-academic responsibilities,
  - ❖ increased likelihood of experiencing isolation and exclusion during their career,
  - ❖ lack of supportive social networks.

Leaky Pipeline

- The leaky pipeline emerged as an important framework to explain the gender gap in STEM.
- The leaky pipeline is used to describe the loss of women in the STEM career progression pathway, from school all the way to senior positions within the field.
- A critique of the framework is that it often fails to explain the experiences of women that are remaining in the pipeline.



The "leaky pipeline" of women in gastroenterology. Source: Devi et al (2023)

Academic Chutes & Ladders

- Others argue that the academic system is not a pipeline. Windsor et al (2021) suggest that it is a game of ‘Academic Chutes and Ladders’
- A hierarchical structure with:
  - ❖ hidden curriculum &
  - ❖ hidden shortcuts.
- The system favours men, as they are more likely to have access to shortcuts, or “academic ladders”.
- Women are more likely to be vulnerable to “academic chutes” because of:
  - ❖ significant changes in personal and professional circumstances such as pregnancy,
  - ❖ bias in hiring or promotion committees,
  - ❖ gender harassment.

Gender & Collaborative Networks

- Research and innovation is not completed in isolation; therefore, effective collaborative ties are essential.
- Several studies examine the role of gender in the formation of collaborative ties in the sciences.
- Kwiek and Roszka (2021) study the role of gender homophily in the sciences:
  - ❖ Homophily underpins many patterns of collaboration amongst men scientists.
  - ❖ However, they find that this is not the case with women scientists, where they are not likely to collaborate with other women.

Research Aims

This study:

- seeks to examine the link between the publication success of publicly funded research projects in the sciences and gender:
  - ❖ whether increased gender diversity is associated with a project with increased publication success.
- aims to investigate how collaborative arrangements impact the publication success of a project.
  - ❖ Research projects often consist of collaborative arrangements involving a wide variety of institutions.
  - ❖ We examine whether these collaborative arrangements and holding a central position in the research funding space is more important for women compared to men.

Research Questions

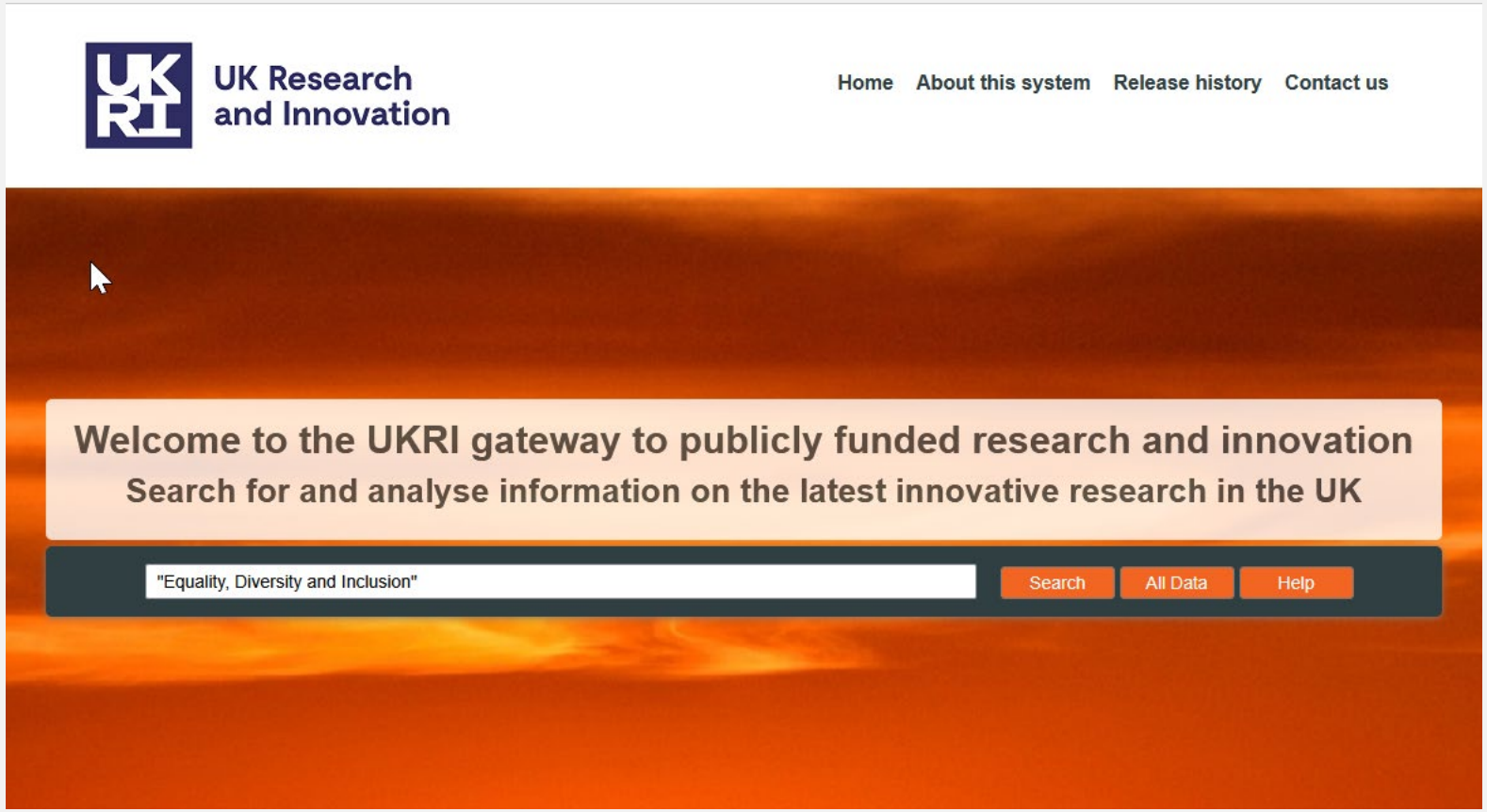
This study addresses the following research questions in the context of STEM UK research council funded projects:

- Is a project with a high proportion of women associated with publishing in journals with a higher journal score?
- Is a project with a woman PI associated with publishing in journals with a higher journal score?
- Is network centrality associated with publishing in journals with a higher journal score?
- Is network centrality more important for publishing in journals with a higher ranking (as captured by a journal metric) when the project has a woman PI?

Data

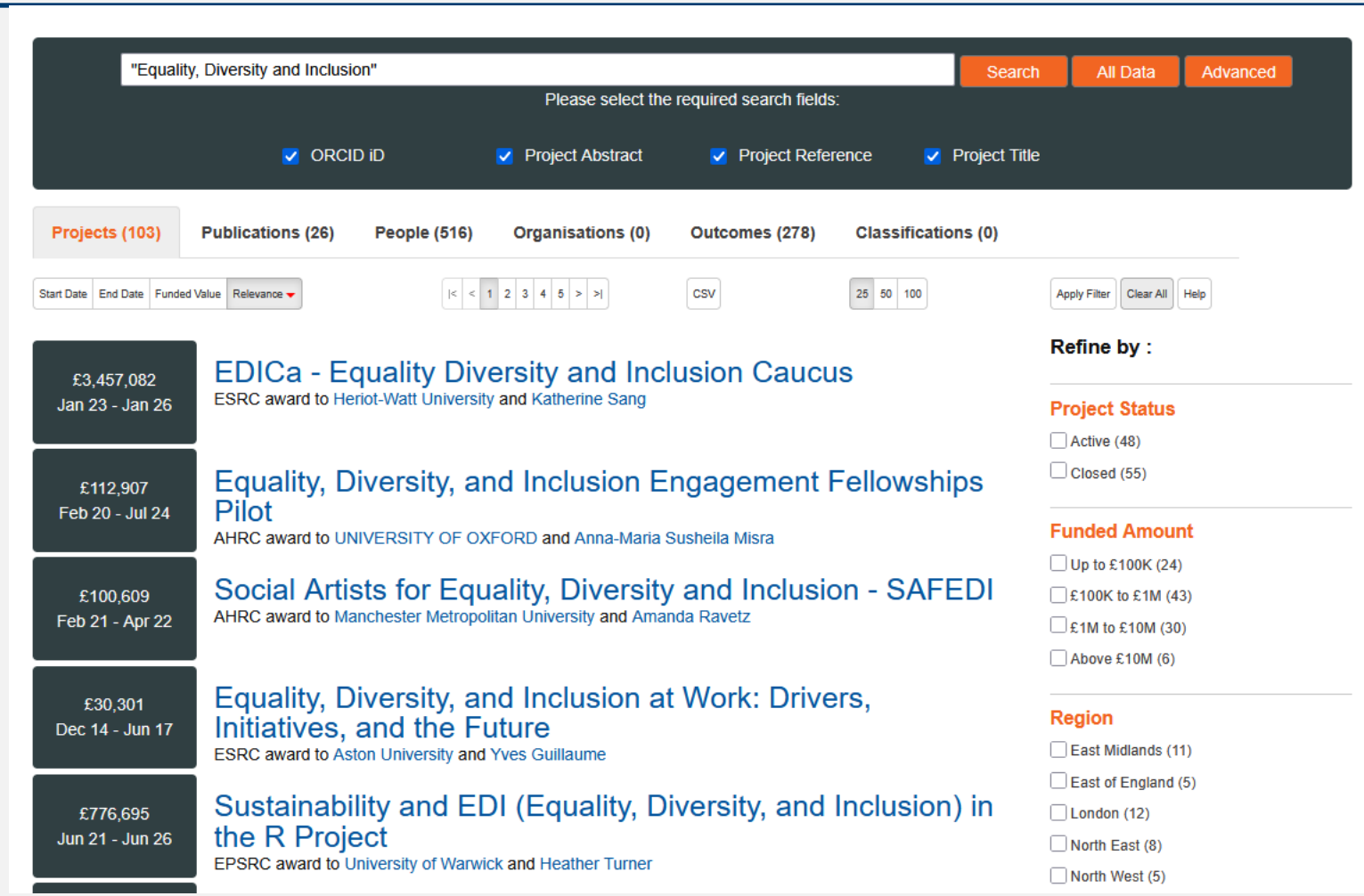
- This study draws on data from the UK research council database, Gateway to Research (GtR).
- GtR provides information on:
  - ❖ funder,
  - ❖ level of funding provided,
  - ❖ project duration,
  - ❖ project partners (at organisational and individual levels),
  - ❖ project outcomes (publications, patents, spinouts, policy impact, further funding).
- As the focus of this article is on STEM, we restrict our analysis to research grants funded by the Engineering and Physical Sciences Research Council (EPSRC).

Data: GtR Demonstration

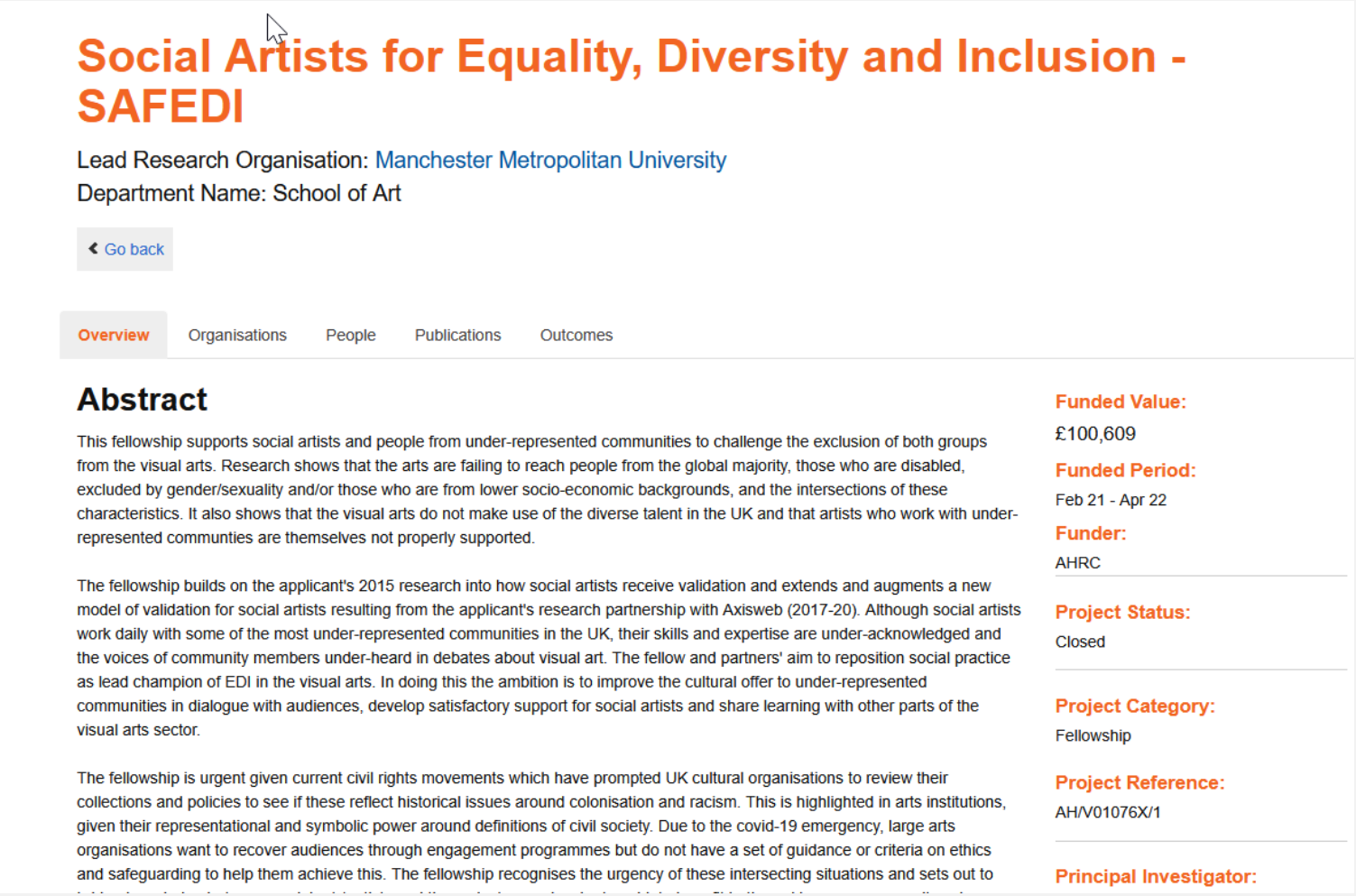


https://gtr.ukri.org/

Data: GtR Demonstration



Data: GtR Demonstration



Social Artists for Equality, Diversity and Inclusion - SAFEDI

Lead Research Organisation: Manchester Metropolitan University
Department Name: School of Art

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Overview | Organisations | People | Publications | Outcomes

Abstract

This fellowship supports social artists and people from under-represented communities to challenge the exclusion of both groups from the visual arts. Research shows that the arts are failing to reach people from the global majority, those who are disabled, excluded by gender/sexuality and/or those who are from lower socio-economic backgrounds, and the intersections of these characteristics. It also shows that the visual arts do not make use of the diverse talent in the UK and that artists who work with under-represented communties are themselves not properly supported.

The fellowship builds on the applicant's 2015 research into how social artists receive validation and extends and augments a new model of validation for social artists resulting from the applicant's research partnership with Axisweb (2017-20). Although social artists work daily with some of the most under-represented communities in the UK, their skills and expertise are under-acknowledged and the voices of community members under-heard in debates about visual art. The fellow and partners' aim to reposition social practice as lead champion of EDI in the visual arts. In doing this the ambition is to improve the cultural offer to under-represented communities in dialogue with audiences, develop satisfactory support for social artists and share learning with other parts of the visual arts sector.

The fellowship is urgent given current civil rights movements which have prompted UK cultural organisations to review their collections and policies to see if these reflect historical issues around colonisation and racism. This is highlighted in arts institutions, given their representational and symbolic power around definitions of civil society. Due to the covid-19 emergency, large arts organisations want to recover audiences through engagement programmes but do not have a set of guidance or criteria on ethics and safeguarding to help them achieve this. The fellowship recognises the urgency of these intersecting situations and sets out to

Funded Value:
£100,609

Funded Period:
Feb 21 - Apr 22

Funder:
AHRC

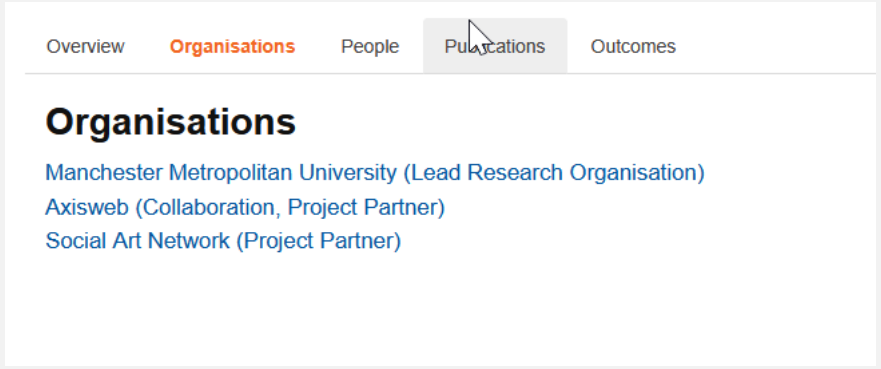
Project Status:
Closed

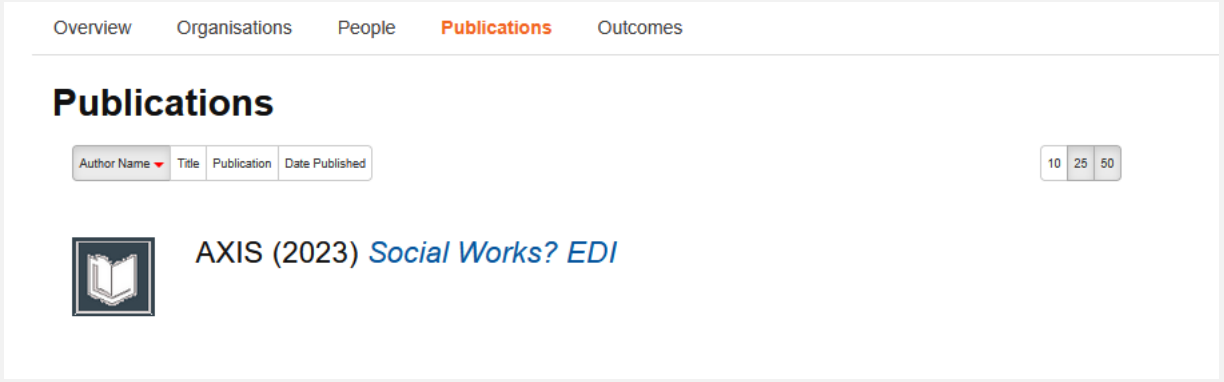
Project Category:
Fellowship

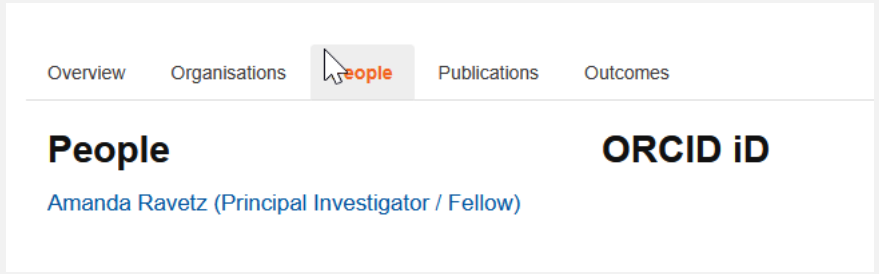
Project Reference:
AH/V01076X/1

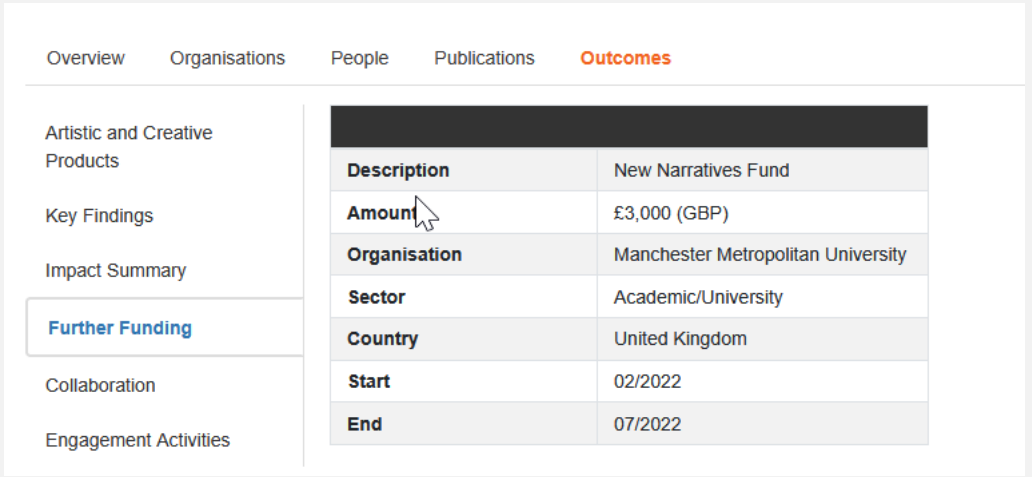
Principal Investigator:

Data: GtR Demonstration







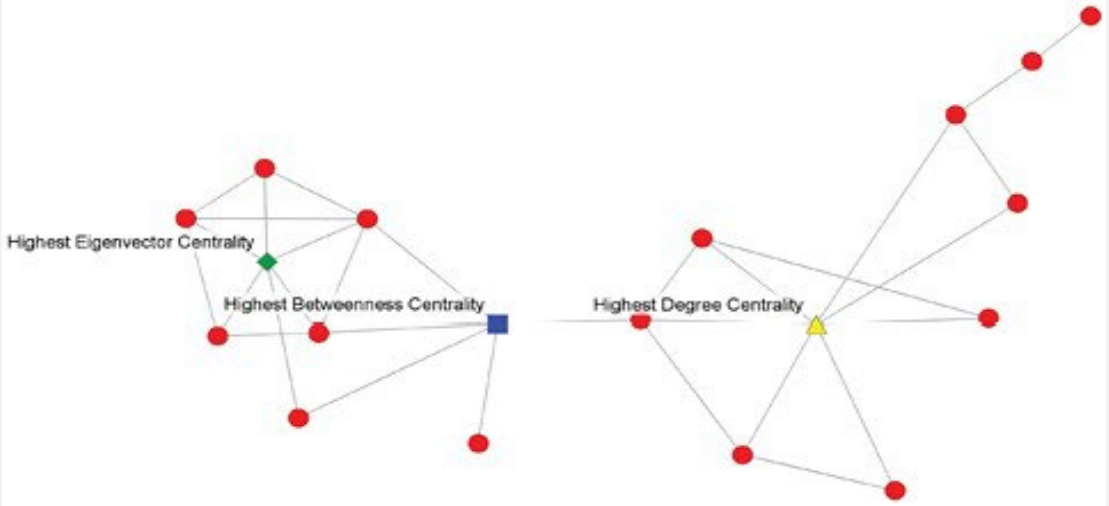


Data

- Projects with an end date between 2010 and 2019 funded by the EPSRC.
- 9,961 projects.
- SCImago journal rank (SJR) is used to capture journal quality.
- Networks:
  - Individual-project network
  - Organisation – project network
  - Network analysis is an established technique that has been widely applied to understand collaboration at both individual and organisational levels.

Methods

- Centrality metrics are used to assess the interplay between network position and project performance. We draw on two types of centrality metrics:
  - ❖ Betweenness Centrality:
    - This refers to the number of times an actor sits on the shortest path between two other actors in a network (Freeman 1977).
    - It captures an actor's brokerage in the network. In the individual network, high betweenness centrality may indicate that an individual has access to a wide variety of diverse information sources, beneficial for innovation, and research activity.
  - ❖ Eigenvector Centrality:
    - Actors with a high eigenvector centrality are connected to other well-connected actors in the network (Bonacich 1987).
    - In this empirical setting, this measure can be viewed as a measure of individual or project prestige



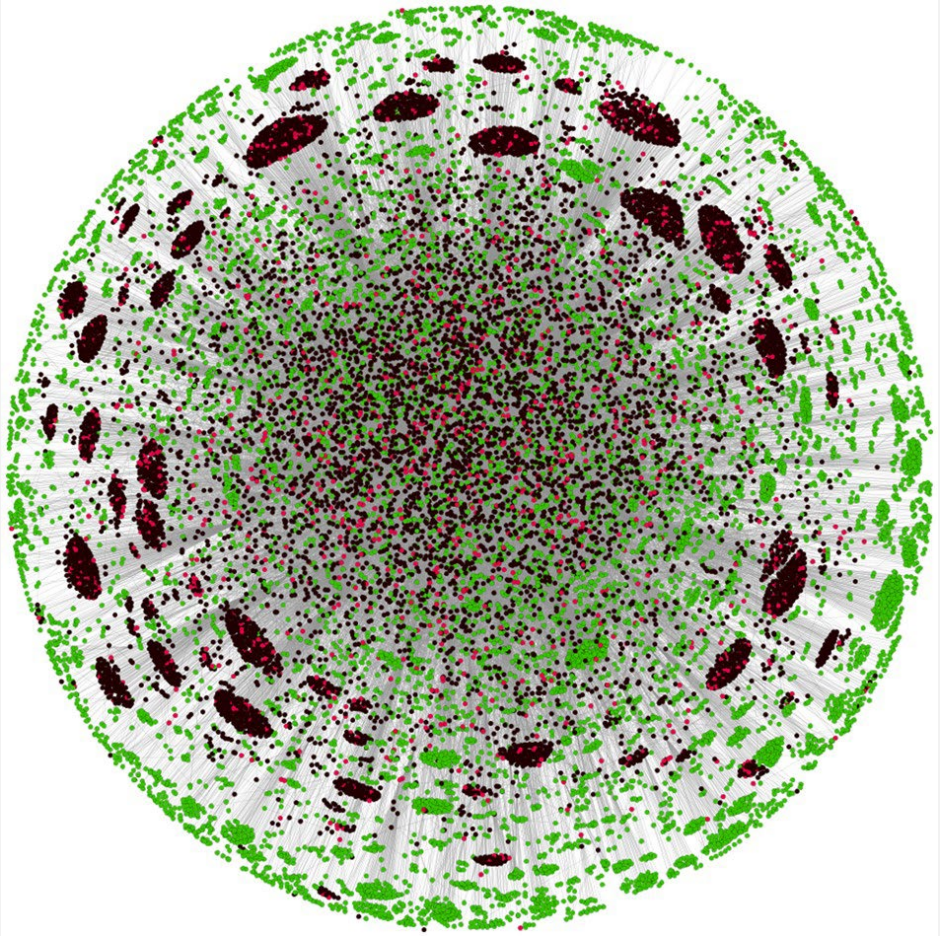
Source: Ortiz-Arroyo (2010)

Method

- To address the research questions posed by this study, we make use of an ordinary least squares (OLS) regression.
- The analysis is undertaken at the project level with the dependent variable being the average SJR score for journal outputs produced by the project.
- There are several independent variables included:
  - project value,
  - project duration,
  - PI gender; this is a dummy variable.
  - proportion of women on the team,
  - lead academic organisation is a member of the Russell group,
  - proportion of non-academic organisations collaborating on the project,
  - centrality effects in the model:
    - eigenvector and betweenness centrality for the project network and the individual network.
    - set of interaction effects are included; interacting network centrality with the woman PI dummy variable to examine whether network centrality is more significant for projects with a woman lead.

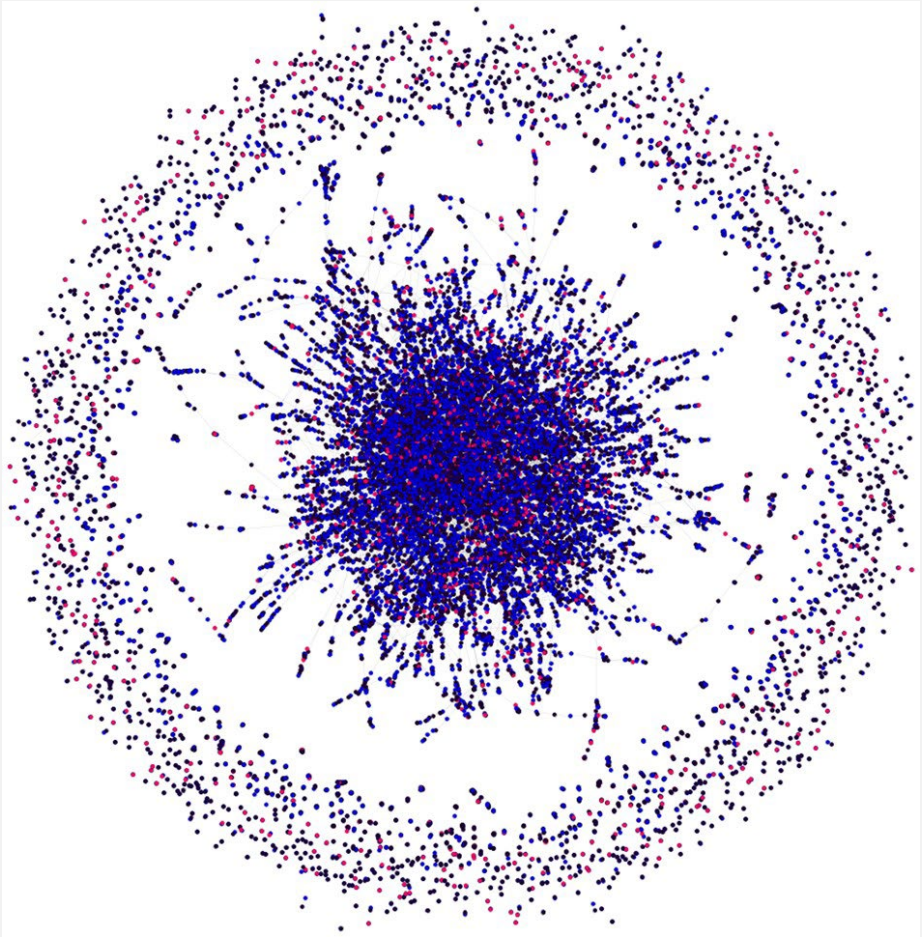
Findings:
Organisation-Project Network

- Organisations are green, and the projects are coloured on the basis of the gender of the PI. Projects with a woman PI are red and projects with a man PI are black.



Findings: Individual-Project Network

- The projects are blue, women are red, and men are black.
- In both networks, the issue of gender diversity in STEM is clear, with the majority of projects led by men, and the majority of individuals that are involved in EPSRC funded research projects are also men.



Findings

- Descriptive statistics for the EPSRC projects

Variable	Mean	Standard deviation
Project value (£)	532,863.09	2,230,563.80
Number of journal article published	12.86	27.41
Project duration (weeks)	147.53	65.08
Proportion of non-academic collaborators	0.38	0.36
Average SJR of published works	1.9	1.91
Proportion women	0.14	0.29
Project betweenness	0.0061	0.031
Project eigenvector	0.0066	0.0075
PI betweenness	0.038	0.082
PI eigenvector	0.0012	0.009

Findings

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	-0.8289***	-0.8294***	-0.8308***	-0.7340***	-0.8241***	-0.8232***
	(0.0590)	(0.0590)	(0.0597)	(0.0604)	(0.0599)	(0.0591)
Project Value	0.0863***	0.0863***	0.0864***	0.0807***	0.0859***	0.0858***
	(0.0056)	(0.0056)	(0.0056)	(0.0056)	(0.0057)	(0.0056)
Project Duration	0.1209***	0.1209***	0.1209***	0.1197***	0.1211***	0.1210***
	(0.0107)	(0.0107)	(0.0107)	(0.0106)	(0.0107)	(0.0107)
Proportion of Non-Academic Organisations	-0.0486**	-0.0485**	-0.0482**	-0.0587***	-0.0487**	-0.0496**
	(0.0157)	(0.0157)	(0.0158)	(0.0157)	(0.0157)	(0.0157)
Russell Group Lead Organisation	0.1377***	0.1377***	0.1376***	0.1166***	0.1371***	0.1371***
	(0.0118)	(0.0118)	(0.0118)	(0.0121)	(0.0119)	(0.0118)
Proportion of Women	-0.0618**	-0.0735*	-0.0733*	-0.0770*	-0.0734*	-0.0739*
	(0.0190)	(0.0332)	(0.0332)	(0.0331)	(0.0332)	(0.0332)
Woman PI		0.0119	0.0118	0.0104	0.0123	0.0126
		(0.0277)	(0.0277)	(0.0276)	(0.0277)	(0.0277)
Project Betweenness Centrality			-0.0009			
			(0.0056)			
Project Eigenvector Centrality				0.0403***		
				(0.0057)		
PI Betweenness Centrality					0.0029	
					(0.0056)	
PI Eigenvector Centrality						0.0094
						(0.0055)
Num. obs.	9961	9961	9961	9961	9961	9961
R2	0.0945	0.0945	0.0945	0.0989	0.0945	0.0948
Adj. R2	0.0940	0.0939	0.0939	0.0983	0.0939	0.0941

Findings

	Model 7	Model 8	Model 9	Model 10
Intercept	-0.8325***	-0.7353***	-0.8267***	-0.8241***
	(0.0598)	(0.0605)	(0.0599)	(0.0591)
Project Value	0.0866***	0.0808***	0.0866***	0.0860***
	(0.0056)	(0.0056)	(0.0057)	(0.0056)
Project Duration	0.1208***	0.1194***	0.1197***	0.1207***
	(0.0107)	(0.0106)	(0.0107)	(0.0107)
Proportion of Non-Academic Organisations	-0.0480**	-0.0584***	-0.0494**	-0.0492**
	(0.0158)	(0.0157)	(0.0157)	(0.0157)
Russell Group Lead Organisation	0.1376***	0.1167***	0.1379***	0.1374***
	(0.0118)	(0.0122)	(0.0119)	(0.0118)
Proportion of Women	-0.0727*	-0.0750*	-0.0911**	-0.0773*
	(0.0332)	(0.0332)	(0.0335)	(0.0332)
Woman PI	0.0113	0.0085	0.0142	0.0135
	(0.0277)	(0.0277)	(0.0277)	(0.0277)
Project Betweenness Centrality	-0.0023			
	(0.0062)			
Project Betweenness Centrality * Woman PI	0.0069			
	(0.0137)			
Project Eigenvector Centrality		0.0381***		
		(0.0062)		
Project Eigenvector Centrality * Woman PI		0.0139		
		(0.0151)		
PI Betweenness Centrality			0.0090	
			(0.0058)	
PI Betweenness Centrality * Woman PI			-0.0730***	
			(0.0196)	
PI Eigenvector Centrality				0.0111*
				(0.0056)
PI Eigenvector Centrality * Woman PI				-0.0327
				(0.0245)
Num. obs.	9961	9961	9961	9961
R2	0.0945	0.0990	0.0958	0.0949
Adj. R2	0.0938	0.0983	0.0950	0.0942

Concluding Comments

- The most notable issue from the descriptive statistics and network visualisations is the lack of women representation on research projects, with over 70% of projects having no women representation, and less than 15% having a woman lead.
- For the positive impact of women on a scientific team to be realised there needs to be ‘critical mass’ of women on the team. The current representation on EPSRC projects is a limiting factor.
- The low levels of women representation suggests that there is a need for policies that not only encourage but guarantee women’s equitable participation in all areas of STEM in UK research council funded projects.
  - ❖ These projects do not only represent research interests, but represent key, potentially career defining, opportunities in the workplace, that can be a steppingstone to upper management positions.
  - ❖ Such a practice could result in an increase in the representation of women in key positions within STEM and may be a first step in patching the ‘leaky pipeline’.

Future work

- Explore other measures of project performance.
- Expand the research to other disciplines. Are these patterns observed outside of STEM? Alternatively unpack the STEM disciplines.
- Draw on the Gateway to Research data to better understand how collaborator selection for funding applications is associated with improved performance for women researchers.

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Thank you

- Thank you for listening.
- If you want to read more about the study, the paper is online.