INNOVATION & RESEARCH CAUCUS

WHO ARE THE INNOVATORS?

An Analysis Of Innovate UK Applicants and Beneficiaries

IRC Report 006

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About the Innovation and Research Caucus

The Innovation and Research Caucus supports the use of robust evidence and insights in UKRI's strategies and investments, as well as undertaking a co-produced programme of research. Our members are leading academics from across the social sciences, other disciplines and sectors, who are engaged in different aspects of innovation and research system. We connect academic experts, UKRI, Innovate UK and the Economic and Social Research Council (ESRC), by providing research insights to inform policy and practice. Professor Tim Vorley and Professor Stephen Roper are Co-Directors. The Innovation and Research Caucus is funded by UKRI via the Economic and Social Research Council (ESRC) and Innovate UK, grant number ES/X010759/1. The support of the funders is acknowledged. The views expressed in this piece are those of the authors and do not necessarily represent those of the funders.

About Extend Ventures

Extend Ventures is a 100% asset-locked not-for-profit community interest company pioneering research that aims to establish an evidence-based understanding of the impact of ethnicity, socio-economic status and educational background, on the ability to attract venture capital for entrepreneurial endeavours in the UK. A small team of serial entrepreneurs, researchers, strategists, and an ex-investment banker are committed to using the power of big data and machine learning to diversify access to finance for underrepresented innovators and entrepreneurs. Through working with entrepreneurs, investors, and leading universities, Extend Ventures is developing a data-driven digital approach to democratising access to the funding and support required to build scalable businesses, for underrepresented entrepreneurs and founding teams.

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Introduction

Innovate UK-UKRI is the UK's innovation agency, which drives productivity and economic growth by supporting businesses to develop and realise the potential of new ideas. It achieves this by connecting businesses to partners, customers and investors, and providing support to businesses across all economic sectors, value chains and UK regions. Innovate UK's focus is therefore on promoting innovative entrepreneurship, rather than on promoting employment or self-employment more generally. As noted in the UK Innovation Strategy 2021, which sets out to make the UK a global hub for innovation by 2035, Innovate UK recognises the importance of addressing inequalities to the achievement of this goal. Ongoing efforts to promote sustainable innovation-led economic growth has resulted in initiatives such as the Innovate UK Strategic delivery plan 2022-25 "No Limits platform and mission'' to transform the talent and skills pipeline and encourage more people from a wide range of backgrounds into innovation. This study, which focuses on understanding the diversity of Innovate UK funding applicants and beneficiaries is one of the ongoing efforts to identify and address inequalities in access to innovation resources.

Innovate UK's Plan for Action for UK Business Innovation highlights Equality, Diversity and Inclusion as a strong foundation underpinning its activities and programmes, which is fundamental to successful business innovation. The document describes the successful outcomes from Innovate UK's work on equality, diversity, and inclusion as:

» a more diverse innovation system that values difference, excites future innovators and enables the best ideas to succeed
» more businesses driving an inclusive culture, improving the UK's ability to attract and retain the best talent and boosting competitiveness and profitability
» more innovations developed with improvements in equality, diversity, and inclusion as a goal, resulting in a higher chance of commercial success and delivering benefits to all parts of society
» a supply of more relevant data that leads to action targeted in the right places and increases inclusion.

Innovate UK is committed to working to address inequalities and barriers experienced by under-represented and diverse groups pursuing business innovation. Building on the insights from the '*Supporting diversity and inclusion in innovation*' report (Vorley et al., 2020), this study focuses specifically on applicants to and beneficiaries of Innovate UK funding. There have been recognised challenges concerning the lack of available and comprehensive data held by Innovate UK on funding applications, which means that the analysis of diversity in broadest terms is not possible. As such, this project employs an innovative array of mixed methods research to construct a portrait of diversity and to better understand the experiences of applicants and explore the degree to which Innovate UK practices align with its statement of intent. However, since May 2022, Innovate UK has also addressed this challenge by putting in place processes to collect comprehensive EDI data on lead funding applicants.

The overarching aim of this study is *to understand the characteristics, i.e. gender, ethnicity and education of Innovate UK applicants and beneficiaries.* The study adopts an intersectional lens to analyse the data, which recognizes the diversity within and between different groups. Even though this report represents an important step to understand the diversity of Innovate UK applicants and

beneficiaries, it does not intend to provide a definitive portrait of the diversity of Innovate UK funding applications. The study applies machine learning techniques in what is the first and largest known analysis of characteristics of Innovate UK funding applicants. It builds on previous work exploring the diversity of innovators, which primarily sought to understand the barriers they face, and the interventions in place to support them. To this end, this study aims to explore and better understand the nature and scale of the 'diversity' challenge in the UK based on recent applications and awards.

The remainder of the report is organized as follows: Section 2 presents a summary of the key challenges and barriers known to be encountered by under-represented founders and innovators in accessing funding and finance. Section 3 introduces the research design in understanding the diversity of Innovate UK funding applications using machine learning and semi-structured interviews. Section 4 then presents the research findings, which includes both an overview of the total and funded applications, as well as qualitative insights from the interviews. Finally, Section 5 reflects on the key insights from the study and advances recommendations for next steps.

Understanding the Context

Understanding whether under-represented founders and innovators face even greater challenges in accessing finance due to their social identity (Smallbone et al., 2003; Verheul and Thurik, 2001) has been the focus of a growing stream of literature. This research is driven by the fact that access to finance plays a vital role in enabling firm survival and growth (Brown and Lee, 2019; Carter et al., 2006; Carter and Peter, 1998; Marlow and Patton, 2005). This is especially relevant during times of crises, such as the Covid-19 pandemic, when micro and small businesses are at a higher risk of failure due to existing vulnerabilities in the marketplace (Saridakis et al., 2023; Wishart et al., 2018). Literature on entrepreneurial finance has mainly focused on understanding the challenges and barriers faced by two under-represented groups i.e. women founders or ethnic-minority founders.

This section therefore focuses on reviewing existing studies on the systemic inequalities and barriers faced by under-represented founders and innovators in accessing funding and investment opportunities. It begins with an overview of under-represented founders and innovators' participation in business innovation in the UK. This is followed by a discussion of the different funding sources available, before highlighting key themes that emerge about the challenges faced by under-represented founders and innovators in accessing funding. A summary of the knowledge gaps identified in this area concludes the section.

2.1 Diverse innovators in the UK

Entrepreneurship and self-employment are important aspects of the UK labour market experience for under-represented and diverse groups (Carter et al., 2015; BEIS, 2018; Jones and Latreille, 2011; ONS, 2018). The positive impact of diversity on innovation and performance is well documented in research (Bouncken, 2004; Díaz-García et al., 2013; Hunt et al., 2018; Nathan, 2014). Likewise, the potential impact of inclusive entrepreneurship for achieving economic growth and societal well-being has led to an increased focus on inclusive innovation policies (Galindo-Rueda and Verger, 2016; OECD, 2019). SME innovation therefore plays a central role in achieving regional economic development in the UK (Treanor, 2021). Ethnic minority-led firms make a significant contribution to the UK's Gross Value Added (GVA) (Roberts et al., 2020). It is estimated that in 2018 women-led firms contributed about £85 billion

to the economy (Rhodes, 2019). A more recent report indicates that during the period 2019-20, minority businesses contributed at least £74 billion to the economy, which comprised £47.9 billion in employee compensation, £4.7 billion in corporation-tax payments, and £21.4 billion in post-tax profits (Legrain and Fitzgerald, 2021).

Furthermore, research suggests that ethnic minority-led firms are more likely to engage in innovation activities than ethnic majority-led firms (Owalla et al., 2021; Roberts et al., 2020). According to an Open report for Minority Supplier Development UK (MSDUK), 8 of UK's 23 tech unicorns (valued at over £740 million) as well as 23 of UK's top 100 fastest growing companies in 2019, were co-founded by minority entrepreneurs (Legrain and Fitzgerald, 2021; Morris, 2021). Under-represented and diverse innovators therefore have a critical role to play in the post COVID-19 economic recovery and the government's "levelling-up" agenda (Legrain and Fitzgerald, 2021; Roberts et al., 2020). However, these groups also seem to face greater disparities in mobilizing resources.

While there is a gradual shift of ethnic minority entrepreneurs towards IT and construction sectors, they are still over-represented in the retail, hospitality and transport sectors that are more adversely affected by economic crises (Roberts et al., 2020). Similarly, women-led firms are typically smaller in size and located in sectors where access to markets may be more constrained (Wright et al., 2015). The British Business Bank report (2020) also found that even when societal inequalities and established gender roles are considered, women entrepreneurs still experience less success than men.

Lack of access to finance, disconnection from key financial, business and political networks, and disproportionate levels of doubt, are some of the recurring themes highlighted as barriers for both women and ethnic minority groups (Klingler-Vidra, 2018). A recent survey found that despite indicating higher intentions to start a business (i.e. 46% for ethnic minority participants; 36% for participants with disabilities; and 33% for the control group), ethnic minority groups were also more likely to cite the lack of finance as a barrier to innovation (i.e. 56% for the ethnic minority participants; 50% for participants with disabilities; and 35% for the control group) (Vorley et al., 2020).

The inability to secure funding can therefore be viewed as a major obstacle to under-represented and diverse founders' participation in innovation activities. Moreover, the lack of diversity in the venture capitalist community in terms of their ethnicity, educational background, and location further exacerbates the funding situation (Diversity VC and OneTech, 2019; Diversity VC, 2023). For example, in 2018, all-women investment teams received only 4% of all deals made (British Business Bank et al., 2019). As under-resourced firms are less likely to invest in Research and Development (R&D) or participate in innovation (Treanor, 2021), the barriers and challenges faced by under-represented and diverse founders and innovators in accessing funding represents a missed opportunity for achieving inclusive economic growth.

2.2 Funding and finance for innovation

Innovation's role in revitalizing economic growth has resulted in the allocation of financial resources to firms with the greatest potential for productivity gains either through increased R&D or the implementation of innovative products, processes or services (Cornelius, 2020; Higón and Driffield, 2011). Additionally, investment capital is a necessary catalyst for growth, with investors acting as advisors to firms and aiding them in navigating growth-related challenges (Spigel, 2017). As a result,

the critical problem of SME funding as a vehicle for growth has received considerable public sector attention within the UK throughout the twentieth century (Oakey, 2003).

Firms typically have access to different forms of finance throughout their life cycle. However, the most acute periods of financial constraints are normally realized in the early expansion stages when the business model is still untested (Cornelius, 2020). Funding available to firms includes personal savings (including resources from family and friends), bank loans, grants from government or philanthropic foundations, venture capital, business angels and more recently crowdfunding. While many founders would prefer to avoid borrowing or diluting their equity, their own personal resources are usually insufficient to build the business during the seed phase when revenues are minimal and cash flows are often negative (Cornelius, 2020).

To bridge this funding gap, and in line with the pecking order thesis, firms tend to rely first on traditional sources of debt-based finance before seeking equity finance (Brown and Lee, 2019). Sources of debt finance generally include: credit card debt, loans from banks, microfinance institutions, government loans, venture debt and crowdfunding (Cornelius, 2020). On the other hand, venture capital plays a prominent role in equity finance. Venture capital (VC) is independently managed, dedicated capital focusing on equity or equity-linked investments in privately held, high-growth companies (Hall and Lerner, 2010). The UK venture capital market, for example, is the largest in Europe and the third largest in the world (Tech Nation, 2021). In 2020, UK investors committed £15bn to early-stage companies (Tech Nation, 2021). VC funds are typically raised from institutional and wealthy individual investors, but could also include government funds.

Although VC remains an important source of funding, especially for technology start-ups and firms in R&D intensive industries who face a higher cost of capital, there has been a gradual shift of VC funding from providing seed capital to expansion and later stage rounds (Cornelius, 2020; Hall and Lerner, 2010). This has resulted in an increase in angel investment groups, internet-based equity crowdfunding, as well as accelerators that provide minimal financial resources to founders in addition to mentorship and networking opportunities (Cornelius, 2020). Institutional investors have also substantially increased their investment in private equity funds, making them a critical source for firms seeking capital. Moreover, as firms mature, the types of debt and equity capital that are accessible to them widens. This could include leveraged loans, subordinated debt, corporate bonds, private equity funds, or going public (Bates et al., 2018; Cornelius, 2020). However, the Covid-19 crisis also had an impact on entrepreneurial finance in the UK, with seed finance deals for startups being most adversely affected and decreasing by almost 40% in the first quarter of 2020 compared to 2019 (Brown et al., 2020). Later stage deals showed greater resilience, and this was attributed to the less risky nature of such deals due to existing relationships with investors (Brown et al., 2020).

The public sector is another important source of funding. However, studies indicate that public and private sector agencies' involvement in the funding of New Technology-Based Firms (NTBF) tends to be short term in nature (Oakey, 2003). It is argued that government grants and loans are frequently "one-off" events (e.g. the SMART and SPUR Award schemes) which do not guarantee continued long-term commitment to an innovation programme (Moore and Garnsey, 1993; Oakey, 2003). Greater collaboration of private and private sector at national and regional levels would result in public sector funds being used to leverage private sector risk beyond the normal commercial practices, and thus engender a greater potential for growth (Oakey, 2003).

Lastly, with the rise of an innovation agenda, funding agencies are also playing a greater role in changing the behaviour of the scientific community (Veletanlić and Sá, 2020). This is exemplified in the UK with the presence of UKRI. The relationship between the introduction of innovation objectives in funding instruments and the changes in funding among research fields over time, makes funding agencies a key site for examining the relationship between the state and science as expressed in programmatic and resource allocation decisions (Veletanlić and Sá, 2020).

2.3 Barriers and challenges to accessing funding and finance

Although there is broad consensus that under-represented and diverse groups generally start with significantly lower levels of financial capital while perceiving higher barriers to accessing funds, the reasons for these discrepancies remain unclear (Carter et al., 2007; Smallbone et al., 2003; Wright et al., 2015). This is partly due to the complex and dynamic nature of entrepreneurial ecosystems, which includes interdependent actors and factors that impact founders' access to resources and support (Brush et al., 2019; Scott and Hussain, 2019; Stam, 2015). Previous research examining women and ethnic minority founder's access to funding has either focused on understanding supply-side factors (i.e. the investors' preferences for specific types of industries, firms or entrepreneurs), demand-side factors (i.e. the founders' preference for growth, profits, industry sector, risk and control), or a combination of both (Carter et al., 2006; Coleman and Robb, 2009). Some of the key themes identified by prior research are highlighted below:

2.3.1 Ethnicity and business financing

The lack of success in accessing bank loans by African-Caribbean-led firms compared to White and other ethnic minority-led firms has resulted in this group's propensity to rely on informal sources of start-up finance, such as family and friends (Deakins et al., 2003; Smallbone et al., 2003). In effect, the importance of financial institutions tends to decline in subsequent years, with ethnic minority founders preferring less intrusive and more "user friendly" financial options that allow full control of their businesses (Hussain and Matlay, 2007). However, there is considerable variation among ethnic minority groups, with South Asian communities more likely to draw on these sources than African-Caribbean or Chinese communities (Deakins et al., 2003).

Studies analysing the impact of racial and ethnic disparities in business financing present mixed findings. Some suggest that the racial disparities in credit availability is likely caused by discrimination. For example, Blanchflower et al. (2003) who analyse loan outcomes by race, find that black-owned small businesses are about twice as likely to be denied credit even after controlling for differences in creditworthiness and other factors. Similarly, Davidson et al. (2010) carry out in-depth interviews with ethnic minority women founders and find that more than half their respondents had experienced discrimination due to their gender or ethnic background, or both. Even for ethnic minority-led firms trying to break out from the typical labour-intensive sectors to more capital-intensive sectors, access to bank funding remains problematic (Ram et al., 2003).

On the other hand, the complex nature of the financing process cannot be assumed to be simply a result of supply-side deficiencies (Ram et al., 2003). Deakins et al. (2003) argue that bank decision-making processes are influenced by four main factors which impact bank managers' assessment of funding requests from ethnic minority entrepreneurs. These include: a) the policies by corporate credit managers; b) the practice by bank managers which can vary from policy; c) the perceptions of both

bankers and ethnic minority entrepreneurs regarding the type of information required, and d) the prejudices through pre-judgement of applications by bankers (Deakins et al., 2003). A study analysing ethnic minority owners' access to bank loans during the pre- and post-Covid-19 period, interestingly finds that while the loan acceptance rates of ethnic minority owners are identical to their White counterparts pre-Covid, ethnic minority owners are more likely to have their loans accepted post-Covid. The availability of generous government supported loan schemes is indicated as a possible reason for this positive discrimination (Cowling et al., 2023).

Other studies exploring the underserved market hypothesis (i.e. that VC firms invest in ethnic minority-led firms in order to earn attractive returns from this underserved market niche) also indicate mixed results. A study by Bates and Bradford (2008) finds that the realised investments are broadly equivalent to those of the mainstream VC industry. Their findings are inconclusive with regards to the presence or absence of discrimination in business financing. However, a later study found that financial returns derived from investing in ethnic minority-led firms exceed those of White-led firms, thus supporting the underserved market hypothesis (Bates et al., 2018). The authors argue that these discriminatory practices (i.e. more likely through preferential treatment than outright discrimination) enhances the profitability of capital providers (Bates et al., 2018). Interestingly, Bengtsson and Hsu (2015) also find that while shared ethnicity between the founder and the VC strengthens the degree of involvement of the VC partner and increases the size and scope of their investment, shared ethnicity is equally associated with worse investment outcomes. Their study helps to highlight some of the possible trade-offs associated with the phenomenon of ethnic investment matching i.e. investing in founders who share a common ethnicity.

2.3.2 Gender and business financing

Researchers analysing the impact of gender on business finance generally agree that gender matters. Carter et al. (2007) find that male and female loan officers vary greatly in terms of the processes they use to negotiate loan applications. While female loan officers appear to focus on procedural and business elements of the loan application process, male loan officers instead emphasise individualised decision making and internal negotiation (Carter et al., 2007) thus highlighting the potentially gendered nature of bank lending processes. Similarly, a study analysing the effect of gender differences in entrepreneurial confidence on access to loans, finds that women founders showing extreme overconfidence (atypical of the norm), are more likely to be viewed negatively by banks resulting in restricted access to capital (Liu and Cowling, 2023).

Examining the venture capital market, Alsos and Lunggren (2017) find that occupational segregation by industry and managerial level results in women lacking the type of experience valued by investors. As such, women founders have a greater need to signal their own as well as their ventures' legitimacy in order to compensate for the lower legitimacy associated with being a woman (Alsos and Ljunggren, 2017). Moreover, signals of viability and commitment, e.g. past performance and large venture size, by men and women founders appear to be rewarded differently by investors, often to the detriment of women (Eddleston et al., 2016).

Several studies also point to differences in initial capitalisation and subsequent funding of men and women-led firms. Women founders start with significantly lower levels of financial capital and go on to raise significantly lower amounts of incremental debt and equity (Carter and Peter, 1998; Coleman and Robb, 2009; Verheul and Thurik, 2001; Wright et al., 2015). These discrepancies have been attributed

to women founders' lack of confidence in their entrepreneurial capabilities and/or their differing ambitions and objectives (Verheul and Thurik, 2001; Watson et al., 2009). Women founders tend to rely heavily on personal rather than external sources of finance, and are more likely to be discouraged borrowers as they perceive higher barriers to accessing finance (Coleman and Robb, 2009; Wright et al., 2015). However, these differences hold even after considering firm variety and owner characteristics (Coleman and Robb, 2009). Additionally, it is argued that women-led firms which are typically smaller in size are more likely to be located in sectors where access to markets may be more constrained (Wright et al., 2015).

Other studies looking at the role of women in the angel market, conclude that there are limited differences between women investors who are active in the market and their male counterparts (Harrison and Mason, 2007). Examining women founders' access to angel capital, Becker-Blease and Sohl (2007) also find that while women seek angel financing at rates substantially lower than that of men, they have an equal probability of receiving investment. They also find that homophily i.e. selection of other team members on the basis of similar ascriptive characteristics like gender or ethnicity (Harrison and Mason, 2007) – also plays a role, with women founders being more likely to seek financing from women investors and likewise for men (Becker-Blease and Sohl, 2007). This implies that a lack of diversity within the VC market could present particular challenges for women founders. For example, a recent report indicates that 39% of London VC firms had no women, while 65% had no senior women partners (Diversity VC and OneTech, 2019). More importantly, Becker-Blease and Sohl's (2007) findings also indicate weaker evidence of homophily in accessing capital, with women founders less likely to receive financing from women angels. They argue that the demographic composition of the angel groups, at least as it relates to gender, therefore matters. Thus simply increasing the diversity of funders without addressing structural barriers might have minimal impact in achieving equality and inclusion. Lastly, while women are more likely to access loans and grants than traditional forms of financing, the grant and loan system still appears to exclude them, and more specifically those from lower socioeconomic backgrounds (Fielden et al., 2006).

2.3.3. Symbolic capital and business financing

Entrepreneurship is a socio-economic process, and human and social capital play an important role in enterprise creation (Anderson and Miller, 2003). Several studies draw upon Bourdieu's concept of "symbolic capital" to account for the social embeddedness of different resources and the different structural positioning of actors (Carter et al., 2006; Cederberg and Villares-Varela, 2019). Bourdieu argued that social life can be conceived as a multidimensional status game, in which people draw upon their economic (financial resources), social (relationships, affiliations, networks) and cultural (educational qualifications, skills, knowledge, practices) capital in order to compete for status or what he termed "symbolic capital" (Anderson and Miller, 2003; Cederberg and Villares-Varela, 2019; Holt, 1998). The social position one is born into therefore has a strong influence on the opportunities one has to develop human and social capital in the family, school and workplace (Anderson and Miller, 2003).

Exploring the impact of an entrepreneurial family background on the development of social and human capital resources, studies find that founders from higher socio-economic backgrounds have greater access to highly effective business support, and that these networks provide a platform from which opportunities can be both recognised and realised (Anderson and Miller, 2003; Scott and Hussain, 2019). Similarly, Cederberg and Villares-Varela (2019) find that ethnic minority founders' agency in shaping their businesses varies significantly based on their access to different resources, and this is

closely linked to their socio-economic position. Founders with substantial financial assets and/or access to capital through family or friends have a significant advantage to their counterparts. Thus further emphasising the role of social class in shaping the entrepreneurial process (Cederberg and Villares-Varela, 2019).

However, the extent to which founders are able to successfully draw upon resources is also moderated by the external structural context. Drawing on the 'forms of capital' model and mixed embeddedness, Ram et al. (2008), find that the rich social capital of Somali business owners in Leicester (e.g. extended social ties facilitating movement to Leicester, the exchange of information about commercial opportunities, the pooling of finance etc.) is conditioned or even subverted by market barriers, under-capitalisation, and the associated sectoral and spatial entrapment. Investors' perception of founders' socio-demographics can also impact firm evaluations (Sauer et al., 2010). Exploring the interactive effects of managers' race and education on firm evaluation, Sauer et al. (2010) find firms led by White executives with highly prestigious educational backgrounds receive the highest stock price projections, while those led by African Americans with similar prestigious education receive the lowest valuations. Another study analysing the impact of founders' perceived gender, ethnicity and education on access to VC funding in the UK, finds that 42.7% of capital invested at seed stage went to founding teams with at least one member from a prestigious university (i.e. Oxford, Cambridge, Harvard, Stanford and their respective business schools) (Brodnock, 2020). The study also indicates that all-ethnic teams received an average of 1.7% of VC investments made at seed, early and late stage, while Black women founders received 0.02% of the total amount invested during the period 2009 to 2019 (Brodnock, 2020). A subsequent report indicates that even though there has been an improvement in VC investment raised by women founders (14.5% of VC investment in 2013-2023 compared to 11% in 2009-2019), women founders remain chronically under-represented. Furthermore, nearly half (47%) of the total investment value was raised by founders who had studied at Russell Group universities (Extend, 2023).

2.4 Summary

Overall, despite the differences in methodology and focus, existing research suggests that gender, ethnic and racial disparities exist in financial market outcomes (Bates et al., 2018). However, similar to studies in entrepreneurial diversity, most studies in entrepreneurial finance tend to focus on specific dimensions of disadvantage, e.g. race, ethnicity, gender, in isolation (Knight, 2016; Martinez Dy, 2020). Few studies have linked the impact of gender, ethnicity or education in accessing finance, and those that do rarely adopt an intersectional perspective in their analysis (Scott and Hussain, 2019). Additionally, the main focus of inclusive innovation initiatives has been on women founders, with diversity in terms of age, disability, class, etc., receiving less attention (Klingler-Vidra, 2018).

Further research adopting a broader perspective is therefore required to better understand the processes that produce such outcomes for particular social groups (Ram and Jones, 2008). The antecedents of exclusion from participation in innovation for under-represented and diverse groups are not only linked to place and regional barriers to support, but also to structural factors such as socio-economic status, family background, education and societal expectations (Treanor, 2021). In addition, the complex and interdependent nature of factors within entrepreneurial ecosystems implies that individual attributes cannot be studied in isolation (Spigel, 2017; Stam, 2015).

Engagement in entrepreneurship is not only influenced by ethnic identity, but also by the specific relations to other identity categories within which that status is embedded (Owalla et al., 2021).

Furthermore, during times of crises like the Covid-19 pandemic, it is the people situated at categorical intersections of race, gender and social status that are likely to be most structurally disadvantaged (Martinez Dy and Jayawarna, 2020). Adopting an intersectional perspective therefore enables scholars and policymakers to pay closer attention to the interplay between individual level and structural factors influencing under-represented and diverse groups' access to resources (Scott and Hussain, 2019; Vorley et al., 2020).

This study builds on this limited knowledge by adopting an intersectional perspective to understanding the diversity of Innovate UK applicants and beneficiaries by examining their profiles and perceptions of engagement with Innovate UK. The research methodology is discussed in the next section.

Research Design

The study utilises a three-part research design: first employing web scraping and machine learning to enable the quantitative analysis of Innovate UK funding applications, while qualitative interviews with applicants were used to understand and contextualise the findings. Data on the gender, ethnicity and education of applicants has not been systematically recorded historically, and so the matching of data using web scraping techniques and the application of machine learning to the data matched enables analysis that would not otherwise be possible. The remainder of this section discusses the stages of the method in turn, and also reflects on the limitations of the study.

3.1 Web scraping and machine learning methods

The purpose of the machine learning component of the study was to understand the profile of Innovate UK applicants by focusing on a subset of characteristics (i.e. ethnicity, gender, education). Analysing applicants' data allows us to understand the distribution of funding outcomes across the applicant population. By comparing the representation of certain categories of applicants in the sample, we also are able to understand where certain categories and characteristics are over or under-represented in the profile of Innovate UK funding applications.

The dataset provided by Innovate UK included 48,024 applications from small and micro businesses (i.e. 1 to 49 employees) made between 2016/17 to 2022/23. For the purposes of this research we have excluded interventions that target specific social groups, namely *Women in Innovation* and *Young Innovators* competitions. The data set included details of the funding competition, the firm, and a named contact person. Of these 33,209 funding applications were matched for the named contact person through web scraping. Using the matched personal data, the algorithm reviews the content, extracting employment information, education history, and a profile photo (for further details on the web scraping and application of the algorithm see Appendix 1). If the personal data does not match, or if uncertainty relating to the match is considered too high, the algorithm flags the applicant data as requiring a manual check (60% of the matched data set was manually checked). Through this approach we classified each application into categories under perceived gender, perceived ethnicity and education.

In terms of perceived gender, classifications were binary, with applicants classified as either a man or a woman. For perceived ethnicity, we focused on the five major ethnic groups identified in the UK i.e. White, Black, Middle Eastern, South Asian and East Asian. For educational background, the most recent educational information recorded by applicants on LinkedIn was used to classify each application into i) Universities of Cambridge and Oxford (Category A); ii) Imperial College London and University
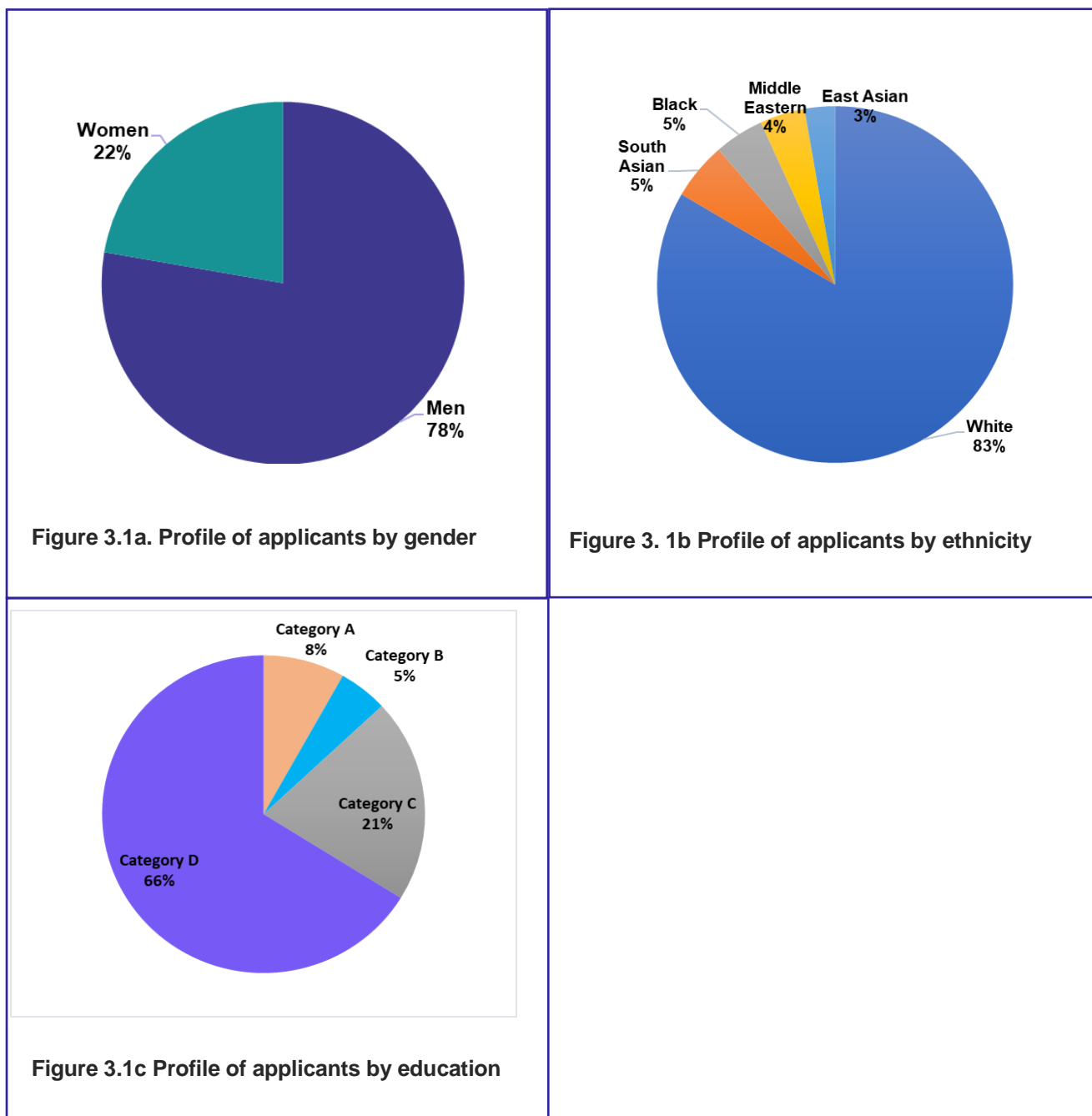
College London (UCL) (Category B); iii) Other Russell group of universities (Category C), and Other Institutions (Category D - which also includes non-tertiary education institutions or no education recorded).

On completion of the web scraping there were 24,957 unique named contacts from small and micro businesses seeking funding as part of the 33,209 applications. Of these, 5,356 applicants had applied multiple times, accounting for 13,608 funding applications (see Table 3.1 below).

Table 3.1 Summary of Innovate UK multiple funding applications

No of Named Contacts	No of applications submitted	Total no. of applications	Percentage
19,601	1	19,601	59.0%
3,707	2	7,414	22.3%
1,011	3	3,033	9.1%
358	4	1,432	4.3%
136	5	680	2.0%
61	6	366	1.1%
42	7	294	0.9%
17	8	136	0.4%
10	9	90	0.3%
8	10	80	0.2%
2	11	22	0.1%
1	13	13	0.0%
1	14	14	0.0%
1	16	16	0.0%
1	18	18	0.1%
24,957		**33,209**	**100.0%**

Prior to analysing the funding applications, we provide a brief description of the profile of 24,957 unique named applicants by gender, ethnicity and education in Figures 3.1a-c.

Figure 3.1a. Profile of applicants by gender

Figure 3. 1b Profile of applicants by ethnicity

Figure 3.1c Profile of applicants by education

3.2 Quantitative Analysis

The final dataset of 33,209 funding applications was used to quantitatively analyse the profile of Innovative UK funding applications, and the extent to which certain characteristics affect their likelihood of success in receiving funding. Table 3.2 below presents a summary of the dataset. The majority of Innovate UK funding applications were from men (78% of total applications). Furthermore, applications from men were consistently more than those from women across each of the different categories i.e. perceived ethnicity and educational tiers. In terms of perceived ethnicity, 83% of total applications were from White ethnic applicants, with the remaining 17% being split between Black (4%), Middle Eastern

(4%), South Asian (6%), and East Asian (3%) applicants. A further analysis of the funding applications from minoritised ethnic groups revealed that 50% of these applications were from East and South Asian applicants (representing 9% of the total applications).

In order to examine the educational background of applicants, we also classified funding applications based on those received from applicants with education from one of the Russell group of universities in the UK[1]. This category was further split into Category A (i.e. Universities of Cambridge and Oxford), Category B (i.e. Imperial College London and University College London), and Category C (Other Russell group) based on the UK rankings. All applicants whom we could not identify as having attended a Russell group university were classified under Category D (which also includes non-tertiary education institutions or no education recorded). Within these categories, approximately 35% of all Innovate UK applications came from applicants educated in a Russell group university, with 14% of these coming from Oxford and Cambridge or Imperial and UCL universities.

Table 3.2: Descriptive summary of Innovate UK funding applications dataset

Perceived Ethnicity	Women	%	Men	%	Total	%
Black	402	5.6%	1,009	3.9%	1,411	4.2%
East Asian	327	4.6%	646	2.5%	973	2.9%
Middle Eastern	203	2.8%	1,153	4.4%	1,356	4.1%
South Asian	283	4.0%	1,544	5.9%	1,827	5.5%
White	5,949	83.0%	21,693	83.3%	27,642	83.2%
Total	**7,164**	**100.0%**	**26,045**	**100.0%**	**33,209**	**100.0%**

Educational Tiers	Women	%	Men	%	Total	%
Category A	685	10%	2,272	9%	2,957	9%
Category B	361	5%	1,424	5%	1,785	5%
Category C	1,463	20%	5,546	21%	7,009	21%
Category D	4,655	65%	16,803	65%	21,458	65%
Total	**7,164**	**100%**	**26,045**	**100%**	**33,209**	**100%**

Our quantitative analysis of the data in relation to the three categories i.e. perceived gender, perceived ethnicity and education of the lead applicant (i.e. defined as the person named on the funding application as the lead, and may not necessarily be the same as the innovator) focused on three main areas:

  (a) the distribution of Innovate UK total applications;

  (b) the distribution of Innovate UK funded applications; and

  (c) the proportions of applications within each category that were awarded funding

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[1] The full list of Russell group universities are: University of Birmingham; University of Bristol; University of Cambridge; Cardiff University; Durham University; University of Edinburgh; University of Exeter; University of Glasgow; Imperial College London; King's College London; University of Leeds; University of Liverpool; London School of Economics; University of Manchester; Newcastle University; University of Nottingham; University of Oxford; Queen Mary University of London; Queen's University Belfast; University of Sheffield; University of Southampton; University College London; University of Warwick; University of York.

We compare the distributions of total and funded applications within each group, as well as intersecting categories to examine variations within the two distributions. These distributions are each illustrated in a chart. In order to examine the Internal Success Rate (ISR) of each category, we analyse the number of funded applications from each category (or intersecting category) in relation to the number of total applicants within the same category. The regression model compares the distribution of applications and funded applications within each of the categories compared to that of a specified reference group. The selection of the reference group for each of the regression models was based on what is theoretically considered to be the category that is most likely to be successful.

Logistic regression models are further used to examine the statistical significance of the extent to which applications received from applicants with certain characteristics are more or less likely to be funded. Regression models make it possible to identify potential associations between an applicant's characteristics and their likelihood of being successful, thus allowing for identification of characteristics that explain the largest proportion of variance in funded applications (Codiroli Mcmaster, 2017). In the first stage, we examine the potential effects of each of the four individual categories on the likelihood of an application becoming successful. As it is also important to understand the extent to which outcomes are influenced by interactions between categories, in the second stage of the regression analyses, we examine the potential impact(s) of intersecting relationships of categories on success or otherwise of an application.

It is also worth noting that predictor variables used in regression frameworks such as the one used in this report, need to be of an appropriate sample size to validate the regression model and its predictions (Riley et al., 2019; Vittinghoff and McCulloch, 2006). A recognised and well used "rule of thumb" is for each predictor variable to have at least 10 events per candidate predictor (Peduzzi et al., 1995). In this regard, the regressions in this report exclude predictor variables with a sample size of less than 10. A note on the same is also included when this is the case.

3.3 Qualitative methods

The second part of the study involved consultations with a stratified sample of applicants about their experience of engaging with Innovate UK around the funding application process. The interviews sought to understand more about their perceptions and experience, as well as how their engagement with Innovate UK could be more inclusive. Between June and July 2021, a series of 27 semi-structured interviews were conducted using a topic guide that covered four key thematic areas: i) about the business; ii) need for business innovation support and funding; iii) engagement and experience of Innovate UK programmes, support and funding (including feedback); and, iv) future intention to access Innovate UK programmes, support and funding. A descriptive summary of the interviewees is presented in Table 3.3. below. The interviews were conducted online, were then transcribed verbatim, before being analysed and thematically coded. The coding focused specifically on diversity and inclusion with regard to access and participation in the funding process. The findings from the interviews are discussed in the next section in relation to the themes from the literature and the analysis of total and funded applications.

Table 3.3: Descriptive summary of interviewees

		Total	Has a disability?		Ethnicity	
			Yes	No	Majority	Minority
Ethnicity	Majority	14	4	10		
	Minority	13	2	11		
Total		**27**	**6**	**21**		
Gender	Men	18	1	17	9	9
	Women	9	2	7	5	4
Total		**27**	**3**	**24**	**14**	**13**

3.4 Limitations

There are a number of limitations associated with the project that are important to acknowledge given the innovative nature of the methods employed and scope of the study. The intention of this study was not to provide a definitive portrait of diversity of Innovate UK funding applications, but offers an important benchmark for Innovate UK to understand more about their applicants. In Section 4 we present the findings and analysis as an initial assessment, which lays the foundations for further research, and identify future questions that merit consideration in Section 5.

There are a number of limitations associated with web scraping as a methodology, with no single approach able to offer a comprehensive solution. The approach used by the study stacked several software packages (see Appendix 1) to maximise the capture of data. However, of the 48,024 Innovate UK funding applications for which data was scraped, 33,209 (c. 69%) had profiles of applicants with matched data and images. This limitation has the potential to introduce bias given the data was scraped from LinkedIn, and thus excludes users not active on LinkedIn. Nevertheless, an analysis of variances indicates that the distribution of total and funded applications in the final dataset of 33,209 is comparable and not significantly different from the population of 48,024 applications (see Table 3.4 below).

Table 3.4: F-Test Two-Sample for Variances

Distribution of total applications	All Data	Matched Data
Mean	2.43902439	2.439024
Variance	25.04016151	23.34071
Observations	41	41
df	40	40
F	1.072810653	
P(F<=f) one-tail	0.412606962	
F Critical one-tail	1.69279721	

Distribution of funded applications	All Data	Matched Data
Mean	2.43902439	2.439024
Variance	22.94647026	21.30887
Observations	41	41
df	40	40
F	1.076850542	
P(F<=f) one-tail	0.408015843	
F Critical one-tail	1.69279721	

Another limitation of this methodology is that assigning gender, ethnicity and education is designated through the application of machine learning based on web scraped information (including the photo), as opposed to being self-selected by individual applicants. The gender, ethnicity and education of the applicant therefore needs to be recognised as 'perceived' based on web scraped information, as the responses are not self-selected. Currently, we have used used basic categories for ethnicity and have taken a binary approach for gender. Our taxonomy collects gender binary data, with applicants classified as either appearing to be men or women. We hope to be able to cover non-binary over time as it becomes more pervasive in its use in public profiles. Additionally, the taxonomy collected on perceived ethnicity data, implies that an applicant could self-select a different option including mixed race, which is not part of the current taxonomy, to describe themselves. A methodological note on the accuracy of the machine learning techniques employed is included in Appendix 2. However, given the manual checks employed the error rate in assigning to the taxonomic groups is considered to be zero, even though the limitations in terms of the percentage of matched profiles versus the total number of Innovate UK funding applications, and how individuals may describe themselves remains. Furthermore, the classification of education only identifies the most recent educational institution indicated on LinkedIn and does not differentiate between different levels of education.

In terms of the qualitative aspect of the study there are two key limitations. First, given the reflective nature of the interviews that focused on previous engagement of interviewees with Innovate UK, there is the possibility of hindsight bias, where participants recall past experiences and reconstruct their stories in ways that makes sense to them. Second, the comparatively small number of interviews

conducted with a limited stratified sample of Innovate UK applicants drawn from the database limits the generalisability of our findings. Larger scale studies targeting under-represented and diverse groups in different regions would build on the insights gained in this report, and extend the qualitative component of the study.

Analysing the Profile of Innovate UK Funding Applications

In this section, we present insights on the impact of gender, ethnicity and education on funding success. Our findings are based on an analysis of the data matched from the web scraping and associated quantitative analysis. Relevant insights from the interviews are also discussed. The last section then focuses on analysing the impact of intersecting categories and characteristics. While all of the regression tables are presented in Appendix 3, statistically significant differences in success rates are highlighted in the tables and charts. Success rates denoted with an asterix (*) or double asterisk (**) are statistically significant at 10% and 5% respectively.

4.1 Gender

Innovate UK applications from men accounted for 78% of all submissions, with those from women representing only 22% of the matched dataset. Likewise, the proportion of funded applications was 78% from men and 22% from women as shown in Figure 4.1a. However, as the analysis of Innovate UK funded applications shows (see Figure 4.1b), there was no statistically significant difference between the success rate of men vs women applicants (Model: *p<0.944, chi square = 0.005)*. The challenge here, therefore, is to encourage more applications from women, given the prospect of their application being successful is on par with men.

Figure 4.1a. Percentage of Applications/ Funded Applications by Gender

Figure 4.1b. Success rate by Gender
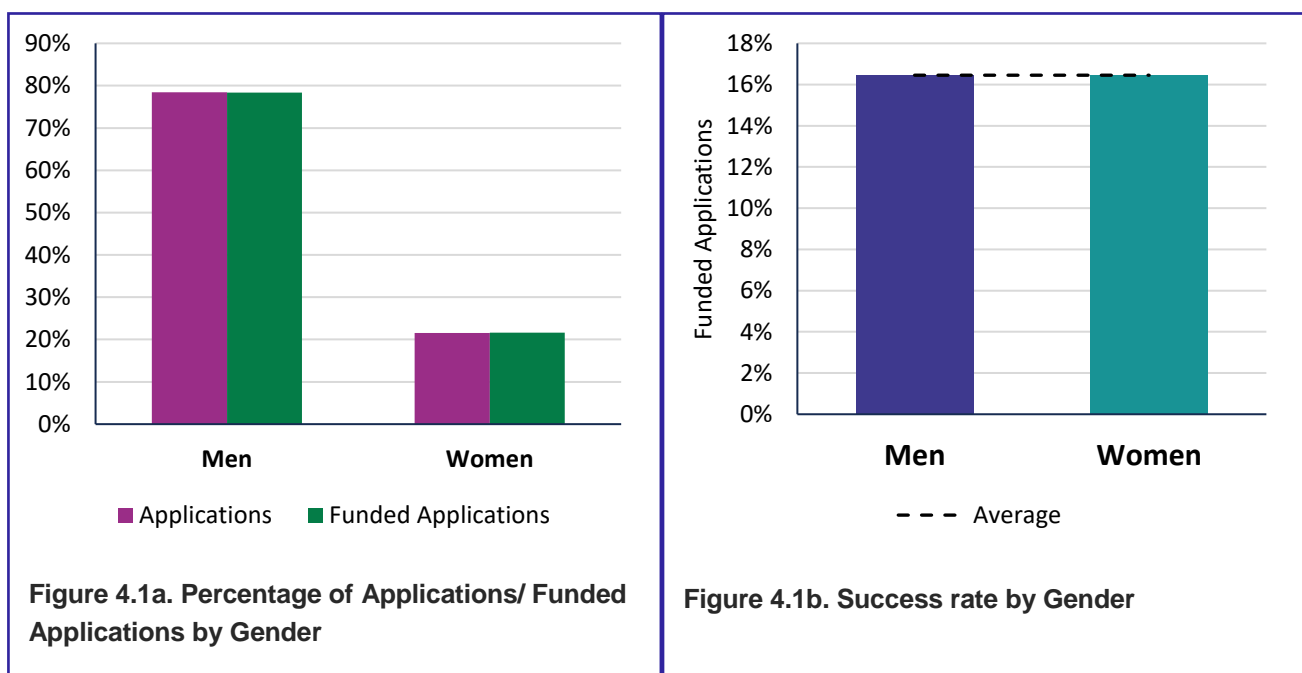
Note: The success rates are not significantly different

During the interviews, one of the issues raised by interviewees concerned the perception of innovation as a game dominated by men both in terms of the number and visibility of innovators profiled, as well as the decision makers in the funding process. While this is hard to refute based on the number of applications received from men, some interviewees also felt that fitting (or not fitting) within this expected profile had an impact on one's success in obtaining funding in general.

...you know, they want somebody in their 20s, you know, some young men in their 20s, who's just graduated from Business School... that's what they want (Applicant)

I think, yes, I think probably having a male name helps. So I don't think we had to say what age we were, I don't think we had to say what gender so I think it was, you know [participant's name], yeah. Okay…. so they had no idea until I walked into the room. (Applicant)

My observation is that if you are a company that is already on your feet, and you've got, you know, that kind of male CEO predominantly that has a very sort of confident approach in writing and speaking, then you can get further on. If you are connected to the system, you can get further on but if you are not… you know, somebody that is realistic, which most women are in their approach, then it becomes that much harder. (Applicant)

While some interviewees felt that Innovate UK had taken proactive steps to ensure women applicants are not disadvantaged, others were of the opinion that having predominantly men as assessors and monitoring officers was an additional barrier for women, especially where the user or beneficiary of the innovation were women. There is merit in understanding more about the assessors and monitoring officers, although this information is not currently published.

But I think Innovate UK has taken very proactive steps to make sure that female applicants are not disadvantaged. I think the way the applications are reviewed, because they're reviewed by multiple reviewers, the decision is being made by a small clique of like-minded individuals. I think the way the review process is set up. Yeah, it's fair and it enables diverse attitudes to what people are reviewing… (Applicant).

Because the people that are funding, and this is something I think you should take back as reflection, Yes, but when the assessors in Innovate UK are predominantly men and how can they possibly understand a role that is predominantly taken by women?... And I think I would be fair, although I don't know 100% that it would be fair to say that these men are older men. So not even millennial men that may have to do this type of a role (Applicant)

So it was hard to judge, but is, I think, generally an issue. The people who are adjudicating, and what kind of their background is tends to be, it tends to be quite, I don't know how to put the even if they have women there, they're successful corporate (Applicant)

Another area of concern that was highlighted in the interviews was concerning awareness and engagement with business support. It is also noteworthy that many of the interviewees commented that networking and other events were dominated by men, with minimal support targeted to women innovators. This applied not just to provision from Innovate UK, but also in terms of support available through Innovate UK KTN, Local Enterprise Partnerships (LEPs) and universities. The ability to access

training and networking opportunities are important in developing the skills and social capital to realise opportunities for innovation-led growth.

Yeah, I mean, yes, for sure. It makes it really hard. So, so, you know, you walk in, for example, you know, the...have events, you know, and if I go in person I will often be the only woman you know of people running... and of course, nobody wants to talk to an old woman. I mean, they're all, you know, in their 40s 30s 20s. They don't want to talk to me, you know, I've got nothing to offer them. This sort of, and so you're just sort of saying I can't be bothered going… (Applicant)

The importance of initiatives such as 'Women in Innovation' were cited by a number of the interviewees as critical to raising the visibility of women in order to mitigate their under representation. Through profile raising campaigns there is an opportunity to increase the visibility of women supported by Innovate UK, and stimulate applications from more women. However, while increasing the number of applications from women is important, there is a need to ensure that the success of women continues to not vary significantly from men.

Furthermore, the need to address structural barriers was also highlighted during the interviews. For example, one interviewee described her decision to choose between 'a family and the firm'. Such challenges are often experienced by women owners/managers of small and particularly micro businesses who have to step away from their business when taking maternity leave, and are often unable to return and pick up where they left off (Kuschel, 2019). These kinds of structural challenges are beyond the realms of Innovate UK alone to address, but go some way to explain the higher number of applications from men.

So yeah, and then and then I know for the [Innovate UK], like women in innovation piece, that's one of the things they want to do. But if they want to encourage women to innovate, then it needs to change at a government level in terms of maternity pay for people who are not employed. Yeah. And that's not something Innovate UK can do anything about but um, yeah, the current system for self-employed or non-profit making organisations does not support maternity leave. And also, I guess, their technology focus naturally aligns themselves to more male dominated sphere (Applicant)

On a more positive note, some of the interviewees also indicated that the requirement to reflect on equality, diversity and inclusion as part of the application process, made them think more consciously about these issues.

...obviously, there's some of the questions about diversity, I guess it has helped us. When you think about it our company is pretty diverse, ethnically. You know, four years ago, we were just three - all men, and we've recruited four women since then with the assistance of the Innovate UK grants, and that is part of the questions about diversity and how to think about that (Beneficiary)

4.2 Ethnicity

Using the AI analysis on matched applicants, as discussed in section 3, we are also able to analyse the total and funded applications based on participants' perceived ethnicity. As shown in Figure 4.2a the vast majority of the total and funded applications were from White applicants (total - 83%, funded -

87%). Overall, applications received from minoritised ethnic applicants account for only 17% of total applications and 13% of funded applications. According to the 2021 census, 80.7% of the working age population in England and Wales were White, 2.5% were Black and 4.4% were Asian. In this regard, White applicants are over-represented and ethnic minorities as a whole are under-represented in both the percentage of Innovate UK applications and funded applications. Analysing the success rates of the different groups (see Figure 4.2b) and using the White ethnic group as the reference, we observe a statistically significant difference in relation to the success rate of two of the other four ethnic groups.

The success rate of applications received from applicants identified as White was 17%, which is above the UK average success rate of 14%. Applications received from South Asian, Middle Eastern and Black applicants are found to be statistically less successful than White applicants with a success rate of 14%, 14% and 8% respectively (Model: *p<0.000,* c*hi square = 115.509*). While the success rates of applications received from East Asian applicants is higher than all other groups (18%), this is found to be not statistically significant. The challenge for Innovate UK therefore seems to be both to encourage more applications from minoritised ethnic groups, and to address the variation in success rates between the different ethnic groups.
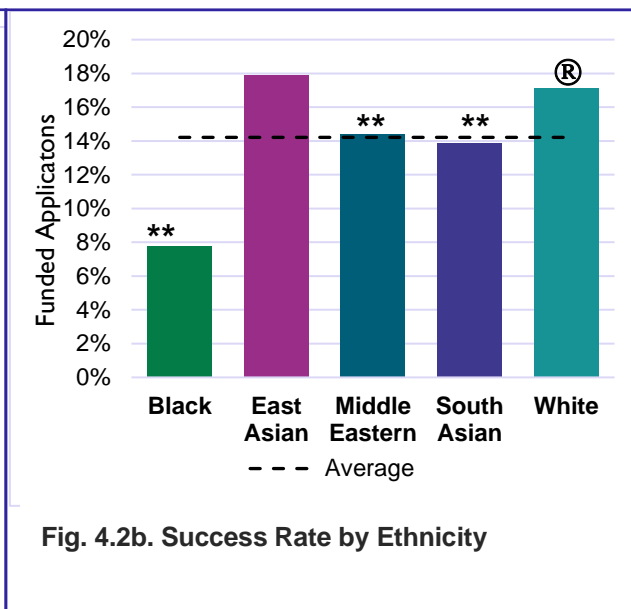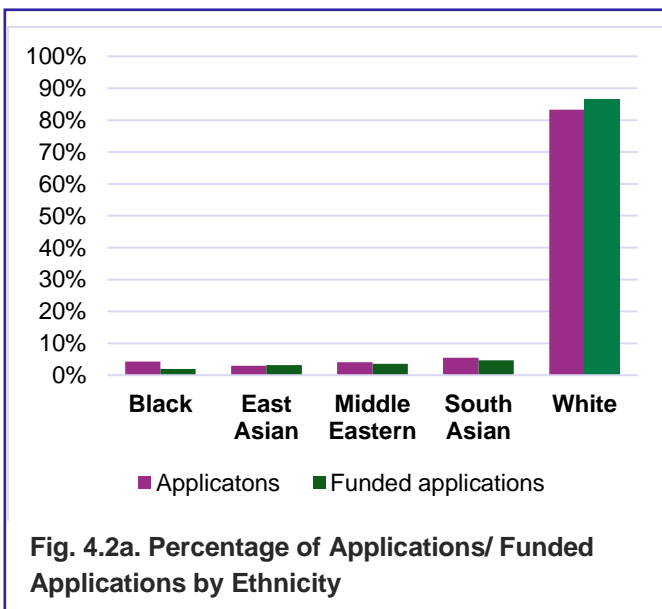
Fig. 4.2a. Percentage of Applications/ Funded Applications by Ethnicity

Fig. 4.2b. Success Rate by Ethnicity

Note: Success rates with asterix (*) and double asterix (**) are statistically significant at 10% and 5% respectively when compared to the reference category (®)

During the interviews there was little reference to the impact of one's ethnicity on the application process. Some of the interviewees felt that it was the technical expertise, rather than the diversity per se, that had an impact on funding success. However, a few of the interviewees also highlighted concerns regarding perceived discrimination due to one's ethnicity, based on their own personal experiences.

No, I don't think so. Because we've got quite a mix of backgrounds, ages, industries, nationalities, as well. So I don't think that would on the side of the reviewers, I think it would be more favorable to us if there is someone in that team who either has a kind of knowledge of environmental engineering, all depends on, you know, the background and the understanding

they have because it is a very technical application... (Applicant)

So that's why I came back to the segment. And of course, being a woman, being older, having had emerging market experience, and being a woman of colour, it's very, very hard to get money to do things. (Applicant)

...my team members are all from a [minoritised] ethnic background. And they are all skilled. They are all skilled. One of them has worked for [Institutions]. I'm talking big networks... And there was a bit in terms of one guy what he said... well one person said these are fantastic, these guys know what they are doing. Another guy says, actually, I don't think these guys have the right skills… I don't know what it is... I mean, I'll give you an example. In my lifetime, I've applied for jobs under my [interviewee name] and I've applied for jobs under my nickname Andy. And I've had more responses to Andy than I have for the [interviewee name]. Okay. This is what I think. I mean, it's sad, I'm not trying to pull the race card here or anything, but I tried to understand this, because I feel we are everything that government promotes. However, we don't get the funding... (Applicant)

The need to have more targeted communication towards minoritised ethnic communities was also highlighted during the interviews. This is in line with previous findings on the limited awareness about Innovate UK support among some minoritised ethnic groups (see Vorley et al, 2020). The minoritised ethnic applicants who were interviewed, both successful and unsuccessful, primarily came to know about Innovate UK support through mainstream channels rather than targeted communications or campaigns.

...And I think other than that, I think [Innovate UK] does a great job with the mentorship and the business support and so forth, which I've benefited from. I think making that more visible to women of colour, you know, ageing entrepreneurs, et cetera, would be important (Applicant)

Given the significant impact that ethnicity appears to have on funding success, and the gaps observed in funding success among different minoritised ethnic groups, further research involving larger targeted focus groups would be useful for gaining a more comprehensive understanding of the systemic barriers impacting minoritised ethnic groups' access to financial capital.

4.3 Education

Our next analysis focuses on understanding the impact of education, distinguishing between Oxford and Cambridge (Category A), Imperial and UCL (Category B), the remainder of the Russell Group (Category C), and Other Institutions - also includes non-tertiary education institutions or no education recorded (Category D). When analysing the matched data (see Figure 4.3a) we find that 35% of the total applications were received from applicants educated at Russell Group universities; of which 9% are from Oxford and Cambridge, 5% Imperial and UCL and 21% Other Russell Group. 65% of total applications are received from applicants categorised under Other Institutions. Regarding funded applications, we find that 43% of these were received from applicants educated at Russell Group universities (Oxford and Cambridge - 11%; Imperial and UCL - 7%; Other Russell Group - 25%), while 57% were from applicants from Other Institutions.
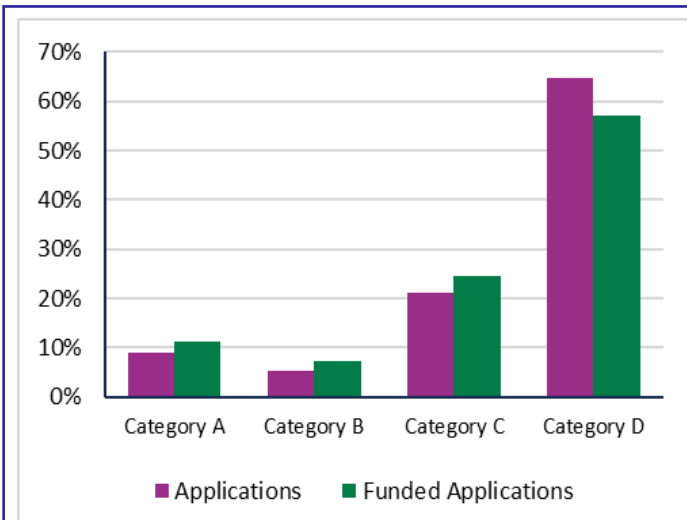
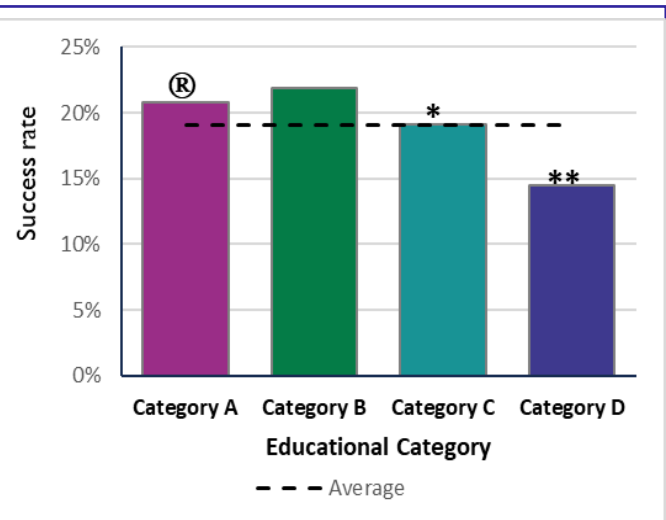**Fig. 4.3a Percentage of Applications/ Funded Applications by Education**

Fig. 4.3b Success Rate by Education

Notes: a) Description of categories can be found in section 3.1 b) Success rates with asterix (*) and double asterix (**) are statistically significant at 10% and 5% respectively when compared to the reference category (®)

Figure 4.3b shows the success rates of applications based on educational background, and using Oxford and Cambridge institutions as the reference group. Applications from those with an educational qualification from Oxford and Cambridge (21%) statistically outperform those classified in the Other Russell Group (19%) and Other Institutions (14%) (Model: *p<0.000, chi square = 171.892*). However, no statistical difference is observed between applications classified under Oxford and Cambridge and Imperial and UCL (22%) categories. The findings highlight that a disproportionately high percentage of applications come from the Russell Group, and the Universities of Oxford and Cambridge in particular.

Only a few applicants referred to their education during the interviews and this mainly tended to be medical practitioners and academics. In such instances their qualification was intrinsically linked to their profession and professional status, and this was generally regarded by interviewees as integral to their ability to be a credible applicant.

> *But I think the real place where you should count is obviously quite often as a question about the team and their capabilities, you know, quite often you're looking things just like, Oh, yeah, this person's got a PhD and 30 years' experience in exactly this subject, and then you typically go so well, that's great, you know, they are absolutely spot on, they can do this, this project. (Applicant)*

> *I don't think that gender would have any impact on it. But considering the end... the high standard that the answers would be, I think that someone who hasn't had the level of education would very seriously be struggling to complete the questions. And also I doubt that they would be successful. I have two masters and I'm struggling, so I think that's quite high (Applicant)*

Beyond the educational qualifications, several interviewees cited the importance of their post education

experience in gaining the experience to make an application to Innovate UK and in some cases establish their business. This serves to highlight the importance of post-qualification training and development to support individuals in starting a business and or pursuing a commercial opportunity. A number of interviewees had accessed business support via Innovate UK KTN, the European Enterprise Network (EEN) (now Innovate UK EDGE) and Growth Hubs, but there was not wide recognition of the support available.

I guess what, in terms of advantage, when I was filling out the form, I think having a corporate background really helps, you know, I used to put a lot of PowerPoints together, so probably quite good at summarising in that kind of way, which I think would disadvantage people who weren't, didn't have that background, and, but also just having the confidence to do it. And I can see that a lot of people would not apply, just because they wouldn't think that it was for them. (Applicant)

Another recurring theme from the interviews was the networks and social capital of applicants - particularly among those associated with Russell Group universities. For some these networks were closely associated with the business, and in one instance were used to explain the lack of diversity in the firm. The strength of the network and social capital of some applicants, linked to their education, gave them access to other capabilities that have supported their innovation activities directly and indirectly. As previous studies have indicated, entrepreneurship is a socio-economic process, and social capital plays an important role in enterprise creation (Anderson and Miller, 2003).

And that's not always about necessarily the best technical or the best creative team, it's about the team that's going to win it. Sometimes that means having a name in there, who's like a hot topic or has some gravitas attached to it? Because the... I think the people who judge who should be awarded the funding are human beings. And they're swayed in the same way that consumers are swayed, if they see a name that that they know, they, they're more likely to trust and believe in it, just as with any brand exercise…(Beneficiary)

So the networking side of it is important. And it definitely unquestionably opens up new networks by being involved in these things. But ultimately, in terms of getting the projects in the first place, I think there is a bit of a game that has to be played. And that game involves collecting together the right group of people who take the right boxes at that moment in time for that particular brief or competition. (Beneficiary)

There is a further task to analyse the group categorised under Other Institutions, which includes those identifying educational qualifications from universities other than the Russell Group as well as those with no recorded qualifications. This categorisation was a limitation associated with the web scraping, and represents another area for further in-depth analysis.

4.4 Intersectionality

Previous research has highlighted the multiple disadvantages that are associated with the intersectionality of identity categories and attributes. In this section we analyse the matched data using an intersectional lens to explore the extent to which the success rates of Innovate UK funding applications are influenced by intersecting categories of gender, ethnicity, education and location. As has been argued elsewhere, an intersectional perspective will therefore enable a more detailed attention

to the interplay within and between individual level factors and the wider social structures impacting under-represented groups' access to resources (Scott and Hussain, 2019; Vorley et al., 2020). However, given the small stratified sample of interviews, it was not within the scope of the study to cover all of the intersections analysed based on the matched dataset. Where applicants and beneficiaries interviewed commented on specific intersectional challenges these findings are incorporated in the discussion, although not in a systematic manner.

4.4.1 Gender and Ethnicity

Analysing the impact of intersecting categories of gender and ethnicity, we observe that, as shown in Figure 4.41a, the majority of total and funded applications were from White men (total – 65%, funded 68%) and White women (total – 17.9%, funded – 18.4%). Furthermore, we find that there is a statistically significant difference in the success rates of applications received from 5 gender-ethnicity intersecting groups, when compared to those received from White men who have a success rate of 17% - reference (Model: $p<0.000$, chi square = 125.510). Applications submitted by Black men (8%), Black women (8%), Middle Eastern men (13%) and South Asian women (14%) were less likely to be funded compared to the reference group. However, applications from Middle Eastern women (22%) outperform applications submitted by the reference group. The success rate of applications received from the other categories are not statistically different from the reference group. The results are shown in Figure 4.41b below.
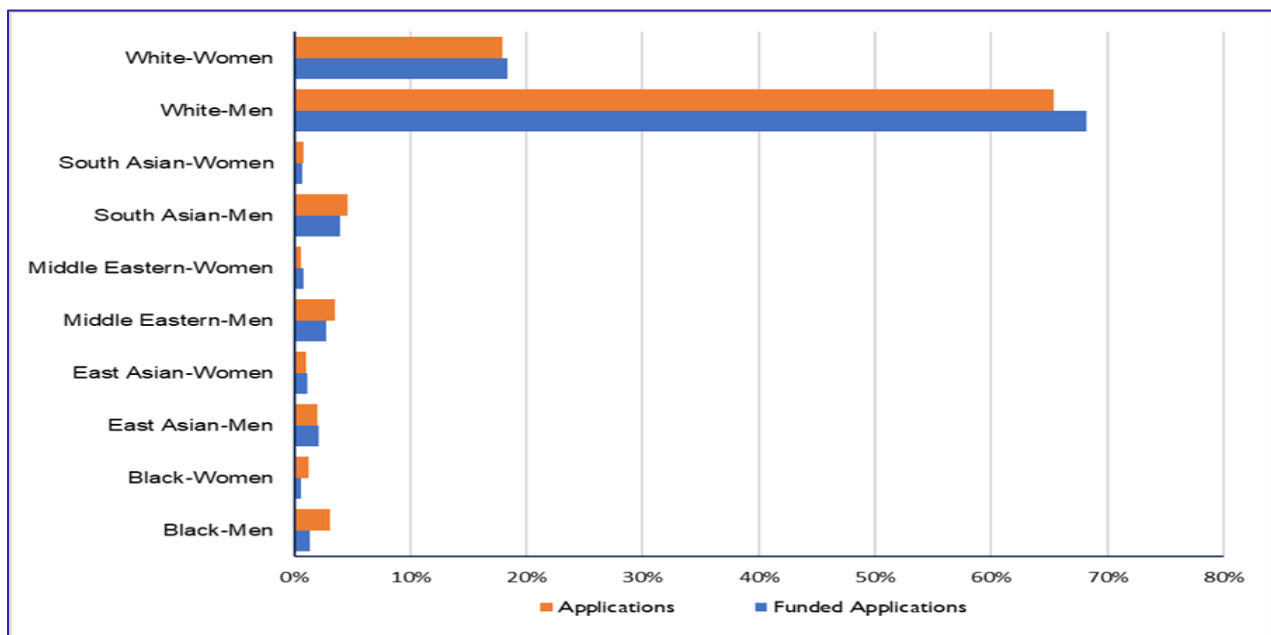

Figure 4.41a Percentage of Applications/ Funded Applications by Gender and Ethnicity
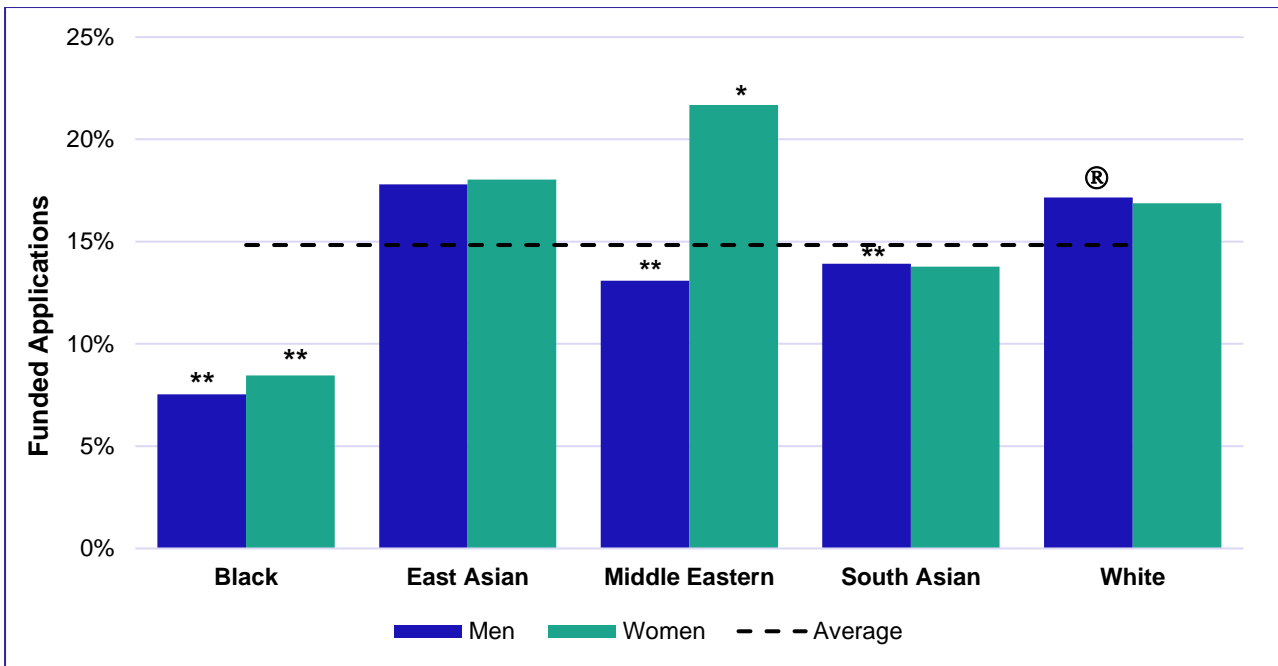
Fig 4.41b Success Rate by Gender and Ethnicity

Note: Success rates with asterix (*) and double asterix (**) are statistically significant at 10% and 5% respectively when compared to the reference category (®)

4.4.2. Gender and Education

Analysing the intersection of gender and education, we find the majority of total and funded applications were from Category D-men (total-51%, funded-45%), Category C-men (total-17%, funded-19%) and Category D-women (total-14%, funded-12%) (see Figure 4.42a below). However, when analyzing the impact on success rate (shown in Figure 4.42b), we find that in general, the success rate of applications received from applicants categorized in Other Institutions (Category D) fall below the overall average (19%). Applications received from men educated at Imperial and UCL universities record the highest success rate at 22%. While this is marginally higher than the success rates of applications received from both men (21%) and women (21%) educated at Oxford and Cambridge universities this was not statistically significant. However, the success rates of applications received from men educated at Oxford and Cambridge universities (reference group) statistically outperform applications received from applicants categorized in Other Institutions (men - 14%; women - 15%) (Model: *p<0.000, chi square = 172.170*).
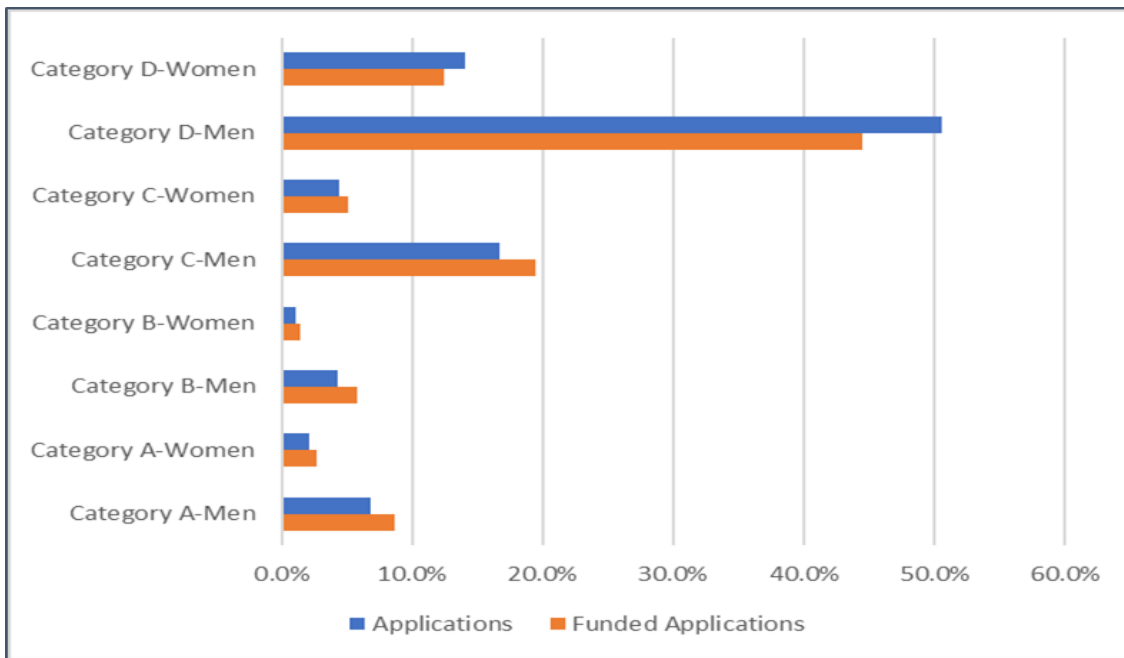
Figure 4.42a Percentage of Applications/ Funded Applications by Gender and Education

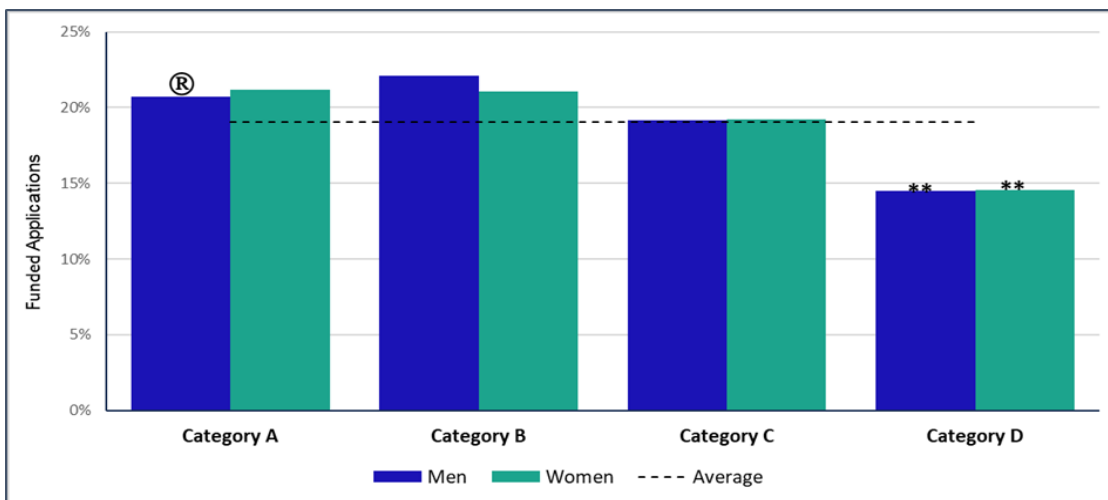*Notes: a) Description of categories can be found in section 3.1*

Fig 4.42b Success Rate by Gender and Education

Notes: a) Description of categories can be found in section 3.1 b) Success rates with asterix (*) and double asterix (**) are statistically significant at 10% and 5% respectively when compared to the reference category (®)

4.4.3 Ethnicity and Education

Our analysis of applications by intersecting categories of ethnicity and education indicated that majority of total and funded applications were from Category D-White (total-54%, funded-49%) and Category C-White (total-18%, funded-22%) (see Figure 4.43a). In assessing the impact of intersecting categories of ethnicity and education, applications received from White applicants educated at Oxford and Cambridge universities (success rate - 21%) are used as the reference group. The regression analyses (Model: *p<0.000, chi square = 291.944*) shows that the success rate of applications from the Russell

Group (including Oxford, Cambridge, Imperial and UCL) educated applicants irrespective of ethnicity is comparable to the reference with the exception of Category A-Black (13%), Category B-Black (10%), Category A-South Asian (18%), Category C-Black (9%) and Category C-South Asian (12%) that are statistically significantly lower than the reference group. Furthermore, we also find that the success rates of applications from applicants categorized in Other Institutions (Category D) irrespective of their ethnicity i.e. Black (7%), Middle Eastern (12%), South Asian (13%), East Asian (15%) and White (15%) were statistically outperformed by the reference group - see Figure 4.43b.
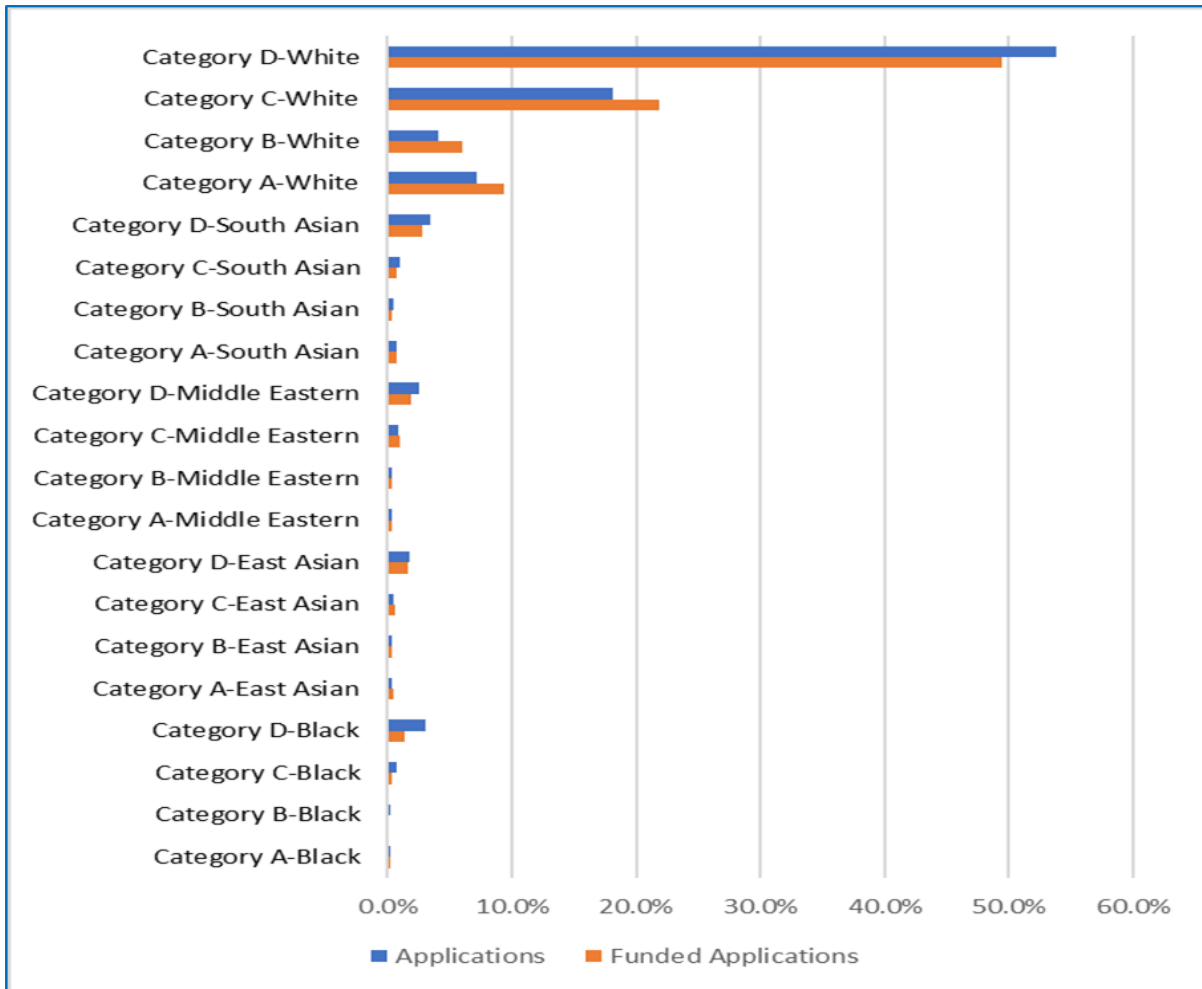

Figure 4.43a Percentage of Applications/ Funded Applications by Education and Ethnicity

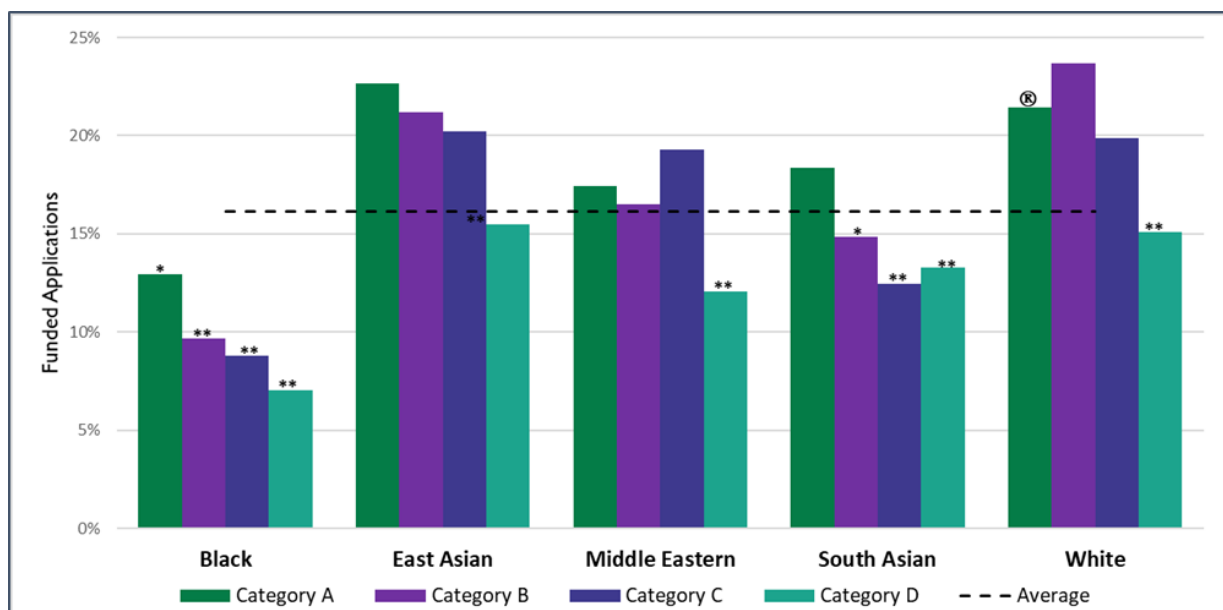*Notes: a) Description of categories can be found in section 3.1*

Fig 4.43b Success Rate by Ethnicity and Education

Notes: a) Description of categories can be found in section 3.1 b) Success rates with asterix (*) and double asterix (**) are statistically significant at 10% and 5% respectively when compared to the reference category (®)

4.4.4. Gender, Ethnicity and Education

In analysing the intersectional implications of gender, ethnicity and education, we observe that total and funded applications mainly came from Category D-White-Men (total-42%, funded-39%), Category C-White-Men (total-14%, funded-17%) and Category D-White-Women (total-11.7%, funded-11%) – see Figure 4.44a below. To analyse the impact on success rates, applications received from White men educated at Oxford and Cambridge universities are used as the reference group, with a success rate of 21% as shown in Figure 4.44b. Out of the possible 40 intersectional categories, the success rates of applications received from 17 groups are found to be statistically different from the reference group (Model: *p<0.000, chi square = 317.257*). We also observe that, with the exception of Category A-Middle Eastern women (38%) and Category B-White men (24%), these groups perform statistically worse than the reference group, and have success rates below the overall average (17%). This included applications received from applicants educated at Oxford and Cambridge institutions (Black women - 7%; Middle Eastern men - 13%), Imperial and UCL institutions (Black men - 8%; South Asian men - 13%); Other Russell Group (Black men - 8% ; Black women -10% ; South Asian men - 11%) and Other Institutions (Black men - 7%; Black women - 8%; East Asian men - 15%; Middle Eastern men - 11%; South Asian men - 14%; South Asian women - 10%; White men - 15%; White women - 15%).

Furthermore, as shown in the interview excerpts discussed in the previous sections, a number of interviewees mention the impact of intersecting categories such as gender, age and ethnicity on access to funding. This reiterates the need to pay greater attention to the heterogeneity of ethnic groups, and especially barriers created by intersecting categories that impact individuals' access to resources (Martinez Dy and Jayawarna, 2020; Owalla et al., 2021). The intersecting impact of education and the related influence on one's social capital was another theme discussed during the interviews. Some of the interviewees noted that having an education from a Russell Group university helped to minimise disadvantages that one might encounter due to one's gender or ethnicity. One's educational

background was therefore perceived to not only provide a strong knowledge base, but also the much-needed social capital which was vital for success. However, the comparatively small number of interviews conducted limits the generalizability of our findings. Larger scale studies targeting under-represented groups in different regions would be useful in extending the qualitative component of this study.

Fig 4.44a: Success Rate by Gender, Ethnicity and Education

Notes: a) Description of categories can be found in section 3.1

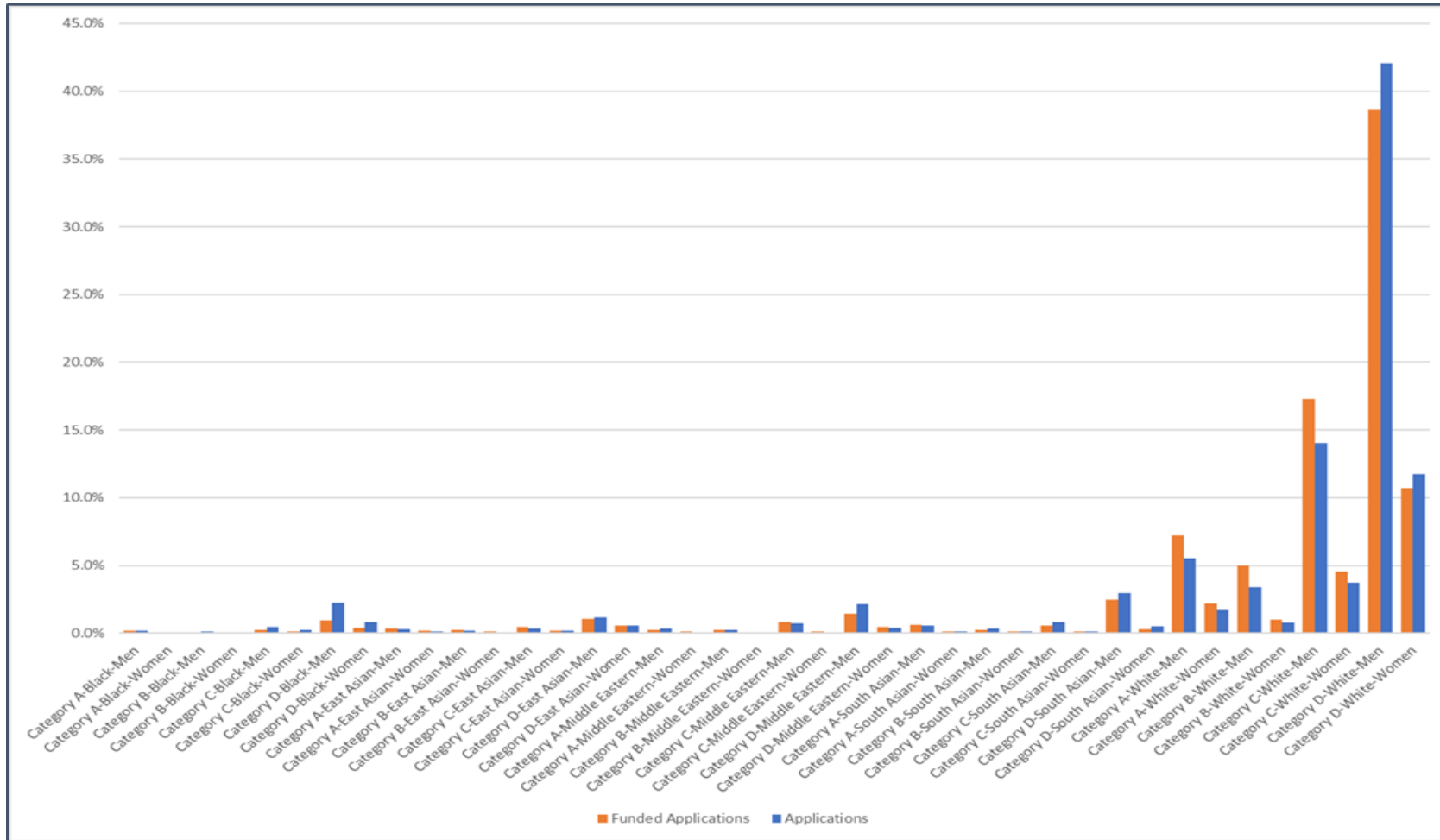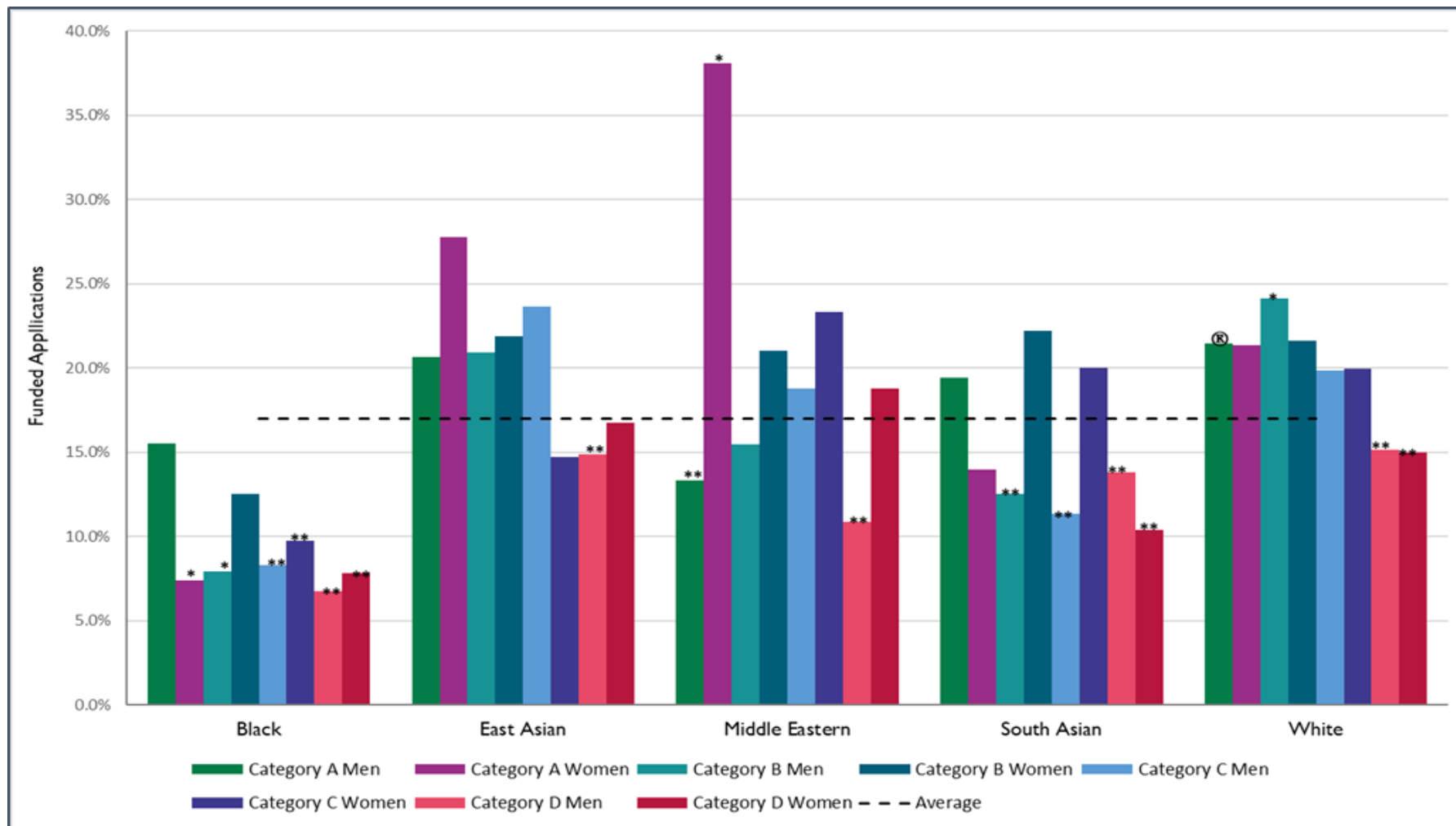**Fig 4.44b: Success Rate by Gender, Ethnicity and Education**

Notes: a) Description of categories can be found in _section 3.1_ b) Success rates with asterix (*) and double asterix (**) are statistically significant at 10% and 5% respectively when compared to the reference category (®)

Conclusions

The aim of this report was to understand more about the applicants to and beneficiaries of Innovate UK funding. The findings provide insights based on a subset of Innovate UK applications led by small or micro businesses between the financial years 2016/17 to 2022/23. There was a total of 48,024 applications, of which 33,209 funding applications were matched using web scraping to identify personal characteristics (i.e. gender, ethnicity and education). Of the 33,209 funding applications there were 24,956 unique applicants. A second part of the study included consultations with a stratified sample of applicants and beneficiaries about their experiences of engaging with Innovate UK regarding the funding process. 27 semi-structured interviews were carried out in June and July 2021.

This study was intended to provide an evidence base to enable Innovate UK to understand more about their applicants and beneficiaries. Historically, this information has not been systematically collected. The insights gained through the application of machine learning methods to analyse historic applications enables the characteristics and their intersections to be analysed. In this respect, the research provides the most robust published profile of Innovate UK applicants and beneficiaries to date.

While in some respects the study presents a stark portrait of Innovate UK's applicants and beneficiaries, as the first retrospective study seeking to understand the gender, ethnicity and education of Innovate UK applicants it also raises a series of questions. How Innovate UK goes about addressing these questions is arguably as, if not more important than the portrait itself. For example, it is crucial that Innovate UK support is regarded as relevant and accessible to any prospective innovator regardless of their gender, ethnicity or education.

A central point, and one that was clear in the qualitative interviews, was that applications must be judged on their merits, and that any potential conscious or unconscious biases associated with the review processes need to be both understood and addressed. The challenge is not simply one of raising awareness or generating more applications from a given under-represented group, but rather ensuring that the best innovations and innovative ideas receive the support necessary to grow. Understanding and addressing the reasons as to the representation and success rates of specific groups is the first step in raising the overall quality of applications - and this must be seen as a primary outcome.

5.1 Next Steps & Further Research

This project is exploratory and was intended to open up new questions about who are the individuals applying to, and beneficiaries of, Innovate UK funding. The data in this report provides a portrait of the diverse characteristics and attributes of Innovate UK applicants and beneficiaries, enabling Innovate UK to better understand the communities seeking and receiving funding. As noted above, the research is not without its limitations, but is the first study to analyse and publish Innovate UK application data. The analysis will enable Innovate UK to better consider how they might target, engage and support different groups of innovators, many of whom are underrepresented.

The findings from the research also highlight a number of avenues for further research that build on the innovative approach adopted in this study. For example, as this study relates to grant funding there is scope to extend the analysis to include applicants and recipients of Innovate UK loans. Additionally, the focus of this research has been on the applicants, but the methodology could also be applied to Innovate

UK assessors and monitoring officers. Assessors play an important role in the review of Innovate UK applications, although their individual characteristics and identities are not systematically captured or recorded. Likewise, monitoring officers play an important role in managing the delivery of Innovate UK funded projects. Using this methodology to explore the gender, ethnicity and education of assessors and monitoring officers would provide further insight in understanding the representation of different groups.

There is scope to extend the analysis beyond Innovate UK, with the opportunity to match firm level data with other data sets to track investment in firms that have both received and not received Innovate UK support. This work would build on and complement previous research conducted by Extend Ventures, and enable the impact of Innovate UK support as a catalyst to growth to be better understood. Future qualitative studies targeting under-represented and diverse innovators in different regions would also build on the insights gained in this report and allow for a more comprehensive understanding of the structural barriers and intersecting identity categories influencing access to resources.

Building on this initial report, the Innovation and Research Caucus and Extend Ventures are keen to continue to work with Innovate UK to understand more about their applicants and their businesses. The ability to access funding is a critical factor in allowing innovators to develop their ideas and in enabling businesses to grow. Further research that provides insight about applicants and beneficiaries will enable Innovate UK to improve engagement with and support of innovators.

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Appendix 1 - Web Scraping

Applicants information

Information on the applicants was collected through web scraping, we focus on the following data:

Education

The education information is saved as reported on the applicant's profile, typically in the form of a list containing information about education institutions, degree titles and subjects studied.

Profile photo

The profile photo is directly saved from the applicant's profile page, and is used to categorise the applicants by perceived gender and ethnicity.

Data acquisition by web scraping

Verification of Director Status

The first process in the data acquisition process was to verify the status of the directors through Companies House ("https://find-and-update.company-information.service.gov.uk"). Companies House was used because of its robust database.

How it Works

An automated search of organisation name and number was completed on the search bar of the Companies House website to obtain the individual company profile url. The applicant's name was automatically searched on their individual company profile. This resulted in the director status of each individual in the dataset.

Profile URL Scraping

The second stage in the process was to collect each applicant's LinkedIn profile. LinkedIn was chosen because of its robust network and database.

How it works

The applicant's name and company name were the keywords used to obtain the personal profile of each applicant in an automated search on LinkedIn. The personal profile urls were saved for further use.

Information Scraping

The third step in the process was to scrape the image, educational background and work experience from individual personal profiles.

How it works

Our algorithm saves the image, educational background and work experience from the personal profile. Work experience was scraped to ensure that the correct profile was scraped.

Data manipulation

Education Tier

Classification algorithm: /script/education_analysis.py

Classification implementation: /script/script_wrap.ipynb

The education history is processed by an algorithm that, for each applicant, returns a corresponding **education tier,** which is the highest rank institution from which the applicant holds a qualification. The possible tier values are defined, in order of importance, as:

- Category A: Oxford and Cambridge universities.

- Category B: Imperial College London and University College London (UCL).

- Other Russell Group (Category C): self-selected association of twenty-four public research universities in the United Kingdom.

- Other Institutions (Category D): any other institution.

Note that business schools and institutes which are part of universities are considered of the same tier as their parent institutions. Tiers are not mutually exclusive, as "Category A" and "Category B" universities are also part of the Russell Group. The algorithm however returns the highest tier for any given institution.

How it works

The algorithm classifies each education history in a tier category, as defined above, by using a look-up table, automatically acquired at start-up. The education information of each applicant is saved as a list of entries containing university/institution names, degrees, subjects, and other information. Each entry is compared to the look-up table, and if it matches any of the universities therein listed, the corresponding tier is assigned. If it does not, the "Other" tier is assigned. To ensure the classification is accurate, the algorithm cleans and formats names, and matches names according to several criteria. In this way, each of the entries of the education history of an applicant is assigned a tier, and the highest tier is chosen to represent the education of the applicant.

Ethnicity and gender assessment

Classification algorithm: /script/ethnicity_analysis/deepface_image_recognition.py

Classification implementation: /script/script_wrap.ipynb

We have developed an algorithm that classifies applicants based on their perceived gender and ethnicity. Gender is classified in a binary way, as appearing to be men, women, or indeterminate.

Ethnicity is classified as perceived belonging to the following categories:

- East Asian (including mixed heritage).

- South Asian (including mixed heritage).

- Black (including mixed heritage).

- Middle Eastern (including mixed heritage).

- White.

The algorithm is based on two processes:

- analysis of applicant's profile photo.

- analysis of applicant's name.

Profile photo: How it works

The algorithm uses the DeepFace package to analyse applicants' photos and return gender and ethnicity values. DeepFace is a state-of-the-art facial recognition system developed by facebook (see references). The ethnicity output from DeepFace is matched to the ethnicity categories as listed in the previous subsection, and each category is assigned a score which measures the likelihood of the applicant of belonging to that category. The gender output from DeepFace is returned as man, woman, or indeterminate if the confidence of prediction is too low.

Full name: How it works

The algorithm uses three distinct packages to analyse the applicant name.

The ethnicity output is provided by the Namsor package, which analyses names semantically to provide an estimate of a person's key demographic variables, such as their ethnicity. The gender output is given by the Namsor package, which accesses an online name database and also returns the probability of a name being of a given gender. The output values are man, woman and indeterminate, when the gender cannot be defined with sufficient confidence.

Web scraping packages used:

Pandas is a Python package that provides fast, flexible, and expressive data structures designed to make working with relational or labeled data both easy and intuitive. Pandas library was imported and used to manipulate the data frame and for feature selection.

BeautifulSoup is a library that makes it easy to scrape information from web pages. It sits atop an HTML or XML parser, providing Pythonic idioms for iterating, searching, and modifying the parse tree. BeautifulSoup was used to scrap the information off webpages.

Genderize a simple API to predict the gender of a person given their name. Based on data collected all over the web". Genderize was used to predict an applicant's gender from their name.

Requests "is a simple, yet elegant, HTTP library that adds query strings to your URLs". Requests was used to get the Urls.

Selenium "The *selenium* package is used to automate web browser interaction from Python". Selenium was used to automate the scraping process.

Chrome driver "is a separate executable that Selenium WebDriver uses to control Chrome". This was used to execute the scraping algorithm with selenium.

Tensorflow is an open source software library for high performance numerical computation. Its flexible architecture allows easy deployment of computation across a variety of platforms (CPUs, GPUs, TPUs), and from desktops to clusters of servers to mobile and edge devices. This was imported for DeepFace to work.

Namsor- Client is a python package that serves as a wrapper for the Namsor classification API. The API can determine the likely gender, ethnicity and country of origin of an individual with a particular name". This was used to get the gender and ethnicity of each individual through their names.

DeepFace "Deepface is a lightweight face recognition and facial attribute analysis (age, gender, emotion and race) framework for python." DeepFace gives access to several state of the art facial recognition deep learning models, and has been used to extract gender and ethnicity information from applicants' photos.

Appendix 2 - Evaluation of AI Methodology

The review of the AI methodologies presented below was completed on the original data provided i.e. 2016/17 to 2019/20. The same AI methodologies have been applied to the additional years i.e. 2020/21 to 2022/23 in preparing the final report.

Prof Nigel Crook

This report summarises the findings of an evaluation of the machine learning methodologies used by the investigators of the Innovate UK funded project entitled "Innovation Caucus - "Understanding the Funding and Investment of Diverse Innovators in the UK: A Market Analysis." This evaluation includes a critical assessment of the data collection methods used and of the various AI algorithms deployed to draw inferences about that data.

The purpose of this project was to use a combination of algorithms, including machine learning and computer vision, to reveal insights into the demographic attributes of Innovate UK applicants over a three year period. Specifically, the project sought to use existing AI algorithms to understand the gender and ethnicity of the applicants over that period.

Data Collection

The initial data collection had already been completed by earlier work done prior to the start of this project. The names of 50,043 applicants were provided by Innovate UK, 12,865 of which were small or microbusinesses. The investigators used web scraping technology to identify and gather information on the directors of small or micro businesses in this data over the period 2016 - 2019. This involved a combination of searching for first name and surname matches on Companies House and verifying each individual's association with the business using LinkedIn. I am confident that the requirements that applicants' names be both listed in Companies House and associated with the business on LinkedIn resulted in a high confidence that the remaining 7,581 names matched the criteria for the project.

Machine Learning

The investigators have used two existing machine learning applications to make inferences about the ethnicity of the 7,581 individuals in the data set. The first was DeepFace (Taigman, 2014) which uses deep learning technologies to identify and classify faces in images. DeepFace was used on the photos of Innovate UK applicants that were extracted from Linkedin to infer their ethnicity and gender.

Taigman et al (2014) report that DeepFace can reach an accuracy of 0.9735 (97.35%) with a standard error of 0.0025 on the 'Labeled Faces in the Wild' database, which is close to human level performance on that dataset (97.53).

The investigators on the Diverse Innovators project, however, found that the accuracy of DeepFace on their image set dropped to 70%. Furthermore, they observed different scores depending on the ethnicity of the individuals in the data set: Black: 85%, white :98%, Middle Eastern:74%, South asian: 73%, East Asian:76%.

The investigators also evaluated the accuracy of a system called 'Namsor' which uses machine learning to predict the gender, country of origin or ethnicity of individuals based on their names. Salman et al

(2020) report that Namsor's accuracy in terms of predicting ethnicity from names is in the range 75-80% on the data sets they used. Other less rigorous sources reported significantly higher scores for accuracy that were in the region of 96 - 98.41%.[2] The investigators on the Diverse Innovators project found that in their data set their accuracy was around 55%.

To mitigate this drop in accuracy, the investigators used an 'ensemble model' approach, combining DeepFace with Namsor to arrive at an increase in classification accuracy. Ensemble models are commonly used in AI and Data Science to improve the stability and classification accuracy of machine learning models by combining multiple weaker models together. The overall objective of enable models is to reduce the variance of the predictions of the combined models leading to the desired improvement in classification accuracy. Two common approaches used are 'bagging', which takes an average of the prediction across a number of classification models, and 'boosting', which uses a voting scheme over multiple classification models.

In addition to adopting an ensemble approach, the investigators also took the precaution of automatically flagging cases where the degree of confidence in the result was below 55%. All flagged cases were then manually checked. Given that the vast majority of cases in the data were while, members of certain groups (especially Asian and Black) regularly ended up being flagged for manual checking. Around 2,000 cases from the 7,581 individuals were manually checked.

In this project, the investigators used a 'bagging' approach to predict ethnicity in which the two models were given equal weight, resulting in an increase of overall classification accuracy and a substantial reduction in variance, as shown below:

Ethnicity	Accuracy (%)	Variance
DeepFace	70%	331.81
Namsor	55%	484.54
DeepFace + Namsor combined	96.98%	222.52

Conclusion

Having reviewed the data collection and inference methods used by the investigators, I am highly confident that:

A. the prior data sample of 7,581 names extracted from the Innovate UK data source strongly matches the criteria for this project.

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[2] https://namesorts.com/2018/01/31/understanding-namsor-api-precision-for-gender-inference/
https://www.oecd.org/migration/forum-migration-statistics/4.Elian-Carsenat.pdf

B. the investigators have taken all reasonable steps to ensure the accuracy of the classifications of gender and ethnicity from the applicant data provided from Innovate UK, and

C. both the data collection and the machine learning approach used have been conducted to a high standard.

It is my opinion that the conclusions drawn by the investigators in this project are founded on informative and accurate inferences made from the data with which they were provided.

References

Taigman, Y., Yang, M., Ranzato, M.A. and Wolf, L., 2014. Deepface: Closing the gap to human-level performance in face verification. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 1701-1708).

Salman, O., Gauch, S., Alqahatani, M., Ibrahim, M. and Alsaffar, R., 2020. Incorporating Diversity in Academic Expert Recommendation. In Proceedings of eKNOW 2020: The Twelfth International Conference on Information, Process, and Knowledge Management. (pp102 - 107)

Appendix 3 - Regression Tables

Table A4.1: Effect of gender on success rate

Parameter	B	SE	z-value	p	Model Significance
Women	-0.0025	0.0360	-0.069	0.945	Chi -Square = 0.0048, p<0.945
Men (Ref)	0[a]				

Table A4.2: Effect of ethnicity on success rate

Parameter	B	SE	Z-value	p	Model Significance
Black	-0.8922	0.1005	-8.8770	<0.0000	Chi -Square = 115.509, p<0.0000
East Asian	0.0539	0.0852	0.6330	0.5265	
Middle Eastern	-0.2058	0.0790	-2.6040	0.0092	
South Asian	-0.2452	0.0695	-3.5280	0.0004	
White (Ref)	0[a]				

Table A4.3: Effect of education on success rate

Parameter	B	SE	z-value	p	Model Significance
Category B	0.0639	0.0730	0.8750	0.3815	Chi -Square = 171.892, p<0.000
Category D	-0.1045	0.0545	-1.9170	0.0553	
Category C	-0.4394	0.0493	-8.9210	0.000	
Category A (Ref)	0[a]				

Table A4.41: Effect of gender and ethnicity on success rate

Parameter	B	SE	Wald	p	Model Significance
Black Men	-0.9338	0.1206	-7.7410	0.0000	Chi -Square = 65.266, p<0.000
Black Women	-0.8079	0.1802	-4.4840	0.0000	
East Asian Men	0.0440	0.1044	0.4220	0.6733	
East Asian Women	0.0604	0.1449	0.4170	0.6769	
Middle Eastern Men	-0.3186	0.0891	-3.5750	0.0004	
Middle Eastern Women	0.2891	0.1713	1.6880	0.0914	
South Asian Men	-0.2477	0.0757	-3.2730	0.0011	
South Asian Women	-0.2598	0.1734	-1.4980	0.1341	
White Women	-0.0205	0.0390	-0.5260	0.5987	
White-Men (Ref)	0a				

Table A4.42: Effect of gender and education on success rate

Parameter	B	SE	Wald	p	Model Significance
Category A-Women	0.0264	0.1069	0.2470	0.8050	Chi -Square = 172.170, p<0.000
Category B-Men	0.0826	0.0822	1.0050	0.3150	
Category B-Women	0.0195	0.1391	0.1400	0.8890	
Category C-Men	-0.0991	0.0620	-1.5990	0.1100	
Category C-Women	-0.0954	0.0842	-1.1330	0.2570	
Category D-Men	-0.4348	0.0562	-7.7360	0.0000	
Category D-Women	-0.4279	0.0664	-6.4470	0.0000	
Category A-Men (Ref)	0a				

Table A4.43: Effect of ethnicity and education on success rate

Parameter	B	SE	z- value	p	Model Significance
Category A-Black	-0.6064	0.3270	-1.8550	0.0637	Chi -Square = 291.944, p<0.000
Category A-East Asian	0.0720	0.2169	0.3320	0.7400	
Category A-Middle Eastern	-0.2535	0.2399	-1.0570	0.2906	
Category A-South Asian	-0.1906	0.1799	-1.0600	0.2893	
Category B-Black	-0.9338	0.4324	-2.1590	0.0308	
Category B-East Asian	-0.0124	0.2508	-0.0490	0.9607	
Category B-Middle Eastern	-0.3213	0.2701	-1.1900	0.2341	
Category B-South Asian	-0.4454	0.2364	-1.8840	0.0595	
Category B-White	0.1290	0.0807	1.5990	0.1099	
Category C-Black	-1.0402	0.2339	-4.4480	0.0000	
Category C-East Asian	-0.0725	0.1931	-0.3750	0.7074	
Category C-Middle Eastern	-0.1326	0.1608	-0.8250	0.4097	
Category C-South Asian	-0.6498	0.1783	-3.6450	0.0003	
Category C-White	-0.0936	0.0594	-1.5760	0.1151	
Category D-Black	-1.2831	0.1320	-9.7220	0.0000	
Category D-East Asian	-0.3966	0.1262	-3.1430	0.0017	
Category D-Middle Eastern	-0.6842	0.1163	-5.8830	0.0000	
Category D-South Asian	-0.5750	0.1003	-5.7310	0.0000	
Category D-White	-0.4280	0.0540	-7.9240	0.0000	
Category A-white (Ref)	0^a				

Table A4.44: Effect of gender, ethnicity and education on success rate

Parameter	B	SE	z-value	p	Model Significance
Category A-Black-Men	-0.3965	0.3671	-1.0800	0.2801	Chi -Square = 317.257, p<0.000
Category A-Black-Women	-1.2276	0.7370	-1.6660	0.0958	
Category A-East Asian-Men	-0.0479	0.2637	-0.1820	0.8559	
Category A-East Asian-Women	0.3426	0.3764	0.9100	0.3627	
Category A-Middle Eastern-Men	-0.5737	0.2927	-1.9600	0.0500	
Category A-Middle Eastern-Women	0.8126	0.4529	1.7940	0.0728	
Category A-South Asian-Men	-0.1233	0.1967	-0.6270	0.5309	
Category A-South Asian-Women	-0.5210	0.4438	-1.1740	0.2403	
Category A-White-Women	-0.0072	0.1180	-0.0610	0.9510	
Category B-Black-Men	-1.1586	0.6043	-1.9170	0.0552	
Category B-Black-Women	-0.6478	0.6198	-1.0450	0.2960	
Category B-East Asian-Men	-0.0331	0.3058	-0.1080	0.9138	
Category B-East Asian-Women	0.0252	0.4314	0.0580	0.9535	
Category B-Middle Eastern-Men	-0.3996	0.3070	-1.3020	0.1930	
Category B-Middle Eastern-Women	-0.0236	0.5656	-0.0420	0.9667	
Category B-South Asian-Men	-0.6478	0.2913	-2.2240	0.0262	
Category B-South Asian-Women	0.0454	0.4049	0.1120	0.9108	
Category B-White-Men	0.1527	0.0900	1.6970	0.0897	
Category B-White-Women	0.0090	0.1639	0.0550	0.9562	
Category C-Black-Men	-1.1067	0.2951	-3.7500	0.0002	
Category C-Black-Women	-0.9265	0.3765	-2.4610	0.0139	
Category C-East Asian-Men	0.1254	0.2315	0.5420	0.5880	
Category C-East Asian-Women	-0.4597	0.3471	-1.3250	0.1853	
Category C-Middle Eastern-Men	-0.1665	0.1732	-0.9620	0.3363	
Category C-Middle Eastern-Women	0.1085	0.4354	0.2490	0.8031	
Category C-South Asian-Men	-0.7568	0.1991	-3.8020	0.0001	
Category C-South Asian-Women	-0.0882	0.3994	-0.2210	0.8253	
Category C-White-Men	-0.0963	0.0675	-1.4280	0.1533	
Category C-White-Women	-0.0912	0.0909	-1.0030	0.3160	
Category D-Black-Men	-1.3282	0.1557	-8.5280	0.0000	
Category D-Black-Women	-1.1708	0.2343	-4.9980	0.0000	
Category D-East Asian-Men	-0.4480	0.1556	-2.8790	0.0040	
Category D-East Asian-Women	-0.3050	0.2019	-1.5110	0.1309	

Parameter	B	SE	z-value	p	Model Significance
Category D-Middle Eastern-Men	-0.8082	0.1327	-6.0900	0.0000	
Category D-Middle Eastern-Women	-0.1651	0.2291	-0.7210	0.4711	
Category D-South Asian-Men	-0.5347	0.1087	-4.9180	0.0000	
Category D-South Asian-Women	-0.8591	0.2624	-3.2740	0.0011	
Category D-White-Men	-0.4269	0.0616	-6.9350	0.0000	
Category D-White-Women	-0.4399	0.0724	-6.0720	0.0000	
Category A-White-Men (Ref)	0[a]				

Separate Note 1

DIRECTOR, PERSONS WITH SIGNIFICANT CONTROL, SECRETARY OR OTHER

As discussed, we have also undertaken a basic descriptive analysis to determine whether the applicants are named as officers or persons with significant control. The names of Innovate UK applicants were compared with data scraped from Companies House in May 2021 and could change, i.e. an individual could be appointed as an officer at any point. The applicants' roles are classified into four categories: Director, LLEP designated member, Secretary or Other. As shown in Figure S1a, the majority of total and funded applications are from applicants categorised as Directors (total 58%, funded 56%), followed by Others (total 40%, funded 41%). Further, with regard to the success rate of applications (see Figure S1b), we observe a statistically significant difference between the Directors (reference group) and Other categories only ($p < 0.0213$, chi square = 9.703). However, caution should be taken when referring to this analysis.
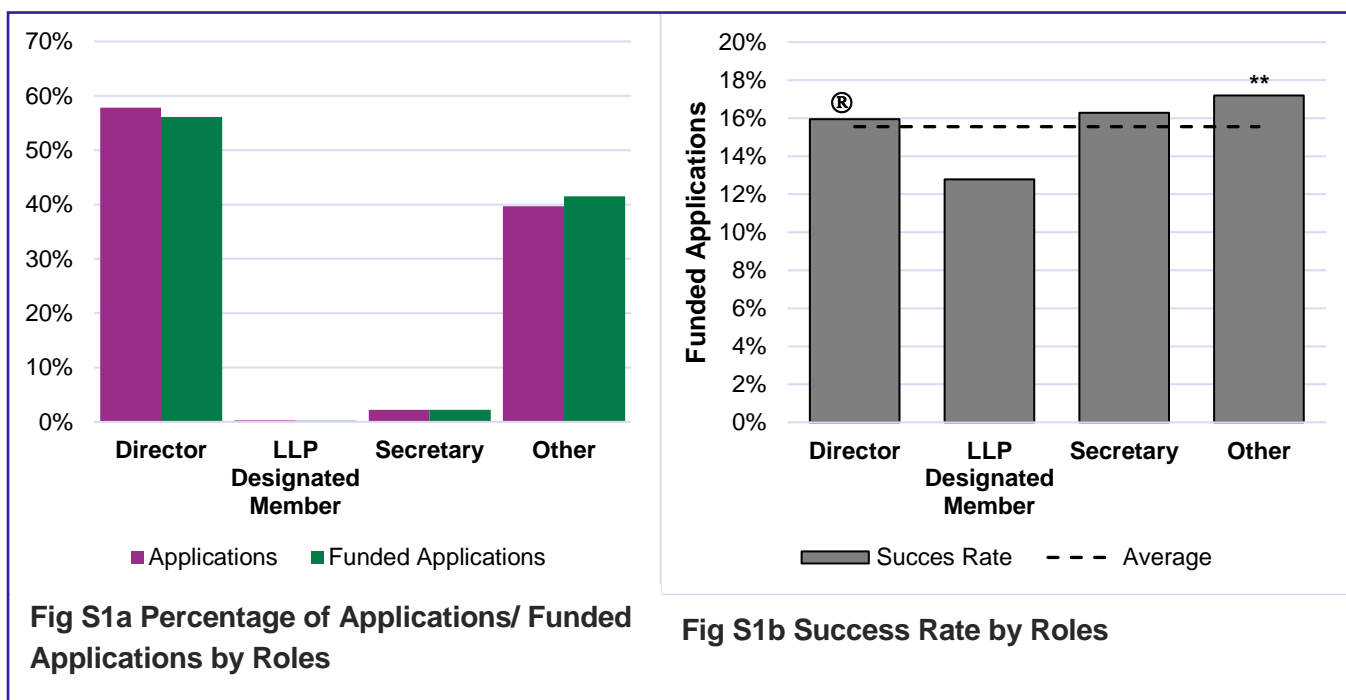
Fig S1a Percentage of Applications/ Funded Applications by Roles

Fig S1b Success Rate by Roles

Note: Success rates with asterix (*) and double asterix (**) are statistically significant at 10% and 5% respectively when compared to the reference category (®)

Separate Note 2

ANALYSES OF APPLICANTS SUBMITTING SINGLE AND MULTIPLE APPLICATIONS

This note provides an analysis of applicants based on the number of submissions during the period 2016/17 to 2022/23. Out of the 24,957 unique named contacts submitting applications for funding, 5,356 applicants made multiple applications, accounting for 13,608 of the total funding applications analysed. An overview of the applicants submitting multiple applications is presented in Table 1 below.

Table S2.1. Overview of applicants submitting multiple applications

No of Named Contacts	No of applications submitted	Total no. of applications	Percentage
19,601	1	19,601	59.0%
3,707	2	7,414	22.3%
1,011	3	3,033	9.1%
358	4	1,432	4.3%
136	5	680	2.0%
61	6	366	1.1%
42	7	294	0.9%
17	8	136	0.4%
10	9	90	0.3%
8	10	80	0.2%
2	11	22	0.1%
1	13	13	0.0%
1	14	14	0.0%
1	16	16	0.0%
1	18	18	0.1%
24,957		**33,209**	**100.0%**

Additionally, we analyse the effects of the social identities of applicants making single and multiple submissions on their success rates. While the regression tables are presented below, statistically significant differences in success rates are highlighted in the figures. Success rates denoted with an asterisk (*) or double asterisk (**) are statistically significant at 10% and 5% respectively. Applicants making multiple submissions are the reference group used in each regression, and are denoted by ®.
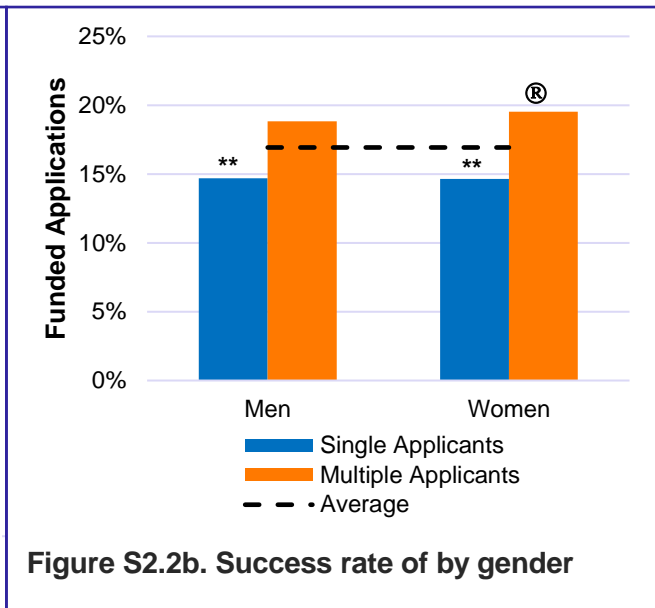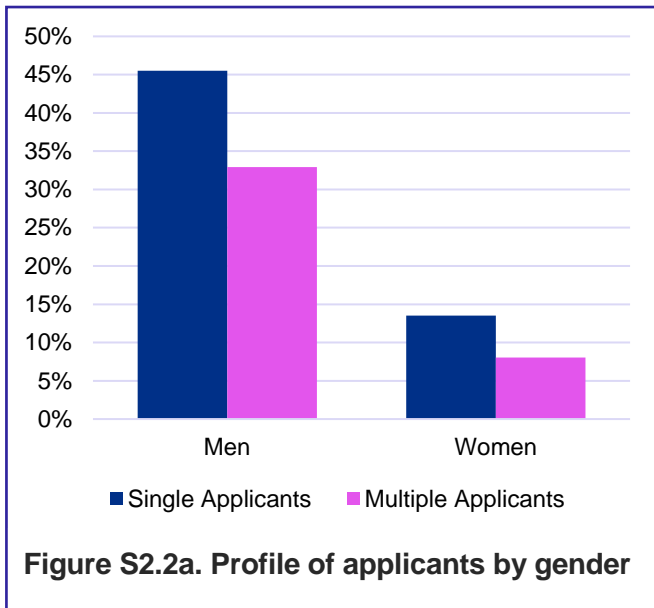
Profile of all applicants

Overall, our findings indicate that in terms of funding success (see Figure S2.1b), applicants submitting multiple applications statistically outperform those submitting single applications (Model: *p<0.000, chi-square = 106.303*). This implies that encouraging participants to apply multiple times, regardless of whether they succeed or fail in the first attempt, should have a positive effect on their success rates in the long term.


Figure S2.1a. Profile of applicants by submissions

Figure S2.1b. Success rate of by number of submissions
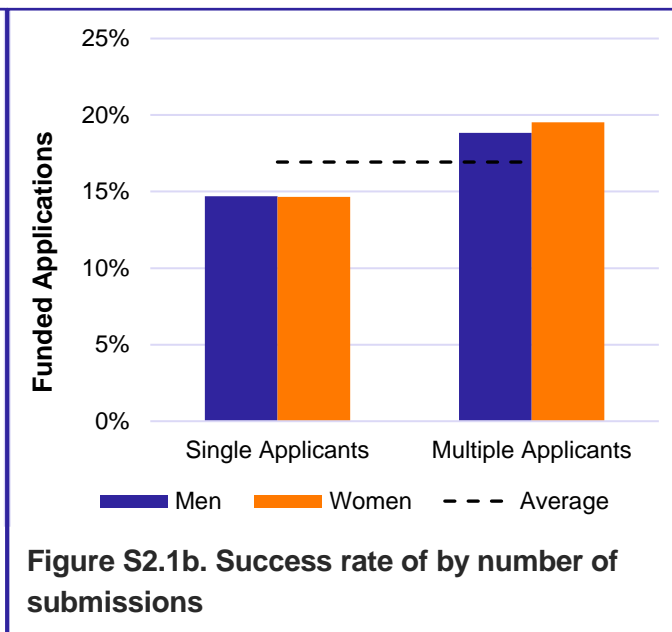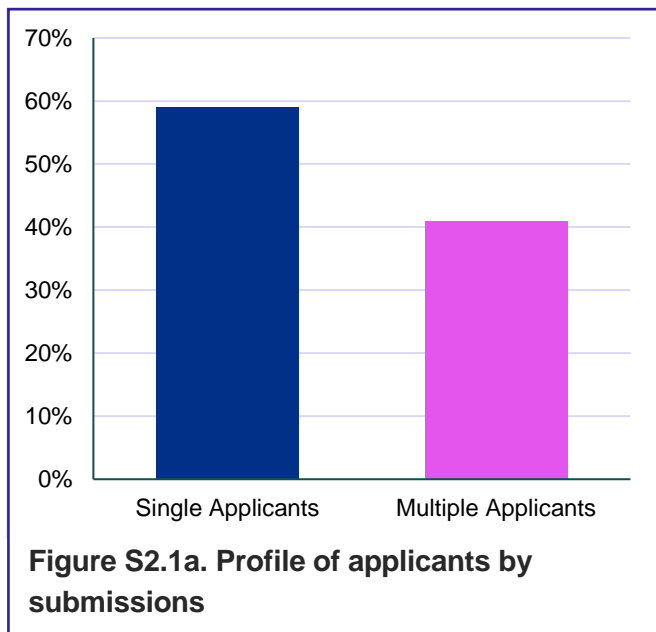
Results of the analyses of the extent to which applicants' gender, ethnicity or education influences their likelihood of making multiple funding applications are presented in the figures below. Looking at the effect of gender, we find that men submit more applications than women, and this is also evident in the percentage of multiple applications submitted by both men and women. However, the success rate of women submitting multiple applications is relatively higher than that of men submitting multiple applications (19% and 20% respectively). Further, both men and women multiple applicants are statistically more likely to have a higher percentage of their applications funded than single applicants (see Figure S2.2b).

In terms of ethnicity, the success rates of East Asian multiple applicants and White multiple applicants were statistically significantly higher than the other intersecting categories (see Figure S2.3b). We also note that multiple applicants from all ethnic groups were more successful than single applicants in their respective ethnic groups. However, Black single and multiple applicants had the least percentages of successful applicants and are statistically less likely to be successful compared to all other ethnic groups. A more detailed result of the inter-category statistical analyses is presented in the regression Table S2.3 at the end of the note.

Figure S2.2a. Profile of applicants by gender

Figure S2.2b. Success rate of by gender

Note: Success rates with asterix (*) and double asterix (**) are statistically significant at 10% and 5% respectively when compared to the reference category (®)

Figure S2.3a. Profile of applicants by ethnicity

Figure S2.3b. Success rate of by ethnicity
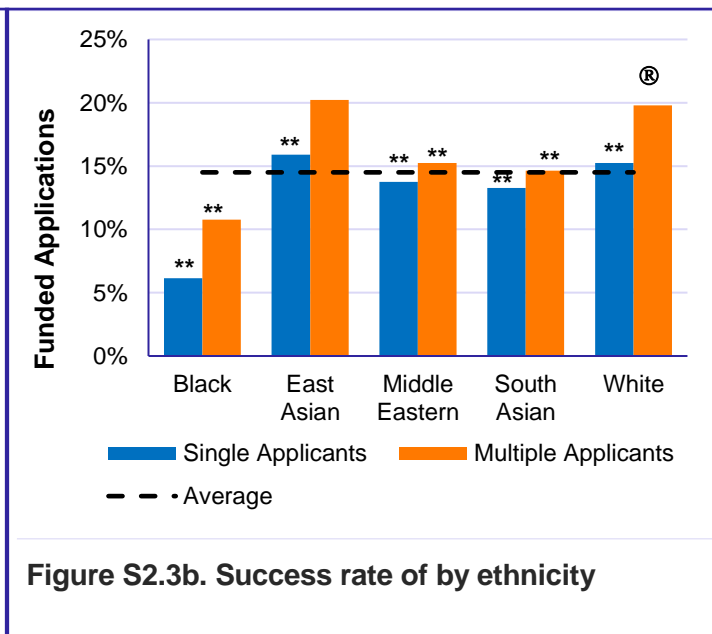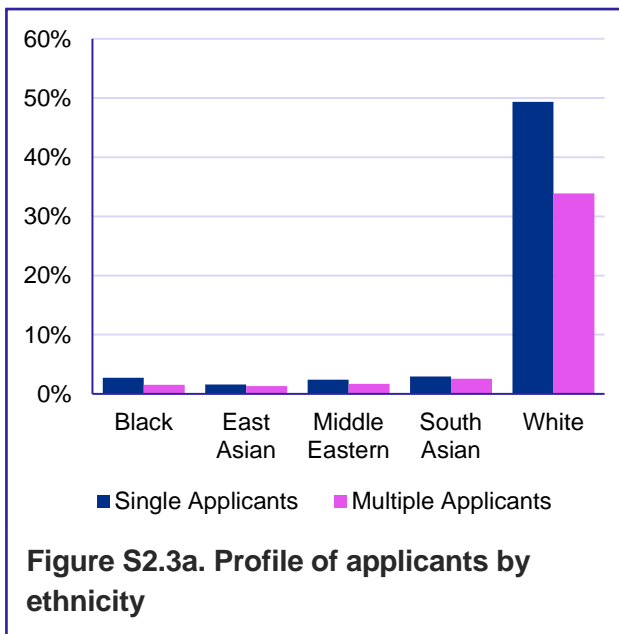
Note: Success rates with asterix (*) and double asterix (**) are statistically significant at 10% and 5% respectively when compared to the reference category (®)

Lastly, analyzing the extent to which applicants' educational affiliation impacts their likelihood of making multiple applications, we find that the percentage of applicants from Oxford and Cambridge (Category A) and Imperial College and UCL (Category B) institutions submitting multiple applications is similar to those submitting single applications from those institutions during the period under consideration. On the other hand, applicants categorized in Other Russell Group (Category C) and Other Institutions (Category D) had more single applicants than multiple applicants (see Figure S2.4a). Oxford and Cambridge multiple applicants were the most successful group with a success rate of 25%, closely

followed by Imperial College and UCL multiple applicants (24%). It is also worth noting that within all of the four educational categories, multiple applicants were more successful than single applicants. Using Oxford and Cambridge multiple applicants as the reference group, we find that all other categories (excluding Imperial College and UCL multiple applicants) are statistically lower than the reference group. Furthermore, applicants categorized in Other Institutions were the least successful among the different groups (see Figure S2.4b). The detailed regressions of these analyses are presented in Table S2.4 below.
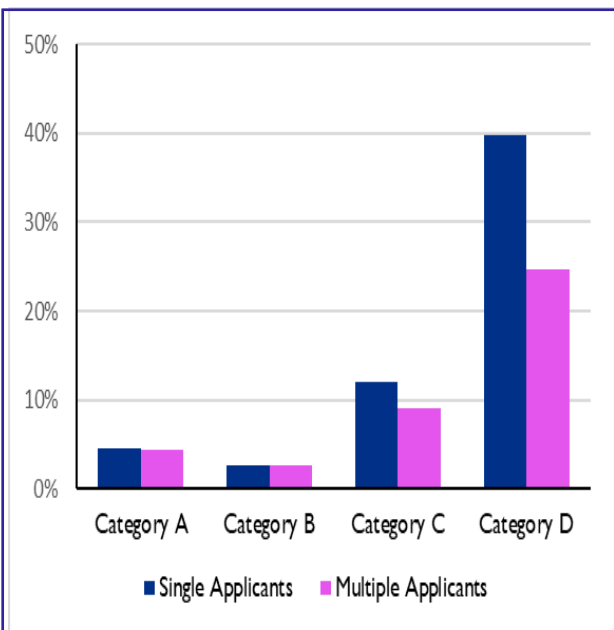

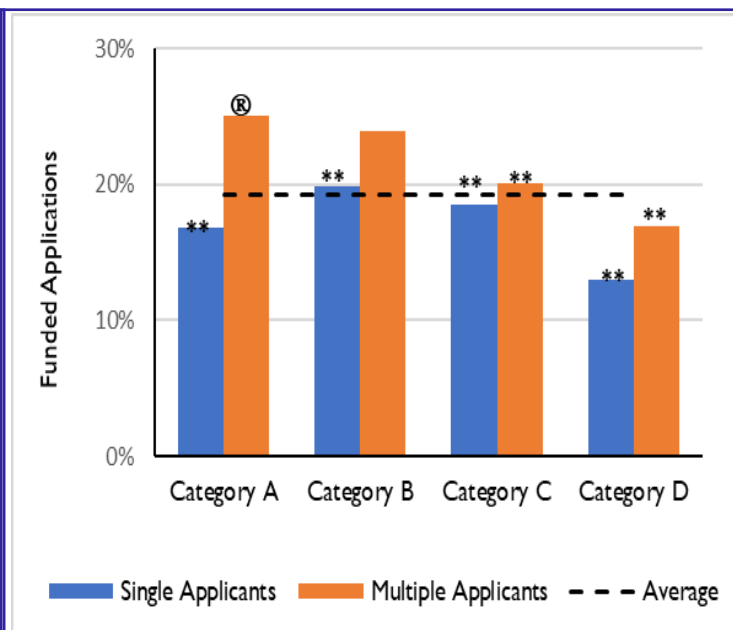**Figure S2.4a. Profile of applicants by educational tiers**

Figure S2.4b. Success rate of by educational tiers

Notes: a) Description of categories can be found in section 3.1 b) Success rates with asterix (*) and double asterix (**) are statistically significant at 10% and 5% respectively when compared to the reference category (®)

In sum, our findings emphasize the fact that applicants submitting applications for several competitions tend to have a higher success rate irrespective of their gender, ethnicity or education. This points to the need to encourage repeat applications by applicants, regardless of whether they succeed or fail in their first attempt, as this should have a positive effect on their success rates in the long term. However, what is not clear from the current analyses is whether the higher success rates of multiple applicants are driven by the submission of multiple applications, or by their initial success in obtaining funding. Further research would be needed to examine this aspect. Gaining a better understanding of applicants' perceptions of the whole application and feedback process could also provide insights on the factors that might influence their likelihood to reapply.

Regression Tables

Table S2.2 Analysis of single and multiple applicants by gender

		Reference category			
		Single Applicants		**Multiple Applicants**	
		Women	**Men**	**Women**	**Men**
Single Applicants	**Women**				
	Men	0.0041**	-		
Multiple Applicants	**Women**	0.3469**	0.3428**	-	
	Men	0.3018**	0.2977**	0.0451	-

*Note: ** significant at 5%; * significant at 10%*

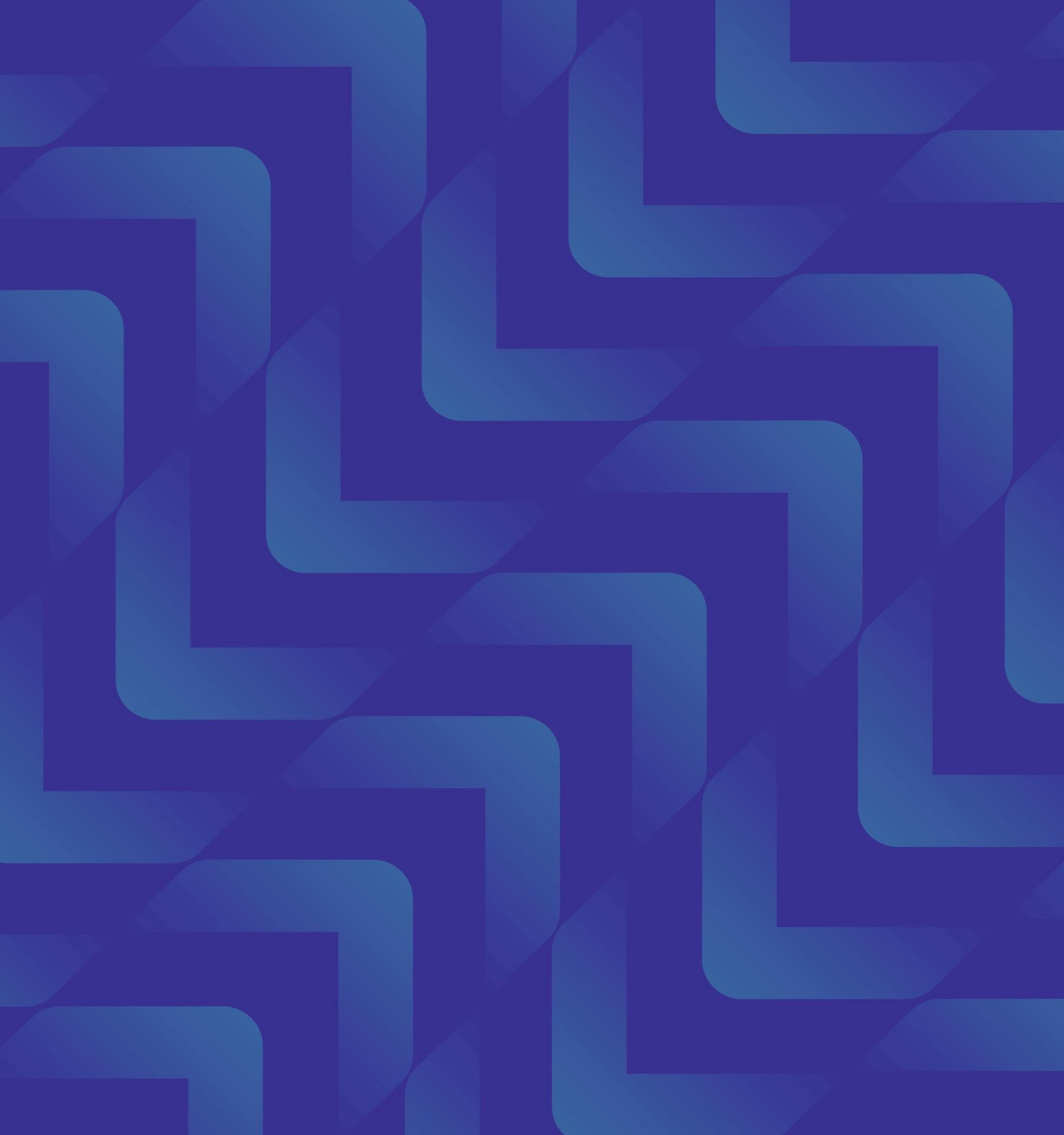**Table S2.3 Analysis of single and multiple applicants by ethnicity**

| | | Reference category | | | | | | | | | |
| | | Single Applicants | | | | | Multiple Applicants | | | | |
		Black	East Asian	Middle Eastern	South Asian	White	Black	East Asian	Middle Eastern	South Asian	White
Single Applicants	**Black**	-									
	East Asian	1.0596**	-								
	Middle Eastern	0.8894**	-0.1701	-							
	South Asian	0.8469**	-0.2127	-0.0426	-						
	White	1.0096**	-0.0499	0.1202	0.1628*	-					
Multiple Applicants	**Black**	0.6110**	-0.4485**	-0.2784	-0.2359	-0.3986**	-				
	East Asian	1.3523**	0.2927*	0.4628**	0.5949**	0.3426**	0.7413**	-			
	Middle Eastern	1.0093**	-0.0503*	0.1199	0.1624	-0.0003	0.3983**	-0.3430**	-		
	South Asian	0.9615**	-0.0981	0.0720	0.1146	-0.0482	0.3504**	-0.3908**	-0.0479	-	
	White	1.3259**	0.2663**	0.4365**	0.4790**	0.3163**	0.7149**	-0.0264	0.3166**	0.3645**	-

Note: **significant at 5%; * significant at 10% and ® is the reference category

Table S2.4 Analysis of single and multiple applicants by educational tiers

		Reference category							
		Single Applicants				Multiple Applicants			
Single Applicants		Category A	Category B	Category C	Category D	Category A	Category B	Category C	Category D
	Category A	-							
	Category B	0.2053*	-						
	Category C	0.1193	-0.0861	-					
	Category D	-0.3007**	-0.5060**	-0.4120**	-				
Multiple Applicants	Category A	0.5072**	0.3019**	0.3880**	0.8079**	-			
	Category B	0.4463**	0.2409**	0.3270**	0.7470**	-0.0610	-		
	Category C	0.2201**	-0.1909**	0.1008*	0.5208**	-0.2871**	-0.2262**	-	
	Category D	0.0145	0.0147	-0.1048**	0.3152**	-0.4927**	-0.4318**	-0.2056**	-

*Note: ** significant at 5%; * significant at 10% b) Description of categories can be found in section 3.1*

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