Personal Characteristics, Traders' Performance and Bubbles in Small and Large Online Asset Markets

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November 12, 2021

Motivation

General Idea

"Invisible hand wave" argument: individual biases do not matter in competitive markets (Thaler, 2015)

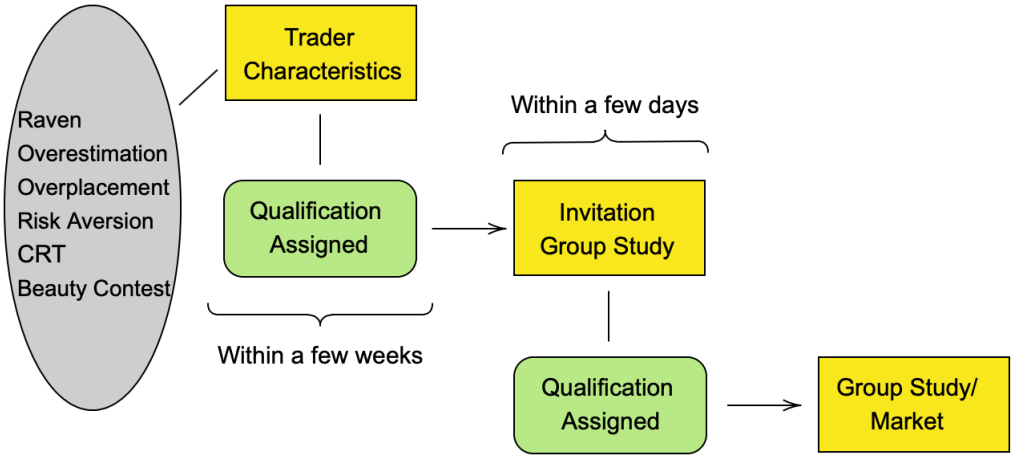
- Are bubbles robust to large markets?
- How robust are the laboratory markets results with student populations to other populations?
- Is there any/more support for the "invisible hand wave" argument in large markets?
- Are traders' characteristics related to traders' performance and their strategies?

What do we do?

Contributions

- Methodological: implement online markets [Arechar et al., 2018]
- Compare individual and aggregate outcomes in small and large markets with different populations
  - [Hommes et al., 2021, Weitzel et al., 2019, Williams, 2008, Bossaerts and Plott, 2004]
- Study the relationship between trader's characteristics (cognitive skills, overconfidence, strategic intelligence), their performance and bubble formation in a unified framework
  - Cognitive finance [Bosch-Rosa and Corgnet, Bosch-Rosa et al., 2018, Corgnet et al., 2018, Miklánek and Zajíček, 2020]
  - Overconfidence [Michailova and Schmidt, 2016, Ahrens et al., 2019],

MTurk Implementation



The environment

Smith, Suchanek and Williams, 1988

- Finite horizon
- Asset has a life of 10 periods
- At the end of each period asset yields $\{0, 8, 28, 60\}$ with equal probability, i.i.d. over time
- After final dividend realization, assets are worthless
- Sequence of two markets
- Total franc holdings at the end of the final period of a randomly selected market are converted to USD and paid to the subjects

Why SSW?

- Fundamental value is well-defined
  - $\Rightarrow$ identify bubbles
- Bubbles are a robust phenomenon in this framework
  - $\Rightarrow$ study the interaction between traders' characteristics, market size, bubble formation and traders' performance
- Environment is widely studied
  - $\Rightarrow$ "ideal" benchmark to compare our results with

Conjectures

Aggregate Level

- Conjecture 1: Bubbles are smaller in larger markets

Individual Level

- Conjecture 2: Personal characteristics matter less in larger markets.

Session Summary

Session	Treatment	No. of Markets	Subjects	Trader's Characteristics
Lg.1	Large Call Market	2	52	Yes
Lg.2	Large Call Market	2	33	Yes
Lg.3	Large Call Market	2	56	Yes
Lg.4	Large Call Market	2	40	Yes
Lg.5	Large Call Market	2	44	Yes
Sm.1	Small Call Market	2	19	Yes
Sm.2	Small Call Market	2	12	Yes
Sm.3	Small Call Market	2	19	Yes
Sm.4	Small Call Market	2	14	Yes
Sm.5	Small Call Market	2	10	Yes
Stu. 1-5	Student Markets	1	9	No

- Avg market earning: \$10.05, Avg Trader Char. earning: \$3.91, Avg Stu. Earnings: \$24
- total market subjects : 299 (MTurk), 45 (students)
- individual tasks from April 2021 to October 2021: 532

Group Study/Market

Market -- Period 1 of 10

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Average dividend for this period to be paid per unit of X:	24.0	**Minimum total dividend to be paid per unit of X held:**	0
Average total dividend to be paid per unit of X held:	240.0	**Maximum total dividend to be paid per unit of X held:**	600

Your cash: 6667.00 francs

Number of units of X you hold: 10.00

Buy Order

Number of units of X you want to buy: 0

The highest price at which to buy: 0.00 francs

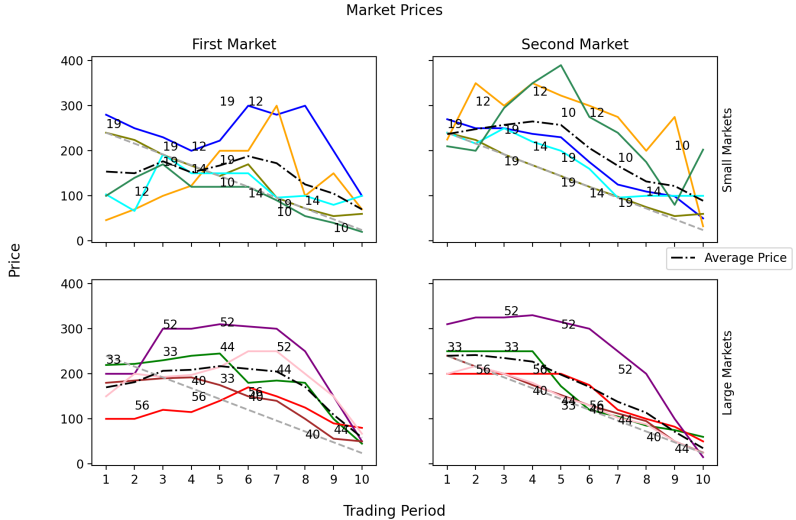
Sell Order

Number of units of X you want to sell: 0

The lowest price at which to sell: 0.00 francs

Next

Small vs Large Overview (MTurk/Online)



Bubble Measures

Medians over all session by market number and size.

Measure	Small 1st	Small 2nd	Large 1st	Large 2nd	Student
Turnover $= \frac{1}{10}\sum_{t=1}^{10} q_t/\mathrm{TSU}$	0.06	0.05	0.09	0.08	0.08
Amplitude $= \max_t \left\{\frac{\mathrm{P}_t - \mathrm{FV}_t}{\mathrm{FV}_1}\right\} - \min_t \left\{\frac{\mathrm{P}_t - \mathrm{FV}_t}{\mathrm{FV}_1}\right\}$	0.82	0.32	0.82	0.34	0.44
Norm. Dev. $= \frac{1}{\mathrm{TSU}}\sum_{t=1}^{10} q_t \lvert \mathrm{P}_t - \mathrm{FV}_t \rvert$	2.90	2.28	5.03	2.40	4.11
RND $= \frac{1}{\mathrm{TSU}}\frac{1}{10}\sum_{t=1}^{10} \frac{\mathrm{P}_t - \mathrm{FV}_t}{\mathrm{FV}_t}$	0.01	0.03	0.04	0.03	0.00
RAD $= \frac{1}{10}\sum_{t=1}^{10} \frac{\lvert \mathrm{P}_t - \mathrm{FV}_t \rvert}{\overline{\mathrm{FV}}}$	0.36	0.36	0.48	0.23	0.29
RPAD $= \frac{1}{\mathrm{TSU}}\frac{1}{10}\sum_{t=1}^{10} \frac{\lvert \mathrm{P}_t - \mathrm{FV}_t \rvert}{\mathrm{FV}_t}$	0.59	0.60	0.68	0.35	0.35

Comparison of Bubble Measures: Small vs Large

Measure	First Market U	First Market P-value	Second Market U	Second Market P-value
TR ($\neq$)	2.0000	0.0317	2.0000	0.0317
Amp. (>)	12.5000	1.0000	15.0000	0.6905
ND (>)	7.0000	0.8889	12.0000	0.5794
RND (>)	10.0000	0.7262	16.0000	0.2738
RAD (>)	10.0000	0.7262	18.0000	0.1548
RPAD (>)	10.0000	0.7262	20.0000	0.0754

Small vs Large Markets (Market level Mann-Whitney U test)

- No differences between small and large markets

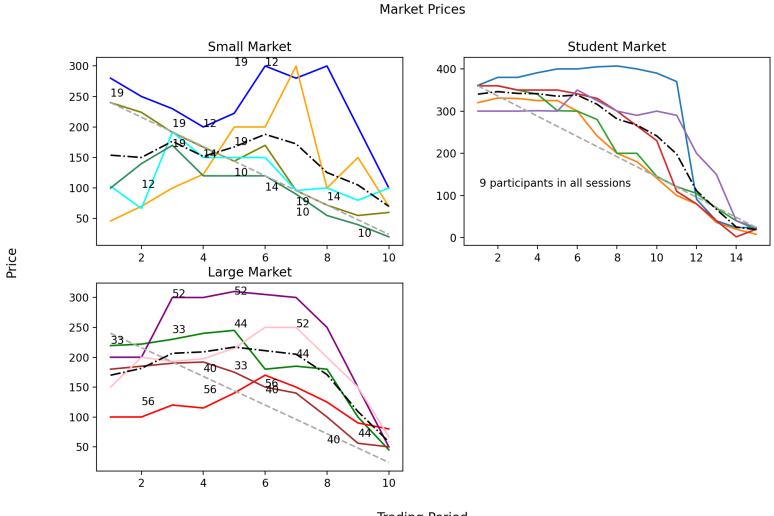
Comparison of Bubbles Measures: First Mkt. vs Second Mkt.

	Small Mkt.		Large Mkt.	
Measure	W	P-value	W	P-value
TR ($\neq$)	3.000	0.312	1.000	0.125
Amp. (>)	13.000	0.094	15.000	0.031
ND (>)	9.000	0.406	15.000	0.031
RND (>)	6.000	0.688	13.000	0.094
RAD (>)	7.000	0.594	14.000	0.062
RPAD (>)	6.000	0.688	15.000	0.031

First vs Second Market (Market level Wilcoxon signed-rank test)

- In small markets bubble measure constant over time
- In large markets price amplitude and devations decrease over time.

Comparison with Student Data



Comparison with Student Laboratory Markets

	Small & Stu.		Large & Stu.	
Measure	U	P-value	U	P-value
TR ($\neq$)	6.0000	0.2222	17.0000	0.4206
Amp. ($\neq$)	19.0000	0.2222	20.0000	0.1425
ND ($\neq$)	11.0000	0.8413	16.0000	0.5476
RND ($\neq$)	16.0000	0.5476	21.0000	0.0952
RAD ($\neq$)	15.0000	0.6905	19.0000	0.2222
RPAD ($\neq$)	18.0000	0.3095	21.0000	0.0952

Market 1 Online Sessions vs Student Laboratory Markets (Market level Mann-Whitney U test)

- Only marginally significant differences in deviations from FV in large markets.

Table 1: Participant Earnings

	Dependent variable: Earnings		
	All	Small	Large
	(1)	(2)	(3)
Raven	0.001	-0.018	0.013
	(0.014)	(0.027)	(0.011)
Overestimation	0.002	0.029	-0.005
	(0.025)	(0.034)	(0.032)
Overplacement	-0.004	-0.030	0.008
	(0.015)	(0.030)	(0.015)
Risk Aversion	-0.004	-0.026	0.010
	(0.026)	(0.035)	(0.039)
CRT	0.160**	0.032	0.204**
	(0.070)	(0.060)	(0.087)
BCG Guess	-0.001	0.005*	-0.005
	(0.004)	(0.003)	(0.006)
Strategic Int.	0.002	0.002	0.005
	(0.003)	(0.007)	(0.004)
Constant	9.869***	10.020***	9.711***
	(0.251)	(0.255)	(0.314)
Observations	550	124	426
R^2	0.017	0.048	0.031
Adjusted R^2	0.005	-0.010	0.015
Residual Std. Error	1.297 (df = 542)	1.022 (df = 116)	1.356 (df = 418)
F Statistic	1.363 (df = 7; 542)	0.834 (df = 7; 116)	1.936* (df = 7; 418)

Note: *p<0.1; **p<0.05; ***p<0.01
Clustered SE at session level.

Table 2: Trader Activity

	Bids	Contracts to Buy	Asks	Contracts to Sell	Total Contracts
	(1)	(2)	(3)	(4)	(5)
Raven	8.682	-0.136	1.281**	0.191	0.055
	(8.435)	(0.340)	(0.559)	(0.146)	(0.270)
Overestimation	4.593	-0.076	-1.175	-0.150	-0.226
	(6.933)	(0.242)	(0.802)	(0.131)	(0.145)
Overplacement	4.658	0.026	0.961*	0.161*	0.187
	(3.802)	(0.187)	(0.503)	(0.097)	(0.249)
Risk Aversion	12.809	-0.330*	-2.228***	-0.287*	-0.618**
	(9.933)	(0.183)	(0.858)	(0.156)	(0.263)
CRT	37.324	-0.055	5.039*	1.613***	1.558***
	(30.526)	(0.467)	(2.687)	(0.387)	(0.525)
BCG Guess	-2.725	0.063**	0.188*	-0.016	0.047
	(2.874)	(0.029)	(0.096)	(0.028)	(0.055)
Strategic Int.	3.164	-0.039	-0.273**	-0.022	-0.062
	(4.179)	(0.036)	(0.121)	(0.037)	(0.067)
Constant	-69.037	10.042**	18.174***	6.606***	16.649***
	(138.954)	(4.051)	(5.628)	(1.983)	(3.934)
Observations	550	550	550	550	550
R^2	0.026	0.013	0.088	0.087	0.028
Adjusted R^2	0.014	0.0001	0.076	0.075	0.016
Residual Std. Error (df = 542)	465.367	13.314	41.255	8.347	16.829
F Statistic (df = 7; 542)	2.080**	1.009	7.461***	7.339***	2.271**

Note: *p<0.1; **p<0.05; ***p<0.01
Clustered standard errors at session level

Table 3: Trader Activity – Prices Below FV

	Bids	Contracts to Buy	Asks	Contracts to Sell	Total Contracts
	(1)	(2)	(3)	(4)	(5)
Raven	2.354**	0.051	0.071	-0.025	0.025
	(1.028)	(0.041)	(0.102)	(0.038)	(0.067)
Overestimation	0.448	-0.058	-0.301	0.0004	-0.058
	(1.001)	(0.061)	(0.263)	(0.045)	(0.066)
Overplacement	2.161***	0.043	0.187	-0.015	0.028
	(0.703)	(0.040)	(0.158)	(0.017)	(0.040)
Risk Aversion	2.180	-0.004	-0.338	0.051	0.047
	(2.477)	(0.084)	(0.323)	(0.059)	(0.092)
CRT	-1.785	0.388**	0.989	-0.126	0.263
	(7.526)	(0.158)	(0.632)	(0.154)	(0.267)
BCG Guess	0.188**	0.013	0.023**	-0.0001	0.013
	(0.088)	(0.009)	(0.009)	(0.010)	(0.008)
Strategic Int.	-0.692***	-0.007	-0.045	-0.011	-0.018
	(0.171)	(0.014)	(0.028)	(0.017)	(0.029)
Constant	-6.003	-0.115	3.937***	2.035***	1.920**
	(21.068)	(0.656)	(1.526)	(0.563)	(0.761)
Observations	550	550	550	550	550
R^2	0.016	0.014	0.025	0.007	0.008
Adjusted R^2	0.003	0.001	0.013	-0.005	-0.005
Residual Std. Error (df = 542)	129.767	5.558	12.968	3.192	6.162
F Statistic (df = 7; 542)	1.220	1.090	1.994*	0.578	0.596

Note: *p<0.1; **p<0.05; ***p<0.01
Clustered standard errors at session level

Table 4: Trader Activity – Before Price Peak

	Bids	Contracts to Buy	Asks	Contracts to Sell	Total Contracts
	(1)	(2)	(3)	(4)	(5)
Raven	0.729	0.117*	0.081	-0.085	0.032
	(1.370)	(0.064)	(0.150)	(0.081)	(0.090)
Overestimation	-0.513	-0.010	-0.378*	-0.150	-0.160*
	(1.037)	(0.036)	(0.221)	(0.093)	(0.092)
Overplacement	2.519***	0.064	0.275**	0.050	0.114
	(0.586)	(0.068)	(0.123)	(0.035)	(0.074)
Risk Aversion	2.378	0.018	-0.324	-0.061	-0.043
	(1.935)	(0.068)	(0.313)	(0.065)	(0.093)
CRT	6.158*	0.526***	1.745***	0.434**	0.960***
	(3.631)	(0.096)	(0.371)	(0.213)	(0.260)
BCG Guess	-0.056	0.011	0.003	-0.003	0.008
	(0.190)	(0.012)	(0.011)	(0.008)	(0.015)
Strategic Int.	-0.352	-0.005	-0.022	-0.019	-0.023
	(0.232)	(0.018)	(0.030)	(0.016)	(0.034)
Constant	15.449	-0.624	4.243**	3.792***	3.168***
	(34.349)	(0.851)	(1.741)	(0.916)	(1.197)
Observations	550	550	550	550	550
R^2	0.015	0.018	0.035	0.026	0.028
Adjusted R^2	0.002	0.006	0.023	0.013	0.015
Residual Std. Error (df = 542)	140.084	6.368	14.348	4.716	8.115
F Statistic (df = 7; 542)	1.147	1.445	2.835***	2.050**	2.204**

Note: *p<0.1; **p<0.05; ***p<0.01
Clustered standard errors at session level

Table 5: Trader Activity – After Price Peak

	Bids	Contracts to Buy	Asks	Contracts to Sell	Total Contracts
	(1)	(2)	(3)	(4)	(5)
Raven	4.408	-0.036	0.651	0.192	0.156
	(6.082)	(0.126)	(0.566)	(0.117)	(0.187)
Overestimation	3.927	-0.112	-0.280	-0.027	-0.139
	(5.076)	(0.203)	(0.283)	(0.089)	(0.139)
Overplacement	1.529	0.094	0.589	0.121	0.215
	(1.401)	(0.130)	(0.429)	(0.081)	(0.192)
Risk Aversion	11.075*	-0.094	-0.871**	-0.071	-0.165
	(6.138)	(0.136)	(0.401)	(0.116)	(0.150)
CRT	37.358	-0.356	3.369**	0.997***	0.641***
	(23.154)	(0.312)	(1.455)	(0.288)	(0.166)
BCG Guess	-2.504	0.043*	0.119***	-0.003	0.039
	(2.152)	(0.023)	(0.035)	(0.018)	(0.033)
Strategic Int.	2.828	-0.032	-0.191***	-0.012	-0.043
	(3.095)	(0.020)	(0.053)	(0.021)	(0.032)
Constant	-76.267	3.485*	5.612	0.070	3.555
	(105.452)	(1.986)	(7.311)	(1.971)	(2.725)
Observations	550	550	550	550	550
R^2	0.026	0.016	0.057	0.051	0.024
Adjusted R^2	0.014	0.003	0.044	0.038	0.011
Residual Std. Error (df = 542)	398.978	8.224	28.103	6.827	10.645
F Statistic (df = 7; 542)	2.079**	1.275	4.648***	4.139***	1.909*

Note: *p<0.1; **p<0.05; ***p<0.01
Clustered standard errors at session level

Summary of Findings

Aggregate

- Bubbles are robust to market size and Mturk Environment
- Outcomes are similar to markets populated by students

$\Rightarrow$ Advantages: cheaper, easier to address external validity criticisms and to reach different populations; Disadvantage: less control than in the lab

Summary of Findings (cont.)

Trader Activity and Performance

- CRT scores are strongest predictor of individual earnings and overall trading activity
- Risk aversion negatively related to trading activity
- Cognitive and strategic intelligence predict bidding activity when prices are below FV
- Overconfidence predicts bidding activity behavior before price peaks.
- Strategic intelligence predicts intention to sell after price peaks.

Conclusion

More work to do

- Explore link between CRT and trading strategies
- Heterogeneity of traders' skills and individual earnings.
- Use machine learning tools to gauge the relative importance of different characteristics
- Level of activity × Market Number × Market size × Trader skills

Skill Index Weights

Variable	Relative Importance	Percentage
CRT	5.421253	0.459740
Overplacement	4.017676	0.340712
Strategic Intelligence	1.251581	0.106138
Raven	0.480716	0.040766
Overestimation	0.059341	0.027281
BCG Guess	0.299075	0.025362

- Tree-based classification model to predict whether subject was in top 20% of earnings for their session.
- Percentage of total relative importance used as weights in corresponding variables to create skill index.

Table 6: Heterogeneity in Traders' Skills and Earnings

	Dependent variable: Earnings	
	All	All
	(1)	(2)
Skill Index	0.553***	
	(0.214)	
Raven		0.035**
		(0.014)
Overestimation		0.031
		(0.026)
CRT		0.333***
		(0.123)
BCG Guess		-0.014
		(0.009)
Strategic Intelligence		0.009
		(0.007)
High Heterogeneity Dummy	-0.090	0.372
	(0.127)	(0.276)
High Heterogeneity Dummy × Skill Index	-0.460**	
	(0.220)	
High Heterogeneity Dummy × Raven		-0.053**
		(0.027)
High Heterogeneity Dummy × Overestimation		-0.057
		(0.039)
High Heterogeneity Dummy × CRT		-0.254**
		(0.124)
High Heterogeneity Dummy × BCG Guess		0.016*
		(0.009)
High Heterogeneity Dummy × Strategic Intelligence		-0.007
		(0.007)
Constant	10.134***	9.662***
	(0.030)	(0.174)
Observations	550	550
R^2	0.025	0.053
Adjusted R^2	0.020	0.028
Residual Std. Error	1.287 (df = 546)	1.282 (df = 535)
F Statistic	4.664*** (df = 3; 546)	2.130*** (df = 14; 535)
Note:		*p<0.1; **p<0.05; ***p<0.01

Bubble Measures By Sessions

		TR		ND		RND		RPAD		RPD	
Sess.	Subj.	Mkt 1	Mkt 2	Mkt 1	Mkt 2	Mkt 1	Mkt 2	Mkt 1	Mkt 2	Mkt 1	Mkt 2
Lg. 1	33	0.09	0.08	4.81	2.78	0.04	0.03	0.63	0.35	0.62	0.35
Lg. 2	56	0.09	0.08	6.89	2.40	0.01	0.03	0.68	0.38	0.31	0.33
Lg. 3	52	0.10	0.08	11.66	10.64	0.11	0.09	1.21	1.00	1.16	0.92
Lg. 4	40	0.11	0.12	3.17	0.85	0.04	0.01	0.31	0.08	0.23	0.08
Lg. 5	44	0.09	0.07	5.03	0.82	0.06	0.00	0.95	0.07	0.86	0.04
Sm. 1	19	0.08	0.05	6.70	2.21	0.08	0.02	1.42	0.50	1.42	0.50
Sm. 2	12	0.09	0.07	9.05	8.66	0.08	0.08	0.98	1.38	0.54	1.37
Sm. 3	19	0.06	0.07	0.66	0.62	0.01	0.02	0.21	0.17	0.21	0.17
Sm. 4	14	0.04	0.04	2.20	2.28	0.01	0.06	0.59	0.60	0.31	0.60
Sm. 5	10	0.06	0.05	2.90	3.44	-0.01	0.03	0.21	1.59	-0.21	1.55

Summary Stats from Ind. Tasks

Table 7: Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Raven	535	11.935	4.413	0	10	15	18
Overestimation	535	−0.788	4.396	−13.000	−3.789	1.475	16.000
Overplacement	533	1.230	6.146	−21.000	−2.000	4.406	26.000
MPL Switching Row	534	6.539	2.765	1.000	5.000	8.000	11.000
CRT	535	1.254	1.110	0	0	2	3
Guess	535	41.646	28.230	0	19	64.5	100

Earning Summmary from Ind. Tasks

Table 8: Earnings Summary (USD)

Task	Mean	Median	SD
Raven	0.565	0.500	0.344
Confidence	1.599	1.890	0.828
MPL	1.200	1	0.599
CRT	0.253	0.200	0.228
BCG	0.295	0	0.922
All Tasks	3.914	3.910	1.608

CRT Scores

Table 9: Raven Score Distribution

raven.1.player.score	n	Houser et al.	Corgnet
<10	14	3.211	6.370
10	24	5.505	1.470
11	49	11.239	7.350
12	42	9.633	9.800
13	63	14.450	18.630
14	68	15.596	15.690
15	76	17.431	18.630
16	53	12.156	12.750
17	34	7.798	6.860
18	13	2.982	2.450

Corr. Matrix of Trader Characteristics

	Raven	Overestimation	Overplacement	Risk Aver.	CRT	BCG Guess	Strategic Int.
Raven	1.0***	-0.46***	-0.48***	-0.03	0.49***	0.03	-0.1**
Overestimation	-0.46***	1.0***	0.48***	0.05	-0.13***	-0.07*	-0.07
Overplacement	-0.48***	0.48***	1.0***	0.07*	-0.15***	0.02	0.01
Risk Aver.	-0.03	0.05	0.07*	1.0***	-0.05	0.08*	0.06
CRT	0.49***	-0.13***	-0.15***	-0.05	1.0***	-0.05	-0.24***
BCG Guess	0.03	-0.07*	0.02	0.08*	-0.05	1.0***	0.69***
Strategic Int.	-0.1**	-0.07	0.01	0.06	-0.24***	0.69***	1.0***

Corr. Bubble Measures and Skills Index

	TR		ND		RND		RPAD		RPD	
Measure	Mkt.	1 Mkt. 2	Mkt.	1 Mkt. 2	Mkt.	1 Mkt. 2	Mkt.	1 Mkt. 2	Mkt.	1 Mkt. 2
Skills Index IQR	0.02	-0.02	-0.21	-0.55	-0.30	**-0.60***	-0.05	-0.53	0.11	-0.54

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