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The Innovation Glass Ceiling and the Female Creative Penalty

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Extended Abstract

We study innovation networks through different domains—from science and technology, to entertainment, to cuisine creation. We adapt a temporally evolving network measure representative of the degree of an innovation's conventionality or atypicality and find systematic differences in the successes of women and men innovators across multiple innovation contexts. We utilize five datasets – a diverse sample of about 7 million international patent application records between 2001-2018 from the US, the UK, and Canada, over 15K items of content from Netflix, and more than 500K recipes from Food.com. We find that the phenomenon of an innovation glass ceiling where women inventors are penalized for boundary spanning work generalizes from technology networks to the other domains of entertainment creation and cuisine innovation.

There is a widespread and consistent gender gap in science and innovation work [5], [7], [2], [3]. This leads not only to gender inequalities in terms of work opportunities [9], salaries[4], and educational choices [11], but also to underutilization of resources as society fails to draw from the full diversity of perspectives available to help solve its most pressing problems. This gender gap extends to patenting success [7], [3], [6], [1]. Figure 1 examines the success rate of patent applications. It pools all completed patent applications (N=4,754,198) by the inferred gender of the first listed inventor(s). Fig 1a demonstrates that the patent grant rate for female inventors is significantly lower than for male inventors or inventors with unknown genders. Fig 1b indicates that the gender difference is consistent across years and with little change in the mean difference despite the growing number of women in science and technology-based fields. Figures 1c and 1d reveal that this gender gap extends beyond the success and failure rate of patent applications. Even when they are granted patent protection, inventions by women lose more claims during the patent examination process (Fig 1c). Because they provide the legally enforceable aspect of a patent's property rights, claims are important measures of patent value10 and so losing claims in examination means the loss of more intellectual property value for women inventors. We also see that women patentees wait longer than men to receive patent protection (Fig 1d). Delays in receiving patent protection can slow business developments, impede product launches, and make it more difficult for start-up firms to secure investment support.

We leverage the tendency to categorize inventions into multiple categories (cooperative patent classification codes for patents, content tags for Netflix entertainment, and recipe tags for the recipes) to produce a category co-classification network that measures how typical or atypical a combination of categories is [10], [8], (e.g. Figure 2a). To explore the relationships between gender and success in boundary pushing inventions, we use the co-classification network to compute a metric for each innovation that represents the degree to which it features common combinations of categories or spans boundaries by combining areas rarely seen together. These scores are normalized within category as z-scores representing how typical or

atypical the categories combined are. The face validity of our measure is bolstered in several ways. Consistent with prior research, we find that inventions that make unusual combinations have higher future impact and value (as measured through citations and maintenance fees).

Women inventors' boundary-pushing inventions are rejected more than men's. Conversely, women's conventional inventions show no differences in patenting rates than men's (Figure 2b). Innovation success rates for men increase when they make novel connections between technological domains, while women face an increased chance of rejection. These differences exist after controlling for technology, team, and negotiating strategies. When performing innovative work, men are more likely to be rewarded as boundary spanners, while women are more likely to be rejected as boundary pushers. These findings from the patenting domain generalize to the contexts of entertainment and recipe creation where female creators also have consistently lower success rates than men when they engage in boundary spanning work.

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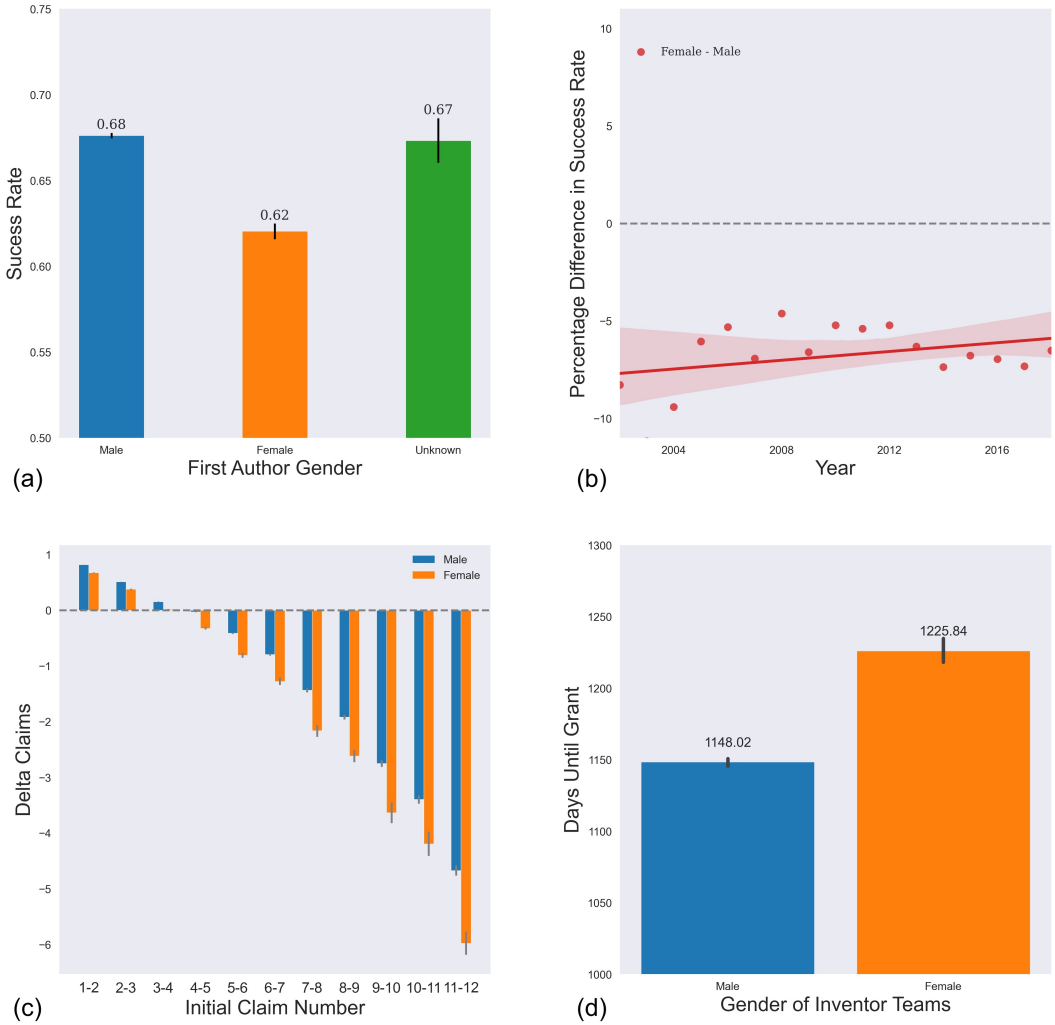
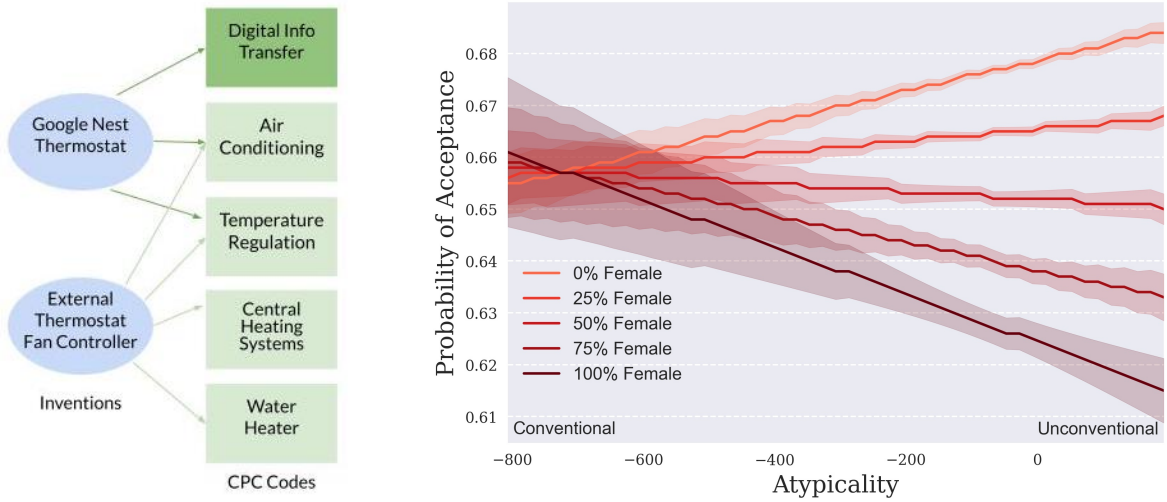


Figure 1: Women inventors have poorer outcomes than men across a variety of success measures. They are less likely to be granted a patent than men or inventors with ambiguously gendered names (a). This success rate difference is consistent across recent years (b). When they are granted a patent, they lose more claims during the examination process (c), and they experience more delay to grant (d). Analysis includes all granted or abandoned applications from 2001–18 for majority gender teams (n = 4,754,198).



(a) CPC Network Atypicality Measure Example

(b) Interaction between Inventor Gender and Atypicality

Figure 2: (a) Example of two inventions and their corresponding CPC code classifications to illustrate atypicality metric calculation. Inventions are denoted by the light blue bubbles and CPC codes are denoted in green squares. The light green CPC code squares are commonly combined in thermostat applications; however, the dark green CPC code square of 'Digital Info Transfer' is not commonly combined with traditional thermostat-related CPC categories, showing that the Google Nest Thermostat represents a more atypical invention. (b) Probability of patent application success by invention atypicality and inventor gender. Increasingly female teams face high penalties for atypical work. Includes statistical control for team size, year, examiner gender, examiner experience, applicant entity size, and CPC class.