Boys will (still) be boys: Gender differences in trading activity are not due to differences in confidence

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Boys will (still) be boys:
Gender differences in trading activity are not due to differences in confidence[*]

**Carlos Cueva, Iñigo Iturbe-Ormaetxe,
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Abstract

The fact that men trade more than women in financial markets has been attributed to men's overconfidence. However, evidence supporting this view is only indirect. We directly test this conjecture experimentally, by measuring confidence using monetary incentives before participants trade in a simulated market. We find that men are more confident and trade more than women, but we do not find that the difference in confidence explains the gender gap in trading activity. We explore alternative candidate channels such as risk aversion, financial literacy or competitiveness but find that these factors are also unlikely to play a role.

Keywords: Behavioral Finance, Overconfidence, Overtrading.

JEL classification numbers: C91, D70, D81, D91.

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1. Introduction

A well-known result in Finance is that investors tend to trade too much, thereby lowering their average returns. Because of active trading and its associated costs, the average individual investor has been found to pay a performance penalty of 0.67 to 3.8 percentage points compared to passive indexing (Barber et al. 2009, Barber and Odean 2000, French 2008, Odean 1999). In the United States, the annual cost of active trading has been estimated to be around $100 billion (French 2008).

The most common explanation for excess trading is *overconfidence* (Benos 1998, Daniel et al. 1998, 2001, Daniel and Hirshleifer 2015, Odean 1998). Overconfident investors believe that the accuracy of their knowledge about asset values is greater than that of the average investor (Odean 1998). Such investors believe that they can attain returns above the market average and are therefore willing to trade aggressively despite significant transaction costs.

In an influential study titled "*Boys Will be Boys: Gender, Overconfidence, and Common Stock Investment*", Barber and Odean (2001) indirectly test the hypothesis that overconfidence causes excessive trading by comparing the trading activity of men and women, using gender as a proxy for overconfidence. In a sample of over 35,000 clients at a large discount brokerage, Barber and Odean find that average portfolio turnover is 45 percent larger for men. Moreover, trading reduces the net returns of both men and women, but the reduction for men is 0.94 percentage points higher. Barber and Odean conclude that their findings provide strong support for the hypothesis that excess trading is caused by overconfidence. However, since the authors only observe a trader's gender, and not his or her overconfidence, their conclusion relies on the strong assumption that overconfidence is the only dimension relevant to trading frequency along which men and women differ.[1]

Several subsequent studies have replicated the large gap in trading activity between men and women (Agnew et al. 2003, Dorn and Sengmueller 2009, Grinblatt and Keloharju 2009). However, the evidence in support of the view that such a gap is due to gender differences in overconfidence is again only indirect. Two separate bodies of work motivate this conjecture: The first, originally from psychology and more recently economics, documents that men are more confident than women regardless of actual ability in areas such as mathematics (Campbell and Hackett 1986, Hyde et al. 1990, Niederle and Vesterlund 2007), academic achievement (Bengtsson et al. 2005, Lundeberg et al. 1994) and finance (Prince 1993, Yablonsky 1991). The second, coming from behavioral finance, posits overconfidence as a key ingredient in theoretically explaining the high volume of trade observed in financial markets (Benos 1998, Daniel et al. 1998, 2001, Daniel and Hirshleifer 2015, Odean 1998).

The purpose of this study is to test directly whether the gender gap in trading activity can really be ascribed to differences in confidence between men and women. We conduct an experiment in which male and female participants can buy and sell risky assets in a simulated market. Subjects are divided into groups of two men and two women who see the exact same price realizations but do not interact

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[1] It is in this sense that we consider *indirect* their test of the hypothesis that overconfidence causes excessive trading.

with each other, allowing us to perform clean gender comparisons.[2] We measure confidence by asking subjects to forecast their position in the group of four, both before and after trading, with a small financial reward for each correct answer.

Our findings reproduce the key stylized result in the literature, namely, that men trade more, and are more confident than women. However, contrary to Barber and Odean's conjecture, we find that confidence does not help to explain any portion of the gender gap in trading activity.

In our experiment, subjects go through a baseline market, one with transaction costs, one with a competitive payment scheme, and one combining both features. Transaction costs are a crucial reason why trading too much is costly. Our experimental design captures this feature of real-world financial markets explicitly. The reason for including a competitive payment scheme is to explore other candidate channels through which gender differences could be driving the observed gap in trading activity, in addition to confidence. To the extent that speculative trading in real-world financial markets has an element of competition, gender differences in willingness to compete are a plausible alternative channel for the gender gap in trading activity.[3]

We explore two other possible channels, which we estimate from subjects' responses in two additional tasks: risk aversion and financial literacy. It is a well-known result that women tend to be more risk averse than men (Charness and Gneezy 2012, Croson and Gneezy 2009, Eckel and Grossman 2008). Since trading is risky, it is important to check whether gender differences in trading activity might be simply due to differences in risk aversion, rather than confidence. Financial literacy has also been consistently observed to be lower among women and has been shown to correlate with a broad range of economic behaviors, including stock market participation (Lusardi and Mitchell 2014).

As in the case of confidence, however, we find no evidence that any of these alternative channels are responsible for the observed gender differences in trading activity. Our results therefore suggest that some other underlying mechanisms must be at play. We discuss some possible avenues of research in this direction in Section 6.

The remainder of this paper is arranged as follows. Section 2 describes the experimental design and procedures. Section 3 reports our main results. Section 4 describes our results concerning treatment effects. Section 5 deals with alternative mechanisms other than confidence. Section 6 concludes.

2 Experimental Design and Procedures

We recruited 192 participants (97 female, 95 male) from the general undergraduate population of the University of Alicante. All subjects were recruited using ORSEE (Greiner 2004). Invitations, sent

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[2] Subjects are not told anything about the gender composition of the group. However, we ensure that every session has a balanced gender composition.
[3] For gender differences in competition, see e.g. Gneezy et al. (2003, 2009), Gneezy and Rustichini (2004), Niederle and Vesterlund (2007).

via email, did not provide any information about the experiment, which was simply described as a "decision-making experiment". We conducted 8 sessions with 24 subjects each, lasting approximately two hours. Subjects earned, on average, 19€ for participating. The experiment was programmed in z-Tree (Fischbacher, 2007).[4]

Our simulated trading task is based on Weber and Camerer (1998) and Weber and Welfens (2007). In our baseline treatment, we give subjects 5,000 units of experimental currency ("pesetas") that they can use to buy and sell units of six risky assets over 9 periods.[5] The price of each asset is determined every period by a stochastic process, independently of subjects' actions. In addition to the baseline treatment, we introduce two variations: *i)* a competitive payment scheme and *ii)* transaction costs.

In the *baseline* treatment (B), subjects earn the value of the portfolio upon liquidation (period 10) plus their remaining cash. In the *competitive* treatment (C), only the winner in each group of four earns the value of her portfolio plus the remaining cash, multiplied by two. The remaining three members of the group do not receive the value of their portfolios, nor their remaining cash. The *transaction costs* treatment (T) is similar to the baseline, but now subjects have to pay a fee for each transaction. The cost is a fixed rate, chosen from the set {1%, 4%, 7%} so that a third of the groups in each session face each rate. All individuals in a given group face the same rate throughout the treatment, which is also the same for purchases and sales. Finally, in the *competitive with transaction costs* treatment (CT), we combine the features of treatments 2 and 3. The experiment is within-subjects (all subjects participate in each treatment) and the treatment order is counterbalanced.[6]

Subjects are randomly assigned into groups of two men and two women. They are told that they are in a group of four but they do not know the identity, or gender, of their group mates.[7] Subjects are also told that each group faces the same price path of the six assets. All markets begin in period –3, in which all assets have the same initial price of 100 pesetas. From period –2 onwards, the price of each asset either goes up by 6% or down by 5%. Subjects are told that each asset has a different probability of a price increase, but they do not know the actual probabilities. They are also informed that the probability of a price increase is constant for each asset over the whole treatment and that price changes are independent of previous prices and subjects' actions. The actual probabilities are chosen randomly without replacement from the set {0.6, 0.55, 0.5, 0.5, 0.45, 0.4}.[8]

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[4] Considering the systematically large gender differences in trading activity that have been observed in empirical studies, we were confident that our target sample size of 192 would have more than enough power to detect such gender differences. For instance, Fellner-Röhling and Krügel (2014) find strongly significant gender differences in trading activity using a more complicated design and a smaller sample size.

[5] Exchange rate: 1.000 pesetas = 1€.

[6] Sessions 1 and 2: B, C, T, CT; sessions 3 and 4: T, CT, B, C; sessions 5 and 6: C, B, CT, T; sessions 7 and 8: CT, T, C, B. Subjects played a short trial period before each treatment.

[7] To ensure that subjects perceive a similar gender-balanced environment in every session, their positions in the laboratory are always male, female, male, female… This is done by asking male and female subjects to randomly draw a number from different boxes: one box contains odd numbers and the other contains even numbers. Subjects are then seated on the cubicle corresponding to their drawn number.

[8] Note that, unlike Weber and Camerer (1998), who use only a single predetermined price path for each asset in their experiment, we determine different random price paths for each group of 4.

Individuals observe prices from period –3 to 10, but can only trade in periods 1 to 9. The first 4 periods are there to provide some information about the assets before trading, while the last period is only used to liquidate portfolios.

To measure confidence, we ask subjects at the beginning and end of each treatment to forecast their own ranking within their group of four in terms of total earnings (final cash + portfolio value).[9] Subjects are reminded that they have been assigned to a group of four participants at random and that they will be paid an additional 100 pesetas for guessing their position correctly. They need to select one out of four options: "First", "Second", "Third" or "Fourth".

To measure risk aversion, subjects complete a Multiple Price List task (MPL, Holt and Laury, 2002) at the beginning of the session. The task consists of a sequence of 21 binary decisions between a fixed lottery and an increasing safe option. The lottery pays a prize of 5,000 pesetas with 50% probability and nothing otherwise. The safe option ranges from 0 to 5,000 pesetas. At the end of the experiment, we randomly select one of the 21 decisions for payment. We measure risk aversion as the difference between the expected value of the lottery (2,500 pesetas) and the elicited certainty equivalent (the safe amount first preferred to the lottery along the sequence) divided by 2,500 so that we normalize the measure between –1 and +1, with 0 representing risk neutrality.

Finally, at the end of the experiment, subjects complete a standard socio-demographics questionnaire which also includes a three-item Financial Literacy Test (Lusardi and Mitchell, 2008).[10]

3 Main Results

We first discuss gender differences in aggregate behavior, disregarding treatment effects. Figure 1 summarizes our main findings. On average, men make 53 percent more trades per period than women.[11] The difference is highly significant (Mann-Whitney U-test, p<0.0001) and of similar magnitude to previous empirical work (Agnew et al. 2003, Barber and Odean 2001).[12] Men are also significantly

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[9] Even though we measure confidence at the beginning and at the end of each treatment, we only use the former measure in our analysis since the latter is clearly endogenous to actual performance in the treatment.

[10] Question 1: Suppose you had $100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow? a) More than $102; b) Exactly $102; c) Less than $102; d) Do not know; e) Refuse to answer. Question 2: Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account? a) More than today; b) Exactly the same; c) Less than today; d) Do not know; e) Refuse to answer. Question 3: Please specify whether this statement is true or false. "Buying a single company's stock usually provides a safer return than a stock mutual fund." a) True; b) False; c) Do not know; d) Refuse to answer. The questionnaire also includes some additional items used for a different study on the disposition effect (Cueva et al. 2017)

[11] 24 observations in the baseline treatment were lost due to a server crash in one session. This session had the same number of male and female participants (as did most). For these subjects, we compute the mean number of trades per period using the other 3 treatments. Additionally, we exclude one (male) subject as a clear outlier from all of our analysis. This subject averaged 76 transactions per period in the baseline treatment, which is over 14 standard deviations above the mean of the rest of our sample (8.5). No other outliers where detected. For instance, the second most active subject in our sample averaged 29 transactions per period.

[12] We focus our analysis on the number of trades rather than on turnover. A problem with turnover is that, unlike in other empirical studies, our subjects start with no assets. This means that purchases in the first few periods will have a huge impact on turnover (since this variable scales transactions by total portfolio value). One solution would be to ignore early purchases until portfolio size stabilizes. However, the choice of which period to start measuring turnover from would be somewhat arbitrary and unlikely to fit all subjects.

more confident than women (p<0.0001).[13] While women typically believe they will be between second and third in their group of four, most men believe that they will end up between first and second in their group.[14]

Panel (c) of Figure 1 illustrates our main result. Namely, that gender differences in trading activity do not disappear when we control for confidence. In particular, except for subjects in the lowest confidence range (confidence ≤ 2.5), men make significantly more trades than women for every other confidence level (Mann-Whitney U-tests, p<0.01).[15]

We next check whether these results hold in each treatment. Table 1 displays mean number of trades, confidence and the correlation between the two, disaggregated by gender and treatment. Indeed, trading activity is significantly larger for men than for women in all treatments. On average, the difference between men and women is 61, 62, 43 and 39 percent in treatments B, C, T and CT, respectively. Confidence is also significantly higher in men at every treatment, and the gap is stable across treatments. Finally, the correlation between confidence and the number of trades in each treatment is only positive and significant for men in B. In all other cases, the correlation is insignificant.
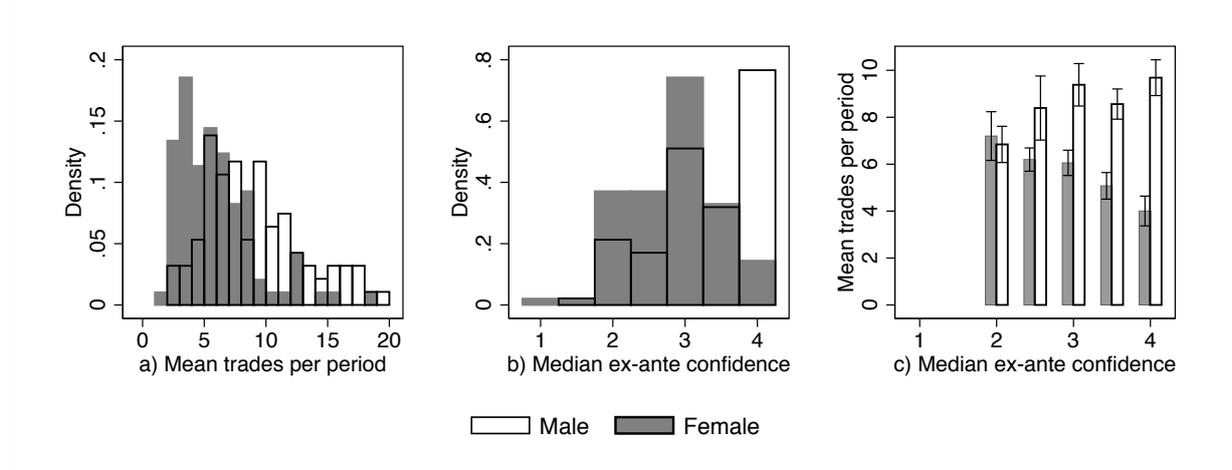
Figure 1. Trading activity and confidence of men and women over all treatments. Panel a) Histograms of mean number of trades per period. Panel b) Histograms of confidence level. Ex-ante confidence is calculated as the median confidence across the four treatments (1=lowest, 4=highest). Panel c) Mean number of trades per period, disaggregated by confidence level (data for confidence level below 2 are omitted due to insufficient observations).

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[13] This is a Mann-Whitney U-test on median ex-ante confidence. Recall that subjects go through 4 treatments, so we take an observation as the median over these four values, as is done in Figure 1.

[14] In trying to explain the gender gap in trading activity, we focus on ex-ante confidence rather than overconfidence (the difference between confidence and actual rank in the group), because the latter is not exogenous to trading activity.

[15] Surprisingly, the right panel of Figure 1 also shows a borderline significant negative correlation between median confidence and mean number of trades for women (Spearman's $\rho = -0.204$; p = 0.045). However, this result does not carry through when we disaggregate behavior treatment by treatment (see Table 1).

Table 1. Means and standard deviations (in parentheses) of number of trades, confidence and overconfidence, disaggregated by treatment and gender.

		B	C	T	CT
# Trades	**Male**	10.614 (5.724)	11.981 (7.326)	6.669 (4.214)	7.350 (4.960)
	Female	6.571 (3.713)	7.389 (4.920)	4.661 (2.764)	5.293 (3.163)
	p-value	<0.0001	<0.0001	0.0003	0.0002
Confidence	**Male**	3.293 (0.711)	3.362 (0.801)	3.106 (0.861)	3.181 (0.879)
	Female	2.812 (0.764)	2.990 (0.823)	2.691 (0.834)	2.835 (0.850)
	p-value	0.0001	0.0008	0.0006	0.0045
Spearman Correlation	**Male**	0.238 (0.031)	0.035 (0.736)	-0.018 (0.864)	-0.008 (0.938)
	Female	0.033 (0.763)	-0.117 (0.253)	-0.108 (0.291)	-0.115 (0.263)
Observations		82 (M), 85 (F)	94 (M), 97 (F)	94 (M), 97 (F)	94 (M), 97 (F)

Note: # Trades = mean number of transactions per period; Confidence = pre-task guess of position in the group of 4 (1 lowest, 4 highest); P-values are computed using Mann-Whitney U-tests. Spearman Correlations display Spearman's ρ and their p-values in parentheses.

Since a subject's confidence may be different in each treatment, we estimate the gender gap using random effects regressions that control for confidence in each treatment. The dependent variable is the natural logarithm of average transactions per period.[16] We estimate 4 random effects regression models with incrementally more controls: Model (1) only includes a dummy for males, treatment dummies, their interactions, and group dummies;[17] Model (2) adds 3 confidence dummies; Model (3) adds confidence×male interactions; finally, Model (4) adds confidence×treatment and confidence× male×treatment interactions. Table 2 reports marginal effects of the male dummy according to these four regressions. Comparing Model 1 with Models 2–4 in Table 2 shows that the estimated gender gap remains highly significant and of very similar magnitude in every treatment whether we control for confidence or not. Full regression results are left to the Appendix.

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[16] This transformation is standard and helps to improve the normality of the data. Adding one to the number of trades before taking logs yields similar results. We choose the former specification because effect sizes are easier to interpret and very few observations are lost (1 in B, 1 in C, 4 in T and 3 in CT).

[17] Recall subjects in each group of four face identical prices and transaction costs.

Table 2. Marginal effects of "male" on (log) average number of transactions per period. Model 1 includes a male dummy, treatment dummies, their interactions, and group dummies. Model 2 adds 3 confidence dummies. Model 3 adds confidence×male interactions. Model 4 adds confidence×treatment and confidence×male×treatment interactions.

	Model 1	Model 2	Model 3	Model 4
B	0.482***	0.491***	0.492***	-
	(0.077)	(0.079)	(0.078)	-
C	0.504***	0.514***	0.514***	0.509***
	(0.094)	(0.096)	(0.097)	(0.099)
T	0.303**	0.313**	0.313**	0.321**
	(0.133)	(0.130)	(0.131)	(0.131)
CT	0.341***	0.349***	0.349***	0.363***
	(0.108)	(0.105)	(0.105)	(0.108)
Confidence	NO	YES	YES	YES
+ Gender interactions	NO	NO	YES	YES
+ Gender & Treatment interactions	NO	NO	NO	YES
N	730	730	730	730

Note: Estimates from random effects GLS regressions with group dummies and standard errors clustered by group. Marginal effects in B for Model 4 are not estimable. See Appendix for full regression results.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

4 Treatment Effects

In this Section, we assess whether there are gender differences in the response to treatment conditions. As we mentioned earlier, the introduction of competition allows us to explore an alternative channel through which gender differences may create a gap in trading activity: willingness to compete. If such a mechanism plays a role, then we would expect the gender gap in trading activity to increase in C, via a reduction in trading activity of women and/or an increase in trading activity of men. Our motivation for introducing trading costs is two-fold. Firstly, it is hard to interpret the economic relevance of large gender differences in trading activity unless trading is costly. Indeed, transaction costs are the key reason why excessive trading is irrational. Secondly, when trading costs are large, only highly confident individuals may be willing to trade. If this is the case, then we might observe a smaller reduction in trading activity in men than in women after the introduction of trading costs.

Table 1 has shown that the gender gap is persistent throughout the four treatments. We now take advantage of our within-subjects design to test for the statistical significance of these treatment effects using paired non-parametric tests.

Figure 2 displays mean number of trades disaggregated by gender and treatment. First, we reject the hypothesis of no treatment differences within groups (Skillings-Mack tests, $p<0.001$ for both men

and women). Second, competition increases trading activity and, surprisingly, the effect is significant at the 5% for women but not for men (B vs C – males: p=0.094, – females: p=0.019; T vs CT – males: p=0.061, – females: p=0.003). However, pairwise difference-in-differences tests fail to reject the hypothesis of no difference between men and women (Mann-Whitney U-tests, C – B: p=0.953; CT – T: p=0.676).

Transaction costs are also clearly associated with a decrease in trading activity for both men and women (Wilcoxon signed-ranks tests, B vs T – males: p<0.001, – females: p<0.001; C vs CT – males: p<0.001, – females: p<0.001). However, pairwise difference-in-differences tests show that their impact is larger in men than in women (Mann-Whitney U-tests, T – B: p=0.006; CT – C: p=0.001). In other words, we find no support for the conjecture that men are less sensitive to transaction costs.[18]
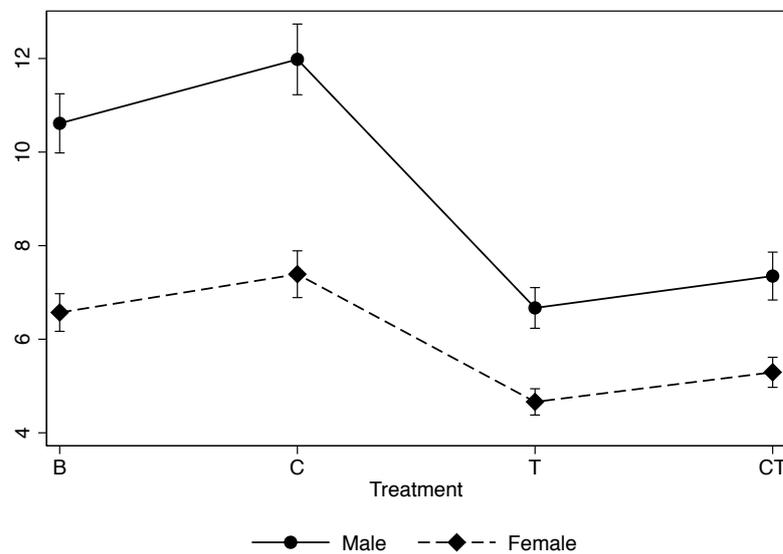

Figure 2. Mean number of trades disaggregated by gender and treatment.

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[18] These results continue to hold if we control for order and group effects using regression analysis (see Appendix).

5 Alternative Explanations

Our evidence strongly suggests that differences in confidence between men and women cannot explain the gender gap in trading activity. Additionally, our analysis of treatment effects does not support the hypothesis that gender differences in willingness to compete explains it either. To rule out other potential mechanisms, we collect data to measure subjects' degree of risk aversion and financial literacy.

Table 3 displays mean values of risk aversion estimated from subjects' choices in the MPL lottery task administered at the start of the experiment. It also displays the proportion of correct answers to each of the financial literacy questions administered at the end of the experiment. Our results show that men are significantly more risk-taking than women. In particular, while women are on average risk averse (Wilcoxon signed-rank test: p=0.001), we cannot reject risk neutrality for men (p = 0.699). Finally, a significantly higher proportion of men answer each of the three financial literacy questions correctly.[19]

Table 3. Means and standard deviations (in parentheses) of risk aversion and financial literacy, disaggregated by gender.

	Risk Aversion	Fin. Lit. 1	Fin. Lit. 2	Fin. Lit. 3
Male	0.025 (0.351)	0.936 (0.246)	0.766 (0.426)	0.670 (0.473)
Female	0.196 (0.429)	0.762 (0.428)	0.454 (0.500)	0.474 (0.502)
N	149	191	191	191
p-value	0.009	0.001	<0.001	0.008

Note: For risk aversion, p-values come from a Mann-Whitney U-test; for each financial literacy question, p-values come from two-tailed Fisher exact tests. The lower number of observations for risk aversion is because 42 subjects made inconsistent choices in the MPL task.

In Figure 3, we partition men and women into four quartiles of risk aversion and four categories of financial literacy. As it can be seen, the gap in trading activity persists in every subgroup.[20] Finally, regression analysis shows that the inclusion of risk aversion and financial literacy makes a negligible difference to the estimated gender gap in trading activity. Table 4 presents the estimated gender effects, while full regression results are left to the Appendix.

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[19] The result that men are more risk seeking than women is well-known (e.g. Charness and Gneezy 2012, Croson and Gneezy 2009, Eckel and Grossman 2008). Gender differences in financial literacy have also been consistently observed (Lusardi and Mitchell 2014), even among college students (Chen and Volpe 2002).

[20] Mann-Whitney U-tests of gender differences in average number of trades give the following p-values: Risk Q1, p=0.003; Risk Q2, p=0.007; Risk Q3, p=0.039; Risk Q4, p=0.003. Fin. Lit. 1, p=0.001; Fin. Lit. 2, p=0.021; Fin. Lit. 3, p=0.002.
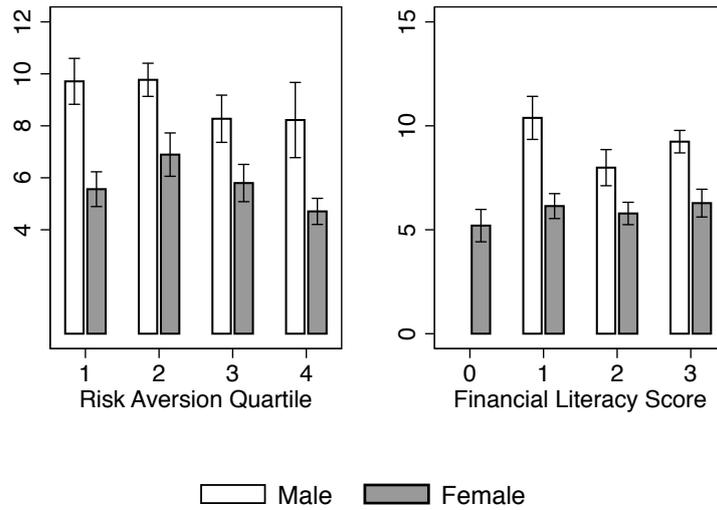
Figure 3. Mean number of trades disaggregated by gender and risk aversion quartile (left), and by gender and financial literacy (right). Male data for a zero score in financial literacy is omitted due to having only a single observation.

Table 4. Marginal effects of "male" on (log) average number of transactions per period. Model (1) only includes gender, treatment dummies, their interactions, and group dummies; Model (2) adds 3 confidence dummies; Model (3) adds risk aversion; Model (4) adds financial literacy.

	Model 1	Model 2	Model 3	Model 4
B	0.581***	0.598***	0.577***	0.566***
	(0.106)	(0.108)	(0.111)	(0.121)
C	0.600***	0.615***	0.593***	0.583***
	(0.117)	(0.122)	(0.124)	(0.129)
T	0.362**	0.379**	0.358**	0.348**
	(0.161)	(0.158)	(0.158)	(0.157)
CT	0.384***	0.396***	0.373***	0.363***
	(0.132)	(0.131)	(0.133)	(0.126)
Confidence	NO	YES	YES	YES
Risk Aversion	NO	NO	YES	YES
Financial Literacy	NO	NO	NO	YES
N	566	566	566	566

Note: Estimates from random effects GLS regressions with group dummies and standard errors clustered by group. See Appendix for full regression results. To keep the four models comparable, 43 subjects were excluded from the regressions due to making inconsistent choices in the MPL task, which made it impossible to determine their risk aversion.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

6 Discussion

Our experimental evidence replicates findings documented in the empirical literature that males are (*i*) more confident and (*ii*) trade more than women. However, we do not find any support for the conjecture by which (*i*) explains (*ii*). The gender gap in trading activity persists when we compare males and females with the same confidence level, or when we control for confidence in our regression analyses. In this respect, our results clearly contradict the conclusions of Barber and Odean (2001) that gender differences in overconfidence are responsible for the gender gap in trading activity.

Three previous experimental studies have attempted to assess jointly the relationship between gender, overconfidence and trading activity. However, for reasons that will become apparent below, it is difficult to draw clear conclusions from their results.

Biais et al. (2005) study miscalibration and self-monitoring in an experimental market with asymmetric information.[21] The authors find that subjects with high miscalibration and low self-monitoring are more likely to suffer from the winner's curse and consequently earn lower profits. However, even though they find significant gender differences in trading activity, neither miscalibration nor self-monitoring differed significantly between men and women.

Deaves et al. (2008) measure three forms of overconfidence: miscalibration, better-than-average ability and illusion of control.[22] In their experiment, subjects trade in several markets with asymmetric information. However, the informativeness of private signals depends on subjects' performance in the general knowledge miscalibration task. The relationship between this form of overconfidence and subsequent trading behavior is therefore built into the experimental design. The authors find significant gender differences in trading activity only in sessions with a balanced gender mix. In contrast, they do not find significant gender differences in any of their overconfidence measures.[23]

Finally, Fellner-Röhling and Krügel (2014) conduct experimental markets with asymmetric information after measuring participants' miscalibration (both in general knowledge and in time series forecasting) and their degree of overweighting of private signals in a prediction task. Although trading activity is significantly higher for men, no gender differences are found in any of their overconfidence measures except in the general knowledge miscalibration task, in which women are in fact more overconfident than men.

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[21] Miscalibration is the overestimation of the precision of one's knowledge. It is measured by asking subjects to provide 90% confidence intervals to a series of (typically general knowledge) questions with a numerical answer, such as the length of the river Nile, for example. Self-monitoring is a self-assessed measure of attention to social cues and adaptation to the social environment.

[22] Better-than-average ability is measured after trading by asking subjects to guess how many people in the experiment had earned more money than themselves. Illusion of control is measured before trading by asking subjects for their level of agreement with two statements concerning their ability to detect or buy securities, which will perform well in the future.

[23] Half of the sessions are conducted in Canada with groups of subjects with similar miscalibration and the same gender. The other half of the sessions are conducted in Germany with a balanced gender mix and either the most overconfident subjects or the least overconfident subjects in terms of the miscalibration task. Firstly, it is likely that the homogenous gender composition of some of these markets had a large effect on trading activity, as found in Cueva and Rustichini (2015). Secondly, the study is conducted with only 34 men and 30 women in total, which, combined with the heterogeneous market conditions, severely limits the power of their analysis.

The first and most important limitation of the three experimental studies above is that neither of them observe clear gender differences in their chosen measures of confidence. In contrast with overconfidence in performance at a given task, which has been shown to vary consistently between men and women, calibration-based overconfidence has not been documented to differ systematically in the same way. This raises doubts as to whether miscalibration is the right measure to explain the gender gap in trading activity. A second limitation of these studies is that experimental asset markets are typically volatile and very sensitive to the actions of a single individual. The behavior of each trader in a given market is not an independent observation, which makes it harder to make reliable *ceteris paribus* comparisons between men and women. This does not happen in our experiment, where prices are determined independently of the actions of traders. A third limitation is that neither of these experiments involve trading costs. In contrast, the empirical finance literature emphasizes trading costs as a key reason why trading too much is costly (Barber et al. 2009, Barber and Odean 2000, Odean 1999). Lastly, with the exception of the signal-based prediction task in Fellner-Röhling and Krügel (2014), none of the confidence measures in these studies are incentivized.

The fact that confidence does not explain why men trade so much more than women in our experiment raises two questions:

(1) Is confidence a good predictor of trading activity?

Despite the theoretical appeal of overconfidence as the primary cause of excess trading, empirical evidence in support of this view is mixed. In our experiment, ex-ante confidence is uncorrelated with trading activity, except for men in the baseline treatment. Glaser and Weber (2007) administered a questionnaire to around 200 online broker clients, which measured overconfidence in three different ways: miscalibration, volatility estimation and better-than-average ability.[24] They only found a significant correlation using the better-than-average measure. The correlation was significant at the 5% level with turnover, and only at the 10% level with the number of trades. On the other hand, Dorn and Sengmueller (2009) surveyed nearly 900 brokerage clients and found no correlation between better-than-average confidence and excess turnover. Finally, Grinblatt and Keloharju (2009) found a significant positive correlation between the number of trades and an overconfidence measure constructed from tests taken in the Finnish army on a sample of around 11,500 men, but no correlation with turnover.[25]

(2) What factors, other than confidence, might explain gender differences in trading activity?

If gender differences in trading activity cannot be explained by differences in confidence, other mechanisms should be explored. Our first approximation was to examine gender differences in competitiveness, risk aversion and financial literacy. However, none of these measures were able to explain a significant portion of the gender gap in trading activity.

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[24] Volatility estimation was measured by asking subjects to forecast time series of stock market prices, providing medians and 90% confidence intervals.

[25] This test was focused on self-assessments about personal abilities, social image and self-worth.

One possibility that we did not examine is that men might enjoy trading more than women do. In their survey, Dorn and Sengmueller (2009) find that traders who report that they enjoy investing and gambling trade much more frequently than the rest. They also find that men are more likely to strongly agree with the statements "I enjoy investing" and "I enjoy taking risky positions". Controlling for these survey responses somewhat reduces the gender gap in turnover, although it still remains large and significant. Along similar lines, Grinblatt and Keloharju (2009) argue that, since trading is a risky activity, it may be particularly attractive to sensation seekers. In support of this hypothesis, the authors find a significant positive correlation between speeding tickets (their proxy for sensation seeking) and trading activity. However, the authors continue to find a large gender effect and do not report how it changes by the inclusion of their sensation seeking measure.

Sensation-seeking and gambling attitudes have been found to systematically vary by gender. For instance, Cross et al. (2011) find in a meta-analysis that men are more sensation seeking than women on both questionnaire and behavioral measures, while Salonen et al. (2017) observe that men have more positive attitudes towards gambling than women. How much of the gender gap in trading activity can be accounted for by a combination of these measures remains an open question. However, it seems clear that future research must look beyond overconfidence.

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Online Appendix

Table A1. Random effects GLS regressions. Dependent variable: log of average number of transactions per period. Model 1 includes a male dummy, treatment dummies, their interactions, and group dummies. Model 2 adds 3 confidence dummies. Model 3 adds confidence×male interactions. Model 4 adds confidence×treatment and confidence×male×treatment interactions.

	Model 1	Model 2	Model 3	Model 4
male	0.482***	0.491***	0.637***	0.638
	(0.0773)	(0.0787)	(0.209)	(0.467)
T	-0.358***	-0.360***	-0.359***	-0.0334
	(0.0660)	(0.0657)	(0.0658)	(0.252)
C	-0.179	-0.179	-0.183	-0.0382
	(0.110)	(0.109)	(0.113)	(0.489)
C×T	0.0773	0.0810	0.0807	0.560**
	(0.0606)	(0.0607)	(0.0568)	(0.264)
male×T	0.0218	0.0223	0.0189	-0.361
	(0.0933)	(0.0932)	(0.0898)	(0.447)
male×C	0.0367	0.0358	0.0353	-0.364
	(0.0664)	(0.0655)	(0.0652)	(0.269)
male×C×T	0.0162	0.0139	0.0192	0.109
	(0.121)	(0.120)	(0.121)	(0.246)
confidence_2		0.0334	0.0997	0.415
		(0.0862)	(0.123)	(0.268)
confidence_3		0.00165	0.0582	0.345
		(0.0776)	(0.119)	(0.267)
confidence_4		-0.0220	0.0322	0.396
		(0.0935)	(0.132)	(0.274)
male×confidence_2			-0.167	-0.296
			(0.201)	(0.492)
male×confidence_3			-0.144	-0.225
			(0.212)	(0.458)
male×confidence_4			-0.139	-0.0969
			(0.212)	(0.430)
T×confidence_2				-0.297
				(0.272)
T×confidence_3				-0.365
				(0.307)
T×confidence_4				-0.387
				(0.328)
male×T×confidence_2				-0.0901
				(0.550)
male×T×confidence_3				0.0141
				(0.509)
male×T×confidence_4				-0.243
				(0.462)

C×confidence_2				-0.563**
				(0.285)
C×confidence_3				-0.444
				(0.281)
C×confidence_4				-0.558*
				(0.294)
male×C×confidence_2				0.498
				(0.555)
male×C×confidence_3				0.479
				(0.468)
male×C×confidence_4				0.338
				(0.452)
C×T×confidence_2				0.421
				(0.313)
C×T×confidence_3				0.426
				(0.293)
C×T×confidence_4				0.429
				(0.357)
male×C×T×confidence_2				-0.0243
				(0.377)
male×C×T×confidence_3				-0.288
				(0.356)
Constant	1.746***	1.747***	1.690***	1.400***
	(0.0513)	(0.0948)	(0.120)	(0.259)
Observations	730	730	730	730
Number of id	191	191	191	191

Note: T=1 if treatment involves transaction costs; C=1 if treatment involves competitive payments; confidence_j = 1 if individual guesses he will be in position jth in the group, where 1 is worst and 4 is best. The regressions include group dummies, omitted for brevity. Standard errors (in parentheses) are clustered by group. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A2. Random effects GLS regressions. Dependent variable: log of average number of transactions per period. Models (1) to (4) incrementally control for confidence, risk aversion and financial literacy.

	Model 1	Model 2	Model 3	Model 4
male	0.581***	0.598***	0.577***	0.566***
	(0.106)	(0.108)	(0.111)	(0.121)
T	-0.366***	-0.366***	-0.367***	-0.367***
	(0.0820)	(0.0821)	(0.0822)	(0.0823)
C	0.0673	0.0754	0.0767	0.0761
	(0.0807)	(0.0793)	(0.0792)	(0.0795)
T×C	0.0466	0.0431	0.0432	0.0433
	(0.0866)	(0.0857)	(0.0854)	(0.0860)
male×T	-0.219	-0.219	-0.219	-0.219
	(0.136)	(0.135)	(0.135)	(0.136)
male×C	0.0193	0.0169	0.0156	0.0167
	(0.112)	(0.112)	(0.112)	(0.113)
male×T×C	0.00194	-0.000404	-0.000477	-0.00125
	(0.143)	(0.142)	(0.142)	(0.143)
confidence_2		0.0524	0.0506	0.0521
		(0.106)	(0.107)	(0.108)
confidence_3		0.0271	0.0202	0.0249
		(0.0871)	(0.0883)	(0.0907)
confidence_4		-0.0212	-0.0339	-0.0296
		(0.108)	(0.106)	(0.109)
Risk aversion			-0.206**	-0.205**
			(0.0980)	(0.103)
Fin. Lit. 1				0.0593
				(0.149)
Fin. Lit. 2				0.0341
				(0.0999)
Fin. Lit. 3				-0.0615
				(0.0812)
Observations	566	566	566	566
Number of id	149	149	149	149

Note: T=1 if treatment involves transaction costs; C=1 if treatment involves competitive payments; confidence_j = 1 if individual guesses he will be in position jth in the group, where 1 is worst and 4 is best; Fin. Lit. j = 1 if question j of the financial literacy test is answered correctly. To keep the 4 models comparable, 43 subjects were excluded from the regressions due to making inconsistent choices in the MPL task, which made it impossible to determine their risk aversion. The regression includes group dummies, omitted for brevity. Standard errors (in parentheses) are clustered by group. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A3. Random effects GLS regression. Dependent variable: log of average number of transactions per period.

male	0.491***
	(0.0782)
T	-0.339***
	(0.0691)
male×T	-0.194*
	(0.111)
C	0.0923
	(0.0595)
male×C	0.0198
	(0.0931)
T×C	0.0230
	(0.0668)
male×T×C	0.0188
	(0.122)
experience2	0.00515
	(0.0394)
experience3	-0.131**
	(0.0520)
experience4	-0.121**
	(0.0477)
Observations	730
Number of id	191

Note: T=1 if treatment involves transaction costs; C=1 if treatment involves competitive payments; experience_j = 1 if individual is in the jth treatment, where 1 is the first and 4 is the last. The regressions include group dummies, omitted for brevity. Standard errors (in parentheses) are clustered by group. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A4. Marginal effects of competition and transaction costs on (log) average number of transactions per period disaggregated by gender.

Competition	female	0.104**	**Transaction Costs**	female	-0.327***
		(0.044)			(0.056)
	male	0.133***		male	-0.512***
		(0.043)			(0.068)
N		730			730

Note: Based on estimates from Table A3. The effect of competition is not statistically different for males and females (Chi-squared test, $p=0.661$). The effect of transaction costs is larger for males than for females ($p=0.043$). *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Experiment Instructions (translated from Spanish for online publication)

Welcome to the experiment. This is an experiment to study how individuals make decisions. We are only interested in what individuals do on average. Do not think that any particular behavior is expected from you.

Please read these instructions carefully. Throughout the experiment, you will be able to buy and sell assets using experimental currency. To simplify the presentation, we will use *pesetas* as experimental currency. The amount of pesetas you can earn depends on the decisions you make and, in some cases, the decisions made by other participants. At the end of the experiment you will be asked to fill in a short questionnaire.

Once you finish the experiment you will be paid privately and in cash the earnings you have obtained in the experiment.

The exchange rate is 1000 pesetas = 1 €

Please, it is important that you make all decisions privately. Therefore, do not talk to other participants during the experiment. You cannot use mobile phones during the experiment. If you need help, raise your hand and remain silent. We will answer your question as soon as possible.

The experiment lasts approximately 2 hours and consists of four rounds and a warm-up round. Each round consists of 14 periods (from -3 to 10). In periods -3 to 0 you will receive information on the prices of 6 assets (A, B, C, D, E and F), although you will not be able to buy or sell. In period 1 of each round you will receive an endowment of 5000 pesetas that you can use to buy and sell units of the 6 assets for the next 9 periods (period 1 to 9).

LOTTERY ROUND

You have 21 decisions between a fixed payment and a lottery. The lottery is always the same: there is a 50 % chance of winning 5000 pesetas and a 50 % chance of winning nothing. At the end of the experiment we will randomly select one of the 21 decisions. If in that decision you chose the safe payment, you will be paid that amount. If you chose the lottery, the computer will "flip a coin": if heads you will get 5000 pesetas and if tails you will get nothing.

FIRST ROUND

In this round, you will be in a group of 4 randomly selected participants. You will never know who is in your group, and no one will know if you are in his/her group, neither during nor after the experiment. The 4 members in the group participate in a small financial market consisting of 6 assets. All assets have the same initial price (in period -3) of 100 pesetas. From there, the price of each asset will change: it will go up by 6% or down by 5%. The probability of a price increase may be different for each asset but is constant for the same asset over each round. At the beginning of each round, the computer randomly chooses new probabilities of up or down for each asset, which will remain constant for that round. That means that the same asset can have a very high probability of rising in a round, and very low in another.

Suppose, for example, that an asset has a probability of price increase of 0.55 (i.e. 55%). This means that in each period, the current price can go up a 6% with a probability of 55%, or down a 5% with a probability of 45% (= 100% -55%).

This means that, if in a given period the price of an asset is 113.9 pesetas, its price in the next period will rise by 6% to 120.7 pesetas (= 113.9 × (1 +0.06)) with probability 0.55 or will fall 5% to 108.2 pesetas (= 113.9 × (1-0,05)) with probability 1-.55 = 0.45 .

These probabilities will be unknown for you. However, remember that they will not change within each round. In addition, price changes are independent of each other and independent of your trading decisions. They are also independent of the decisions of others.

In each of the periods from period 1 to period 9 you can buy or sell assets. In the figure below you can see the computer screen. At the top, you can see the prices of assets A-F throughout the round. In this case, we only show prices up to period 5.

Periodo	5 de 10								Tiempo restante [sec]: 9
	Per.-3	Per.-2	Per.-1	Per.0	Per.1	Per.2	Per.3	Per.4	Per.5
Activo A Precio: / Comp./Vend. (+/-)	100 / ---	96 / ---	92 / ---	98 / ---	104 / 3	110 / -2	116 / 0	122 / 0	116 / 0
Activo B Precio: / Comp./Vend. (+/-)	100 / ---	106 / ---	100 / ---	96 / ---	102 / 4	96 / 0	92 / -2	88 / 0	84 / 0
Activo C Precio: / Comp./Vend. (+/-)	100 / ---	96 / ---	92 / ---	98 / ---	94 / 6	100 / 0	96 / 8	92 / 0	98 / 0
Activo D Precio: / Comp./Vend. (+/-)	100 / ---	106 / ---	100 / ---	96 / ---	102 / 8	108 / -2	102 / -2	96 / 0	102 / 0
Activo E Precio: / Comp./Vend. (+/-)	100 / ---	106 / ---	112 / ---	118 / ---	126 / 4	134 / 0	142 / -1	150 / 0	160 / 0
Activo F Precio: / Comp./Vend. (+/-)	100 / ---	96 / ---	92 / ---	98 / ---	94 / 7	90 / 7	86 / -1	82 / 0	78 / 0

	En mi cartera	Precio Actual		
Activo A	1	116	Compra 1	Vende 1
Activo B	2	84	Compra 1	Vende 1
Activo C	14	98	Compra 1	Vende 1
Activo D	4	102	Compra 1	Vende 1
Activo E	3	160	Compra 1	Vende 1
Activo F	13	78	Compra 1	Vende 1
SALDO:	392			

The top of the screen shows the evolution of the prices of the six assets A-F from period -3, and all the transactions you have already made.[26] Since in periods -3, -2 , -1 and 0 you cannot buy or sell, the number of transactions for these periods is always 0. Purchases from period 1 onwards are represented by positive numbers and sales by negative numbers.

The bottom of the screen contains your transactions. Here you can decide whether to buy or sell one or more units of assets A-F. The column "En mi cartera" indicates the number of units of each asset you own. The column "Precio actual" means the price you pay for each additional unit you want to buy and also the price you receive for each unit you want to sell. You can also see how many pesetas you still have available under "SALDO".

If you want to buy an asset, you have to pay for each unit the current price of the asset. You can never spend more money than you have available (your "SALDO"). To purchase an asset, you have to click the "Compra 1" button. If you want to buy more than one unit, you simply have to click as many times as units you want to buy.

Example: Suppose we are in period 5 and Asset A has a price of 116 pesetas, as in the figure above. If you decide to buy 3 units of A, you will have to click three times on the "Compra 1" button. You will spend 3×116 = 348 pesetas in this transaction. This amount is subtracted from your SALDO.

If you own units of an asset, then you have the option to sell these units. For each unit you sell you will receive the current price of the asset. The number of units you sell cannot exceed the number of units you own.

Example: Suppose we are in period 5 and Asset C has a price of 98 pesetas, as in the figure above. You have 14 units of C and you want to sell 3 of them. To do this you have to click 3 times on the "Vende 1" button. You will receive 3×98 = 294 pesetas that will be added to your SALDO.

In each period, you have a limited time to make your decisions. This time will be one minute. You will see the remaining time in red on the top right corner of the screen.

The round ends in period 10. In period 10 you will not be able to buy or sell assets. The prices of period 10 will determine the final value of your portfolio. The value of the portfolio will be added automatically to your "SALDO" and will be part of your earnings.

At the beginning and end of the round we will ask you to tell us what position you believe you will be in terms of profits within the group of 4 people to which you belong. Every time you guess correctly, you will be paid 100 pesetas.

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[26] Due to a small programming error, prices were rounded to the nearest even number, rather than to the nearest integer. No subject seemed to notice this otherwise inconsequential fact.

Also, before periods 1, 6 and 10 we will ask you to guess, which one of the 6 assets is the best (i.e., the one whose probability of price increase is highest), which one is the second best, which one is the worst (the one whose probability of price increase is the lowest) and which one is the second worst. Each time you guess correctly the four questions, you will receive an additional 100 pesetas. For these two decisions, there is no time limit. However, we ask you not to take too long because the round cannot continue until you make your decision.

In short, your gains in this first round are:

Your SALDO

+ The value of the assets in your portfolio

+ What you have earned guessing your position

+ What you have earned guessing the assets

To familiarize yourself with the mechanics of the experiment, we will start with a small trial practice.

SECOND ROUND

This second round is similar to the first, with a variation. As in the first round you will be in a group of 4 randomly selected participants. You will never know who is in your group, and no one will know if you are in his/her group, neither during nor after the experiment. Again, you will have an initial endowment of 5000 pesetas to participate. The difference with the previous round has to do with the profits you can get. Specifically, your earnings in this round are:

If you are the winner in your group of 4 (i.e., if at the end of the round the value of your assets plus your "SALDO" is greater than those of the other 3 members of your group), you will receive:

(The value of the assets in your portfolio + your "SALDO") × 2

+ What you have earned guessing your position

+ What you have earned guessing the assets

If you are not the winner in your group of 4, then you will receive:

+ What you have earned guessing your position

+ What you have earned guessing the assets

THIRD ROUND

This third round is similar to the first round, with a variation. As in the first round you will be in a group of 4 randomly selected participants. You will never know who is in your group, and no one will know if you are in his/her group, neither during nor after the experiment. Again, you will have an initial endowment of 5000 pesetas to participate. The difference is that each time you buy or sell an asset, you will have to pay a fee that is a percentage of the value of the asset. The fee is the same for all members of each group, although it can vary across groups. At the bottom of the screen you will see the amount of the fee.

Example: We are in period 3 and asset A has a price of 130 pesetas. The fee applied to transactions is 1%. If you want to buy 4 units of A you have to pay $4 \times 130 = 520$ pesetas plus $4 \times 130 \times 0.01 = 5.2$ pesetas in fees. In total this transaction has a cost of $520 + 5.2 = 525.2$ pesetas. This amount is subtracted from your "SALDO".

Example: We are in period 8 and asset E has a price of 90 pesetas. The fee is 4%. Suppose you own 5 units of E and you decide to sell 3 of them. By selling those 3 units you receive $3 \times 90 = 270$ pesetas, but you have to pay fees of $3 \times 90 \times 0.04 = 10.8$ pesetas, so your net revenue will be $270 - 10.8 = 259.2$ pesetas that will be added to your "SALDO".

IMPORTANT: The fee will be charged automatically each time you press the "Compra 1" or "Vende 1" button. You must be careful because if you buy a unit of an asset and sell it within the same period, you will pay the fee twice.

Your earnings in this round are:

Your SALDO
+ The value of the assets in your portfolio
+ What you have earned guessing your position
+ What you have earned guessing the assets

FOURTH ROUND

This fourth and final round is similar to the second round, but also as in the third round each time you buy or sell an asset, you will have to pay a fee that is a percentage of the value of the asset. The fee is the same for all members of each group, although it can vary across groups. At the bottom of the screen you will see the amount of the fee. As in previous rounds you will be in a group of 4 randomly selected participants. You will never know who is in your group, and no one will know if you are in his/her group, neither during nor after the experiment. Again, you will have an initial endowment of 5000 pesetas to participate.

Your earnings in this round are:

If you are the winner in your group of 4 (i.e., if at the end of the round the value of your assets plus your "SALDO" is greater than those of the other 3 members of your group), you will receive:

(The value of the assets in your portfolio + your "SALDO") × 2
+ What you have earned guessing your position
+ What you have earned guessing the assets

If you are not the winner in your group of 4, then you will receive:

+ What you have earned guessing your position
+ What you have earned guessing the assets

Once you finish the four rounds, your total earnings will be the sum of the earnings of the four rounds plus the result of the lottery round.

To finish we ask you to answer a short questionnaire. Once you finish you can leave the room and wait outside. Do not forget to pick up your ID number. We will call you to come in to collect your earnings.

Thank you all!