Why do women so rarely become STEM professionals?

On the significance of the difference between mathematics skills and self-concept

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Introduction

- Since decades, Switzerland has a shortage of professionals in STEM occupations (Science, Technology, Engineering, Mathematics).
- Furthermore, there is huge gender gap in STEM.
- Consequently, existing educational policy tries to make STEM training more attractive for females.
- These efforts have only been mildly successful so far. Occupational gender segregation remains very pronounced in the Swiss labor market.
- Why is occupational segregation so persistent? In particular, why do women so rarely decide to become a STEM professional?

Hypotheses

- Generally, occupational gender segregation may have various causes (e.g. interplay between labor market and family policy, stereotypes, gendered eduction, . . .).
- With respect to STEM, however, gender-specific skills in math and analytic thinking will be relevant.
- It is very obvious:
  - Women are not fit for math and this is why the do not want to become STEM professionals.
  - Probably something about the brain; let's ask the evolutionary biologists.
- Well, as social scientists we don't like this explanation.

Hypotheses

- Self-fulfilling prophecy:
  - Even if we do observe a gender difference in math skills, this does not mean that there is a (biological) difference in talent.
  - It seems obvious that gender stereotypes affect socialization and math learning.
  - For example, there is evidence that the behavior of teachers matters (e.g. gender bias grading).
  - Also, stereotypes will affect the effort that children put into their math learning.
  - As a consequence, the stereotype becomes true.

Hypotheses

- The role of the mathematical self-concept:
  - We further argue that gender stereotypes affect how women and men evaluate their own skills ("It can not be what may not be").
  - In particular, we argue that women underestimate their math skills compared to men. That is, on average, among women and men with identical math skills, women are less confident in their skills than men.
  - Because women "think" that they are not good at math, they are opposed against STEM, even if they would have the necessary skills.
- This is the hypothesis that we want to test.
  - Can we find evidence for such a gendered evaluation of one's own skills?
  - Do educational decisions depend on such a gender-bias?

Data

- 2nd cohort of TREE (Transitions from Education to Employment)
  - Wave 0: 8267 observations; baseline measurement of math skills, mathematical self-concept, and occupational aspirations in 9th grade (at about age 15)
  - Wave 1: 7971 observations; type of education 1 year after leaving school
  - Wave 2: 6903 observations; type of education 2 years after leaving school
- For details on the 2nd cohort TREE data, see Hupka-Brunner et al. (2021). For details on scales included in the data, see Sacchi and Kerbs-Oesch (2021).

Measures

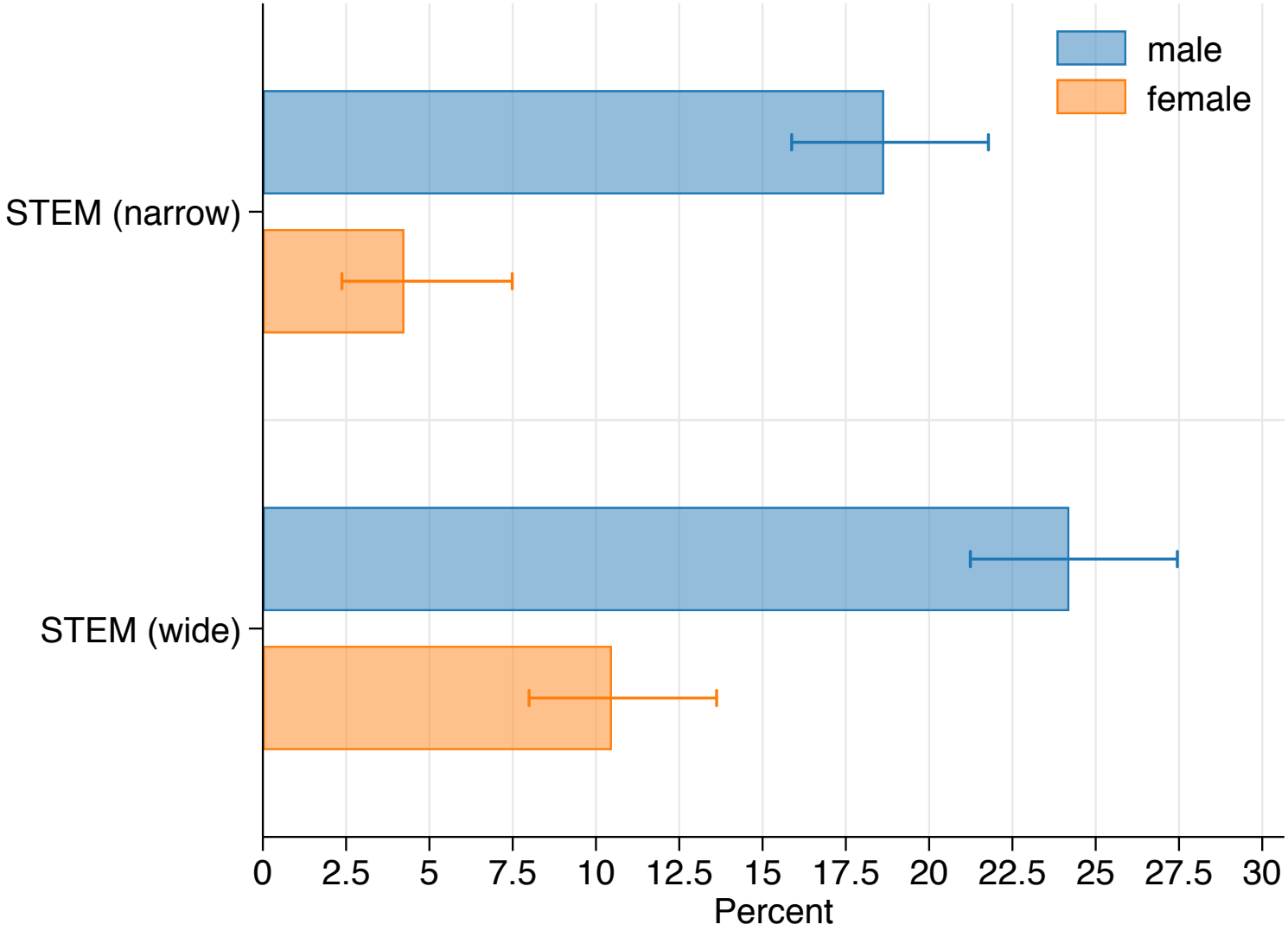
- Measure of math skills: WLE score from the extensive AES math assessments covering the Swiss curriculum.
- Two measures for the mathematical self-evaluation
  - general "self-concept" (agreement with questions such as "I am good at math" etc.)
  - specific "self-efficacy" ("How likely can you solve the following tasks?"); for simplicity, we use the arithmetic mean from four subscales (calculation, algebra, geometry, probabilities)
- Two measures for STEM aspiration
  - Wave 0: classification of the "job at the age of 30" into STEM professionals (at tertiary education level) and other occupations
  - Waves 1/2: classification of current educational track into tracks that likely lead to a STEM profession and other tracks

Methods

- We quantify under- and overestimation of one's own skills by comparing respondents' ranks in the distribution of skills and the distribution of self-evaluations.
  - A positive rank difference points to a relative overestimation, a negative difference points to a relative underestimation.
  - If there is no gender bias in self-evaluation, the average rank difference will be zero for both men and women.
- To quantify the effect on STEM aspirations, we conduct Oaxaca-Blinder decompositions (for binary dependent variables) accounting for skills as well as the rank differences between skills and self-evaluation.

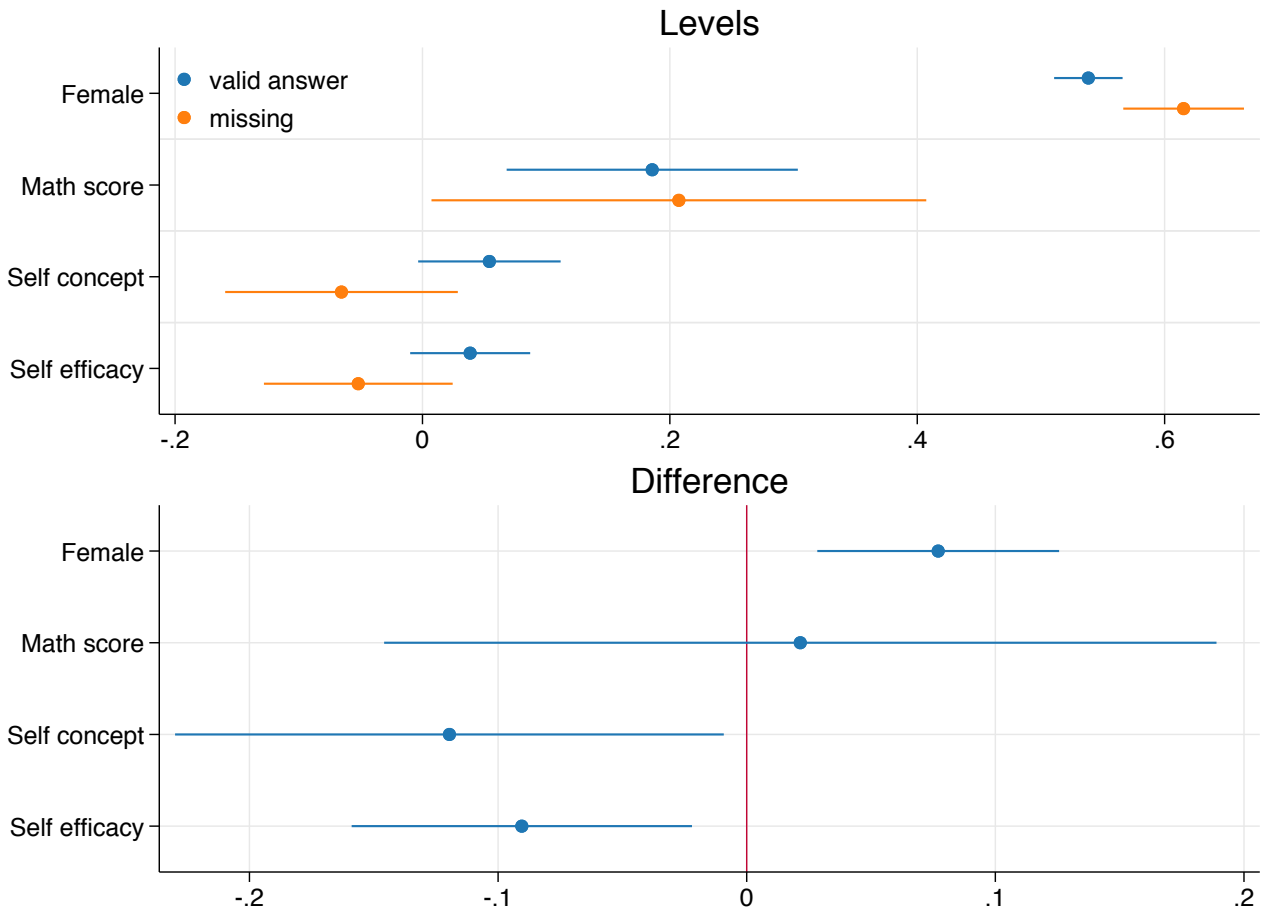
Raw gender difference in STEM aspirations (job at 30)

- Gender gap in STEM aspirations: about 14 percentage points



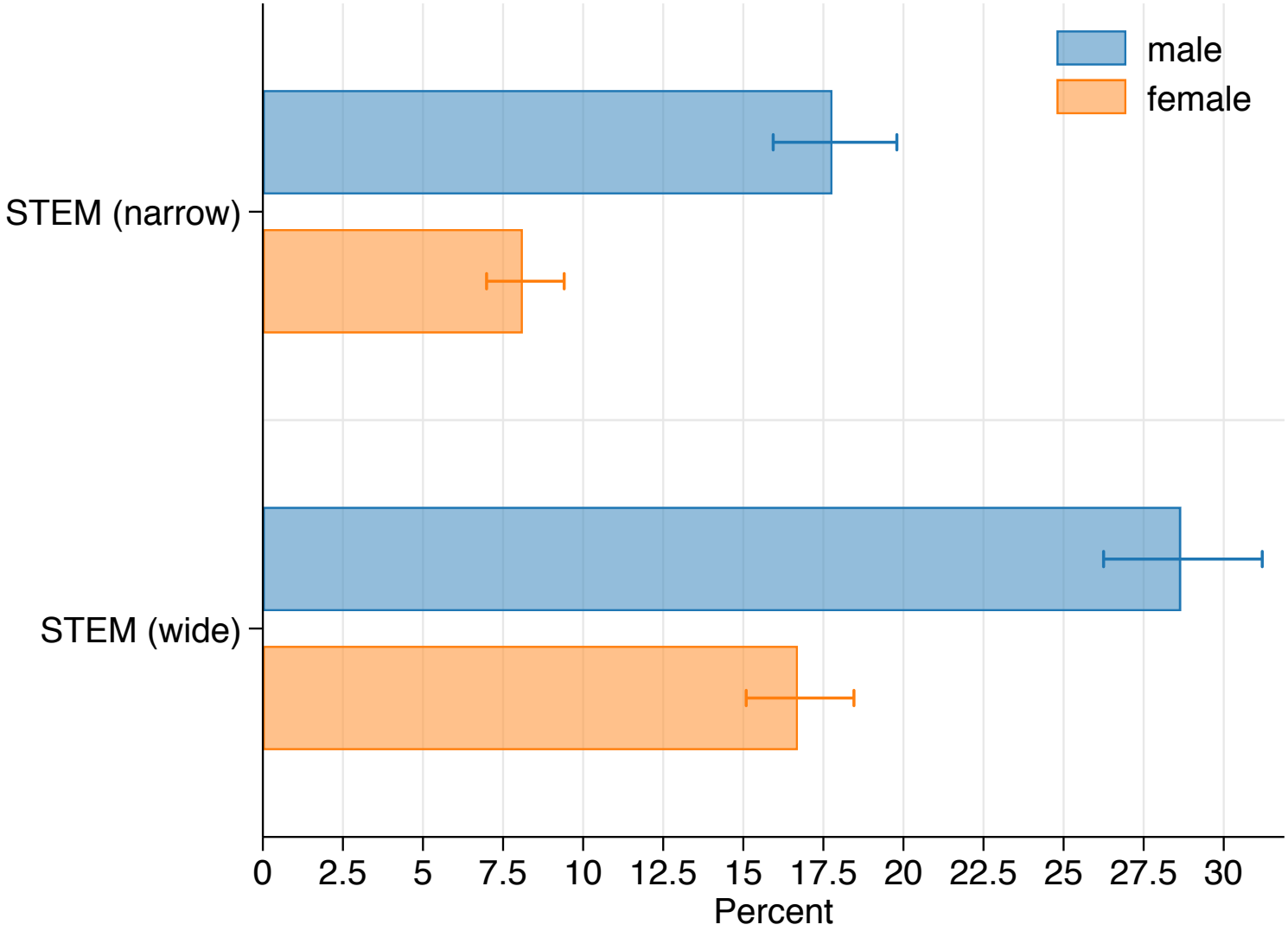
Raw gender difference in STEM aspirations (job at 30)

- Note that the analysis only includes respondents who provided a valid answer to the question on their likely job when they will be 30 years old (77% of respondents).



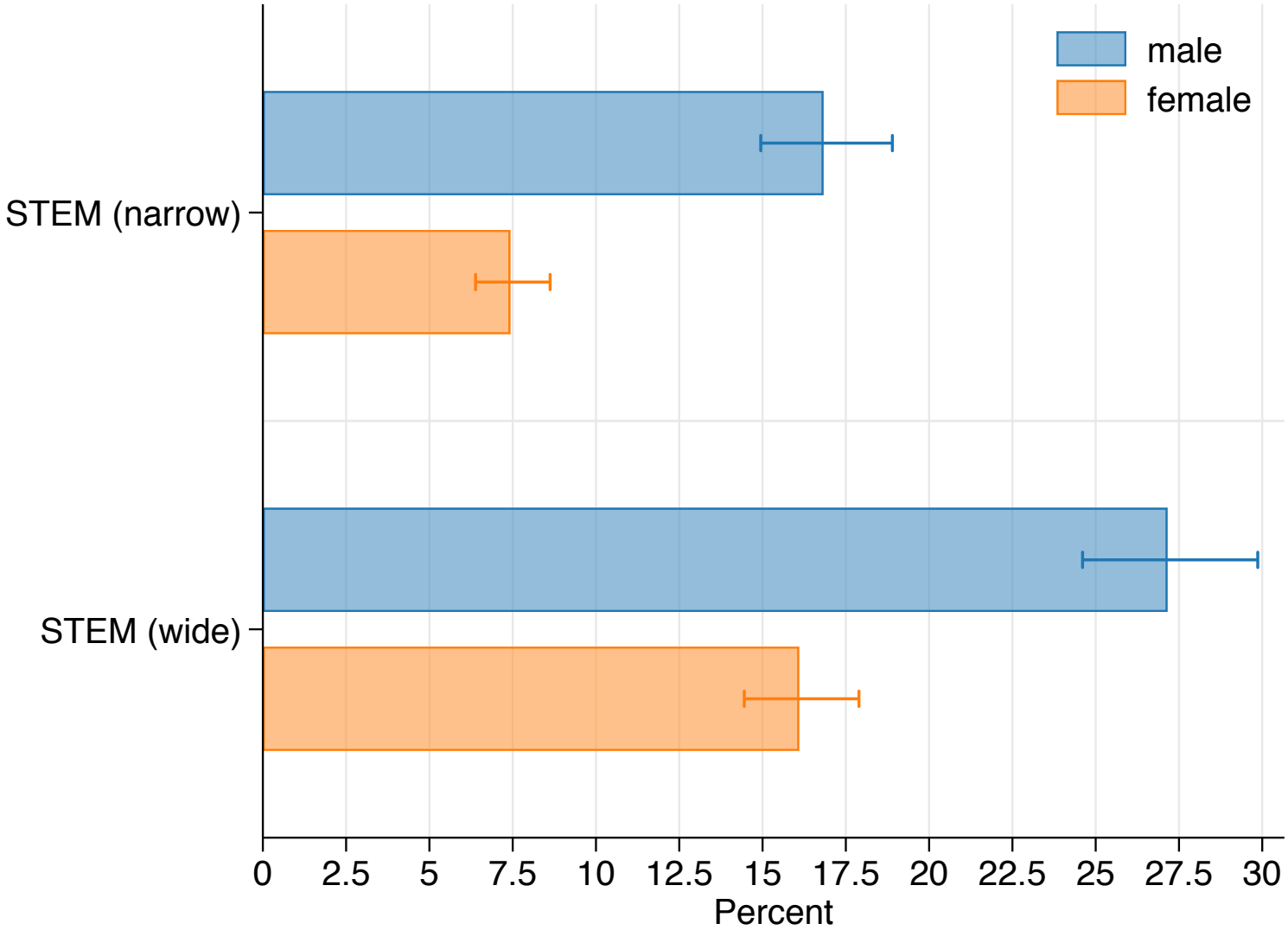
Raw gender difference in STEM education (Wave 1)

- Gender gap in STEM aspirations: 10–12 percentage points



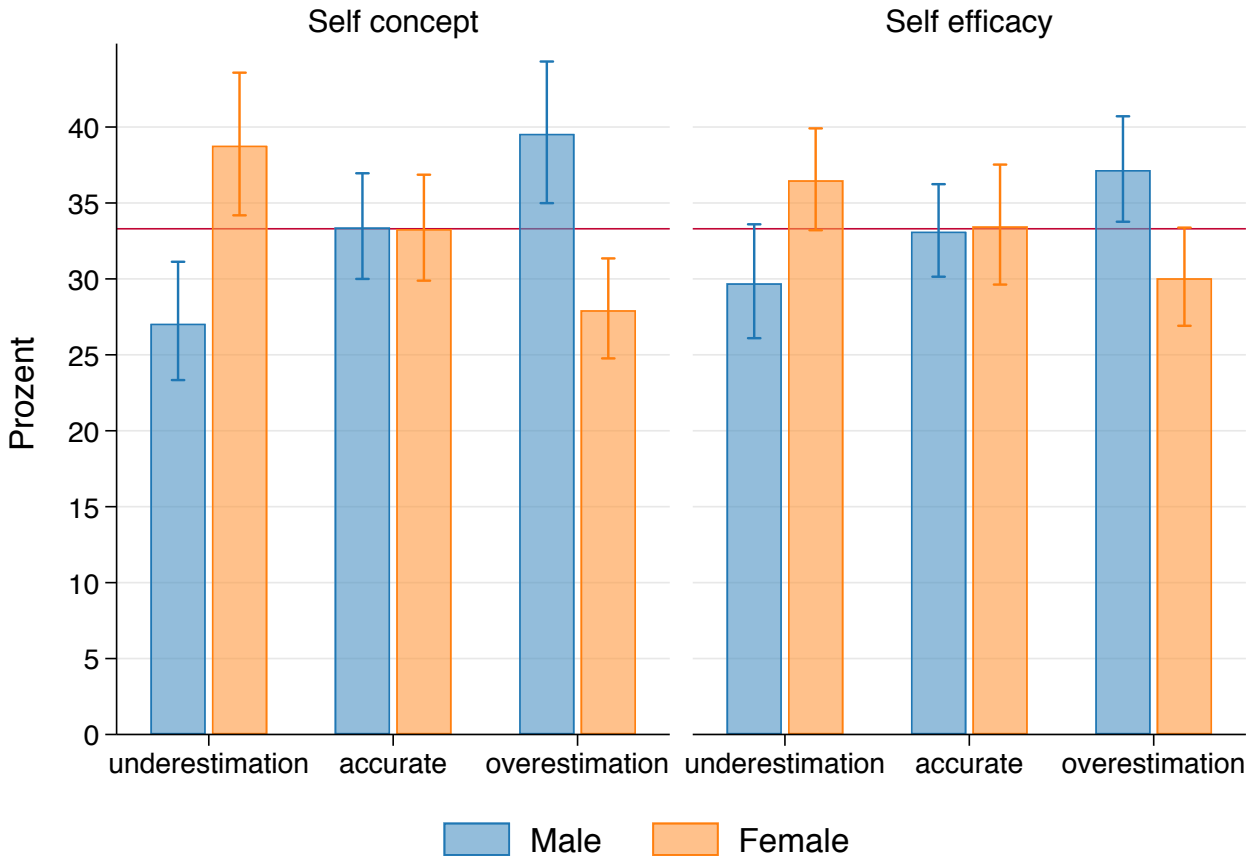
Raw gender difference in STEM education (Wave 2)

- Gender gap in STEM aspirations: 9.5–11 percentage points



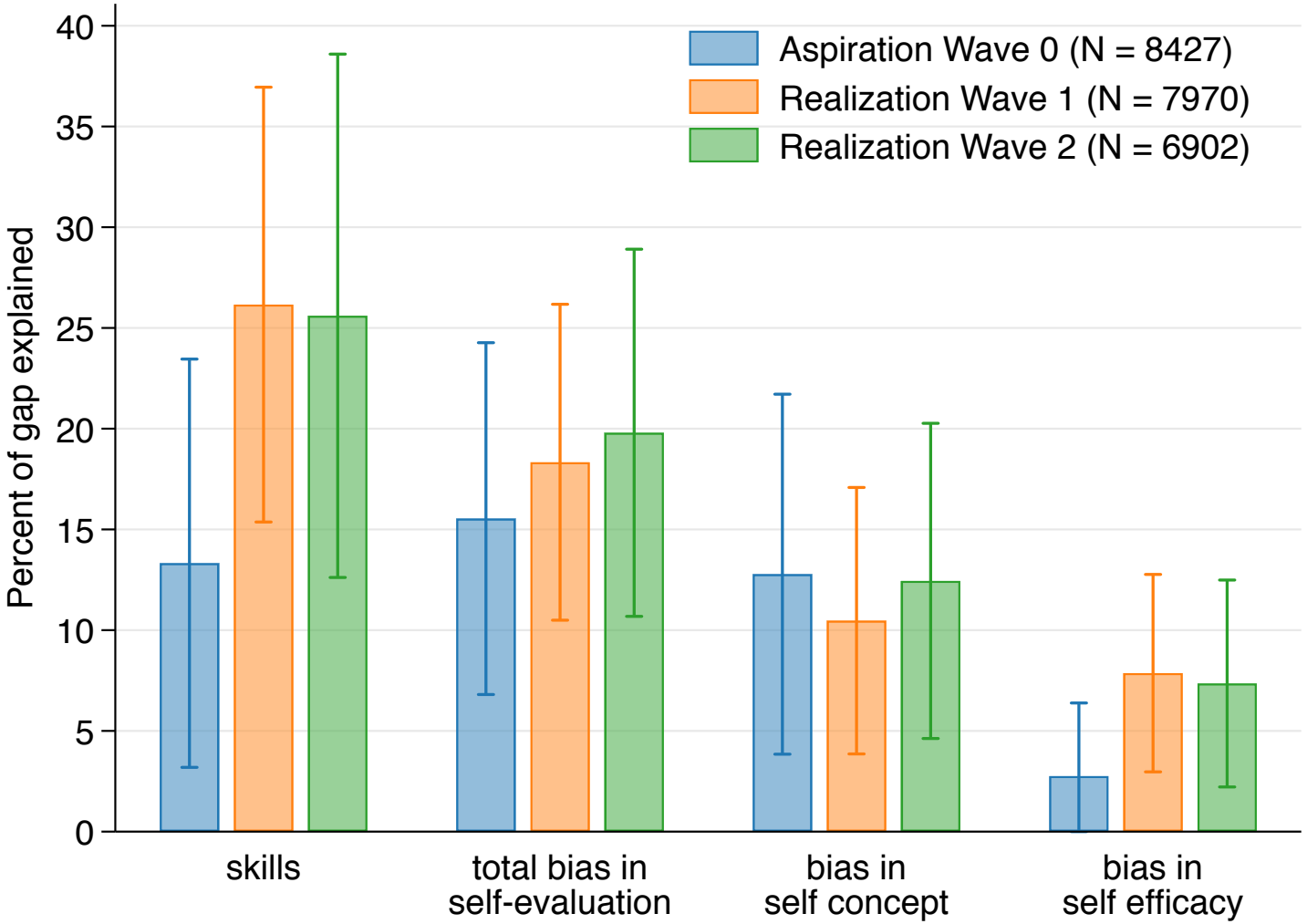
Gender bias in mathematical self-evaluation

- Distribution of females across terciles of rank differences between skills and self-evaluation



[The gender gap in average rank differences is 9 and 5.5 points, respectively. Correlation between self-evaluation and skills is 0.38 and 0.59, respectively.]

Explanation of STEM gender gap (OB decomposition)



[using rank differences between skills and self-evaluation; results show contribution of gender gap in self-evaluation over and above skills gap]

Conclusions

- Skill differences between women and men explain some of the gender gap in STEM aspirations/choice (although, of course, these skill differences may already be a result of stereotypes affecting learning).
- Also the self-evaluation of these skills plays an important role: females are less likely to choose STEM because they underestimate their skills compared to men.
  - That is, women's lower preference for STEM fields is related to their lower confidence in their mathematical skills, independently from their true skills.
  - The bias in general self-concept seems more important for aspirations; for the realized educational choice, the bias in specific self-efficacy gains relevance.
- The difference in the self-concept is most likely due to gender stereotypes; hence, at least part of the gender STEM gap is due to gender stereotypes that affect women's confidence in their own skills.

Conclusions

- Pros and cons of the data; why TREE?
  - + simple answer: only data source I know for Switzerland that contains the relevant information (math tests and detailed self-evaluation measures)
  - + ready-to-use data; for example, for this project the provided scales (Sacchi and Krebs-Oesch 2021) were very helpful
  - + large sample (although panel attrition is a serious issue in TREE2)
  - + possibility to observe how the STEM gender gap evolves during the transition from education to employment
  - + possibility to study "revolving door" effects (yet to be done)
  - – no possibility to analyze how stereotypes and biases in self-evaluation develop during childhood and youth; TREE would have to start much earlier in the lives of the respondents

References

- Hupka-Brunner, S., Jann, B., Koomen, M., Krebs-Oesch, D., Meyer, T., Müller, B., von Rotz, C., Sacchi, S., Wilhelmi, B. (2021). TREE2 study design. Bern: TREE. DOI: 10.7892/boris.152018.
- Jann, B., Hupka-Brunner, S. (2020). Falsche Selbsteinschätzung hält Frauen von technischen Berufen fern. *Die Volkswirtschaft* 93(3): 41–44.
- Jann, B., Hupka-Brunner, S. (2020). Warum werden Frauen so selten MINT-Fachkräfte? Zur Bedeutung der Differenz zwischen mathematischen Kompetenzen und Selbstkonzept. *Swiss Journal of Educational Research* 42(2): 391–413.
- Sacchi, S., Krebs-Oesch, D. (2021). Scaling methodology and scale reporting in the TREE2 panel survey. Documentation of scales implemented in the baseline survey (2016). Bern: TREE, University of Bern. doi: 10.7892/boris.152055