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Competition and Gender in the Lab vs. Field

Experiments with Off-Grid Renewable Energy Entrepreneurs in Rural Rwanda

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Contents

1. Introduction	1
2. Related Literature	3
3. Experimental Design and Data	4
3.1 The Experiment	5
3.2 Descriptive Statistics	7
4. Empirical Strategy	8
5. Results and Discussions	9
5.1 Performance in the Lab under Piece Rate, Tournament and Preferred Incentive	
Treatments	9
5.2 Entrepreneurs' Willingnesss to Compete	2
5.3 Performance in the Lab vs. Field	5
6. Conclusion1	9
References	1
Appendices	7

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Rebecca A. Klege and Martine Visser*

Abstract

Applications of lab experiments to real-world phenomena are limited. We fill the gap by examining how gender attitudes and performance under competitive situations in the lab reflect microenterprise outcomes in the renewable energy sector of Rwanda – a country with progressive gender policies despite its traditional patriarchal setup. We use the standard Niederle and Vesterlund (2007) experimental design in addition to a unique dataset from off-grid microenterprises, managed by entrepreneurs who have been working in mixed and single-sex teams since 2016. Our findings show that the gender composition of teams does not affect decisions to compete in the lab. However, returns to education and risk-taking in the real world are more valuable for single-sex teams than for mixed gender teams. We also show that under competitive situations, women perform as well as men. Findings from the field strongly support findings in the lab that female-owned enterprises do not underperform in competitive settings, which corroborates the external validity of our lab results. Given that lab and field findings suggest no significant differentials in terms of competitiveness or performance of females, there exists ample scope to increase women's involvement in the renewable energy sector of Rwanda.

Keywords: competition, gender differences, entrepreneurs, performance, renewable energy

JEL Codes: C91, C92, J16, Q49

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Klege and Visser

1. Introduction

Traditional job markets are mostly male-dominated despite recent efforts by development organisations to close the gender gap. Women often face various social restrictions (including overseeing most household chores, receiving less schooling, and lower returns to their labour) in both developed and developing countries (World Bank, 2015). This problem is more severe in rural areas where social barriers such as culture and social norms play a significant role.

Despite the well-established advantages associated with the provision of modern energy sources to rural communities, studies in the renewable energy literature have shown that provision of energy sources alone is not enough to achieve the desired empowerment levels and economic freedom for women. Women's journeys towards better welfare opportunities and livelihoods could be fast-tracked if they were well represented at all levels of the energy supply chain (Baruah, 2017; 2015). Entrepreneurship has therefore been used as a breakthrough point for women in this sector (Clancy et al., 2012; Clancy, Oparaocha & Roehr, 2004). This has resulted in several initiatives and projects targeted at female entrepreneurship. Typical examples are the Solar Sisters initiative, Women's Integration into Renewable Energy (WIRE) and Women's Entrepreneurship in Renewables (wPOWER) under the Energy4Impact initiative.

Though entrepreneurship is a vital tool for promoting women's empowerment, it is essential to note that a predominant characteristic associated with successful entrepreneurship is the ability to compete (Shane, Locke & Collins, 2003). Women have been shown to be less willing to compete and are often outperformed by men under competitive conditions (Dato & Nieken, 2014; Niederle, & Vesterlund, 2011; Ergun, Rivas & García-Muñoz, 2010; Croson & Gneezy, 2009; Niederle & Vesterlund, 2008; 2007; Datta Gupta, Poulsen & Villeval, 2005). This suggests that, apart from the well-established social barriers affecting women's participation in the labour market, females' unwillingness to compete can also influence their performance levels even after taking up entrepreneurship initiatives may have limited potential if due consideration is not given to women's competitiveness and performance abilities.

To date, very little is known about the competitive and performance abilities of women working as sales point entrepreneurs in the renewable energy sector. Our study contributes to the global discussion on women's competitive decisions and performance levels by using lab-in-thefield experiments to first examine how gender attitudes towards competition differ amongst village-level entrepreneurs (VLEs) in Rwanda. The study then demonstrates how performance under competitive situations in the lab reflects microenterprise operations in the field by using a unique dataset from off-grid microenterprises managed by entrepreneurs already working in mixed and single-sex teams since 2016.

Rwanda provides a unique study context for the following reasons. Rwanda, though a traditional patriarchal society, is today frequently cited for its commitment towards women's participation and gender equality policies (Burnet, 2011). This comes after the 1994 genocide which saw the death of at least 500,000 people, the majority of whom were men (Debsscher & Ansoms, 2013). Many women became widows and took over traditional male-dominated social and economic activities. The government of Rwanda has since implemented several gender policies, such as the integration of gender as a fundamental right in the constitution, enforcing a gender quota system for local and national government, and the creation of its first Ministry of Gender Equality. These top-down approaches brought about improved economic and career opportunities as well as higher levels of women's participation in government. Although such policies have substantially improved the postcolonial patriarchal gender roles, rural women are yet to harness the full benefits of the government's women-friendly policies (Burnet, 2011).

Furthermore, the renewable sector of Rwanda is booming as the government of Rwanda is determined to promote private sector involvement, in its quest to accelerate rural electrification to off-grid communities in order to provide 100% energy access to its citizenry. However, women's participation in the private energy sector of Rwanda is low, as there are no gender policies governing the private energy sector (Parshotam & van der Westhuizen, 2018). Examining women's competitiveness in this context not only enriches the economic literature on competitiveness but also provide key insights into women's abilities in the private energy sector of Rwanda.

To implement our objective, the study first partners with Nuru Energy – a for-profit social enterprise. Nuru Energy provides low-cost solar mobile phone and light recharging centres to offgrid poor communities in rural Rwanda. They operate by delivering power in the form of rechargeable light emitting diodes (LEDs) via local village enterprises. LEDs are recharged by a centralised pedal-and-solar-powered recharge station, which is operated by community-run microenterprises. As part of a more extensive study to understand the role of a gender quota business model in empowering women, 272 new microenterprises in Rwanda have been established. These enterprises are randomized into three gender treatments such that each enterprise is owned by either an all-male team, an all-female team or a mixed gender¹ team, each consisting of four members. While such a gender quota-based business model provides an enabling environment for entrepreneurship and self-employment for women, it is essential to further

¹ The mixed gender team consist of equal representation of men and women: two men, two women per team.

investigate attitudes towards competition in such a context and examine whether performance in the lab reflects microenterprise activities in the field.

The study measures willingness to compete and performance under competition using the standard experimental design of Niederle and Vesterlund (2007) for a sample of 374 entrepreneurs from off-grid microenterprises in rural Rwanda. Subsequently, field outcomes – sales and self-reported incomes from microenterprise operations – are used to measure the field performances of gender teams. Our study shows that women operating off-grid microenterprises in Rwanda do not shy away from competition and perform as well as men in the lab. Comparing the performance of mixed gender and female-owned microenterprises to male-owned enterprises in the field, we find similar results of no performance differences between gender teams. Findings from the field strongly support findings in the lab that female-owned enterprises do not underperform when given the opportunity, which further corroborates the external validity of our lab results.

The rest of the paper proceeds as follows. Section 2 presents a review of related literature. The experimental design and data used for the study are detailed in Section 3. This is followed by the empirical strategy of the study in Section 4. Results and discussion of findings are reported in Section 5. Section 6 concludes.

2. Related Literature

A growing experimental literature has explored gender differences in attitudes towards competition with a focus on three broad areas: competition entry decisions, performance levels and gender composition of competing groups². Results show that women are less willing to compete (Zhong et al., 2018; Apicella et al., 2017; Sutter & Glaetzle-Ruetzler, 2015; Booth & Nolen, 2012; Niederle & Vesterlund, 2007) and women have lower performance levels than men when they do compete (eg., Dariel et al., 2017; Dato & Nieken, 2014; Niederle et al. 2013). This may explain why women are less represented in the labour market and why, at the subsistence level, female-operated firms are less profitable than those operated by their male counterparts (Buvinic & Furst-Nichols, 2016).

The literature on competition has, however, been skewed towards student-based experiments in Western societies (*See Appendix 1 for a summarised review of studies on students and non-students' samples including their respective study area to date*). Developments in the literature show that culture or the context in which these experiments are conducted can influence competitive outcomes. Gneezy et al. (2009) explain this by comparing patriarchal and matrilineal societies. Whereas the observed gender gap in the patriarchal society of Masai in Tazania emulates

² For a detailed review on these key areas, see Niederle and Vesterlund (2011) and Croson and Gneezy (2009).

most findings in Western countries, the matrilineal society of Khasi in northeast India shows a reversed gender gap. A follow-up study by Andersen et al. (2013) shows that, although no gender gap exists between these two societies at age 7, by age 15, these two communities start exhibiting very different characteristics towards competition. These studies have since paved the way for more society-specific studies (Booth et al., 2018; Bönte et al., 2018; Dariel et al., 2017; Cassar et al., 2016; Apicella and Dreber, 2015).

Although the competition literature is extensive, to date, applications of such experimental studies are limited. Little is known about the extent to which competition measures in the lab relate to real outcomes. Studies have attempted to examine competition in real-world situations or by using natural field experiments (Ors et al., 2013; Paserman, 2007; Lavy, 2012); however, the direct link of competition measures to real-world outcomes is still scarce. Zhang (2013) and Buser et al. (2014) directly examine how competition predicts educational choices of students. Both studies show that choices in the lab under competitive incentives correspond to choices of study, but were unable to study students' performance outcomes under exam conditions. Berge et al. (2015) argue that an individual's decision to compete does not necessarily imply success in the real world. To test this, they use small-scale entrepreneurs in Tanzania. Findings from Berge et al. (2015) show a positive association between competitiveness in the lab and field choices. Their study, however, was unable to explicitly examine the gender differences associated with their results due to limited data.

Our study fills the gap in the competition literature by using a unique dataset from entrepreneurs operating in specific gender groups (all-male, all-female and mixed-gender teams) in rural Rwanda to examine the relationship between lab and field outcomes. The study, therefore, does not only contribute to the competition literature but will also provide insights into the ability and performance of women, which is of relevance to microenterprise development in the renewable energy sector.

3. Experimental Design and Data

Our sample subjects are entrepreneurs operating off-grid microenterprises in the Rulindo and Ruhango districts of Rwanda, as part of a larger randomised control trial (RCT) focused on the use of a gender quota business model to empower women in the renewable energy sector. These entrepreneurs have been operating in randomly assigned gender groups since 2016, with each group consisting of four members. Their core role is to recharge lights for customers at a fee. As of March 2017, before conducting the experiments, there were 129 actively working microenterprises (one per village). This provided the study with a total population size of 516^3 entrepreneurs. Out of the 516 actively working entrepreneurs, 374 of them agreed to participate and completed the experiment⁴. This response rate (72.5%) is large enough to be representative of the established microenterprises.

3.1 The Experiment

A series of experiments focused on entrepreneurs' attitudes towards competition, risk aversion and prosocial measures. Below, we fully describe the experimental design and procedures of the two behavioural measures utilised in this study, namely the competition and risk experiment. Detailed instructions used for the experiment can be found in the supplementary material in *Appendix 3*.

The competition games follow the standard experimental design of Niederle and Vesterlund (2007) in which VLEs solve real problems under piece rate and tournament incentivised schemes. A total of 25 experimental sessions were conducted between March and June 2017. In each session, VLEs were presented with a set of 20 simple addition problems to be solved in five minutes with no performance feedback between tasks. The addition problems were handed to VLEs in a booklet form such that each page had only one problem, as presented below:

75	85	60	15	ANSWER ⁵
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Participants performed these tasks (consisting of 20 problems each) under three different treatments, namely: piece rate, tournament and preferred incentive treatments.

In the first task (piece rate treatment), participants earned 50 Rwandan francs (RWF) – approximately 0.055 United States Dollars (USD) – for each correct answer provided. In the second task (tournament treatment), participants competed in randomly assigned gender groups (mixed and single-sex) of between two and six⁶ members (*Table I Appendix 2 shows the full distribution*). Here, the designated groups are different from VLEs' actual microenterprise gender groups in the real world. This guaranteed the anonymity of group members and limited any

³ 129 X 4 = 516

⁴ Most entrepreneurs who could not make it were not either available during the information stage or had other engagements on the day the experiment was conducted.

 ⁵ For instance, participants were expected to add these four numbers and provide the answer (235 – for this example) in the space labelled ANSWER, which was left empty on the actual decision sheets for all twenty questions.
 ⁶ We tried to assign groups of four, which is consistent with VLEs' group sizes in the field. Since we did not have control of the numbers and gender of participants showing up, we also allocated groups other than the preferred

four-member groups.

potential informed decisions that could arise when the identity of team members is known to participants. Subjects were, however, informed about the demographic distribution of their respective groups (age, marital status and gender distributions)⁷ given that each session had a representation of the three gender assignment groups. All participants were made to solve the addition problems again. Thereafter, VLEs with the highest score in each group received an amount of 150 RWF (approximately 0.17 USD), which is three times more than the piece rate amount, for each correct answer. Other members of the group received nothing for their effort. In the situation of a tie, earnings were split equally among the top performers of the group.

The third round (preferred incentive treatment) offered VLEs the opportunity to choose a preferred payment incentive (choosing either the piece rate or tournament payment schemes). Subjects then solved the addition problems for the third time. VLEs who choose the tournament compensation scheme now had their scores from the third round compared to those of their group's opponent's scores from task 2⁸. VLEs were not allowed to use calculators. However, the booklets in which the problems were solved had enough space for scratch work. Instructions and incentives were read out loud to VLEs in Kinyarwanda (the official local language of Rwanda) before the start of each task.

We continued with the risk experiment after VLEs completed the competition games. The risk experiments closely follow Brick and Visser (2015), which was based on the earlier design of Gneezy and Potters (1997) as well as Moore and Eckel (2006). This proceeds as follows: VLEs were asked to make twenty-two choices, with each choice providing VLEs with two options. The first option provided VLEs with a sure payoff (increasing from 160 RWF (~ 0.18 USD) in the first choice to 580 RWF (~ 0.64 USD) in the twenty-second choice). The second option offered a lottery with a 30% probability of receiving 1200 RWF (~1.33 USD) and a 70% probability of receiving nothing. A risk-averse VLE will prefer the first option (the certain payoff) while a more risk-loving VLE will prefer the lottery. A spinning wheel is used to determine the payoffs for VLEs who preferred the gamble. The choices of subjects enabled the study to calculate risk measures using VLEs' switching points between the sure payoffs and the lottery (Booth et al., 2018; Vieider et al., 2015; Brick & Visser 2015).

⁷ This enabled the study to inform participants about the gender distribution of groups in a more subtle way by also including age and marital status.

⁸ Thus, if a VLE chooses to compete in Task 3, he/she receives RWF150 if his/her score in Task 3 is greater than group members' score in the previous task (Task 2); if not, the VLE receives nothing. This is to ensure that a decision by a group member to choose the piece rate payment incentive does not affect comparison of scores in the third task (Niederle & Vesterlund, 2011).

3.2 Descriptive Statistics

Table 1 provides details of entrepreneurs' backgrounds and an overview of field outcomes used in the analysis. VLEs' background information is obtained from survey data conducted as part of the larger RCT study detailed in Barron et al., 2019. The average village-level entrepreneur is married, 42 years of age, risk-averse, and has at least primary education (7 years of schooling) and a household size of 11 people.

Variable	Observation	Mean	Min	Max
Background				
Age	374	42.19	18	76
Education	374	6.9	1	16
Female	374	0.49	0	1
Marital Status	374	0.90	0	1
VLE Group	374	1.97	1	3
Household size	343	11	1	12
Household Head	336	0.59	0	1
District	374	1.35	1	2
Risk measure (Switching	374	6.33	1	22
Point)				
Business Outcomes				
Recharge frequency (Sales)	374	209.12	1	576
Income from Business	335	946.62	0	9000

Table 1: Background	and Fie	d Variables
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Note: Age is the age of the VLE in years, Education is in years of schooling, Female is a dummy showing whether the VLE is male or female, Marital status indicates whether VLE is married. Household size is the number of people living in the VLE's household. Household head shows whether the VLE is a household head. For the microenterprise outcomes, Risk measure shows the level of VLEs' attitudes towards risk-taking, ranging from 1 (highly risk-averse) to 22 (risk seeking). Recharge frequency, which is used as a proxy for sales, is the number of times VLEs recharge lights for customers. Income is VLEs' self-reported income (in RWF) from operating the microenterprise.

For field outcomes, we focus on recharge frequency data as a proxy for sales and selfreported incomes of VLEs, which measures the performance levels of microenterprises. Nuru Energy has a centralised server that regularly receives recharge frequency data from the various enterprises. The centralised data station provides the study with the sales information for each microenterprise. Self-reported incomes from business operations are obtained from the survey data. Specifically, we consider the total recharge frequency of lights for three months and the average income per month. A Nuru microenterprise on average has a total of 209 recharges in three months, with the average VLE reporting an income of 946 RwF per month.

4. Empirical Strategy

The study aims at examining entrepreneurs' attitudes towards competition and comparing entrepreneurs' performance levels in the lab to performance in business. For entrepreneurs' attitudes towards competition, we estimate a standard probit model depicted in equation 1:

$Competition_entry_i = \gamma_0 + \gamma_1 Female_i + \gamma_3 X_i + \gamma_4 V_i + \mathcal{E}_i$ (1)

where the dependent variable is a dummy variable measuring the willingness of entrepreneurs to participate in a competition such that *Competition_entry*_i = 1 if the VLE chooses the tournament and 0 if the VLE chooses piece rate in the third round of the experiment. *Female*_i = 1 indicates that a participant is female. Other explanatory variables X_i are indicators from the experiment (e.g. scores from round 2, susceptibility to time pressure and response to competition against peers (Tournament – Piece rate), risk preferences, number of VLEs per session) and are standard explanatory variables included in willingness to compete estimations (Booth et al., 2018, Dariel et al., 2017, Niederle & Vesterlund, 2007). We also control for VLEs' background indicators V_i (age, education, marital status, household size, household head, geographical districts of operation).

To examine how entrepreneurs' performance levels compare to field outcomes, we estimate equation 2 using an Ordinary Least Squares (OLS) estimation approach:

$Perfomance_{i} = \gamma_{0} + \gamma_{1} Gender_Teams_{i} + \gamma_{3}X_{i} + \mathcal{E}_{i}$ ⁽²⁾

Equation 2 is estimated for lab and field outcomes. For lab outcomes, the dependent variable *Perfomance_i* is VLEs' scores under competition. *Gender_Team* is the real-world gender teams in which entrepreneurs are working: all-male, all-female or the mixed gender teams. Each team consist of four members such that the all-male and all-female teams have four males and four females respectively per gender group, while the mixed gender teams have two males and two females working together in a group. Individual background characteristics remains the same as in equation 1. For field outcomes, we use the recharge frequency of lights (sales) and the inverse hyperbolic sine transformation⁹ of self-reported incomes from VLEs to measure performance. We face the problem of some VLEs reporting zero income when considering the self-reported incomes. The inverse hyperbolic sine transformation enables us to deal with the zeroes associated with VLEs' self-reported incomes. Standard errors for the field estimation are clustered at the

⁹ This is an improved way of dealing with zeros in a variable

village level, since there is only one microenterprise per village.

5. Results and Discussion

5.1 Performance in the Lab Under Piece Rate, Tournament and Preferred Incentive Treatments

Table 2 shows the performance levels of VLEs in the lab for all treatments. In the first two treatments (Piece rate and Tournament), VLEs scored an average of 7.73 and 9.83 respectively. This performance varies from 7.54 to 8.16 for single and mixed gender groups under the piece rate incentive. Men significantly perform better in the all-male groups, with an average score of 8.23 than females in the all-female groups, who scored 6.85 on the average (P-value = 0.003). In the mixed-gender groups, both men and women show no performance differences under the piece rate incentive (P-value = 0.262)

For the tournament incentive, performance ranges from 9.49 to 10.64 for single and mixed gender groups, with the all-male groups performing better than the all-female groups (P-value = 0.023). Performance under the tournament also improved significantly despite a high correlation between piece rate and tournament scores of approximately 0.73 and 0.72 for men and women respectively. On average, all gender groups solved two more problems under the tournament compensation scheme compared to the piece rate treatment with no significant difference (P-value = 0.488). This suggests no gender difference associated with improvement in performance after moving from the piece rate (task 1) to the tournament treatment (task 2). Improvement in performance from task 1 to task 2 may be due to the initial learning effect, as explained by Niederle and Vesterlund (2007).

variable		Obs	Combined	Male	Female	Diff	P-value
Piece rate (Task 1) Ov	verall	374	7.73	8.38	7.06	1.32	0.002***
Sir	ngle- sex	261	7.54	8.23	6.85	1.39	0.003***
Mi	ixed	113	8.16	8.69	7.57	1.12	0.262
Tournament (Task 2) Ov	verall	374	9.83	10.56	9.09	1.47	0.004***
Sir	ngle- sex	261	9.49	10.12	8.85	1.28	0.023**
Mi	ixed	113	10.64	11.52	9.66	1.86	0.062*
Task 2–Task 1 Ov	verall	374	2.10	2.17	2.03	0.15	0.488
Sir	ngle- sex	261	2.0	1.89	2.0	-0.11	0.793
Mi	ixed	113	2.48	2.83	2.09	0.74	0.292
Preferred incentive (Tas	sk 3):						
Tournament Ov	verall	172	11.7	12.19	11.22	0.98	0.256
Sir	ngle- sex	119	11.18	11.69	10.57	1.11	0.204
Mi	ixed	53	13	13.35	12.6	0.75	0.872
Piece rate Ov	verall	201	10.39	11.06	9.78	1.28	0.015**
Sir	ngle-sex	141	10.34	11.07	9.72	1.35	0.021**
Mi	ixed	60	10.5	11.03	9.93	1.10	0.353
Task3 – Task 2 Ov	verall	172	1.02	1.03	1.02	0.01	0.730
(Tournament Sin	ngle -sex	119	1.03	1.07	0.98	0.09	0.788
Choosers) Mi	ixed	53	1.02	0.92	1.12	-0.19	0.899

Table 2: Performance Levels of VLEs in the Lab

We also present average scores for the third task under the preferred incentive treatment. VLEs who chose to compete solved an average of 11.7 problems, with performance varying from 11.18 to 13 for single and mixed gender teams respectively. There is no significant difference in performance for all-male and all-female teams (11.69 for men and 10.67 for women) with a corresponding P-value of 0.204. Similarly, men and women in mixed gender groups have identical performance levels (13.35 and 12.6, respectively, P-value = 0.872). Comparing performance in task 2 (tournament) to task 3, Table 2 shows a slight increase in performance for both VLEs who chose to compete and those who did not. Both men and women solved an average of one more problem in Task 3, but this difference is insignificant (P-value = 0.730). The improvement in

performance under the preferred incentive treatment cut across all gender groups, with no gender group performing better than the other.



Figure 1: CDF of Correctly Solved Problems (Task 1: Piece Rate & Task 2: Tournament)

In Figure 1, we show the cumulative distributions for piece rate and tournament treatments by gender. This shows the cumulative probability of correctly solving a given number of problems. The figure clearly emphasizes the existing gender gap reported in Table 2 under the first two tasks (Piece rate and Tournament). In both treatments, women show a higher chance of solving a lower number of problems than men. This indicates higher performance levels for men than women.

Figure 2 shows the cumulative distributions of VLEs who chose to enter the competition under the preferred incentive treatment (task 3). In the first graph, we show the cumulative probability of solving a given number of problems for VLEs assigned to mixed gender teams during the competition games. The cumulative distributions for single-sex teams are shown in the second graph in the right panel. The third graph in Figure 2 shows the distribution for all VLEs (combined) irrespective of their gender group assignment.



Figure 2: CDF of Correctly Solved Problems (Task 3: Tournament)

We find no substantial difference in the cumulative distributions either men or women. Mixed and single-sex teams show similar performance trends for both men and women. However, in the single-sex teams, women show a slightly higher cumulative probability distribution for lower scores than men. The probability of correctly solving a given number of problems under the tournament in task 3 overall is similar for both men and women.

5.2 Entrepreneurs' Willingness to Compete

This section first analyses competition entry decisions of VLEs. Out of the 374 VLEs who participated in the experiment, 172 (46%) preferred to compete. Comparing the 46% of participants who chose to compete in our sample to other tournament entry rates (29.6% to 54%) from previous studies (Dariel et al., 2017; Apicella et al., 2017; John, 2017; Khachatryan et al.,

2015; Gneezy et.al., 2009; Niederle & Vesterlund, 2007)¹⁰, we see that, while our reported competition entry rate generally falls within the topmost percentile, it does not deviate from previously reported rates. Female entrepreneurs select into competition 43% of the time, while men select into competition 49% of the time. The Fischer exact test (P=0.299) indicates that this marginal difference between women's and men's competition entry is insignificant. While there is a possibility that high-ability participants may self-select into the competition, subjects in our study did not receive any form of performance feedback between experimental rounds, enabling the study to hedge against such potential selection bias. We, however, acknowledge that participants are still likely to have beliefs about their ability.

Table 3 shows the results for tournament entry decisions of entrepreneurs based on VLEs' gender composition of groups in the experiment. Columns 1 - 3 show that being male or female does not affect entrepreneurs' decisions to compete. Instead, education and risk-taking are more important drivers of competition entry decisions in the single-sex teams than in the mixed gender teams. Risk preferences (being risk-loving) is an important driver for competition entry in the all-female groups, whereas it does not play a significant role in mixed gender teams. Married women have a higher likelihood of choosing competition in the all-female groups than in the mixed-gender groups, as shown in column 4. These results suggest no gender gap in competition entry amongst entrepreneurs operating off-grid microenterprises in rural Rwanda.

Although our finding contradicts a large body of literature which shows that women are reluctant to make competition entry decisions (Croson & Gneezy, 2009), it is perhaps not surprising in the context of Rwanda given its history and progressive gender mainstreaming policies implemented subsequently. Following the 1994 genocide which mainly targeted men and boys, 70% of Rwanda's population were women.

¹⁰ We detail many more studies in Appendix 1

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Combined	Mixed	Single-sex	All -	All- Males
				Female	
Dummy for Females	0.0322	0.120	0.0257	-	-
	(0.0814)	(0.143)	(0.0933)		
Scores from round 2	0.0183**	0.0397***	0.0067	0.0063	0.00614
	(0.0078)	(0.0114)	(0.010)	(0.0151)	(0.0135)
Tournament - Piece rate	-0.0190*	-0.0376**	-0.0085	0.0074	-0.0162
	(0.0104)	(0.0157)	(0.0140)	(0.0207)	(0.0180)
Number of participants per	-0.0036	-0.0213**	8.00e-05	-0.0039	0.0074
session	(0.0049)	(0.0099)	(0.0059)	(0.0078)	(0.0081)
Risk taking (Switching	0.0088^{**}	0.0082	0.0108***	0.0126**	0.0081
Point)					
	(0.0036)	(0.0072)	(0.0042)	(0.0060)	(0.0059)
Education	0.0247**	0.0197	0.0315**	0.0301	0.0274
	(0.0110)	(0.0182)	(0.0140)	(0.0211)	(0.0193)
Household head	0.0237	-0.0580	0.0723	0.182	-0.185
	(0.0808)	(0.147)	(0.0922)	(0.115)	(0.193)
Household size	-0.0213	-0.0303	-0.0170	-0.0203	-0.0118
	(0.0151)	(0.0282)	(0.0180)	(0.0259)	(0.0253)
Age	-0.0017	0.0069	-0.0037	-0.0013	-0.0047
	(0.0027)	(0.0049)	(0.0030)	(0.0045)	(0.0041)
Rulindo District	0.0285	-0.0033	0.0374	-0.133	0.125
	(0.0780)	(0.102)	(0.122)	(0.137)	(0.147)
Married	0.0545	0.187	0.0070	0.228*	-0.215
	(0.0920)	(0.140)	(0.114)	(0.130)	(0.232)
Dummy for single-sex	0.0265	-	-	-	-
teams	(0.0708)				
Observations	335	102	233	118	115
Log pseudolikelihood	-213.09	-58.82	-147.89	-68.55	-70.56

Table 3: VLE's Competition Entry Decisions

Results are marginal effects from a Probit estimation. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

This forced the country to involve women in the rebuilding of the nation. As a result, traditionally male-dominated positions were offered to women. These national gender policies have gradually permeated the perceptions of the younger generation, which is evident in the baseline survey data collected as part of the larger RCT study. In the survey, children of VLEs were asked questions about their general gender perceptions. Their beliefs suggest that wives should be equally educated as husbands, boys should not get more resources for education, and daughters should have similar rights as sons in terms of inheriting property (*as reported in Appendix 2, Table 2*).

In line with these beliefs, Burnet (2011) also identifies that the deliberate gender policies implemented by the government have translated into notable successes at the local level. These successes include increased levels of respect from village members and family, improved decision making at the household level, women's access to education, and enhanced capacity for women to freely speak and be heard at village meetings. This is an indication that the gender equality agenda in Rwanda is gradually changing perceptions and empowering women to take on challenging roles irrespective of the entrenched cultural barriers still existing in the country. The progressive women's empowerment policies in Rwanda could be a contributing factor to explain why we see no significant gender difference in VLEs' decision to perform tasks under competitive situations.

Further, the original business model of Nuru before the current gender quota system under study also demonstrates how women expressed great interest in the entrepreneurship prospects of the Nuru program. Thus, the willingness of women to take on entrepreneurship roles despite its associated competitive characteristics is an additional explanatory factor as to why no gender differences exist in the tournament entry decisions of VLEs. A more recent study by Dariel et al. (2017) supports our finding by showing that women in the United Arab Emirates are willing to participate in competition. Their results were also obtained in the context of a very entrenched patriarchal society after several policies towards women's empowerment and women's participation in the labour market were put in place.

Risk-taking and competitiveness, though different concepts, can be related in nature. Niederle and Vesterlund (2007) explain that competition involves uncertainty in earnings, such that any gender gap associated with risk preferences can influence decisions to compete. Our results show that VLEs with more risk-taking orientations are more likely to choose competition in single-sex teams, particularly in the all-female teams, but this is not the case for the mixed and all-male teams.

The relationship between risk attitudes and competition entry decisions is well established in the literature. For instance, van Veldhuizen (2017) and Bartling (2009) show that less riskaverse individuals self-select into competition. As a result, the gender gap observed in competition entry decisions is significantly driven by differences in risk attitudes. Similarly, Cardenas et al. (2012) explore this concept by comparing results from two countries: Sweden and Colombia. They find a positive relationship between risk-loving individuals and competitiveness in Sweden but find no such relationship amongst Colombian boys and girls. In line with Niederle and Vesterlund (2007), they conclude that, whereas risk-taking is a key driver of competition entry decisions, other factors such as overconfidence could also influence decisions to compete. Our results that riskloving VLEs are more likely to choose competition is widely supported by these previous studies.

5.2 Performance in the Lab vs. Field

Table 4 reports regression results on whether performance levels of women and men differ significantly under competition and further compares performance levels of gender teams in the lab to performance during field operations. Results from column 1 show no gender difference in performance when VLEs compete. Column 2 shows that the gender of teams in which VLEs compete also does not affect performance: all-female and mixed gender teams perform as well as male teams in the lab.

A large body of literature finds that opponents' gender influences performance under competition, such that women tend to perform better in single-sex environments than in co-gender environments (Delfgaauw et al., 2013; Booth & Nolen 2012; Niederle & Vesterlund, 2008; Gneezy et al., 2003). These studies suggest that the gender gap increases when women compete with men – the basis for the continuous debate about single-sex schools relative to mixed gender schools. However, Lee, Niederle and Kang (2014) test the gender composition of teams by examining whether single-sex schooling reduces the gender gap in performance. Contrary to other studies, their study reveals that single-sex schools do not necessarily reduce the gender gap in competitiveness. This is consistent with our finding that performance of women does not improve under single-sex tournaments. A subsequent study by De Paola et al. (2015) is also consistent with our finding that the gender of one's opponent does not affect competitiveness.

	1	2	3	4
VARIABLES	Competition	Competition	Sales	Income
Female	-1.127			
	(1.120)			
Female Teams		-0.820	43.771	0.550
		(1.088)	(31.786)	(1.191)
Mixed Teams		1.054	65.857*	-0.128
		(1.162)	(34.256)	(0.911)
Age	-0.027	-0.031	1.200	-0.038
	(0.038)	(0.038)	(1.074)	(0.038)
Education	0.781***	0.772***	-2.308	-0.138
	(0.097)	(0.094)	(3.040)	(0.105)
Rulindo District	0.914	0.250	-13.532	-0.540
	(0.779)	(0.990)	(29.804)	(0.857)
Hhead	-0.370	0.153	7.738	0.914
	(1.164)	(0.971)	(19.430)	(0.902)
Hhsize	0.343*	0.365*	9.188	-0.166
	(0.206)	(0.214)	(7.795)	(0.214)
Married	1.519	1.532	-67.62**	-0.319
	(1.429)	(1.430)	(33.199)	(1.332)
Risk -taking	-0.036	-0.021	2.536*	0.061
(SwitchingPoint)	(0.052)	(0.052)	(1.283)	(0.044)
Observations	154	154	154	149
R-Squared	0.295	0.303	0.111	0.051

*** p<0.01, ** p<0.05, * p<0.1. Village clustered standard errors for all field estimations.

Consistent with Lee et al. (2014) and De Paola et al. (2015), we find that competing in single-sex teams does not improve performance in the lab. While the gender of VLEs and the gender composition of teams does not affect performance under competition, education and household size are significant factors driving VLEs' competition performance.

Previous studies demonstrate the importance of education as a key driver of performance when evaluating outcomes such as labour productivity and economic competitiveness (Cabrera & Le Renard, 2015; Sahlberg, 2006). In Rwanda, significant progress has been made by the government to ensure universal education access. For instance, the National Gender Policy (2010) and Girls' Education Policy (2008) address gender gap issues through affirmative quota systems. More women after the genocide now have access to education, with many rural families convinced

about the importance of educating the girl child (Burnet, 2011). The World Bank indicators show that between 1990 and 1992 (before the genocide), 14,000 fewer girls than boys accessed primary education; however, by 2008, approximately 16,000 more girls than boys were in primary schools. The increase in access to education for women could be a contributing factor for the high competitiveness levels of Rwandan women.

Our results pertaining to household size probably originate from competition within the household for limited resources. Downey (1995) explains that household heads and parents have finite resources such as time, energy and money. They are forced to share these limited resources with children and other members as the household increases in size, which can result in the dilution of resources. The fact that VLEs from larger households perform better compared to smaller households may be due to the urgent need to provide for household members, which increases their desire to perform well in return for higher experimental payoffs.

In the second panel of Table 3 (columns 3-4), we report results related to performance in the field. Two field indicators at the group level – sales (column 3) and business income (column 4) – are used as measures for microenterprise performance. As with the experimental results, our field results indicate no significant differences in performance based on the gender of teams.

Married men and women also tend to have lower sales performance levels, although married women are more likely than unmarried women to choose competition in our experiment. This finding contradicts studies in the entrepreneurship literature (Failie & Robb, 2009; Wickramasinghe & De Zoyza 2008), which suggest a positive relationship between marriage and business performance. These studies also explain that married women tend to have lower business performance levels than men. We show in *Table 3, Appendix 2* that there is no significant difference between married women in the all-female teams and married men in the all-male teams in our case. Our finding that married people do not perform well in business might be explained by the additional time married people invest in maintaining their families, which may reduce hours of work and in effect reduce business performance.

Results also show that mixed teams perform slightly better than all-male teams. Business performance of women has been constantly underestimated (Brush and Cooper 2012; Minniti and Naude 2010; de Bruin et al. 2007; Ahl 2006) based on broader characteristics and context-related factors such as industry type, field experience and business size (Baker and Welter, 2017). Sappletton (2018) shows that the underestimation of women and the observed differences between female and male-owned businesses are due to the unequal comparison of business models in a given industry. For instance, women often engage in retail businesses focused on serving local markets. Such businesses are smaller in size, have lower growth rates and yield lower profits

despite their high competition levels. Emerging management literature demonstrates how measures of business performance such as business sizes and growth rates of an industry tend to favour men, whereas no performance differences are associated with more specific indicators such as profitability, number of employees, number of orders and closure rates (Zolin 2013; Robb & Waston 2012). Our finding that male-owned enterprises do not outperform female-owned enterprises resonate with these emerging studies, given that we compare the performance of entrepreneurs working in the same industry under the same business model with similar terms and conditions.

Comparing performance in the lab to performance of microenterprises in the real world, we find similar results that female and mixed gender microenterprises perform as well as maleowned enterprises. The external validity of experiments is often low and continuously criticised by empirical researchers. The artificiality under which lab experiments are conducted makes it difficult for real-world generalizability (Schram, 2005). Roe and Just (2009) argue that the best way to overcome the limitations associated with a single research method is to apply multiple approaches to the same phenomenon. Showing that similar results can be achieved when experimental results are compared to real-world operations of microenterprises corroborates the external validity of our findings.

Recent years have also seen the government of Rwanda depend heavily on the private sector's participation in implementing off-grid solutions due to the fast pace at which the state wishes to attain 100% electricity access. As a result, national policies have contributed substantially to the rapid growth of the private sector, especially for solar companies. The government has also taken steps towards increasing gender equity energy policies in the country, yet private companies are still not required to include gender mainstreaming in their operations (Parshotam & van der Westhuizen, 2018). Despite the support from government, women's participation in the private sector is limited, as some companies potentially see the inclusion of women as a limitation for the maximization of revenue (Parshotam & van der Westhuizen, 2018). Our results, showing that women are as competitive and perform as well as male-owned enterprises over various outcome measures, demonstrate the capacity for Rwandan women to participate successfully in a profit-oriented enterprise, an indication for the private energy sector to reconsider the inclusion of more women.

6. Conclusion

A large body of literature investigates gender differences in competition among student subjects in the lab. Yet, the application of such studies to a real-world phenomenon is scarce. This study examines competitiveness from the perspective of gender inclusivity in the renewable energy value chain in a context where the government of Rwanda is determined to promote private sector involvement, in their quest to accelerate rural electrification to off-grid communities.

Our study adds to the existing literature on competitiveness and gender by being the first to test these concepts in the renewable energy sector, using a unique subject pool of entrepreneurs operating off-grid gender-focused microenterprises in rural Rwanda – a country globally known for its progressive gender policies. Further, the extent to which competition results in the lab reflect real-world situations has not received much attention in previous studies. This study provides new evidence to support the extent to which experimental results are consistent with profitability in the field, to corroborate the external validity of our findings.

Our findings show that, under competitive situations in the lab, women operating off-grid microenterprises in Rwanda are not less willing to enter competition; female VLEs perform as well as men when they work in both all-female and mixed gender groups; and gender of opponents does not affect their performance. Results also show that, in single-sex groups, education and risk-taking are key drivers of the decision to compete; in the all-female teams, risk-loving women are more likely than risk-averse women to compete. Consistent with our experimental results, field findings also show that female-owned and mixed gender-owned microenterprises perform as well as male-run enterprises. Therefore, the assertion that women underperform in business does not hold for the rural Rwanda woman working as sales agents in the energy sector.

While the study unleashes the applicability of experimental results by adding to the competition literature, our research also provides insights for the private energy sector. Currently, women's participation in the private energy sector of Rwanda is low, as some companies potentially see the inclusion of women as a limitation for revenue maximization (Parshotam & van der Westhuizen, 2018). By showing that women are equally competitive and are also likely to perform as well as men when given the opportunity, our study provides an impetus for private energy companies in Rwanda to reconsider the involvement of more women in this sector. It further provides support for the notion of gender quotas within this sector to even out disparities in access to labour markets for women, especially in recent times, when pro-gender national policies are gradually permeating the perceptions and sense of agency among the people of Rwanda.

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Appendices

Appendix 1

Table I: List of Studies Based on Niederle–Vesterlund (2007) Experimental Design

Student Subjects

Studies	Country	Task	Sample	Tournam	ent Entry
			Size	Male	Female
	Addi	tion tasks			
Zhong et al. (2018)	Singapore	Addition	197	49%	25%
Dariel et al (2017)	UAE	Addition	147	50%	54%
Apicella et al. (2017)	USA	Addition	100	58%	38%
Halko & Saaksvuori (2017)	Finland	Addition	80	74%	54%
Reuben, Wiswall & Zafar, (2017)	USA	Addition	257	54%	27%
Buser, Dreber & Mollerstrom, (2017)	USA	Addition	104	52%	28%
Berlin & Dargnies (2016)	France	Addition	228	63%	35%
Brandts, Groenert & Rott, 2014)	Spain	Addition	112	59%	30%
Wozniak et al. (2014)	USA	Addition	128	54%	31%
Niederle et al. (2013)	USA	Addition	84	74%	31%
Cadsby et al. (2013)	Canada	Addition	132	36%	9%
Price, (2012)	USA	Addition	310	66%	49%
Mueller & Schwieren (2012)	Germany	Addition	127	42%	26%
Kamas & Preston (2012)	USA	Addition	310	41%	23%
Dargnies (2012)	France	Addition	76	85%	51%
Balafoutas, Kerschbamer & Sutter (2012)	Austria	Addition	134	59%	31%
Balafoutas & Sutter (2012)	Austria	Addition	72	64%	30%
Healy & Pate (2011)	USA	Addition	192	81%	28%
Niederle & Vesterlund (2007)	USA	Addition	80	73%	35%
	Oth	er tasks			
Buser, Gerhards & van der Weele, (2018)	Denmark	Mix	297	42%	26%
Banerjee, Gupta & Villeval (2018)	India	Memory task	168	22%	16%
Wozniak et al. (2014)	USA	Verbal	128	54%	31%
Gupta, Poulsen & Villeval, (2013)	France	Mazes	100	60%	34%
Shurchkov (2012)	USA	Verbal	128	39%	30%
Buser et al. (2017b)	Denmark	Mix	297	42%	26%
Banerjee et al. (2017)	India	Memory task	168	22%	16%

Non-student Subjects

Studies	Country	Task	Sample Size	Tournan	nent Entry		
				Male	Female		
Adults							
Bönte et al. (2017)	Germany	Math	225	56%	45%		
Cassar, Wordofa & Zhang (2016)	China	Addition	358	36%	26%		
Apicella and	Tanzania	Skipping rope	191	45%	30%		
Dreber (2015)		Bead collection	88	52%	37%		
		Handgrip strength	70	67%	29%		
Gneezy et al.	Tanzania (patriarchal)	Bucket toss	172	50%	26%		
(2009)	India (matrilineal)	Bucket toss	146	39%	54%		
	Cl	nildren					
(Zhang, 2015)	China (Han)	Addition	96	63%	48%		
	China (Yi)	Addition	96	60%	38%		
	China (Mosuo)	Addition	80	75%	48%		
Buser, Peter & Wolter (2017)	Switzerland	Addition	249	68%	51%		
Alma°s et al. (2016)	Norway	Addition	483	52%	32%		
Sutter et al. (2016)	Austria	Addition	246	44%	21%		
Khachatryan et al.	Armenia	Addition	824	54%	52%		
(2015)		Word search		57%	56%		
Sutter & Glaetzle- Ruetzler, (2015)	Austria	Addition	717	40%	19%		
Lee, Niederle & Kang (2014)	South Korea	South Korea	640	30%	22%		
Dreber, von Essen	Sweden	Addition	216	36%	17%		
& Ranehill (2014)		Word search	216	33%	28%		

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Appendix 2

Number of Female Group Male Group Mixed-gender Total Number of people per group Groups Group 2 2 2 3 4 -------4 3 10 3

16

8

2

Table I: Distribution of Groups and Number of People per Group

26

Table II: Differences in Expected Gender Behaviours by Children

Variable	Male	Female	Difference	P-value
Wives should be less educated than	3.44	3.6	-0.3.6	0.34
their husbands				
Boys should get more	3.92	3.98	-0.05	0.64
resources/opportunities for				
education than girls				
Girls should be allowed to study	1.57	1.57	0.00	0.99
for as long as they like - as high as				
they want				
Daughters should have a similar	1.72	1.82	-0.10	0.48
right in terms of inheriting				
property as sons				

VARIABLES	Sales
Female Teams	29.412
	(46.999)
Mixed Teams	51.136
	(76.835)
Age	1.222
	(1.087)
Education	-2.263
	(3.074)
Rulindo district	-13.543
	(30.166)
Hhead	9.453
	(20.281)
Hhsize	9.285
	(7.907)
Married	-76.616*
	(45.088)
Risk-taking	2.513*
	(1.298)
Female X married	17.674
	(55.889)
Mixed X married	17.190
	(85.268)
Observations	154
R-Squared	0.111

Table III: Joint Effect of Gender Teams and being Married on Sale