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REPLICATION PAPER

Intertemporal consumption and debt aversion: a replication and extension

Steffen Ahrens[1] · **Ciril Bosch-Rosa**[2] · **Thomas Meissner**[3]

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Abstract
We replicate Meissner (Exp Econ 19:281–298, 2016), where debt aversion was reported for the first time in an intertemporal consumption and saving problem. While Meissner (2016) uses a German sample, our participants are US undergraduate students. All of the original study's main findings replicate with similar effect sizes. Additionally, we extend the original analysis by introducing a new individual index of debt aversion, which we use to compare debt aversion across countries. Interestingly, we find no significant differences in debt aversion between the original German and the new US sample. We then test whether debt aversion correlates with individual characteristics such as gender, cognitive reflection ability, and risk aversion. Overall, this paper confirms the importance of debt aversion in intertemporal consumption and saving problems and validates the approach of Meissner (2016).

Keywords Debt aversion · Replication · Intertemporal consumption and saving

JEL Classification C91 · D84 · G11 · G41

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✉ Steffen Ahrens
steffen.ahrens.econ@gmail.com

1 Chair of Macroeconomics, Freie Universität Berlin, Berlin, Germany

2 Chair of Macroeconomics, Technische Universität Berlin, Berlin, Germany

3 Department of Microeconomics and Public Economics, Maastricht University, Maastricht, The Netherlands

1 Introduction

Debt is a powerful tool to allocate resources over time. Used appropriately, it increases welfare and fosters growth (Cecchetti et al., 2011). Yet, many people show an aversion to debt with far-reaching consequences for individual welfare and economic growth. For instance, debt averse entrepreneurs might pass on profitable investment opportunities (Paaso et al., 2021), debt averse households might waive profitable retrofit investments (Schleich et al., 2021), and debt averse high school students might forego a college or university degree (Boatman et al. 2017; Callender & Jackson, 2005; Callender & Mason, 2017).

In a recent laboratory experiment with German undergraduates, Meissner (2016) studies the role of debt in an intertemporal consumption and saving problem.[1] According to theory, agents optimally allocate their expected lifetime income over time, saving when income is high and borrowing when income is low (e.g., Fisher, 1930; Friedman, 1957; Modigliani, 1986). By contrast, the experimental results of Meissner (2016) show that participants generally fail to solve such intertemporal optimization problems. Furthermore, participants are less willing to borrow than they are willing to save to smooth consumption. The author interprets this asymmetry as an indication of debt aversion.

This paper is an exact replication in the sense of Chen et al. (2021) of the experiment by Meissner (2016).[2] There are several reasons to replicate this study. First, debt aversion is a relevant problem that has not yet received much attention in the dynamic optimization literature [see, e.g., Duffy (2016)]. Replicating existing work lends credibility to the limited existing results. Second, the task in the original experiment is complex, so reproducing the original results will help establish a reliable experimental design to study debt aversion. Third, Meissner (2016) uses a sample of the student population in Germany, a country which—by international standards—is known for moderate levels of household debt (e.g., Christelis et al., 2021), an excessive reliance on cash payments (e.g., Bagnall et al., 2016; von Kalckreuth et al., 2014), and low tuition fees for higher education (e.g., OECD 2021), which imply low levels of student debt. Therefore, the observed debt aversion in Meissner (2016) could be specific to populations without previous experience acquiring debt, or even specific to Germany, which is known for its cultural abhorrence of debt. As Nietzsche notes, in German debt is spelled as "Schuld," which means both "debt" and "guilt," to argue that "debt" *with oneself* is the source of guilt and bad conscience (Nietzsche, 2021).

It is well-known that culture matters in experimental settings (Chen et al., 2021; Henrich et al., 2001). Against this background, we use a population composed of undergraduate students at the University of Illinois at Urbana-Champaign (UIUC) to test the robustness of the results of Meissner (2016). The US is known for having a more tolerant view of debt (Calder, 2009) and for encouraging it through its

[1] For an extensive survey of laboratory experiments on dynamic stochastic optimization problems, see Duffy (2016).

[2] While the author of the original experiment is an author of the present paper, he was not directly involved in running the new experimental sessions.

institutions (Garon 2011). Therefore, as is common in the United States, students at UIUC incur student debt to pay for tuition fees and other expenses during their studies. The US Department of Education reports an average annual cost of studying at UIUC of $15,880 and a median total debt after graduation between $15,000 and $26,000 depending on the field of study.[3] Therefore, it is safe to assume that the student body at UIUC is less restrictive about acquiring debt and has more homegrown experience acquiring it compared to German students.

Furthermore, we extend the original analysis of Meissner (2016) by developing an index of debt aversion that allows us to compare debt aversion of students in the original sample of Meissner (2016) to the students from UIUC. Additionally, we collect information on participants' gender, risk aversion, and cognitive reflection ability, as measured by the Cognitive Reflection Test (CRT, Frederick, 2005). We are especially interested in the cognitive reflection of participants, as it is a strong determinant of financial behavior both in and outside the laboratory [see Gomes et al. (2021) and Bosch-Rosa and Corgnet (2022) for an overview of results in the field and the lab, respectively].[4]

Our results show that the findings of Meissner (2016) replicate. Participants fail to smooth consumption optimally and are disproportionately more reluctant to smooth consumption via debt compared to savings. Moreover, the effect sizes are similar and there appears to be no difference in the degree of debt aversion between the two samples. Testing for correlation with individual characteristics, we find no evidence that risk aversion or gender correlate with debt aversion. However, we find some weak evidence suggesting that cognitive reflection ability could be negatively correlated with debt aversion.

To our knowledge, this is the first intertemporal consumption and saving experiment to compare the behavior between an American and a European sample. Moreover, existing literature on debt aversion is scant, and we are not aware of any direct intercultural comparisons. However, some recent related empirical evidence exists: Hundtofte et al. (2019) test whether individuals in Iceland and the US use short-term credit to smooth consumption when they experience a transitory negative income shock. They find that individuals from neither Iceland nor the US use short-term credit to smooth consumption, but rather adjust consumption downwards. This is in line with observed behavior in our experiment, where participants are also reluctant to borrow to smooth consumption.

The remainder of the paper is organized as follows. Section 2 presents the experimental design, Sect. 3 reports the results of the replicated experiment and how

[3] This cost includes tuition, living costs, books and supplies, and fees minus the average grants and scholarships for federal financial aid recipients.

[4] There is a vivid debate in the literature on whether the CRT *is* a measure of cognitive ability or an independent rationality factor [e.g., Frederick, 2005; Campitelli & Gerrans, 2014; Pennycook et al., 2016]. On the one hand, Toplak et al. (2011, 2014) argue that CRT is an indicator of rational thinking performance that is independent and separable from cognitive ability. On the other hand, in a recent meta-analysis Otero et al. (2022) conclude that ability to solve the CRT cannot be interpreted as an independent cognitive factor, but rather as a combination of cognitive ability and numerical ability. To avoid any confusion, for the remainder of the paper we opt to refer to what the CRT measures as "cognitive reflection."

personal characteristics correlate with the new debt aversion index. Finally, Sect. 4 concludes.

2 Experimental design

The design of the experiment is identical to Meissner (2016) and implements a simple life-cycle model of consumption. In each period of a life-cycle ($t = 1, \dots, 20$), participants choose how much of their wealth (w_t) to consume (c_t) and how much to save (a_t). Savings can be positive or negative, where negative savings are referred to as debt. We abstract from any interest payments on savings or debt and there is no discounting. Each period, participants are provided with an exogenous income (y_t), which follows a trend stationary stochastic process. Consequently, wealth in period t is defined as $w_t = y_t + a_{t-1}$. In the initial period of a life-cycle, participants start with zero savings ($a_0 = 0$) and in the final period of the life cycle all wealth has to be consumed as saving is not possible ($a_{20} = 0$). Taken together, the latter two restrictions imply that life-cycle consumption must be equal to life-cycle income, i.e., $\sum_{t=1}^{20} c_t = \sum_{t=1}^{20} y_t$.

Consumption decisions are incentivized using a time-separable CARA utility function of the form $u(c_t) = 250\left(1 - e^{-\theta c_t}\right)$, where θ denotes the parameter of absolute risk aversion, which we set equal to $\theta = 0.02$ as in Meissner (2016). The participant's objective is to choose a stream of consumption that maximizes her life-cycle utility. Therefore, in any period t, the decision problem of participants is given by:

$$\max_{c_t} E_t \sum_{t=\tau}^{T} u\left(c_t\right), \tag{1}$$

$$c_t + a_t = w_t, \tag{2}$$

$$w_t = y_t + a_{t-1}, \tag{3}$$

$$a_0 = 0, a_T = 0. \tag{4}$$

Given CARA utility, Meissner and Rostam-Afschar (2017) show that for any income process $y_t = y_0 + st + \varepsilon_t$, where $P\left(\varepsilon_t = \sigma_\varepsilon\right) = P\left(\varepsilon_t = -\sigma_\varepsilon\right) = 0.5$, $\forall t$, period-t optimal consumption is given by

$$c_t^*\left(w_t\right) = \frac{1}{T - t + 1}\left[w_t + \zeta_t - \Gamma_t(\theta\sigma_\varepsilon)\right], \tag{5}$$

$$\zeta_t = (T - t)\left(y_0 + s\left(\frac{T + t + 1}{2}\right)\right), \tag{6}$$

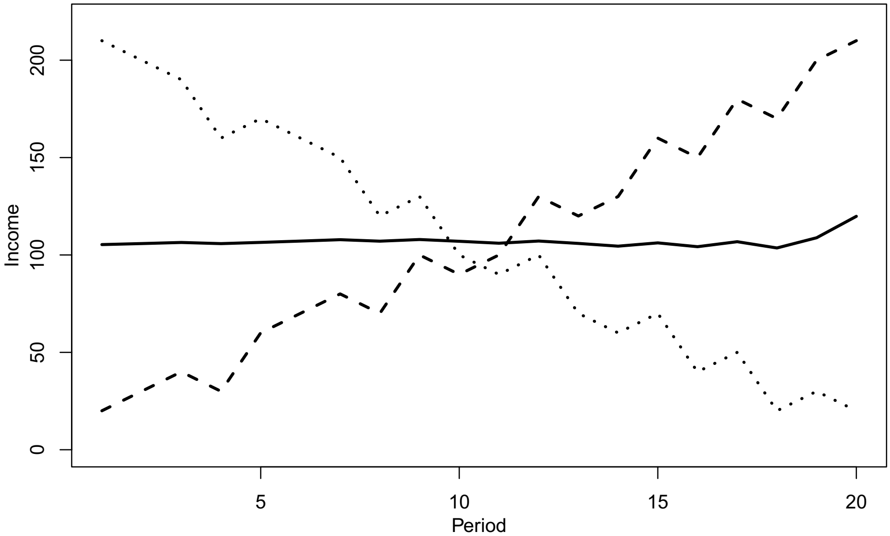


Fig. 1 Example increasing income stream (dashed line), decreasing income stream (dotted line), and optimal consumption (solid line)

$$\Gamma_t(\theta\sigma_\varepsilon) = \sum_{j=0}^{T-t} \sum_{i=1}^{j} \log\cosh\left(\frac{\theta\sigma_\varepsilon}{T-t+1-i}\right), \tag{7}$$

where ζ_t is the expected life-time income $\zeta_t = E_t\left[\sum_{j=1}^{T-t} y_{t+j}\right]$ and $\Gamma_t(\theta\sigma_\varepsilon)$ are precautionary savings. Equations (5)–(7) imply a smooth consumption path over the life-cycle for the given income process specified above.

The treatments in this experiment differ with respect to the income process. In the *borrowing treatment*, participants face an income process $y_t^B = 10t + \varepsilon_t$, which increases over the life cycle. To smooth consumption, participants have to borrow early on in their life-cycle and repay their debt from high income later in the life-cycle. In the *saving treatment*, participants face a decreasing income process given by $y_t^S = 210 - 10t + \varepsilon_t$. Here, participants have to save early in the life-cycle and then live of their savings later on. In each period, the shock ε_t takes the value of $+10$ with 50% probability and the value of -10 with 50% probability. Given the same shock sequence, Eqs. (5)–(7) imply the same optimal consumption path for both the increasing and the decreasing income process. Figure 1 provides an exemplary increasing (dashed line) and decreasing (dotted line) income processes for a given shock sequence and the associated optimal consumption path (solid line).[5]

To assess learning effects and to add a within-subject dimension, each participant plays three rounds of the borrowing treatment and three rounds of the savings treatment.

[5] The shock sequence varies between rounds, but is the same for all sessions and participants.

Table 1 Summary statistics

Variable	Obs	Mean	Std. Dev.	P5	P95
CRT score	91	1.967	1.069	0	3
Female	90	0.389	0.49	0	1
Risk aversion	85	6.518	3.8	0	14

CRT score is the number of correct answers in the CRT. *Female* takes the value one for female participants and zero otherwise. *Risk aversion* contains the number of safe options in a multiple price list

2.1 Experimental procedures

Each session consisted of six rounds, each 20 periods long. In the Borrowing First (BF) sessions, participants first played the *borrowing treatment* for three rounds followed by three rounds of the *saving treatment*. In the Saving First (SF) sessions, the order of the treatments was inverted. While participants knew that the session had six rounds, the specific instructions for each type of income process were read immediately before the start of each three-round sequence. As this experiment is an exact replication, we refer the reader to Meissner (2016) for further details on the experimental procedures.

After the experiment, participants were asked to fill out a questionnaire which contained a hypothetical multiple price list to assess individual risk aversion, the cognitive reflection test (CRT), and some individual characteristics, such as gender, field of study, and nationality. We also asked participants if they had previously seen the CRT questions.[6] The instructions of the experiment and the questionnaire can be found in Appendix 2.

3 Results

The experiment was conducted during the fall of 2016 at the University of Illinois at Urbana-Champaign and the experimental software was written in z-Tree (Fischbacher, 2007). A total of 91 participants took part in the experiment, 44 in the Borrowing First sessions and 47 in the Saving First sessions. Most of the participants were undergraduate students in the field of business, engineering, and economics, similar to Meissner (2016). Table 1 contains summary statistics on CRT score, gender and risk aversion of our sample. Each session lasted around 60 minutes and participants earned \$19.12 on average. The minimum payment was \$5.50.

[6] Around 15% of participants reported to have seen the CRT questions previous to our experiment. Interestingly, participants who report knowing the CRT do not score significantly higher (Mann–Whitney U test, $p = 0.69$).

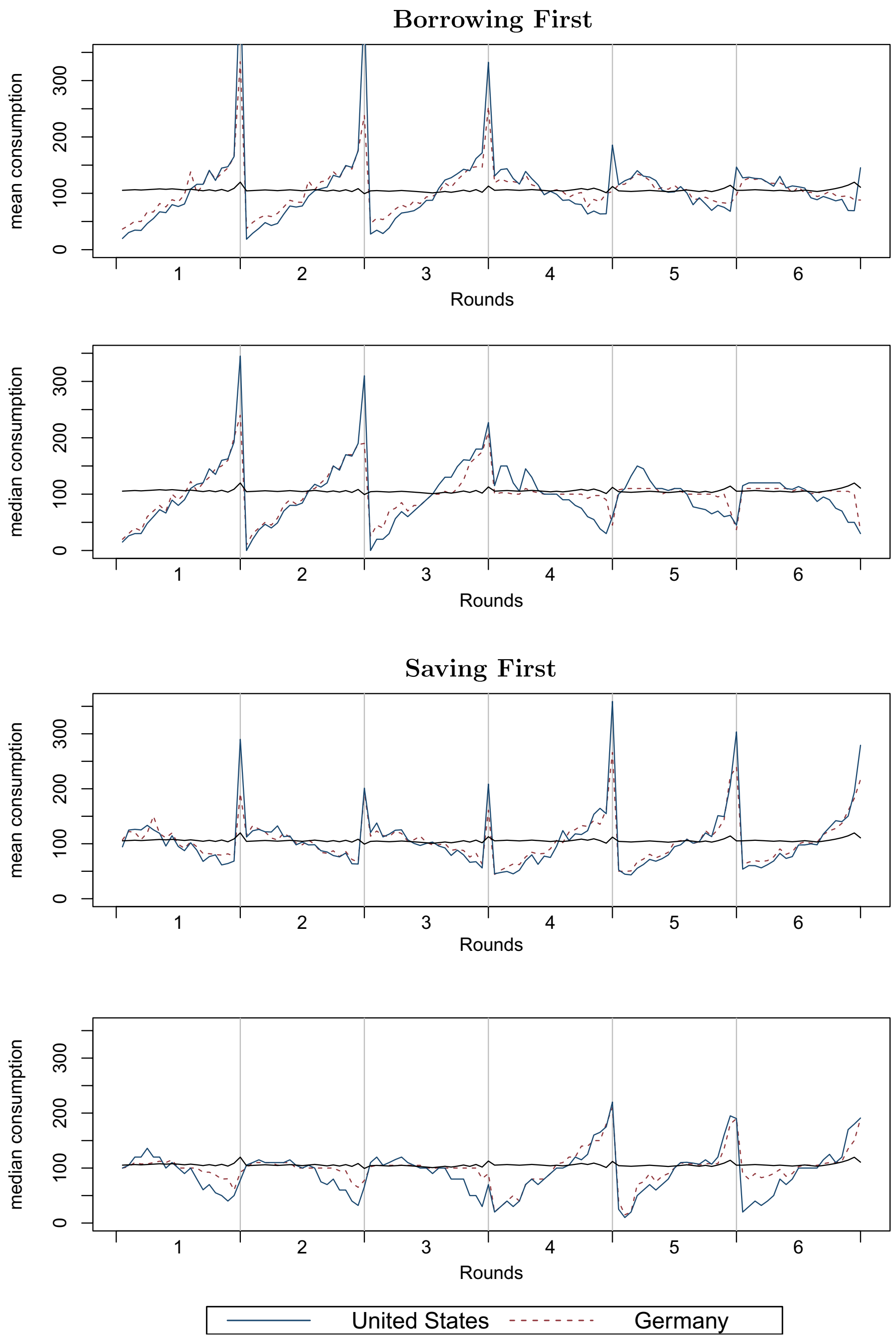


Fig. 2 Median and mean consumption

3.1 Consumption choices

Figure 2 shows the mean and median consumption of all participants in the Borrowing First sessions (upper two graphs) and the Savings First sessions (lower two graphs). The solid blue lines represent the results for the US sample, while the dashed red lines represent the results for the German sample from Meissner (2016). The solid black line marks the optimal consumption path according to Eqs. (5)–(7).

For both samples, the mean and median consumption increases steadily over the life-cycle when the income stream is increasing, whereas they decrease steadily over the life-cycle when the income stream is decreasing. Furthermore, in both cases, the mean and median consumption profiles are generally much steeper (i.e., less smooth) for increasing income streams relative to consumption profiles arising from decreasing income streams. Such similarities point towards a comparable behavior of participants across both populations.

To further analyze the individual behavior of participants, we follow Meissner (2016) and define three different ways to measure the deviations from optimal consumption m_1, m_2, and m_3:

$$m_1 = \sum_{t=1}^{20} \left(c_t^*\left(w_t\right) - c_t\right) \tag{8}$$

$$m_2 = \sum_{t=1}^{20} \left|c_t^*\left(w_t\right) - c_t\right| \tag{9}$$

$$m_3 = \sum_{t=1}^{20} \left(u\left(c_t^*\left(w_t^*\right)\right) - u\left(c_t\right)\right), \tag{10}$$

where $c_t^*(w_t)$ is optimal consumption conditional on current wealth and $c_t^*(w_t^*)$ is the unconditional optimal consumption as a function of the optimal wealth. These measures summarize the accumulated deviations of a participant within each life-cycle, allowing us to study how participants behave under each type of income stream. For example, for m_1, any value above zero means that participants are under-consuming, while values below zero imply over-consumption. m_2 allows us to measure the absolute deviations from optimal consumption, and m_3 the loss of utility derived from such over-/under-consumption.

In Fig. 3 we plot the median of m_1, m_2, and m_3 across all participants for each round and country. The behavioral patterns appear to be similar across countries, with both types of participants over-consuming in savings rounds and under-consuming in borrowing rounds (see m_1). It is also clear that US participants perform worse than those from Germany, as measure m_2 appears to be higher for the US than for Germany (i.e., US participants consume relatively less than Germans in borrowing rounds and consume relatively too much in saving rounds). Importantly, across

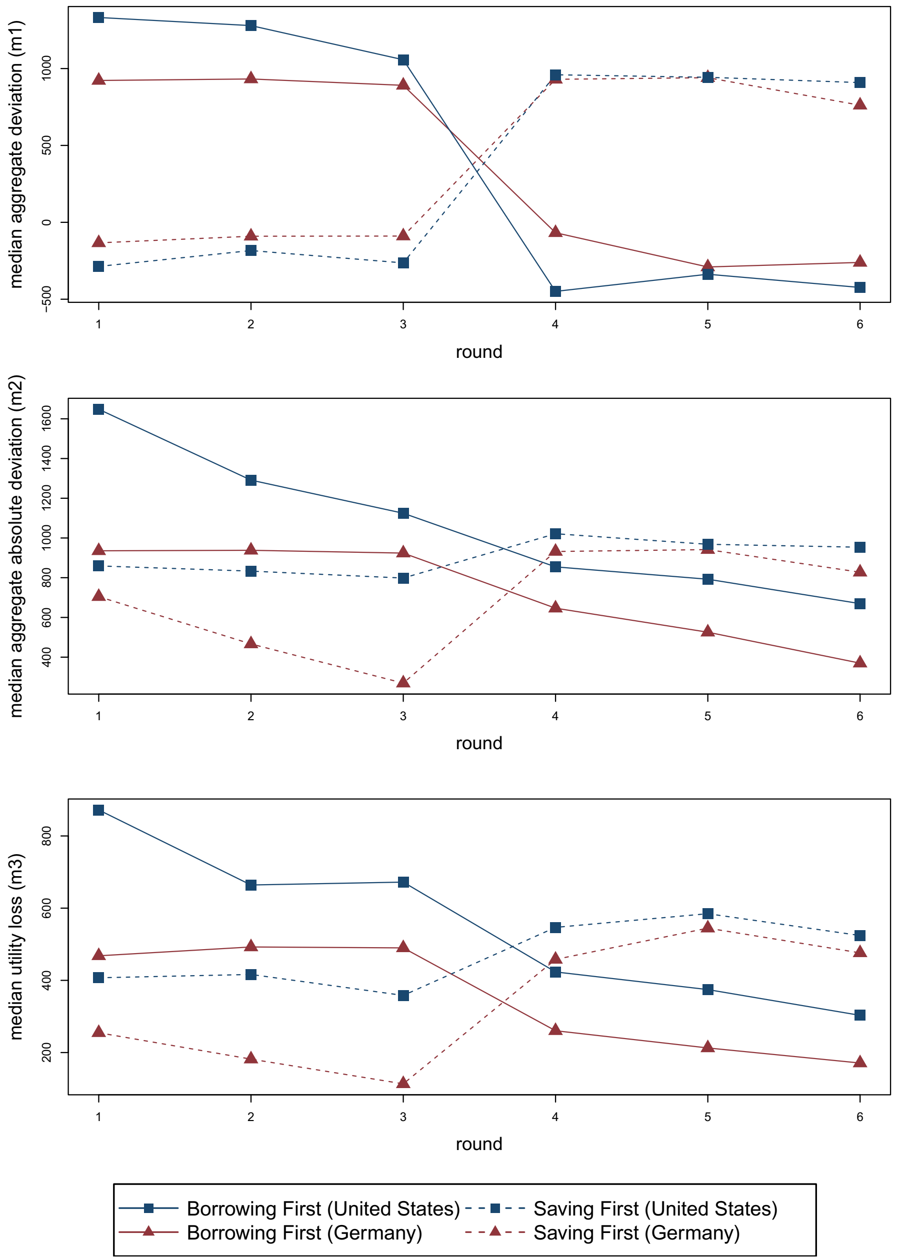


Fig. 3 Median aggregate deviations

all three measures, the median deviation is significantly higher for both countries when participants face an increasing income stream (i.e., when they should borrow) than when they face a decreasing income stream (i.e., when they should save).

Table 2 Median measures m_1, m_2, m_3 by country

Measure	Session	Round					
		1	2	3	4	5	6
United States							
Median m_1	BF	1331.968	1279.272	1057.301	-448.976	-337.514	-423.506
	SF	– 286.689	– 183.513	– 263.750	959.476	943.169	908.636
p-value		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Median m_2	BF	1648.105	1291.288	1124.624	854.537	792.410	669.553
	SF	859.351	833.197	798.277	1021.381	968.282	953.587
p-value		< 0.001	< 0.001	< 0.001	0.005	0.014	0.060
Median m_3	BF	872.064	664.189	672.204	423.347	374.457	303.111
	SF	407.131	416.362	358.253	546.759	584.643	524.210
p-value		0.001	0.004	0.002	0.049	0.037	0.085
Germany							
Median m_1	BF	922.395	932.217	890.805	– 67.671	– 290.294	– 260.731
	SF	– 133.438	– 90.453	-89.256	929.985	940.529	761.430
p-value		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Median m_2	BF	935.503	938.093	923.923	646.581	525.672	369.829
	SF	704.668	466.493	269.223	932.037	941.523	827.583
p-value		0.017	0.009	0.005	0.185	0.096	0.222
Median m_3	BF	468.009	492.488	489.947	260.469	212.785	171.035
	SF	254.897	181.869	113.385	457.959	544.636	476.155
p-value		0.041	0.059	0.007	0.439	0.155	0.409

For each country and round we present the median measure (m_1 to m_3) across participants for each round for each treatment order (BF or SF). The reported p-values are from Mann–Whitney U tests comparing the values for each round

Table 3 Cohen's d in Germany and the US

Measure	Country	Rounds 1–3	Rounds 4–6
m_1	US	1.310	1.156
	Germany	1.031	1.335
m_2	US	0.632	0.467
	Germany	0.339	0.320
m_3	US	0.125	0.117
	Germany	0.146	0.268

In Table 2, we report the median of m_1, m_2, and m_3 for each round as well as the p-values from pair-wise Mann–Whitney U test comparisons across types of sessions. In most cases, the differences in deviations between treatments are statistically different. Importantly, the relative differences in deviations from optimal consumption in the saving and borrowing rounds are similar across samples. This can be seen in Table 3 where we report the effect sizes of the difference in deviations across

Table 4 Learning

Measure	Condition	Round					
		1	2	3	4	5	6
United States							
Median $\Delta_r^{r-1} m_2$	BF	NA	175.824	55.160	306.502	17.784	6.571
p-value			0.008	0.023	< 0.001	0.061	0.455
Median $\Delta_r^1 m_2$		NA	175.824	398.853	737.771	890.776	883.846
p-value			0.008	< 0.001	< 0.001	< 0.001	< 0.001
Median $\Delta_r^{r-1} m_2$	SF	NA	183.457	30.174	– 381.133	10.412	2.168
p-value			0.001	0.102	< 0.001	0.078	0.804
Median $\Delta_r^1 m_2$		NA	183.457	192.474	– 124.496	– 3.739	– 23.383
p-value			0.001	< 0.001	0.286	0.741	0.757
Germany							
Median $\Delta_r^{r-1} m_2$	BF	NA	58.268	18.724	69.507	98.323	19.958
p-value			< 0.001	0.057	0.020	0.003	0.223
Median $\Delta_r^1 m_2$		NA	58.268	137.011	370.480	439.567	575.866
p-value			< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Median $\Delta_r^{r-1} m_2$	SF	NA	66.591	80.909	– 202.889	62.482	54.239
p-value			< 0.001	< 0.001	< 0.001	0.143	0.007
Median $\Delta_r^1 m_2$		NA	66.591	155.424	– 40.365	37.363	69.948
p-value			< 0.001	< 0.001	0.413	0.752	0.381

For each country and round we present the *median differences* in measure m_2 between consecutive rounds ($\Delta_r^{r-1} m_2 = m_2^{r-1} - m_2^r$) and with the first round ($\Delta_r^1 m_2 = m_2^1 - m_2^r$). The reported p-values are from Wilcoxon signed rank tests

treatments for each measure and country.[7] In most cases, the effect sizes are relatively close to each other. The exceptions are rounds 1–3 for m_2, which are slightly larger for the US sample. This difference is most likely driven by the large deviations from optimal consumption in the first round of the savings treatment for the US sample (see the middle panel of Fig. 3).

In fact, while participants in Meissner (2016) seem to improve their consumption decisions over time, the new sample seems to be consistently worse in the borrowing treatment compared to the saving treatment. To analyze the learning of participants, in Table 4 we replicate Table 2 of Meissner (2016) and present the *median differences* in measure m_2 between consecutive rounds r ($\Delta_r^{r-1} m_2 = m_2^{r-1} - m_2^r$) and with the first round ($\Delta_r^1 m_2 = m_2^1 - m_2^r$).[8] As in the original experiment, we see that the differences between consecutive rounds of the same treatment (saving or borrowing)

[7] To report effect sizes we calculate Cohen's d for each measure (m_1, m_2, m_3) across both samples. In our case, this is the standardized difference of the mean deviation from optimal consumption between the saving and borrowing treatments. For more details, see Cohen (1988).

[8] Note that differences in the first three rounds compared to the last three rounds may be caused by both learning and the treatment effect.

Table 5 Determinants of deviations from optimal consumption

	(1) Combined	(2) US	(3) US	(4) US	(5) US
Round	– 64.13*** (15.40)	– 76.44*** (23.08)	– 71.62*** (22.80)	– 71.07*** (23.94)	-71.07*** (24.01)
Germany	– 321.5*** (105.4)				
CRT score		– 364.2*** (63.80)			– 320.4*** (62.88)
Female			528.5*** (154.6)		310.7** (151.3)
Risk aversion				41.63** (18.09)	17.57 (17.83)
CRT known		74.08 (160.3)			65.46 (185.8)
Constant	1363.2*** (87.97)	2111.2*** (169.9)	1180.9*** (113.8)	1129.8*** (178.1)	1782.4*** (212.2)
N	1002	546	540	510	510
adj. R^2	0.049	0.200	0.096	0.043	0.234

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In each column, we regress measure 2 (m_2) on different covariates. The first column contains data from Germany and US. Columns (2)–(5) use only data from the US. All standard errors are clustered at the participant level

are positive and significant in all cases except one. Also, as in Meissner (2016), participants perform significantly worse in the first round compared to later rounds in BF sessions. However, participants do not perform better in the borrowing rounds compared to the first round in SF sessions. The replication of this result supports the idea that participants perform worse in scenarios requiring borrowing than in scenarios requiring saving and that there is an asymmetric process in which learning from borrowing rounds spills over to saving rounds, but not the other way around.

3.1.1 Determinants of deviations from optimal consumption

To understand what determines deviations from optimal consumption, in Table 5 we regress the individual m_2 for each participant in each round on a series of covariates. In the first column, we use the full sample and include the variable *Germany,* which takes the value of one for observations from Meissner (2016), and *Round*, which controls for the round. The results show that German participants tend to have smaller deviations from optimal consumption. This difference in performance is mostly driven by differences in the borrowing rounds as can be seen in Tables 7 and 8 of Appendix 1, where we reproduce Table 5 by partitioning the data into saving and borrowing rounds.

Additionally, in columns (2)–(5) of Table 5 we analyze the effect that CRT, gender, and risk aversion have on determining deviations from optimal consumption. These measures were only collected for the US sample, so all analyses on individual characteristics are limited to US participants. In column (2) we analyze the effect of cognitive reflection, using the number of correct answers in the CRT (*CRT score*). The coefficient is large, negative, and statistically significant, indicating a strong correlation between cognitive reflection ability and deviations from optimal consumption. This is consistent with Ballinger et al. (2011), who also report a negative correlation between cognitive ability (albeit measured with a different test) and deviations from optimal consumption. In columns (3) and (4) we introduce a gender dummy (*Female*) and *Risk aversion*, which counts the number of safe choices a participant has made in a multiple price list (MPL) risk elicitation task (see Appendix 2 for more details). *CRT known* takes the value of one if participants self-reported having seen the CRT previously and zero otherwise. The results show that both females and participants with high risk aversion deviate more from optimal consumption. In column (5) we run the full model, including CRT, gender, and risk aversion. All the results are robust except for risk aversion, which loses explanatory power once we control for CRT and gender.[9]

3.2 Debt aversion

Deviations from optimal consumption do not yet imply debt aversion. All else equal, larger debt aversion should lead to larger differences in deviations from optimal behavior between the saving and the borrowing treatment. Therefore, we construct an individual measure of debt aversion by taking the aggregated difference in absolute deviations from conditional optimal consumption (using m_2) in the saving and borrowing treatment and normalizing by the aggregated deviations in both treatments. This individual index of debt aversion (*DA*) allows us to compare debt aversion across the two samples and is formally defined as:[10]

$$\mathrm{DA} = \frac{\mathbb{1}_{\mathrm{BF}}\left(\sum_{r=1}^{3} m_2^r - \sum_{r=4}^{6} m_2^r\right) + (1 - \mathbb{1}_{\mathrm{BF}})\left(\sum_{r=4}^{6} m_2^r - \sum_{r=1}^{3} m_2^r\right)}{\sum_{r=1}^{6} m_2^r}, \quad (11)$$

where $\mathbb{1}_{\mathrm{BF}}$ is an indicator function that takes the value of one for participants in the Borrowing First sessions and zero otherwise. The larger the debt aversion index, the larger is m_2 in rounds that require borrowing relative to those that require savings to consume optimally. The normalization ensures that the measure is limited to the interval $[-1, 1]$. A measure of DA$= 1$ indicates that a participant only deviates from optimal consumption in the borrowing treatment, and a measure of DA $= -1$ that she only deviates from optimal consumption in the saving treatment. A measure of DA $= 0$ indicates that deviations are the same in the borrowing and the saving treatment and thus that there is no debt aversion. Note that this index does not measure

[9] In Tables 7 and 8 of Appendix 1 we split our sample into the saving and borrowing treatments, respectively. These tables replicate Table 5 and show that our results are robust; higher CRT results in better savings and borrowing decisions, while being female and risk aversion results in inferior savings and borrowing decisions in both treatments.

[10] For notational convenience, indices referring to participants are omitted.

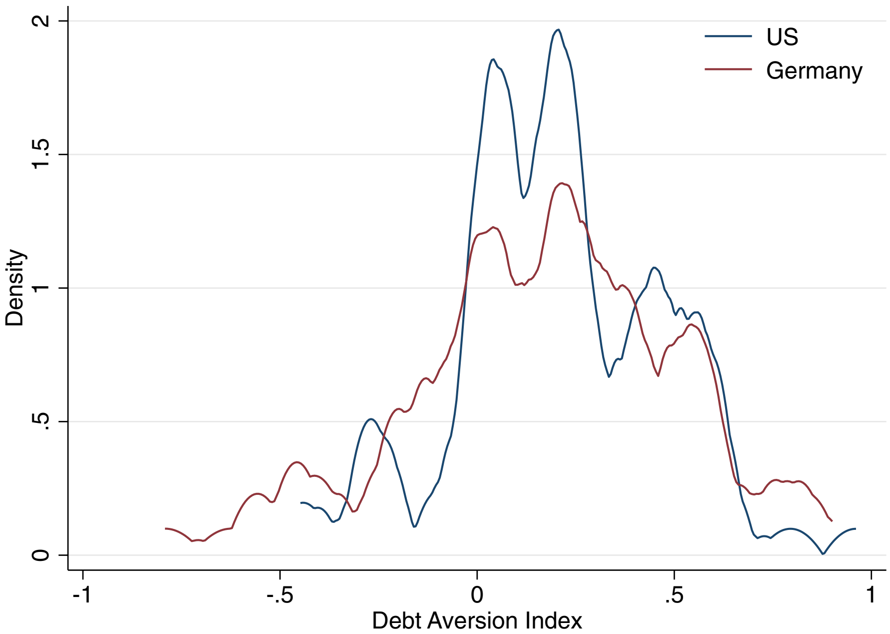


Fig. 4 Debt aversion in Germany and the US

debt aversion itself, as it is constructed based on deviations from optimal consumption. However, it may serve as a proxy that can be expected to correlate with debt aversion since a more debt averse person will borrow less in the borrowing treatments and therefore have a higher DA in these rounds.[11]

Figure 4 illustrates the distribution of the debt aversion index in Germany and the US. A Mann–Whitney *U* test fails to reject a difference in distributions between the German and the US data ($p = 0.5644$).

Table 6 contains regressions where the index of debt aversion (*DA*) is the dependent variable. In specification (1) we use the combined data of the US and Germany and control for country and order effects. *Saving First* is a treatment dummy that takes the value of one for participants in the Saving First sessions, while *Germany* is a dummy that takes the value of one if the observation belongs to the original German sample. The results show that participants who start with the saving treatment are less debt averse. However, this is likely an artifact caused by learning effects. As shown in Table 4 and Fig. 3, learning from saving rounds spills over to borrowing rounds, but learning from borrowing rounds has a smaller impact on behavior in the saving rounds. This asymmetry in learning spillovers results in lower perceived *DA* for those participants in SF sessions.

[11] One might argue that a simpler proxy for debt aversion could be deviations from optimal consumption in the borrowing treatment. We prefer our index, because it controls for other confounding factors. For instance, a person may simply be bad at solving the intertemporal optimization problem, regardless of whether they have to borrow or save. This person would look like they are debt averse according to the deviations in the borrowing treatment only, but not using the debt aversion index.

Table 6 Individual characteristics and debt aversion

	(1) Combined	(2) US	(3) US	(4) US	(5) US
Saving First	– 0.215***	– 0.252***	– 0.242***	– 0.241***	– 0.247***
	(0.0444)	(0.0497)	(0.0504)	(0.0539)	(0.0541)
Germany	– 0.0438				
	(0.0446)				
CRT score		0.0401*			0.0379
		(0.0233)			(0.0251)
Female			– 0.0431		– 0.00598
			(0.0517)		(0.0590)
Risk aversion				0.000365	0.00145
				(0.00712)	(0.00754)
CRT known		0.0504			0.0402
		(0.0688)			(0.0762)
Constant	0.318***	0.250***	0.346***	0.324***	0.242***
	(0.0378)	(0.0575)	(0.0423)	(0.0649)	(0.0851)
N	167	91	90	85	85
adj. R^2	0.118	0.218	0.194	0.185	0.184

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: In each column, we regress the debt aversion index (DA) on different covariates. The first column contains data from Germany and the US. Columns (2)–(5) use only data from the US

Importantly, in specification (1) we detect no differences across countries. While the coefficient for the country dummy is negative, which would indicate that German students are less debt averse than those from the US, the effect is small and not statistically significant. This result implies that there are no systematic differences between the levels of debt aversion between American and German students and, therefore, that the original results of Meissner (2016) are robust to different credit cultures and (likely) experience acquiring debt.

In specifications (2)–(5) we only include observations from US participants to study the effect of different covariates on DA.[12] Specifications (2)–(4) show that only CRT has a weak positive correlation with debt aversion: participants with higher CRT scores appear to be more debt averse. Gender and risk aversion do not seem to be correlated with debt aversion. However, after controlling for gender and risk aversion in specification (5), CRT appears to lose explanatory power ($p = 0.13$).

In summary, there seems to be some weak evidence for a positive correlation between CRT and debt aversion. Evidence for a positive correlation between CRT and debt aversion would be interesting, as CRT has the opposite effect on deviations from optimal consumption (see Sect. 3.1.1). As our debt aversion index is built using

[12] One could be worried about multicollinearity, as gender and risk aversion are typically found to be correlated. In our data females are more risk averse ($\rho = 0.319$, $p = 0.003$) and have lower CRT scores ($\rho = -0.2736$, $p = 0.009$). However, the variance inflation factors are no larger than 1.16 for any of the included variables, which indicates that multicollinearity is not a problem.

deviations from optimal behavior, this suggests that participants with a higher CRT score generally deviate less from optimal consumption, but have a higher asymmetry in deviations from optimal consumption in the borrowing and saving condition, compared to participants with lower CRT score. However, given the weak association, we would caution against over-interpreting this result.

4 Conclusion

Meissner (2016) runs a life-cycle consumption and saving experiment in which he shows that participants perform relatively worse when they need to borrow to consume optimally than when they need to save. This asymmetry is interpreted as a tendency to avoid getting in debt, that is: debt aversion. However, participants in the original experiment are undergraduate students from a large public university in Germany. Therefore, it is possible that the observed debt aversion in Meissner (2016) is limited to the specific population it considers. Germany is known for its low debt levels and for a tradition of shunning debt. Moreover, undergraduate students of public universities in Germany are unlikely to have any experience acquiring debt, which might also contribute to Meissner (2016)'s results (Duffy 2016).

The present paper replicates Meissner (2016) with undergraduate students from the United States. The United States is known to be more tolerant towards debt (Calder 2009) and to encourage it through its institutions (Garon 2011). All of the main findings from the original study replicate with similar effect sizes, confirming the importance of debt aversion even within a population that is likely more exposed to debt. Importantly, we do not find evidence suggesting that debt aversion differs between participants from the US and Germany. Additionally, we extend Meissner (2016) by constructing an individual measure of debt aversion and testing whether it correlates with individual characteristics of our participants. We do not detect any effect of gender or risk preferences on the levels of debt aversion. Interestingly, we find that the CRT score is negatively correlated with deviations from optimal consumption but weakly positively correlated with debt aversion. However, we would caution against over-interpreting this result, as the evidence is rather weak. In this light, future research may focus on further improving our understanding of the relation between debt aversion and cognitive ability as well as other individual characteristics, particularly in representative samples.

To conclude, our paper contributes by successfully replicating a pioneering experiment on debt aversion. We do so by using a population that *a priori* could be expected to have a more positive attitude towards debt and more experience using it. Nonetheless, all of the main findings are replicated.

A1 Additional tables

A1.1 Borrowing/Saving sample split

See Tables 7 and 8.

Table 7 Measure 2 (m_2)—Saving treatment only

	(1) Combined	(2) US	(3) US	(4) US	(5) US
Round	– 53.97* (29.83)	– 71.93** (33.85)	– 67.10* (38.50)	– 71.87* (41.85)	– 80.15** (36.23)
Germany	– 209.7* (109.1)				
CRT score		– 367.2*** (70.87)			– 335.2*** (70.35)
Female			459.9*** (154.5)		238.1* (139.5)
Risk aversion				29.31* (16.30)	8.614 (15.15)
CRT known		15.85 (141.0)			36.97 (163.0)
Constant	1090.9*** (132.9)	1872.7*** (225.5)	959.8*** (174.4)	978.3*** (211.0)	1698.5*** (254.1)
N	501	273	270	255	255
adj. R^2	0.031	0.280	0.099	0.030	0.299

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: In each column, we regress measure 2 (m_2) on different covariates. The first column contains data from Germany and US. Columns (2)–(5) use only data from the US. All standard errors are clustered at the participant level

Table 8 Measure 2 (m_2)—Borrowing treatment only

	(1) Combined	(2) US	(3) US	(4) US	(5) US
Round	– 78.68** (32.58)	– 90.28** (43.36)	– 84.81* (44.57)	– 74.63 (50.12)	– 67.49 (46.37)
Germany	– 434.6*** (118.9)				
CRT score		– 359.8*** (71.76)			– 306.2*** (72.98)
Female			593.9*** (179.7)		382.8* (195.5)
Risk aversion				53.73** (24.27)	27.58 (26.09)
CRT known		135.7 (205.0)			90.76 (232.6)
Constant	1652.0*** (125.9)	2380.1*** (196.8)	1434.7*** (170.1)	1298.2*** (264.1)	1879.5*** (277.4)
N	501	273	270	255	255
adj. R^2	0.073	0.175	0.108	0.059	0.222

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: In each column, we regress measure 2 (m_2) on different covariates. The first column contains data from Germany and US. Columns (2)–(5) use only data from the US. All standard errors are clustered at the participant level

A2 Instructions

Instructions (Part 1)

The experiment you are participating in today is part of a research project. It is meant to analyze economic decision making. The rules and instructions are the same for every participant. Your payoff depends on your decisions during the experiment. Please read the instructions carefully.

During the experiment you are not allowed to talk and exchange information with other participants. If you have a question, please raise your hand. An experimenter will come to you and answer your question. Please don't ask your questions out loud. If you break one of these rules we are obliged to exclude you from participation.

Overview

First you will have time to read the instructions. After that we will go through the instructions together and you will answer a quiz in order to make sure you understand the instructions. After that you may ask questions before the start of the experiment. After the experiment you will be asked to fill out a short questionnaire.

The experiment consists of 6 separate **rounds**, each of which consists of 20 **periods**. The duration of the experiment is around 1.5 hours. Instructions, quiz and questionnaire will take around 30 minutes. The remaining hour is dedicated to the actual experiment. In every period a countdown of 30 seconds will be displayed. You may take more or less time to reach your decision. The countdown is meant to provide some indication on how much time you can take in every period to finish the experiment in one hour. You may finish the experiment even if you play for more than one hour.

The following instructions apply to the first three rounds of the experiment. After three rounds, the experiment pauses and you will be asked to type in a password. You will be handed new instructions for the following three rounds, containing the password needed to continue with the experiment. After the last round, your experiment payoff will be displayed. Please raise your hand when you have finished the last period. You will be given a short survey. After filling in the survey, please raise your hand again. When everyone has filled in the survey, you will be given a short quiz. At the end of the session you will be individually called to the front desk to receive your experiment payoff.

You are playing an **"investment game"** and decide in every period how many **points** you want to purchase. The sum of all points purchased in one round is that **round's total result**. Your payoff depends on the results from two randomly drawn rounds.

Income, Savings and Wealth

In every period you obtain a certain **income**, denoted in the experimental currency "tokens." Your task is to choose in every period how many tokens you want to spend in order to purchase points. Thereby you (implicitly) also choose how many tokens you want to save or borrow. The difference between income and spending in one period is called **savings**. At any period in the experiment, your **wealth** is defined as the sum of savings from all previous periods. This implies that savings from one period added to the wealth in this period yields the wealth in the next period.

Note that the sign of your savings can be both positive and negative. If, in any given period, you decide to spend less tokens than your income, your savings have a positive sign. In this case your wealth in the next period is your wealth in this period **plus** the absolute amount of savings in this period.

If, in any given period, you decide to spend more tokens than your income, your savings have a negative sign. In this case your wealth in the next period is your wealth in this period **minus** the absolute amount of savings.

Example: assume your income in one period is 50 tokens and you spend 30 tokens to purchase points. Your savings IN THAT PERIOD are 20 tokens. If, instead, you spend 70 tokens your savings are -20 tokens. In the first case your wealth in the next period is the wealth in this period plus 20 tokens. In the latter case your wealth in the next period is this period's wealth minus 20 tokens.

Your wealth may as well take positive or negative values, depending on whether the sum of your savings from previous periods was positive or negative. Your wealth in the first period is 0 tokens.

In the last period of each round, your current wealth plus income will be spent automatically in order to purchase points. This implies that the sum of tokens spent in all periods of one round equals the sum of income obtained in all periods of this round.

In other words: you may spend more or less than your income in one period. However, over one round, the sum of income always equals the sum of tokens spent.

Determination of Income

Your **income** is **randomly** determined. Income y_t follows the random process:

$$y_t = 10 * t + \varepsilon_t$$

The index "t" denotes the period for which income is determined. Since the slope of the process is $+10$, it has a positive trend. Therefore, your expected income is increasing over time. ε_t is the random part of the process and can be either $+10$ or -10, both occurring with equal probability of 50%. For example, income in period 6 is $y_6 = 10 * 6 + \varepsilon_6$. Since ε_6 is either $+10$ or -10, your income in period 6 is either 70 or 50. Since one round consists of 20 periods, income in the last period will either be 210 or 190.

It is very important to understand that ε_t is truly randomly determined in each period. Which value ε_t takes in one period does **not** depend on the values it had in previous periods or how you behaved in previous periods.

Tokens and Points

Your task is to decide in every period how many tokens you want to spend in order to purchase points. Tokens are transformed to points as follows:

$$\text{Purchased points} = 250 * (1 - e^{-0.02*(\text{chosen amount of tokens})})$$

A graph of this function and a table with relevant function values are attached to the instructions.

Please note that the above function is defined on the positive as well as the negative domain. If you choose to spend a negative amount of tokens, you will receive a negative amount of points. In this case you "sell" points and gain tokens. Should your wealth plus income (in tokens) in the last period of a round be negative, you will automatically sell points in order to make sure that your token-account is balanced.

Payoff

Your payoff depends on the results from two randomly drawn rounds. One round is randomly drawn from the first three rounds and the other is randomly drawn from the second three rounds. Your payoff is calculated as follows:

$$Payoff\ in\ US\ dollar = \frac{(Result1 - 3000) + (Result2 - 3000)}{100},$$

where Result1 is the first randomly drawn result and Result2 is the second randomly drawn result.

Example: suppose the first randomly drawn result is 4300 points and the second randomly drawn result is 3800 points. Your payoff is:

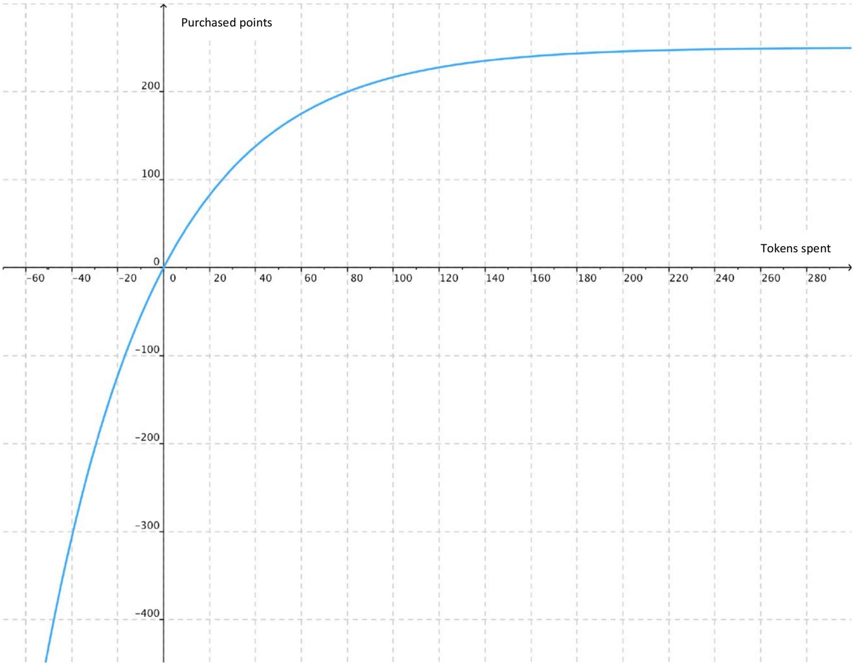
$$\frac{(4300 - 3000) + (3800 - 3000)}{100} = \frac{1300 + 800}{100} = \$21$$

Independent of your results you will be guaranteed \$5.50 for participation. If your payoff is below \$5.50 according to the formula above, you will not receive your calculated payoff but \$5.50 instead.

Quiz and Questions

You will now be asked to answer a short quiz regarding the contents of these instructions. In case you have questions after that, please raise your hand. An experimenter will come to you and answer your question.

Graph


Purchased points
Tokens spent
200
100
0
-100
-200
-300
-400
-60
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280

Table

Tokens spent	Purchased points
-250	-36853,29
-100	-1597,26
-50	-429,57
-40	-306,39
-30	-205,53
-20	-122,96
-10	-55,35
0	0
10	45,32
20	82,42
30	112,8
40	137,67
50	158,03
60	174,7
70	188,35
80	199,53
90	208,68
100	216,17
110	222,3
120	227,32
130	231,43
140	234,8
150	237,55
160	239,81
170	241,66
180	243,17
190	244,41
200	245,42
210	246,25
220	246,93
230	247,49
240	247,94
250	248,32
260	248,62
270	248,87
280	249,08
290	249,24
300	249,38
500	249,99
1000	250

Instructions (Part 2)

In the following three rounds only the random process that determines your income will change. Consequently, compared to the first part of the instructions, only the paragraph "Determination of Income" changes. The rest of the instructions is still valid.

Determination of Income

Your **income** is **randomly** determined. Income y_t follows the random process:

$$y_t = 210 - 10 * t + \varepsilon_t$$

The index "t" denotes the period for which income is determined. In contrast to your former income process this income process has a **negative** trend, since the slope of the process is -10. Therefore, your expected income is decreasing over time. The income process has a positive intercept (210). ε_t is the random part of the process and can be either $+10$ or -10, both occurring with equal probability of 50%. For example, income in period 6 is $y_t = 210 - 10 * 6 + \varepsilon_6$. Since ε_6 is either -10 or $+10$, your income in period 6 is either 140 or 160. Since one round consists of 20 periods, income in the last period will either be 0 or 20.

It is very important to understand that ε_t is truly randomly determined in each period. Which value ε_t takes in one period does **not** depend on the values it had in previous periods or how you behaved in previous periods.

The password to continue with the experiment is: 4213

Questionnaire

Please fill in your terminal number below so that we can link your decisions during the experiment to this questionnaire. Afterwards, please allow approximately 10 minutes to answer the following questions.

Your terminal number:

1. Please describe your strategy, how you have made your decisions during this experiment. Have you changed your strategy during the experiment? If yes, please explain why.

2. In the first part of the experiment (first three rounds), did you use a different strategy than in the second part of the experiment? If yes, please explain why. If no, please explain why.

Please go to the next page…

3. Assume you had the hypothetical choice between options A and B below. Option A yields a payoff as indicated in column 1 with 100% probability, while option B yields $30 with 50% probability and $0 with 50% probability. Option A takes different values, which are given in column 1. Please indicate for every row, which option you consider preferable and type your answer in the respective empty field in the third column.

Option A	Option B	Your decision (A or B)
$0	$30 with 50% probability $0 with 50% probability	
$1	"	
$2	"	
$3	"	
$4	"	
$5	"	
$6	"	
$7	"	
$8	"	
$9	"	
$10	"	
$11	"	
$12	"	
$13	"	
$14	"	
$15	"	
$16	"	
$17	"	
$18	"	
$19	"	

Please go to the next page...

4. Please fill in your field of study (if student):____________________________

5. Please fill in your gender: ___________________________

6. Please fill in your nationality: __________________________

Please raise your hand once you have answered all questions.

Your terminal number:

Quiz

In this quiz, we ask you to answer three questions of differing difficulty. Please try to answer as many of them as possible. You have 5 minutes of time, and you will receive one US dollar for each question answered correctly.

1. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?

   ____

2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?

   ____

3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?

   ____

4. Have you seen these questions before (yes/no)? ________________________

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