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An experimental analysis of the existing differences of productivity across genders

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Abstract

This paper contributes to the empirical literature on the connection between productivity and gender by using experimental methods in order to produce the relevant data that is missing. This experiment is based on a principal agent game in which principals offer payments and agents choose a costly level of effort, unobservable to the principal. The experimental findings confirm that, an uncertain outcome activity, females are less productive than males.

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1. Introduction

Gender wage gap cannot be explained only by the difference in characteristics between men and women (education, work experience, occupation …). After isolation of these individual characteristics, this gap persists (e.g. Altonji and Blank, 1999). Can the gender wage gap be explained by productivity differences between males and females? I examine this question in a laboratory experiment using a principal-agent game, in which a player (the principal thereafter) must decide how much to pay another player (the agent thereafter) who may choose an effort level (productivity).

There are several papers studying the relationship between wages, productivity and gender. Hellerstein and Neumark (1999) find that the gender wage gap corresponds to a gender productivity gap of approximately the same size. Therefore, the wage discrimination is not a justification for wage disparities between male and female workers. The women's lower pay may be explained by their lower productivity levels. In contrast to these findings, Hellerstein et al. (1999) report that gender wage differentials are larger than the corresponding productivity differentials, indicating that women are victims of wage discrimination. Hægeland and Klette (1999) analyze the wage differences and differences in productivity between males and females in Norway, Crepon et al. (2002) in France, Ilmakunnas and Maliranta (2005) in Finland, and McDevitt et al. (2009) in Canada. These studies conclude that women are less productive than male workers and that wages reflect these differentials.

All quoted studies focus on wage equations that are estimated as a function of individual level data. It is difficult to measure the productivity level of the workers and to isolate individual characteristics. This paper contributes to the empirical literature on the connection between productivity and gender by using experimental methods in order to produce the relevant data that is missing. The results show that women are less productive than men when production/performance concerns an uncertain outcome activity.

2. Experimental Design

The experiment consists in an adaptation of the principal agent game. In each session, 20 subjects are randomly assigned either to the role of principal or agent. In total 120 students participated in the experiment (6 sessions × 20 subjects). Participants are privately informed about their assignment which was kept constant over the whole session. Note that our data are drawn from a much larger study of the principal-agent game, one that had several goals beyond the study of gender effects.

At the beginning of each round (10 rounds), 5 groups made up of 4 subjects are randomly formed. Each group so formed, contains randomly two principals and two agents. At the end of each round, new groups are randomly formed. Costs, payoffs, and outcomes are measured in Experimental Currency Units (ECU). At the end of the experiment, each subject is paid in cash according to his cumulative payoff.

In each round, the principal can either be in a "Good State" or in a "Bad State". Each round is divided into five stages:

In stage 1, each of the two principals in each group proposes a payment, $w \in \{6, 12, 18, \ldots, 102, 108\}$, which will be paid to the agent if the "Good State" comes true for the principal.

In stage 2, both agents of the group receive both proposed payments and can then realize mouse clicks on their computer during 30 seconds.

In stage 3, the agent who makes the highest number of clicks (let say Agent 1) decides first. He must choose between accepting one of the two payments made by principals and rejecting both payments. If he accepts one payment, the second agent (let say Agent 2) must decide between accepting the remaining payment and refusing it. If Agent 1 refuses both payments, Agent 2 faces the same choice that Agent 1 in the first step: accepting one of the two payments made by principals or rejecting both.

In stage 4, if an agent accepts a payment, he then has to choose an effort, $p \in \{9\%, 18\%, \dots 90\%, 99\%\}$, unobservable by the principal. This effort corresponds to the probability of realization of the "Good State". After the choice of p by the agent, the central computer randomly draws a number between 0 and 100. If the number drawn is less than or equal to the value of p the good state is realized. If the number drawn is greater than the value of p the bad state is realized. To each possible effort corresponds a cost for the agent, $C(p)$, which is given in table 1.

In stage 5 of the game, players are informed about the realized state and the individual payoff. Furthermore, at the end of each round, subjects receive the following summary data: the principal's contract offer, the order of the agents' choice, the agent's acceptance decision, the realized state and the realized payoffs.

Table 1: Costs associated with each value of *p*

***p* (%)**	9	18	27	36	45	54	63	72	81	90	99
***C*(*p*)**	0.2	1	2.2	3.9	6.1	8.7	11.9	15.6	19.7	24.3	29.4

The agent earns zero if he rejects the payment(s). If he accepts one payment, he earns $w - C(p)$ in the "Good State" and loses $-C(p)$ in the "Bad state". The principal earns $144 - w$ in the "Good State" and 36 in the "Bad state". Table 2 summarizes the various possible cases. The optimum payment offered by the principal is $w = 54$, and the optimum effort chosen by the agent is $p = 90\%$[1]. Each subject participated in one of the six organized sessions, and was paid a participation fee plus all earnings from games played. The average gain has been 27€.

Table 2: Payoffs

State	**Agent's payoff in case of refusal**	**Agent's payoff in case of acceptance**	**Payoff of the principal**
Good	0	w - C(p)	144 - w
Bad	0	- C(p)	36

3. Experimental Results

All of our statistical tests require a 5% rejection threshold of the null hypothesis. The first part of this section analyses the principals' payment offers. Afterwards, I analyze the agents' decisions in terms of acceptance and effort level.

[1] For more information on the theoretical predictions of the game, see Ennasri, A. and Willinger, M. (2011).

3.1. Payment Offers

Table 3: Avearage contract offer according to gender

Gender	**Men**	**Women**
Prediction	54	
G1	48.2	50.8
G2	55.5	60.0
G3	62.3	66.8
G4	58.5	45.6
G5	51.8	53.0
G6	66.8	54.0
Total	**57.1**	**55.0**

Table 3 shows the average of contract offers by gender for each of the six groups. The average payment offered by men is 57.1 and 55 by women, a non-significant difference (p-value = 0.916, Wilcoxon two-sided) and which doesn't differ from the theoretical prediction (t-test, p-value = 0.308 for male and p-value = 0.748 for female).

Figure 1: Evolution of the average payment over time according to the gender

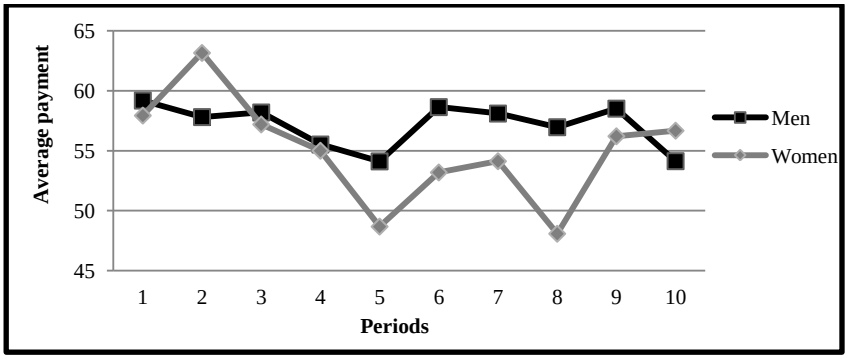

Figure 1 shows the evolution of the average payment over time by gender. The figure also shows that over time the average payment offered by the male is not significantly larger than the one offered by the female (p-value = 0.114, Wilcoxon one-sided). Therefore, there is no evidence for a difference in payment offers between male and female.

Table 4: Agent's Expected Surplus Share

Gender	**Men**	**Women**
Prediction	33%	
G1	31.9%	33.1%
G2	36.7%	41.8%
G3	43.8%	49.7%
G4	40.5%	27.6%
G5	32.4%	35.4%
G6	49.2%	34.2%
Total	**39.1%**	**37.0%**

Table 4 shows the agent's expected surplus share (ESS), i.e. the agent's expected net payment divided by the total expected surplus assuming that he chooses optimally the level of effort. The agent's ESS is 39.1% for men and 37.0% for women, an insignificant difference

(p-value = 0.916, Wilcoxon one-sided). However, the ESS is significantly larger than theoretical prediction, i.e. 33.3%, for men (t-test, p-value=0.039) but not significantly different for women (t-test, p-value=0.246). Therefore, we conclude that men and women offer similar payments that allow them to share the expected surplus in their favor.

3.2. Agent's Decision

Table 5: Acceptance rate according to gender

Gender	**Men**	**Women**
Prediction	100%	100%
G1	87%	80%
G2	94%	88%
G3	92%	100%
G4	100%	96%
G5	93%	95%
G6	90%	83%
Total	**93%**	**90%**

Table 5 shows the acceptance rates. From a theoretical point of view, all payments should be accepted[2]. The acceptance rate is 93% for males and 90% for females, which are not different (p-value = 0.463, Wilcoxon two-sided). Approximately 10% of the payments are rejected whatever the gender, in accordance with earlier findings about payment offers (Keser and Willinger, 2000).

I use a Logit panel regression in order to estimate the acceptance probability of a payment. The acceptance probability of subject *i* in period *t* is given by:

$$p(A_{it} = 1) = \frac{e^{z_i}}{1+e^{z_i}}, \text{ where } \quad Z_i = \alpha + \beta_1 P_{it} + \beta_2 F + \mu_i + \varepsilon_{it} \qquad (1)$$

P_{it} is the payment of subject *i* in period *t*, F is a dichotomous variables indicating the gender (1 for female and 0 for male). μ_i is a normally distributed random variable that captures the individual random effect and ε_{it} is a standard random error term. Results from the random effects panel regression are summarized in table 6. The Wald test shows that the models are globally significant.

Table 6: Logistic regression of the acceptance probability

Acceptance probability	**Coef.**	**Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
Payment offers	0.179	0.023	7.60	0.000	0.133	0.225
Female	0.261	0.733	-0.36	0.721	-1.699	1.175
Constant	-4.128	0.969	-4.26	0.000	-6.029	2.227

Wald $\chi^2(2) = 57.78$, Log likelihood = -95.943, Prob > $\chi^2 = 0.0000$

An increase of the payment has a significant and positive impact on the acceptance probability. The estimated female coefficient is insignificant, indicating that men and women react similarly to payments in acceptance choice. Therefore, the acceptance probability is not affected by gender.

[2] Participation constraint is always satisfied.

Table 7: Average effort level for accepted contracts

Gender	**Men**	**Women**
Prediction	**90%**	
G1	85.4%	55.9%
G2	66.4%	64.0%
G3	82.2%	66.8%
G4	76.1%	56.8%
G5	79.5%	63.2%
G6	80.3%	76.0%
Total	**78.3%**	**63.8%**

Table 7 shows the average effort level chosen by male and female after accepting a payment. Males choose an average effort of 78.3% whereas women choose an average effort of 63.8%. Indeed, males choose an average effort significantly higher than females do (p-value = 0.027, Wilcoxon one-sided). Nevertheless, effort levels are significantly lower than the optimal effort for both genders (t-test, p-value = 0.003 for men and p-value <0.001 for women).

Table 8 shows the results of a random-effects panel regression, with effort level as the dependent variable.

Table 8: Determinants of the choice of effort level

Effort level	**Coef.**	**Std. Err.**	**Z**	**P>|z|**	**[95% Conf.**	**Interval]**
Payment received	0.481	0.031	15.35	0.000	0.420	0.543
Female	-12.811	1.697	-7.55	0.000	-16.137	-9.484
Constant	51.996	2.195	23.68	0.000	47.693	56.299

Wald $\chi^2(2) = 288.16$, Prob > $\chi^2 = 0.0000$, Log likelihood = -2292.105

Results show that the effort level is strongly correlated to the payment received. The estimate indicates a positive relationship between payment and effort. The estimate shows also that the gender dummy is significantly and negatively correlated with effort: for the same payment, females choose significantly lower effort than males. Therefore, there is evidence for a gender effect concerning the choice of the effort level.

4. Discussion

In this article, I examine a repeated principal-agent game in which women and men were randomly assigned to the roles of principal and agent. Subjects could not identify their playing partners. My results therefore show that gender does appear to be connected to the effort level. In the experiment, for a given payment, women choose on average an effort level 18% lower than men. Therefore, in uncertain outcome activity, there are some evidences of a gender productivity gap: males are more productive than females. One possible explanation is that women are more risk averse than men (Eckel and Grossman, 2002, 2008). Also, my results indicate that, under these experimental conditions, gender does not influence the payment offers and acceptance rates. Hence, men and women differ neither in the payment offers nor in acceptance decision. For that purpose, it would be interesting to realize some experiment that disentangles the effort and risk aversion and inform the participants about the partner gender.

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