Gender and Peer Effects on Performance in Social Networks

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MSE, Economics and Psychology Seminar

16 November 2018

Motivation

- **Effort at work depends on wage rate, nonwage income, and characteristics but also on peer effects** (Kandel and Lazear, 92).
- Mixed evidence on effects of social interactions on performance at work:
  - *Strong positive* effects on the productivity of less able workers:
    - Under performance-pay (Hannan et al., 08; Azmat and Iriberri, 16).
    - Under flat wage (Falk and Ichino, 06; Mas and Moretti, 09, Kuhmen and Tymula., 12).
  - *Null or weak positive* peer effects (Eriksson et al., 09; Bellemare et al.,10; van Velhuizen et al., 18)
  - *negative* peer effects
    - Demotivation of less able workers (Barankay, 12).
    - Disappointment-averse employees (Gill and Prowse, 12).
    - Strategic substitutability in effort (Faton and Fortin, 18)

Motivation

- Besides, **mixed evidence as to how males and females may respond differently to economic incentives**:
  - Some evidence that females, as opposed to males, appear to do worse when facing competitive incentive schemes (gneezy,03;04).
  - However, a recent meta-analysis has shown that females and males respond to steeper incentives similarly (Bandiera,16).
  - Females tend to shy away from competitive incentive schemes (niederle, 07) and more attracted by cooperative ones (Kuhn,15).
- Differences in preferences and confidence in one's own relative abilities: key in explaining gender-specific responses (Croson,09).

Motivation

- Literature focuses on monetary schemes: paid few attention to non-monetary incentives (peer effects and work organization).
- **Very few studies have addressed gender-specific peer effects on work effort** (*homogenous* peer effects is usually assumed):
  - Bellemare et al. (10): peer performance at work differ by gender but only under fixed wage (not under piece rate).
  - Hahn et al. (17) find that feedback on peer math performance has a different effect according to gender (low-ability females work harder when working with peers).
  - Lavy and Sand (17): no significant differences in peer effects on academic progress between males and females.

Motivation

- **Interactions at work can be structured through social networks**.
  - In a social network, each individual may have his own reference (or peer) group to which he is connected.
- Information flows through a social network specific to each work environment, e.g.:
  - Unidirectional graphs where information flows one-way **from** peers to subjects.
  - Bidirectional graphs where information flows from peers to subjects and from subjects to peers.
- **The influence of peer effects may vary depending on the structure of work environment.**

Figure: Bidirectional network at work...

Motivation

- **Various mechanisms may potentially explain peer effects at work**. In our design (same tasks, information feedback):
  - **Social learning**.
  - **Conformity** (social norms).
  - **Rivalry** (competitiveness).
- **Is it possible to provide a test to distinguish between these mechanisms in our design** ?

Motivation

- **Three aims of the paper:**
  - Analysis of peer effects on effort at work using a social network model with **gender heterogeneity.**
  - We compare peer effects on performance across gender **when the work environment varies**.
  - We characterize the **mechanisms** through which peer effects influence individual outcome.
- We design **lab experiments** in which subjects are paid according to a piece rate scheme to perform real tasks repeatedly.

Advantages of Lab Experiments

- **Exogenous networks** (chosen by the experimentalist).
  - No self-selection of subjects through networks which can be a source of endogeneity issues (e.g., presence of homophily).
- Knowledge (by the econometrician) of each subject's true reference group: **no problem of partial network**.
- **No measurement errors** on piece rates and performances.
- The choice of network structure (by the experimentalist) **allows to identify endogenous and contextual peer effects.**

Theoretical model

- Our basic theoretical approach:
  - Linear-in-means social network model (we test the linearity of the model and do not reject it).
  - Gender specific endogenous and contextual peer effects.
  - Exogenous social network architecture (no correlated effects).
  - 3 network structures: isolated, unidirectional (also isolated + unidirectional = pooled) and bidirectional social networks.
  - Everybody performs same tasks.
- Inspired by Arduiny et al. (16), we show that our model is identified under some conditions.

Baseline treatment: isolated subjects

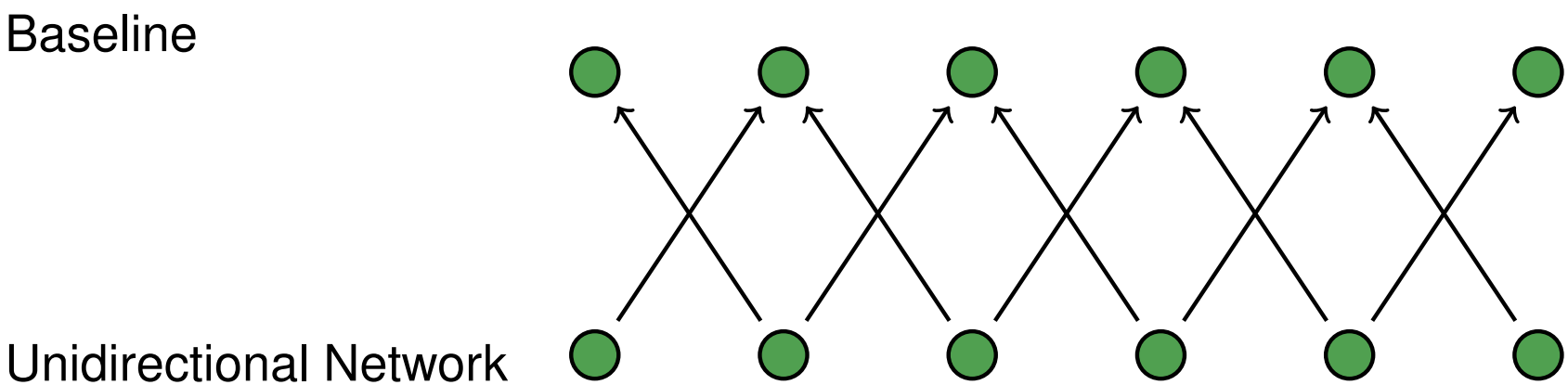
Random effects semi-log model with gender heterogeneity:

$$e_{it}^{j} = \alpha_{i}^{j} + \alpha_{1}^{j} w_{it}^{j} + \eta_{it}^{j}, \tag{1}$$

- $E(\eta_{it}^{j} | \boldsymbol{w}_{i}^{j}, \alpha_{i}^{j}) = 0,\ E(\alpha_{i}^{j} | \boldsymbol{w}_{i}^{j}) = E(\alpha_{i}^{j})$.
- $j = m, f;\ \ i = 1, \ldots, n^{j};\ \ t = 1, \ldots, T$.
- e_{it}^{j} is type-j (male or female) individual i's performance at period t.
- w_{it}^{j} is his/her piece rate wage (in log).
- One session and one explaining variable, to simplify the notation.

Unidirectional Network treatment: subjects with peers

Figure: Graph of a Unidirectional Network



Unidirectional Network treatment

- Information on wage and performance flows from subjects in the Baseline treatment to those in the Unidirectional Network Treatment.

Linear-in-means semi-log effort function (with gender heterogeneity):

$$e_{it}^{j} = \beta_{i}^{j} + \beta_{1}^{j} w_{it}^{j} + \beta_{2}^{j} \frac{1}{n_{i}^{j}} \sum_{k \in N_{i}^{j}} e_{kt} + \beta_{3}^{j} \frac{1}{n_{i}^{j}} \sum_{k \in N_{i}^{j}} w_{kt} + u_{it}^{j}.$$

- $\beta_{2}^{j} > 0$ captures performance effect due to social learning, competitive rivalry or conformity. β_{3}^{j} captures contextual effect.
- We assume between-gender heterogeneity but within-gender homogeneity (for sake of simplicity).
- No simultaneity issues with exogenous explanatory variables.

Unidirectional (Pooled) Network treatment

- Assume that wage effect is the same in the Baseline and in the unidirectional network treatments. One has: $\alpha_1^j = \beta_1^j$, with $j = m, f$.
  - This is tested in the paper (not rejected as shown later).
  - This occurs when the peer effects mechanism is rivalry (not conformity).
- The pooled set of baseline and unidirectional network forms a unidirectional bipartite network.
- The (concatenated by individual) pooled model can be written as:

$$\boldsymbol{e}_t^j = \boldsymbol{\beta}^j + \beta_1^j \boldsymbol{w}_t^j + \beta_2^j \boldsymbol{R}^j \boldsymbol{e}_t + \beta_3^j \boldsymbol{R}^j \boldsymbol{w}_t + \boldsymbol{u}_t^j,$$

- where $\boldsymbol{R}^j$ is the type-j interaction matrix; $j = m, f$; $t = 1, \ldots, T$.

Bidirectional Network treatment : subjects with peers

Figure: Graph of a Bidirectional Network

Bidirectional Network treatment

- Information flows from peers to subjects and from subjects to peers.
- Each subject is assumed to behave non-cooperatively.
- Each subject ignores the fact that his own performance may influence other subjects in the network.
- $=>$ Nash equilibrium with self-consistent expectations.
- The best response equation for type-j subjects at time t is:

$$\boldsymbol{e}_t^j = \gamma^j \boldsymbol{\imath}^j + \gamma_1^j \boldsymbol{w}_t^j + \gamma_2^j \boldsymbol{G}^j \boldsymbol{e}_t + \gamma_3^j \boldsymbol{G}^j \boldsymbol{w}_t + \boldsymbol{\varepsilon}_t^j,$$

  - $\boldsymbol{G}^j$ is a row-normalized interaction matrix for type-j subjects.
- Identification and simultaneity issues since $\boldsymbol{e}_t$ is endogenous.

Bidirectional Network treatment

- The (concatenated) macro model, which includes all periods and all subjects is given by:

$$\begin{aligned}\boldsymbol{e}_T = &\gamma^m \boldsymbol{d}_T^m + \gamma^f \boldsymbol{d}_T^f + \gamma_1^m \underline{\boldsymbol{w}}_T^m + \gamma_1^f \underline{\boldsymbol{w}}_T^f + \gamma_2^m \underline{\mathbb{G}}^m \boldsymbol{e}_T + \gamma_2^f \underline{\mathbb{G}}^f \boldsymbol{e}_T \\ &+ \gamma_3^m \underline{\mathbb{G}}^m \boldsymbol{w}_T + \gamma_3^f \underline{\mathbb{G}}^f \boldsymbol{w}_T + \boldsymbol{\varepsilon}_T,\end{aligned}$$

  - where $\boldsymbol{d}_T^j$ is a $(Tn \times 1)$ vector of type-j indicators,
  - $\underline{\boldsymbol{w}}_T^j$ is a $(Tn \times 1)$ vector of type-j wage rates indicators,
  - $\underline{\mathbb{G}}^j$ is the block-diagonal type-j interaction matrix for the T periods.

- Spatial model with two lagged spatial dependent variables.

Identification of the Bidirectional Network Model

Proposition

Assume that the macro model holds. Assume also that $|\gamma_2^j| < 1$, and that $\gamma_1^j \gamma_2^j + \gamma_3^j \neq 0$, for $j = m, f$. If the matrices $\mathbb{I}^m, \mathbb{I}^f, \underline{\mathbb{G}}^m, \underline{\mathbb{G}}^f, \underline{\mathbb{G}}^{m^2}, \underline{\mathbb{G}}^{f^2}, \underline{\mathbb{G}}^m \underline{\mathbb{G}}^f, \underline{\mathbb{G}}^f \underline{\mathbb{G}}^m$ are linearly independent, then the parameters of the macro model are identified.

- Application of Proposition 1 in Arduini et al. (16).
- $\underline{\mathbb{G}}^{m^2} \boldsymbol{w}_T, \underline{\mathbb{G}}^{f^2} \boldsymbol{w}_T, \underline{\mathbb{G}}^m \underline{\mathbb{G}}^f \boldsymbol{w}_T, \underline{\mathbb{G}}^f \underline{\mathbb{G}}^m \boldsymbol{w}_T$ can be used as instruments.
- Mean wage rates of peers of type m of peers of type-m workers and peers of type f of peers of type f workers are instruments.

Peer effects mechanisms

- Three potential channels through which peer effect may affect subjects in our design:
  - Social learning: information set affected by interactions between a subject and peers. Unlikely: simple task and no communications.
  - Conformity: individual utility depends (-) on the distance between his performance and the mean performance of peers.
  - Competitive rivalry: positive relationship between mean peer performance and the marginal utility of own performance.

Peer effects mechanisms

- When isolated individuals (here, Baseline), possible to perform a test of rivalry vs pure conformity (Boucher and Fortin, 16).
  - Under pure conformity, effect of individual characteristics (wage rate) on his effort is smaller in unidirectional network than Baseline.

    $=>$ The individual does not want to perform much differently from his peers since his utility will decrease.
  - Under rivalry, the effect of individual on his effort should be the same under Baseline and under Unidirectional Network.
- Test of competitive rivalry: coeff. of individual characteristics in Baseline are the same as in Unidirectional Network.

Experimental design: Baseline treatment

- Two sessions; 18 participants per session; 16 periods per session.
- Period: Subjects have to perform a task in isolation during 2.5m.
- multiplying series of one 2-digit number by one 1-digit number: 22×7. Possibility to read magazines (on-the-job leisure).
- The numbers are displayed on the computer screen and, if correct, a new task is displayed.
- Random piece-rate at each period: €0.10, €0.50, or €1. Feedback: own payoff.
- Random show-up fee of either €2, €4, or €6 (mimics nonwage income).
- Two variants of the Baseline: 1) Subjects are not informed that they will be matched to other subjects. 2) They are. *Image effect*?

Experimental Design: unidirectional network treatment

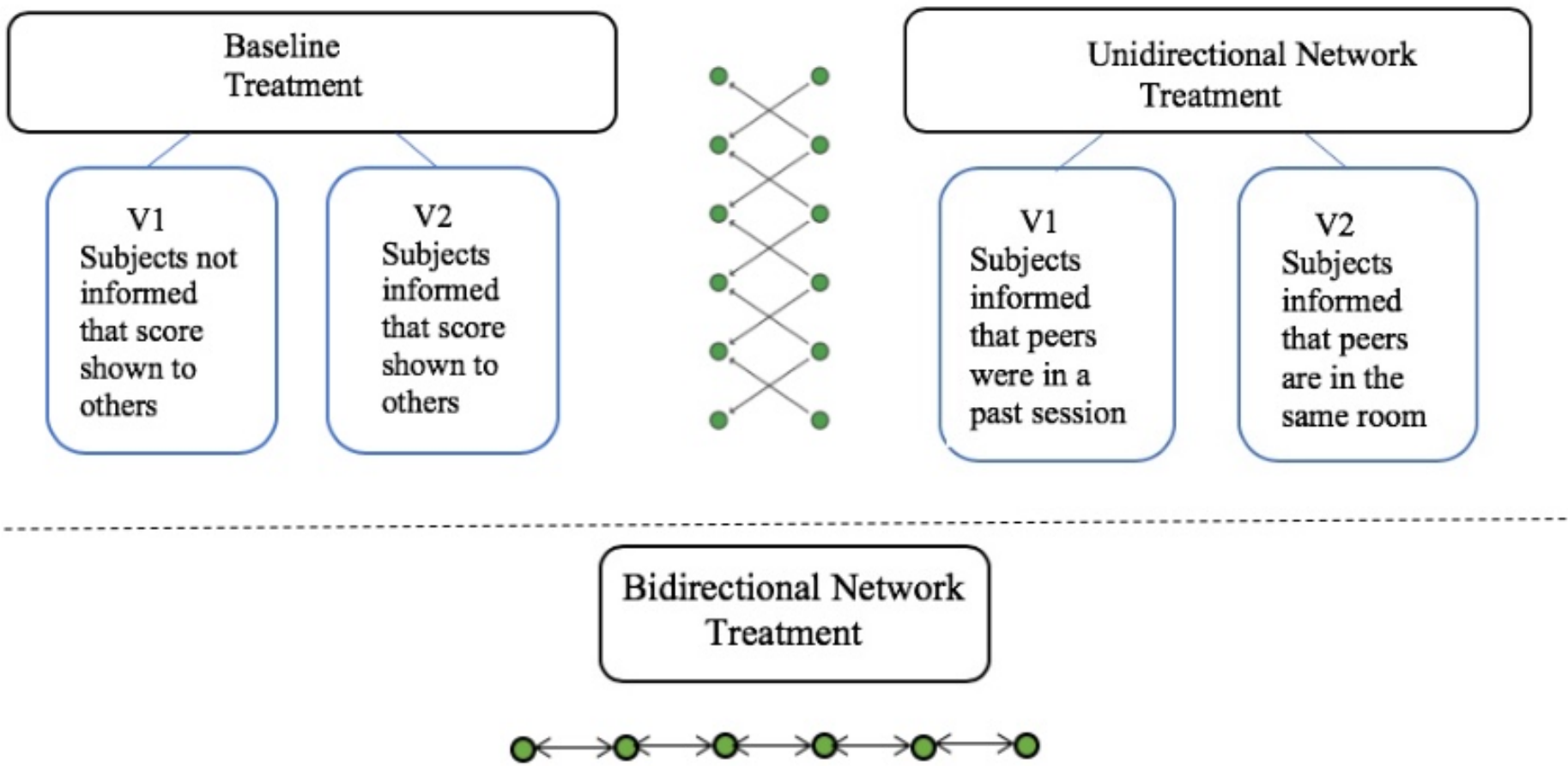
- 1 or 2 peers from Baseline.
- Individual information:
  - Peers' mean characteristics (age, relative wealth, gender, school, show-up fee).
  - Peers' mean piece-rate and mean performance in the same period.
  - At the end of each period, summary screen (own performance, piece rate and earnings).
- Common information:
  - Two variants: Peers were in a past session; peers are present in the lab : *Presence effect.*
  - Peers received the same problems to solve in the same order.
  - Piece-rates could differ but were chosen among (€0.10,€0.50,€1).

Experimental Design: Bidirectional network treatment

- Each subject is paired with 1 or 2 peers depending on his location in the lab.
- Information at the beginning of each period:
  - peers' mean piece-rate.
- Common information:
  - peers receive the same problems to solve in the same order.
  - piece-rates can differ but were chosen among (€0.1,€0.5, €1).
- Each period consists now of several rounds to allow for convergence to the Nash equilibrium:
  - 4 periods.
  - Up to 5 rounds in each period.
  - Information at the end of each round: peers' mean performance.
  - A new round starts if the mean score in the network varies by more than 5%.
  - Only observations at convergence used in estimations.

Experimental Design Figure

Figure: Experimental Design



Procedures

- 24 sessions conducted at GATE in Lyon, France.
- 375 undergraduate students mostly from the local engineering and business schools, recruited via ORSEE (Greiner, 2015).
  - 10 sessions with Baseline treatment (84 subjects): 2 sessions in isolation + 8 with information.
  - 11 sessions with Unidirectional Network treatment (87 subjects): 3 sessions without peers + 8 sessions with peers.
  - 11 sessions with Bidirectional Network treatments (204 subjects)
- Computerized with Z-Tree (Fischbacher, 2007).
- Mean duration: 60 minutes.
- mean payoff = €15.64 (SD: 8.45).

Econometric analysis

- Explanatory variables of Baseline model (no peers):
  - time trend (learning + fatigue)
  - piece-rate (in log)
  - show-up fee [proxy for nonwage income (Dickinson, 99)]
  - relative wealth of the family
  - age
  - dummy for studying in the Engineering Central School
- Explanatory variables of unidirectional, pooled and bidirectional network models:
  - augment the Baseline model with contextual variables: mean individual variables of subject's peers.
  - + peers' mean performance.

Econometric analysis

- Models for Baseline and unidirectional networks: estimated by Random Effects approach.
  - Robust standard errors clustered at the individual level.
  - Hausman tests never reject the Random Effects model as compared with the Fixed Effects model.
- Model for Bidirectional Networks: Spatial Pseudo Maximum Likelihood (allows for robust standard errors).
  - Results similar but more precise than IV approach.

Summary statistics

Treatments	Baseline		Unid. Network		Bid. Network	
	Average	Std-Err	Average	Std-Err	Average	Std-Err
Males (%)	46.43	(50.17)	48.28	(50.26)	50.00	(50.12)
Age	21.08	(1.71)	22.99	(6.19)	21.85	(2.98)
Relative wealth	4.96	(2.15)	4.66	(1.88)	5.12	(1.85)
ECS (%)	27.38	(4.86)	16.09	(36.96)	27.94	(44.98)
Show up fee	4.29	(1.52)	3.98	(1.82)	4.13	(1.60)
Piece rate	0.54	(0.38)	0.54	(0.37)	0.53	(0.37)
Performance	18.20	(7.39)	17.84	(8.78)	18.95	(7.58)
Number of ind.	84		87		204	
Number of obs.	1344		1392		510	

Result summary in various network configurations

Baseline

- Piece-rate (log):
  males: 0.873**
  females: 0.306*

- image
  males: 1.386
  females: 2.17

Pooled Unidirectional

- Piece-rate (log):
  males: 0.973***
  females: 0.271**

- Perf. peer effect:
  males: 0.179***
  females:0.179***
- Presence:
  males: -0.002
  females: -0.077
- Pooled Test:
  males: 0.624;
  females: 0.311

Bidirectional

- Piece-rate (log):
  males: 0.728
  females: 0.422

- Perf. Peer effect:
  males: 0.274***
  females: -0.057

Result Summary

- **Performance peer effects differ by gender**:
  - Males respond (+) to peer performance in unidirectional and bidirectional networks (0.179***, 0.274***).
  - Females respond (+) in the unidirectional networks, but not so in the bidirectional networks (0.179***, -0.057).
- Female and male performances are insensitive to the fact that own performance is communicated to subjects: **no image effect**.
- Males and females are indifferent to having peers in the same session: **no presence effect.**
- The **competitive rivalry mechanism is not rejected**.

Result Summary

- Our results suggest that females, as opposed to males, perceive the bidirectional networks as a different work environment.
- Females may perceive bidirectional networks (with bidirectional flow) as more competitive than unidirectional networks (with unidirectional flow).
- As long as females, unlike males, tend to shy away from competition, females may be led to ignore their peers' perf.
- Our results suggest that more competitive informational incentives may also have a discouraging effect on their effort.

Conclusion

- Some possible implications:
  - Our results suggest that providing feedback on peer performances may increase effort under certain conditions.
  - These conditions include the mode of work organization (network type) and the gender composition of the workforce.
  - In a predominantly female environment, preferable to organize the networks such that the information on perf. flows one way.
  - In a predominantly male environment, the network structure matters little.

Conclusion

- Laboratory experiments have their own limitations.
  - The task subjects are asked to perform is artificial.
  - However, there is now widespread agreement about the external qualitative validity of laboratory experiments (Fréchette, 14).
  - Herbst and Mas (2015) have shown that the laboratory estimates of peer effects on productivity are similar to those from field exp.

Conclusion

- Some possible extensions:
  - Influence of other structures of networks (e.g., bidirectional circle network).
  - Allows peers performance effects to vary for females when their peers are male or female.
  - Allows peers performance effects to vary for males when their peers are male or female.

Result Summary

- Individual effects also vary considerably across gender.
  - Males appear to be sensitive to the level of financial incentives (piece-rates) except in the Bidirectional Network models.
  - Females are also influenced by piece rates but the effect is much smaller than that of males in all cases.
  - As expected, attending a engineering school associated with a larger performance for both males and females.
  - However, males ECL attendees outperform other males only in the Pooled and the Bidirectional networks.

Result Summary

- The contextual peer effects vary across genders mostly in the Bidirectional Network treatment.
  - Females react negatively (-2.974*) to having more males among their peers, whereas no such effect is observed for males (2.33).
  - The proportion of peers from the engineering school: no impact on female perf. (0.953) but a negative one on males (-6.759***).
  - Mean peer age has a positive effect on female performance (0.719***) and a negative one on male performance (-0.798***).

Result Summary

- Contextual effects also suggest that females react differently than males to information about their peers in the bidirectional networks.
- Gender differences in contextual effects consistent with bidirectional network perceived as more competitive by females.
- As argued by Mobius (2011), females may be more "ego-defensive", i.e., more aversed toward relative performances.