Illusion of Relevance: Anchoring in Economic and Financial Knowledge

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Abstract
Contemporary research documents various psychological aspects of economic thought and decision-making. The main goal of our study is to analyze the role of the *anchoring (bias)* (Tversky and Kahneman, 1974) in perceiving economic and financial information, and, in particular, the effect of perceived relevance of the anchors on the degree of the bias. Anchoring bias refers to people's tendency to form their estimates for different categories, starting from a particular available, and often irrelevant, value and insufficiently adjusting their final judgments from this starting value. We carry out an experiment involving a group of MBA students, asking them to recall a number of recent economic and financial indicators (stock and bond market index returns, rates of inflation, currency exchange rates, etc.), with half of the participants receiving actual information about some unrelated indicators (anchors), before answering the questions. We document that significant anchoring bias is exhibited, on average, for each of our experimental questions and by vast majority of the participants, the degree of the bias being higher for women and older participants. Furthermore, in the context of the effect of anchors' perceived relevance, we find that people exhibit significantly stronger bias in cases when the anchor is presented as a similar category. Our findings indicate that if, at least at the first glance, an anchor bears some similarity to the target question, then the resulting answer may be more assimilated towards the anchor.

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JEL Classification: D83, D89, G10.

1. Introduction

What do you expect the return on stock X to be next year? Suppose that before answering this question you have just read an analyst's report indicating that the annual return on stock Y in the last year was 20 percent. Would this information influence your answer? Would your estimate be higher than if the analyst's report indicated that the return on stock Y was minus 20 percent? And what if instead of the analyst's report, you read a newspaper article telling that the number of personal computers in Europe increased over the last three years by 20 percent?

When making judgments for which the answer is ambiguous, most people start with a particular value that is available to them, and then adjust their final judgment from this value, even if the starting value is entirely random. If this kind of adjustment is insufficient, then a phenomenon known as *anchoring* (or *anchoring bias*) occurs. Since first proposed by Tversky and Kahneman (1974), this phenomenon has been documented and studied extensively in various fields of knowledge, environments, and settings.

In this study, we analyze the effect of anchoring in perceiving economic and financial data. Particularly, we wish to shed light on the effect of perceived "relevance" of the anchors on the degree of the bias exhibited. We carry out an experiment involving a group of MBA students, asking them to recall a number of recent economic and financial indicators for Israeli economy, in general (rates of inflation, interest rate of the Bank of Israel, currency exchange rates), and Tel Aviv Stock Exchange, in particular (stock and bond market index values and returns, yield to maturity rates on government bonds). To detect and analyze the anchoring bias, we adopt the experimental design consistent with Jacowitz and Kahneman (1995). We randomly attribute our participants to one of the two groups: (i) "Control" group (Group C): participants in this group are given no additional information and asked to provide their best estimate for each of the questions,

and (ii) "Anchoring" group (Group A): participants in this group are asked the *same* questions, yet, before each question they receive *unrelated* economic or financial indicators ("anchor indicators"), of the same order of magnitude and expressed at the same scale. Since anchoring bias is supposed "to draw people's estimates closer to the anchor", we expect that the answers given by participants in Group A should be closer to anchor indicators than the answers given by participants in Group C, and therefore, in order to measure the degree of anchoring bias, for each person and for each question, we compare the deviations of both group's answers from the anchor indicators.

We document that significant anchoring bias is exhibited, on average, for each of our experimental questions and by the majority of the participants in Group A, the degree of the bias being higher for women and older participants. Furthermore, as a major hypothesis of our research, we expect the anchoring bias to be more strongly pronounced in cases when the provided anchors *look* "relevant", even if people can realize that these are actually unrelated to the target questions. Respectively, we divide our experimental questions into two categories, according to the types of anchors being provided: (i) questions with "relevant" anchors (economic and financial indicators of the same category as the target indicators), and (ii) questions with "irrelevant" anchors (economic and financial indicators of some other categories than the target indicators), and analyze the differences in anchoring measures between the categories of questions. In support of our hypothesis, we find that people exhibit significantly stronger anchoring bias for the questions with "relevant" anchors than for those with "irrelevant" anchors. The difference persists for all groups of participants in our sample.

Our findings indicate that if, at least at the first glance, an anchor bears some similarity to the target question, then the resulting answer may be more assimilated towards the anchor, implying a wider field for potential manipulations from the viewpoint of those who might be interested, for example, in convincing people to invest into a stock or to buy a product. That is, the illusion of relevance may affect people's decision-making.

The rest of the paper is structured as follows. In Section 2, we review the literature on anchoring, featuring both psychological aspects and economic applications. In Section 3, we describe our experimental design and research approach. Section 4 defines our hypotheses and provides the empirical tests and the results. Section 5 concludes and provides a brief discussion.

2. Literature review

2.1. Psychological evidence and implications of anchoring

Human judgments fall prey to a variety of systematic biases and distortions (for an overview, see, for example, Kahneman, et al. (1982)). Tversky and Kahneman (1974) propose that in assessing the likelihood of uncertain events and predicting or recalling certain values or outcomes, people rely on a number of simplifying rules of decision-making, called heuristics. One of the heuristics they discuss is the process of *anchoring* (or *anchoring bias*). They argue that in many situations people make estimates by considering an initial value that they adjust upwards or downwards to yield a final estimate. Such adjustments are often insufficient, leaving judgments biased in the direction of the initial "anchor" value. In what is probably the best-known demonstration of this effect, Tversky and Kahneman (1974) first ask their research participants whether the percentage of African nations in the United Nations (*target* number) is higher or lower than an *arbitrary* number (the anchor) which is randomly determined by spinning a wheel of fortune (e.g., 65% or 10%). Participants are then asked to give their best estimate of this percentage. Absolute judgments are assimilated to the provided anchor value so that the mean estimate of participants who received the high anchor was 45%, compared to 25% for participants who received the low anchor.

Anchoring effects have proved to be a truly ubiquitous phenomenon that has been observed in a broad array of different judgmental domains (for review, see, for example, Mussweiler and Strack (1999a), English (2008)). Jacowitz and Kahneman (1995) ask students a number of general knowledge questions (like length of Mississippi or height of Everest), and report that participants who are given high anchors provide higher estimates than those who are given low anchors. Similar results are also obtained by Strack and Mussweiler (1997) and Mussweiler and Strack (1999b).

Cervone and Peake (1986) document that people receiving high anchors subsequently estimate their own capabilities higher than those who are given low anchors. Plous (1989) argues that the anchoring bias affects people's probability assessments. Furthermore, Chapman and Johnson (1994) ask people to evaluate a number of lotteries varying in their expected values and ranges, and find that the higher the anchor they are given, the higher the minimal sum for which they would sell the lottery.

Anchoring effects are well-documented in legal judgment. Markovsky (1988) reports that subjects exposed to large monetary anchors suggest higher rewards for a witness who comes forward to testify about a crime. Chapman and Bornstein (1996) ask their experiment participants to act as jurors and to decide on the amount of personal injury compensation for a specific case, and find that the higher the requested compensation, serving as a random anchor, the higher the compensation actually awarded by the "jurors". This may constitute a really interesting result, implying that the more people ask for, the more they get. In the same spirit, English and Mussweiler (2001) carry an experiment involving a group of professional judges, and conclude that sentencing decisions are anchored towards the sentences demanded by prosecutors. The magnitude of this influence proves to be dramatic, as judges who consider a high demand of 34 months give final sentences (for the same crimes) that are almost 8 months longer than judges who consider low demand of 12 months. The effect appears to be independent of judges' experience.

A large number of studies consider the effects of anchoring in a variety of additional domains. Ehrbeck and Waldman (1996) concentrate on the existing evidence that professional forecasters in various domains make predictable forecast errors persisting over time, and construct a formal behavioral model implying that making repeated forecasts, the forecasters may be anchored towards their own previous forecasts and the prediction patterns typical of able forecasters. English (2008) asks a group of students to estimate the average price of a German midsize car, after providing them both a standard anchoring and some additional, relevant or irrelevant, information, and finds that the estimates are biased towards the anchor and that relevant knowledge decreases the effect of anchoring. Bowman and Bastedo (2010) analyze the anchoring effects in assessments of institutional reputation, and document that world university rankings published by Times Higher Education Supplement influence peer assessments of reputation in subsequent surveys.

Not only is the anchoring effect influential in a plethora of laboratory and real-world settings, this influence is also remarkably robust. In particular, anchoring is independent of many potentially moderating variables. For one thing, anchoring occurs even if the anchor values are clearly uninformative for the critical estimate, for example because they were randomly selected (for example, Mussweiler and Strack (2000), Tversky and Kahneman (1974)). Moreover, anchoring remains uninfluenced by the extremity of the anchor (for example, Chapman and Johnson (1994), Strack and Mussweiler (1997)) so that even implausibly extreme values yield an effect. For example, in the study by Strack and Mussweiler (1997), estimates for Mahatma Gandhi’s age are assimilated to an unreasonably high anchor value of 140 years. Furthermore, anchoring effects appear to be independent of participants’ motivation (for example, Wilson, et al. (1996)). Specifically, the attempts to

improve accuracy by awarding a prize for the best estimate prove unsuccessful. In addition, it has been demonstrated that anchoring occurs independently of participants' expertise (Englich and Mussweiler (2001)). Furthermore, anchoring effects are characterized by an exceptional temporal robustness and persist over fairly long periods of time. For example, in a study by Mussweiler (2001), anchoring effects are still apparent a week after the anchor value had been considered. Probably the most striking demonstration of the robustness of the phenomenon, however, stems from research demonstrating that explicit instructions to correct for a potential influence of an anchor do not mitigate the effect (Wilson et al. (1996)). Even explicitly forewarning judges about the potential distortion and informing them about its direction does not diminish the effect. This suggests that anchoring is an exceptionally robust phenomenon that is difficult to avoid.

2.2. Economic applications of anchoring

The vast research on anchoring originates from psychology, and takes roots in a number of fields and domains. Still, by the present moment, the applications of the effect of anchoring that may be classified as "economic" are relatively scarce.

Northcraft and Neale (1987) demonstrate that real-estate pricing decisions depend on the listing price for the property. They have real-estate agents and non-professionals estimate the value of a property. Participants are given a ten-page booklet including all the information that is important for real-estate pricing and the listing price of the house, either above or below the actual appraisal value of the property. Replicating the typical anchoring finding, the authors document that participants' estimates for the value of the property are assimilated towards the provided anchors. Similar results are obtained both for experts and amateur subjects.

Gruen and Gizycki (1993) use anchoring to explain the widely-observed anomaly that forward discounts do not properly explain subsequent exchange rate movements. The anchoring phenomenon may be relevant to the "sticky prices" that are so talked about by macroeconomists. So long as past prices are taken as suggestions of new prices, the new prices will tend to be close to the past prices. The more ambiguous the value of a commodity, the more important a suggestion is likely to be, and the more important anchoring is likely to be for price determination.

Fischer and Statman (2000) discuss economic implications of a number of behavioral biases and suggest that stock market analysts may employ mean historical dividend yields and price-earnings ratios as anchors for forecasts of future dividend yields and price-earnings ratios, though historical figures diverge from their means by wide margins, and so may the future figures.

Galinsky and Mussweiler (2001) explore the role of anchoring in buyers' and sellers' behavior and their subsequent profits. They show that first offers may influence the final negotiation outcomes, because they serve as judgmental anchors to which the final outcomes are assimilated. They also demonstrate that whichever party, the buyer or the seller, makes the first offer obtains a better outcome from her viewpoint. Zielonka (2004) carries an experiment involving financial analysts, and finds that certain historical peaks and lows in security and index quotes serve as mental anchors in technical analysis.

The effect of anchoring is also analyzed in the context of consumer decision-making. Biswas and Burton (1993) suggest that price claims in advertisements influence consumer behavior, because they function as anchors in product evaluation. Simonson and Drolet (2004) report the effect of anchoring on consumers' willingness-to-pay and willingness-to-accept.

Beggs and Graddy (2009) document anchoring effect in art auctions by showing that art works may be sold at much higher prices in "hot" markets when the auction buyers may be anchored by high prices that were previously set.

Overall, previous economic studies dealing with the effects of anchoring either explicitly provide some anchors (for

example, Northcraft and Neale (1987), Zielonka (2004)), or assume some implied ones (for example, Biswas and Burton (1993), Beggs and Graddy (2009)). To our best knowledge, there are yet no studies comparatively testing the effect of different anchors on people's decision-making. Present study makes an effort to fill this gap, by analyzing the effect of perceived "relevance" of anchors on the degree of the resulting anchoring bias.

3. Experimental design and research approach

Previous studies documenting the anchoring effects employ two major approaches of introducing an anchor:

1. *Standard anchoring*: According to this approach, people are exposed to an external anchor, and then sequentially make a comparative and an absolute judgment about the critical target quantity (for example, Tversky and Kahneman (1974), Chapman and Johnson (1994)).
2. *Basic anchoring*: This approach does not involve a direct comparison of anchor and target. Here, merely increasing the accessibility of the anchor value prior to the critical estimate is sufficient to produce anchoring effects. For example, Wilson et al. (1996) ask students to copy either five pages of high numbers or five pages of words before estimating the number of fellow students who would get cancer. Those who have copied five pages of high numbers appear to give higher estimates than those who have copied five pages of words. Many other papers (for example, Northcraft and Neale (1987), English and Mussweiler (2001)) explicitly provide some "starting points" (listing price, sentence demanded, etc.), and then ask for the target estimates, without comparing them to the anchors.

In present study, we adopt the second approach. We run an experiment involving 67 MBA students from the Technion, Israel Institute of Technology, and the University of Haifa[1]. We ask our participants to recall a number of recent economic and financial indicators for Israeli economy, in general, and Tel Aviv Stock Exchange, in particular. For this kind of questions, MBA students may serve a competent audience. To introduce and to control for the effect of anchoring, we randomly attribute our participants to one of the two groups[2]:

- "Control" group (Group C): Participants in this group are given no additional information and asked to provide their best estimate for each of the respective indicators.
- "Anchoring" group (Group A): Participants in this group are asked the *same* questions, yet, before each question they receive unrelated economic or financial indicators ("anchor indicators"), of the same order of magnitude and expressed at the same scale. For example, we provide the current value of S&P 500 Index and ask the participants to provide their best estimate for the current value of TA-25 Index[3] - clearly, unrelated figure.

We present the questionnaire for Group A, as provided to the participants at the Technion[4] as Research Questionnaire list.

Since anchoring bias is supposed "to draw people's estimates closer to the anchor", the general intuition says that the answers given by participants in Group A should be closer to anchor indicators than the answers given by participants in Group C[5].

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[1] 40 males and 27 females with mean age of 33.5 took part in the experiment, 26 of them at the Technion and 41 at the University of Haifa.

[2] There were 32 participants in Group C (21 males and 11 females, with mean age of 33.3), and 35 participants in Group A (19 males and 16 females, with mean age of 34.2).

[3] Index that tracks the prices of the shares of the 25 companies with the highest market capitalization on the Tel Aviv Stock Exchange.

[4] The experiment was run on May 13, 2010 at the Technion, and on May 21, 2010 at the University of Haifa. Since a part of the "anchor indicators" (questions 1, 4, 9, 18, 20) are updated on daily basis, they were different for Group A at the Technion and at the University of Haifa. Group C questionnaires, of course, included the same questions without "anchor indicators". In all questionnaires, we asked for participants' personal details (sex, age, previous education).

[5] A number of previous studies provide different anchors to two different groups, and subsequently suggest that each group's answers should be closer to the respective anchor. We use the Control group and let the answers of its participants be "independent" of any anchors, and therefore, suggest that the answers in the Anchoring group should be closer to the anchor.

Research questionnaire (Group A)

Thank you for taking part in the experiment!
Please, don't consult your colleagues while answering the questions. The questionnaire is anonymous and is intended for research purposes only.

Below you will find a number of real financial data. Please fill in the missing numbers, according to your best estimation.

1. The current value of S&P 500 Index is 1172 points.
   I suppose that the current value of TA-25[6] Index is _____.
2. The S&P 500 Index annual return at 2009 was 23.45%.
   I suppose that the TA-25 Index annual return at 2009 was _____%.
3. The average annual return of S&P 500 Index over the years 2007-2009 was-7.70%.
   I suppose that the average annual return of TA25 Index over the years 2007-2009 was _____%.
4. The current value of S&P 500 Index differs from the Index's historical high by 25.11%.
   I suppose that the current value of TA25 Index differs from the Index's historical high by _____%.
5. The manufacturing production in Israel increased in 2008 relatively to 2007 by 7.39%.
   I suppose that the TA-100[7] Index annual return at 2009 was _____%.
6. The average annual rate of increase in the manufacturing production in Israel over the years 1998-2008 was 3.55%.
   I suppose that the average annual return of TA-100 Index over the years 2007-2009 was _____%.
7. The major increase in the manufacturing production in Israel in the last decade took place in 2000. The manufacturing production increased by 9.88%.
   I suppose that the current value of TA-100 Index differs from the Index's historical high by _____%.
8. The DAX Index annual return at 2009 was 23.85%.
   I suppose that the Mid-Cap-50 (Yeter 50) Index[8] annual return at 2009 was _____%.
9. The current value of DAX Index differs from the Index's historical high by 23.71%.
   I suppose that the current value of Mid-Cap-50 (Yeter 50) Index differs from the Index's historical high by _____%.
10. The agricultural output in Israel increased in 2008 relatively to 2007 by 7.45%.
    I suppose that the Tel-Bond 20 Index[9] annual return at 2009 was _____%.
11. The agricultural output in Israel increased in 2008 relatively to 1998 by 16.28%.
    I suppose that the current before taxes 5-years yield to maturity on Galil (CPI-linked fixed rate) government bonds is equal to _____%.
12. The major increase in the agricultural output in Israel in the last decade took place in 2004. The agricultural output increased by 10.1%.
    I suppose that the current before taxes 5-years yield to maturity on Shahar (non-linked fixed rate) government bonds is equal to _____%.
13. The inflation rate in the US in from the beginning of this year is 1.8%.
    I suppose that the inflation rate in Israel from the beginning of this year is _____%.
14. The inflation rate in the US in 2009 was 2.7%.
    I suppose that the inflation rate in Israel in 2009 was _____%.
15. The average annual inflation rate in the US over the years 2007-2009 was 2.29%.
    I suppose that the average annual inflation rate in Israel over the years 2007-2009 was _____%.
16. The gross domestic product of Israel increased in 2008 relatively to 2007 by 2.2%.
    I suppose that the current Interest Rate of Bank of Israel is equal to _____%.
17. The gross domestic product of Israel increased in 2006 relatively to 2005 by 3.4%.
    I suppose that the current Prime Interest Rate[10] is equal to _____%.
18. The Yen/Shekel exchange rate changed from the beginning of this year by -0.45%.
    I suppose that the Dollar/Shekel exchange rate changed from the beginning of this year by _____%.
19. The Yen/Shekel exchange rate changed over the year 2009 by -3.66%.
    I suppose that the Dollar/Shekel exchange rate changed over the year 2009 by _____%.
20. The Dollar-to-British Pound exchange rate (Dollars for 1 Pound) changed from the beginning of this year by -6.67%.
    I suppose that the Euro/Shekel exchange rate changed from the beginning of this year by _____%.
21. The Dollar-to-British Pound exchange rate (Dollars for 1 Pound) changed over the year 2009 by -9.13%.
    I suppose that the Euro/Shekel exchange rate changed over the year 2009 by _____%.

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[6] Index that tracks the prices of the shares of the 25 companies with the highest market capitalization on the Tel Aviv Stock Exchange.
[7] Index that consists of the 100 stocks with the highest market capitalization on the Tel Aviv Stock Exchange.
[8] Index that includes 50 stocks with the highest market capitalization that are not included in the TA-100 Index.
[9] Index that consists of the 20 corporate bonds, fixed-interest and CPI-linked, with the highest market capitalization among all the bonds traded on the Tel-Aviv Stock Exchange.
[10] Quoted basic interest rate fixed by large commercial banks. In the last years, in Israel, it is actually equal to the Interest Rate of the Bank of Israel plus 1.5%.

To calculate the measures of anchoring, we use the method, which is consistent with that proposed by Jacowitz and Kahneman (1995). First of all, we calculate the anchoring measure for each answer given by each participant in group A in the following way:

$$A_n^i = 1 - \frac{\left\| RA_n^i - I_n \right\|}{DC_n} \quad (1)$$

where: A_n^i - Anchoring (bias) measure for question *n* and person *i*, RA_n^i - actual answer (Response) to question *n* given by participant *i* from Croup A, I_n - anchor Indicator (anchor) for question *n*, DC_n - mean Deviation from the anchor for question *n*, in Group C, which, in its turn, is calculated as:

$$DC_n = \frac{\sum_{j=1}^{NC} \left\| RC_n^j - I_n \right\|}{NC} \quad (2)$$

where: RC_n^j - actual answer (Response) to question *n* given by participant *j* from Group C, NC - Number of participants in group C (32 participants).

Participant *i* from Group A who does not exhibit anchoring bias should provide the same value of RA_n^i that she would have provided without being exposed to the anchor, i.e. probably, the same value as her RC_n^i would have been if she were by herself a part of Group C. That is, in terms of Equations 1 and 2, *without anchoring bias*, the deviations of RA_n^i and RC_n^i from I_n should not be different[11], and therefore, the value of A_n^i should be equal to zero. The maximal value of the anchoring measure is equal to one and is obtained for a participant in Group A that, having received an anchor, provides the answer to question *n* that is exactly equal to the anchor. A_n^i may get any value. For example, it may be negative if participant *i* from Group A provides an answer to question *n* that deviates from the anchor farther than do, on average, the answers in Group C.

As follows from Equations 1 and 2, we employ absolute *individual*, rather than average, deviations of actual answers from the anchors. This approach arises from the fact that both RA_n^i and RC_n^j may be *on average* equal, and in this case, the use of averages may produce meaningless results. In contrast, employing the absolute individual deviations allows us to detect, for each participant in Group A, if her (anchor-affected) answer is closer to the anchor than it would probably have been without it. In other words, in order to arrive at mean anchoring measures, one should start from the individual measures, and that is what we do.

Furthermore, we do calculate the mean anchoring measures:

for each question:

$$AQ_n = \frac{\sum_{i=1}^{NH} A_i^n}{NA} \quad (3)$$

where: AQ_n - mean Anchoring measure for Question *n*, NA - Number of participants in group A (35 participants).

And for each participant *i* in Group A:

$$AP^i = \frac{\sum_{n=1}^{NQ} A_i^n}{NQ} \quad (4)$$

where: AP^i - Personal Anchoring measure for participant *i*, NQ - Number of Questions in the questionnaire (21 questions).

4. Testable hypotheses and results

The major goal of our paper is to analyze the effect perceived "relevance" of anchors on the degree of anchoring bias. In this context, we first calculate mean anchoring measures for each of the questions and for each of the participants, and then analyze the differences in these measures for different groups of questions, by types of anchors provided.

4.1. Anchoring bias, by experimental questions

[11] On average, given that Groups C and A are similar by their participants' characteristics, which is ensured by randomly attributing students from the same class to one of the two groups.

At the first stage, we calculate the anchoring measures (A_n^i) for each question and for each participant, and subsequently, the mean (over 35 participants from Group A) anchoring measures (AQ_n) for each of the experimental questions. We expect that participants in Group A will, on average, provide answers that will be closer to the respective anchor indicators than those by participants in Group C.

Table 1 : Anchoring measure statistics, by questions

The table reports, by questions, summary statistics of the anchoring measures (A_n^i) calculated for each of the participants in Group A as follows:

$$A_n^i = 1 - \frac{\left\| RA_n^i - I_n \right\|}{DC_n} \text{ with } DC_n = \frac{\sum_{j=1}^{NC} \left\| RC_n^j - I_n \right\|}{NC}$$

Where: A_n^i - Anchoring (bias) measure for question *n* and person *i*, RA_n^i - actual answer (Response) to question *n* given by participant *i* from Croup A, I_n - anchor Indicator (anchor) for question *n*, DC_n - mean Deviation from the anchor for question *n*, in Group C, RC_n^j - actual answer (Response) to question *n* given by participant *j* from Group C, NC - Number of participants in group C (32 participants).

The last column presents, for each question, the statistics for the hypothesis that the mean anchoring measure is greater than zero, which is consistent with Group A participants on average exhibiting anchoring bias, for the respective question.

Question No.	***Anchoring measure (A_n^i)***						$AQ_n > 0$: ***t-statistic (p-value, %)***
	Mean (AQ_n)	**Median**	**Standard Deviation**	**Maximum**	**Minimum**	**No. (percent) of positive**	
1	0.641	0.678	0.353	0.971	-0.465	34 (97.14)	10.75 (0.00)
2	0.396	0.675	0.912	0.978	-2.800	31 (88.57)	2.57 (1.48)
3	0.704	0.843	0.370	0.980	-0.343	32 (91.43)	11.26 (0.00)
4	0.718	0.855	0.300	0.991	-0.252	34 (97.14)	14.17 (0.00)
5	0.042	0.348	1.224	0.980	-3.788	26 (74.29)	0.20 (83.92)
6	0.421	0.654	0.552	0.994	-0.868	29 (82.86)	4.51 (0.01)
7	0.422	0.696	0.636	0.993	-1.382	25 (71.43)	3.92 (0.04)
8	0.173	0.654	1.141	0.992	-3.850	27 (77.14)	0.90 (37.52)
9	0.744	0.729	0.212	0.995	0.174	35 (100.00)	20.72 (0.00)
10	0.378	0.596	0.592	0.954	-1.613	26 (74.29)	3.78 (0.06)
11	0.396	0.425	0.419	0.934	-0.308	25 (71.43)	5.60 (0.00)
12	0.440	0.496	0.456	0.976	-0.416	27 (77.14)	5.70 (0.00)
13	0.292	0.665	0.656	0.888	-1.851	25 (71.43)	2.64 (1.25)
14	0.544	0.737	0.576	0.934	-2.480	34 (97.14)	5.58 (0.00)
15	0.701	0.828	0.259	0.994	-0.015	34 (97.14)	15.99 (0.00)
16	0.276	0.270	0.561	0.948	-1.919	27 (77.14)	2.92 (0.62)
17	0.044	0.091	0.942	0.921	-4.215	19 (54.29)	0.28 (78.39)
18	0.573	0.832	0.609	0.993	-1.961	29 (82.86)	5.57 (0.00)
19	0.712	0.836	0.322	0.983	-0.224	33 (94.29)	13.09 (0.00)
20	0.389	0.384	0.459	0.997	-0.982	30 (85.71)	5.01 (0.00)
21	0.434	0.640	0.391	0.924	-0.406	28 (80.00)	6.58 (0.00)

Therefore, for each of the 21 experimental questions, we hypothesize the following:

Hypothesis 1:

H0: $AQ_n = 0$ (no anchoring bias for question *n*)

H1: $AQ_n > 0$ (positive anchoring bias for question *n*)

Table 1 comprises summary statistics of A_n^i separately for each of the experimental questions, and the tests of Hypothesis 1. The results strongly indicate the existence of anchoring bias for all the questions. *All* the 21 mean anchoring measures are positive, majority of them significantly (18 at 5% level, including 16 at 1% level), ranging from 0.042 to 0.744. Moreover, for all the questions, vast majority of the participants (for one question, even all of them) exhibit the bias.

4.2. Anchoring bias, by participants and categories of participants

Having documented the anchoring effect for each of the questions, we henceforth calculate the mean (over 21 questions) personal anchoring measures (AP^i) for each of the participants in Group A. Furthermore, we analyze these personal anchoring measures for the total sample and for the subsamples by the following classifications:

a) Sex: males (19 participants) and females (16 participants).

b) Age: we divide our sample in two roughly equal age categories: (i) younger than 33 (17 participants), and (ii) 33 and older (18 participants).

c) Previous education: B.A./B.Sc. (23 participants) and M.A./M.Sc. (12 participants) academic degree.

Table 2 : Personal anchoring measure statistics, by categories of participants

The table reports, by categories of participants, summary statistics of the personal anchoring measures (AP^i) calculated for each of the participants in Group A as follows:

$$AP^i = \frac{\sum_{n=1}^{NQ} A_i^n}{NQ} \quad \text{with } A_n^i = 1 - \frac{\left\| RA_n^i - I_n \right\|}{DC_n} \text{ and } DC_n = \frac{\sum_{j=1}^{NC} \left\| RC_n^j - I_n \right\|}{NC}$$

Where: AP^i - Personal Anchoring measure for participant *i*, NQ - Number of Questions in the questionnaire (21 questions) , A_n^i - Anchoring (bias) measure for question *n* and person *i*, RA_n^i - actual answer (Response) to question *n* given by participant *i* from Croup A, I_n - anchor Indicator (anchor) for question *n*, DC_n - mean Deviation from the anchor for question *n*, in Group C, RC_n^j - actual answer (Response) to question *n* given by participant *j* from Group C, NC - Number of participants in group C (32 participants).

The last column presents, for each category of participants, the statistics for the hypothesis that the mean of the personal anchoring measures is greater than zero, which is consistent with the respective category of participants on average exhibiting anchoring bias.

Category of participants (No. of participants)	***Personal anchoring measure (AP^i)***						**Mean $AP^i > 0$: t-statistic (p-value, %)**
	Mean	**Median**	**Standard Deviation**	**Maximum**	**Minimum**	**No. (percent) of positive**	
Total Sample (35)	0.450	0.502	0.263	0.830	-0.178	33 (94.29)	10.13 (0.00)
Sex:							
Male (19)	0.285	0.345	0.244	0.650	-0.178	17 (89.47)	5.08 (0.01)
Female (16)	0.645	0.646	0.098	0.830	0.442	16 (100.00)	26.39 (0.00)
Age:							
28-32 (17)	0.353	0.499	0.317	0.767	-0.178	15 (88.24)	4.59 (0.00)
33+ (18)	0.541	0.528	0.158	0.830	0.217	18 (100.00)	14.50 (0.00)
Previous education:							
B.A./B.Sc. (23)	0.421	0.499	0.280	0.770	-0.178	21 (91.30)	7.22 (0.00)
M.A./M.Sc. (12)	0.504	0.559	0.227	0.830	0.013	12 (100.00)	7.68 (0.00)

In this personal context, we expect that the participants in Group A exhibit the anchoring bias, and therefore, for the total sample and for each of the subsamples, we hypothesize as follows:

Hypothesis 2:

H0: $Mean\ AP^i = 0$ (no anchoring bias for the respective sample/subsample)

H1: $Mean\ AP^i > 0$ (positive anchoring bias for the respective sample/subsample)

Table 2 presents summary statistics of AP^i for the total sample and for each of the subsamples, and the tests of Hypothesis 2. The results indisputably support the latter. On average, 33 out of 35 participants in our experiment exhibit anchoring bias, their personal anchoring measures ranging from -0.178 to 0.830 (with the general mean of 0.450). Clearly, the means of the personal measures are significantly positive for all the categories of the participants. In addition, we observe that the anchoring bias is stronger pronounced for females and for older participants, while previous education seems to have little effect on the degree of the bias.

4.3. Effect of the anchors' "relevance" on the degree of the anchoring bias

In this Subsection, we make an effort to shed light on the effect of the perceived "relevance" of the anchors on the degree of anchoring bias.

Previous studies dealing with the effects of anchoring employ some fixed anchors, either explicitly provided by the researchers (like in the classical study by Tversky and Kahneman (1974)) or implied by the situations in which people find themselves (for example, Beggs and Graddy (2009) use the prices set in the previous rounds of art auctions as implicit anchors for those who take part in the following rounds). Several studies analyze the effect of people's pre-existing knowledge on the degree of the anchoring bias. Mussweiler and Strack (2000) manipulate their experiment participants' knowledge by providing them some additional information, and conclude that the less people know about the target object, the more they assimilate their estimates to the anchor. Kudryavtsev and Cohen (2010) reach similar conclusion by demonstrating that the magnitude of anchoring bias is greater for relatively more difficult questions. English (2008) finds that relevant knowledge decreases the magnitude of basic anchoring effect.

Yet, to our best knowledge, there are no studies comparing the effects of different anchors on people's thinking and decision-making. In this study, we suggest that the degree of anchoring bias may be affected by the type of anchor provided to the subjects. Namely, we concentrate on the degree of perceived "relevance" of the anchors. In this context, we expect that even if an anchor is, in fact, completely irrelevant for answering a question, it may have stronger effect on people's answers if it is presented not just as an arbitrary number or a strikingly unrelated result or category, but as an answer to some other question, which may seem to have some common features with the target one.

Consequently, we build our experimental questionnaire so that the anchors provided to Group A may be classified into two major categories[12]:

1. "Relevant" anchors – economic and financial indicators of the same category as the target indicators, but calculated for another country. For example, in Question 1, participants get the information about the current value of S&P500, and are then asked to recall current value of TA-25 Index. Or, similarly, in Question 14, we provide the annual rate of inflation in the US in 2009, and then ask the subjects to recall the annual rate of inflation in Israel in 2009.
2. "Irrelevant" anchors - economic and financial indicators of some other categories than the target indicators. For example, in Question 5, we let our participants know that manufacturing production in Israel increased in 2008

[12] Both types of anchors are, of course, completely or almost completely irrelevant for the target questions. That is why we use the terms "relevant" and "irrelevant" in inverted commas.

relatively to 2007 by 7.39%, and then ask them to recall what the annual return on TA-100 Index[13] was in 2009.

Overall, our questionnaire includes 11 questions with "relevant" anchors (Questions 1, 2, 3, 4, 8, 9, 13, 14, 15, 18, 19) and 10 questions with "irrelevant" anchors (Questions 5, 6, 7, 10, 11, 12, 16, 17, 20, 21).

Consequently, according to the intuition above, we expect the anchoring bias to be more pronounced in cases when the anchors provided are "relevant", or in other words, we suggest that mean anchoring measures (AQ_n) will, on average, be higher for the questions with "relevant" anchors than for the questions with "irrelevant" anchors. Respectively, for both groups of questions, we calculate the means and the medians of AQ_n, and hypothesize the following:

Hypothesis 3:

H0:

$$Mean/Median\ AQ_n(\text{"}relevant\text{"}) = Mean/Median\ AQ_n(\text{"}irrelevant\text{"})$$

(similar degree of anchoring bias for both categories of questions)

H1:

$$Mean/Median\ AQ_n(\text{"}relevant\text{"}) > Mean/Median\ AQ_n(\text{"}irrelevant\text{"})$$

(stronger anchoring bias for the questions with "relevant" anchors than for the questions with "irrelevant" anchors)

Table 3 reports summary statistics of AQ_n for the total sample and separately for both categories of questions, and test statistics of Hypothesis 3. First of all, as we have already noted in Subsection 4.1, mean anchoring measures are positive for all the questions in our questionnaire[14]. Furthermore, we observe that, consistently with Hypothesis 3, the mean and the median of AQ_n are significantly higher for the questions with "relevant" anchors (0.563 and 0.641, respectively) than for those with "irrelevant" anchors (0.324 and 0.393, respectively). That is, our participants' answers are significantly more assimilated towards the anchors, if these *look* relevant or informative, in spite of the fact that these anchors hardly bear any relation to the target questions, and our participants are competent enough to reveal it.

Now, in order to provide additional support for our findings, we perform another test aimed at comparing the degree of anchoring bias in cases when the "relevant" and "irrelevant" anchors are provided. For each of the participants in Group A, we calculate mean personal anchoring measures *separately* for both categories of questions:

$$APR^i = \frac{\sum A_i^n \mid relevant}{11} \quad (5)$$

$$API^i = \frac{\sum A_i^n \mid irrelevant}{10} \quad (6)$$

where: APR^i - mean Personal Anchoring measure for questions with "Relevant" anchors, for participant *i*, API^i - mean Personal Anchoring measure for questions with "Irrelevant" anchors, for participant *i*, $\sum A_i^n \mid relevant$ - sum of participant *i*'s Anchoring measures for questions with "relevant" anchors, $\sum A_i^n \mid irrelevant$ - sum of participant *i*'s Anchoring measures for questions with "irrelevant" anchors.

Consequently, we expect that, on average, mean personal anchoring measures for the questions with "relevant" anchors should be higher than for those with "irrelevant" anchors. That is, for the total sample and for each one of the subsamples, as defined above, we hypothesize that:

Hypothesis 4:

H0:

$$Mean/Median\ APR^i = Mean/Median\ API^i$$

(similar degree of anchoring bias for both categories of questions)

H1:

$$Mean/Median\ APR^i > Mean/Median\ API^i$$

(stronger anchoring bias for questions with "relevant" anchors than for questions with "irrelevant" anchors)

[13] Index that consists of the 100 stocks with the highest market capitalization on the Tel Aviv Stock Exchange.

[14] We may also mention that the mean AQ_n for the total sample (21 questions) is exactly equal to the mean personal anchoring measure for the total sample (35 participants) reported in Table 2 (0.450 both). Of course, the "order of calculation of means" (first, over the participants, and then, over the questions, or vice versa) does not change the final result.

Table 3 : Mean anchoring measure statistics, for questions with "relevant" and irrelevant" anchors

The table reports, by categories of questions, summary statistics of the mean anchoring measures (AQ_n) calculated for each question as follows:

$$AQ_n = \frac{\sum_{i=1}^{NH} A_i^n}{NA} \text{ with } A_n^i = 1 - \frac{\left\| RA_n^i - I_n \right\|}{DC_n} \text{ and } DC_n = \frac{\sum_{j=1}^{NC} \left\| RC_n^j - I_n \right\|}{NC}$$

Where: AQ_n - mean Anchoring measure for Question *n*, NA - Number of participants in group A (35 participants), A_n^i - Anchoring (bias) measure for question *n* and person *i*, RA_n^i - actual answer (Response) to question *n* given by participant *i* from Croup A, I_n - anchor Indicator (anchor) for question *n*, DC_n - mean Deviation from the anchor for question *n*, in Group C, RC_n^j - actual answer (Response) to question *n* given by participant *j* from Group C, NC - Number of participants in group C (32 participants).

The last row reports statistics for the tests of equality of means and medians between the questions with "relevant" and "irrelevant" anchors.

Questions by categories of anchors (No. of questions)	**Mean anchoring measure (AQ_n)**					
	Mean	Median	Standard Deviation	Maximum	Minimum	No. (percent) of positive
Total Sample (21)	0.450	0.422	0.211	0.744	0.042	21 (100.00)
"Relevant" (11)	0.563	0.641	0.194	0.744	0.173	11 (100.00)
"Irrelevant" (10)	0.324	0.393	0.155	0.440	0.042	10 (100.00)
Tests of equality[a]:						
Stat. value (p-value, %)	3.09 (0.60)	2.43 (1.51)				

[a] We employ t-test for the equality of means between series, and Wilcoxon/Mann-Whitney test for the equality of medians between series

Table 4: **Mean personal anchoring measure statistics, for questions with "relevant" and "irrelevant" anchors**

The table reports, by categories of participants, summary statistics of the personal anchoring measures calculated separately for the questions with "relevant" (APR^i) and "irrelevant" (API^i) anchors, for each of the participants in Group A:

$$APR^i = \frac{\sum A_i^n \mid relevant}{11} \text{ and } API^i = \frac{\sum A_i^n \mid irrelevant}{10}$$

$$\text{with } A_n^i = 1 - \frac{\left\| RA_n^i - I_n \right\|}{DC_n} \text{ and } DC_n = \frac{\sum_{j=1}^{NC} \left\| RC_n^j - I_n \right\|}{NC}$$

Where: APR^i - mean Personal Anchoring measure for questions with "Relevant" anchors, for participant *i*, API^i - mean Personal Anchoring measure for questions with "Irrelevant" anchors, for participant *i*, $\sum A_i^n \mid relevant$ - sum of participant *i*'s Anchoring measures for questions with "relevant" anchors, $\sum A_i^n \mid irrelevant$ - sum of participant *i*'s Anchoring measures for questions with "irrelevant" anchors, A_n^i - Anchoring (bias) measure for question *n* and person *i*, RA_n^i - actual answer (Response) to question *n* given by participant *i* from Croup A, I_n - anchor Indicator for question *n*, DC_n - mean Deviation from the anchor for question *n*, in Group C, RC_n^j - actual answer (Response) to question *n* given by participant *j* from Group C, NC - Number of participants in group C (32 participants).

The last row of each block reports statistics for the tests of equality of means and medians between the questions with "relevant" and "irrelevant" anchors, for sample/subsamples of participants.

Category of participants (No. of participants)	Personal anchoring measures					
	Mean	Median	Standard Deviation	Maximum	Minimum	No. (percent) of positive
Total Sample (35):						
APR^i	0.563	0.62	0.272	0.898	-0.034	33 (94.29)
API^i	0.324	0.382	0.304	0.766	-0.499	29 (82.86)
Tests of equality[a]: Stat. value (p-value, %)	3.47 (0.09)	3.31 (0.09)				
Sex:						
Male (19):						
APR^i	0.408	0.506	0.286	0.831	-0.034	17 (89.47)
API^i	0.15	0.232	0.289	0.766	-0.499	13 (68.42)
Tests of equality[a]: Stat. value (p-value, %)	2.86 (0.70)	2.45 (1.42)				
Female (16):						
APR^i	0.749	0.769	0.123	0.898	0.486	16 (100.00)
API^i	0.531	0.517	0.156	0.754	0.231	16 (100.00)
Tests of equality[a]: Stat. value (p-value, %)	4.37 (0.01)	3.49 (0.05)				
Age:						
28-32 (17):						
APR^i	0.458	0.545	0.315	0.84	-0.034	15 (88.24)
API^i	0.237	0.28	0.369	0.766	-0.499	12 (70.59)
Tests of equality[a]: Stat. value (p-value, %)	1.88 (6.99)	1.84 (6.54)				
33+ (18):						
APR^i	0.663	0.669	0.18	0.898	0.202	18 (100.00)
API^i	0.407	0.388	0.204	0.754	-0.017	17 (94.44)
Tests of equality[a]: Stat. value (p-value, %)	4.01 (0.03)	3.31 (0.09)				
Previous education:						
B.A./B.Sc. (23):						
APR^i	0.556	0.623	0.266	0.866	-0.03	22 (95.65)
API^i	0.273	0.394	0.331	0.74	-0.499	17 (73.91)
Tests of equality[a]: Stat. value (p-value, %)	3.21 (0.25)	2.97 (0.30)				
M.A./M.Sc. (12):						
APR^i	0.576	0.592	0.294	0.898	-0.034	11 (91.67)
API^i	0.423	0.376	0.224	0.766	0.064	12 (100.00)
Tests of equality[a]: Stat. value (p-value, %)	1.44 (16.28)	1.65 (9.89)				

[a] We employ t-test for the equality of means between series, and Wilcoxon/Mann-Whitney test for the equality of medians between series.

Table 4 presents summary statistics of APR^i and API^i for the total sample and for each of the subsamples, and the tests of Hypothesis 4, which is strongly supported by the results. Mostly important the mean and the median of APR^i for the total sample (0.563 and 0.620, respectively) are significantly higher than the mean and the median of API^i (0.324 and 0.382, respectively). This relation also holds for all the subsamples, the differences being slightly more pronounced for women, older, and less educated participants. Thus, we may conclude that on the "individual level", our participants exhibit stronger anchoring bias if they are given some anchors that may mistakenly seem to be "relevant" for the target questions.

Overall, the results in this Subsection, probably making up the major contribution of our paper, demonstrate that even if people can understand that an anchor is, in fact, completely unrelated to a given question, their answers still may be significantly more assimilated towards the anchor if, at the first glance, it just looks "relevant" or informative.

5. Conclusions and Discussion

Our paper explores the role of anchoring in perceiving economic and financial information, and, in particular, the effect of perceived "relevance" of the anchors on the degree of this bias.

Employing an extensive experimental questionnaire and an audience which is sufficiently competent in economic and financial matters, we reveal the effect of anchoring in recalling real-world outcomes. We find that the effect is exhibited, on average, for each of our experimental questions and by vast majority of the participants, its degree being higher for women and older participants.

Furthermore, we hypothesize that anchoring bias is more strongly pronounced in cases when the anchors *look* more "relevant" for the target questions, even if people realize that the anchors are actually inappropriate. We divide our experimental questions into two categories, according to the perceived "relevance" of anchors, and analyze the differences in anchoring measures between the categories of questions. The results support our hypothesis, indicating that our participants exhibit significantly stronger anchoring bias for questions with "relevant" anchors than for those with "irrelevant" ones. The difference persists for all groups of participants in our sample.

Our findings may have important implications for decision-making in various fields of real life. We not only document that decision-making may be influenced by some arbitrary anchors, but find that the magnitude of this influence is more pronounced if, at least at the first glance, the anchors bear some similarity to the target. That is, for example, when an investor considers purchasing a stock and respectively, tries to forecast its future returns, she may be more anchored towards contemporaneous or recent returns of some other stocks than, say, towards the general rate of economic growth. Moreover, even some fundamental information about the issuing company may be relatively neglected, as it is often expressed on some other scale and does not immediately resemble the potential target estimate.

Both "sides of the game" might pay attention to this result. On the one hand, everyone who is willing to sell an asset and has some potential of manipulating the buyers' knowledge about the asset (stock issuers, product manufacturers) may consider integrating in the product description some, not really relevant, high figures that may somehow resemble the target estimate (past stock returns, similar products' prices), in order to increase the buyers' estimates for the product price[15]. Emphasizing such figures may often bring greater advantage to the sellers than a comprehensive description of the product's characteristics. On the other hand, potential buyers should look for the fundamentals and just superficially consider those available pieces of information that, after a bit of critical thinking, appear to have nothing to

[15] In fact, that is what many sellers readily do.

do with the target estimate. In other words, the illusion of relevance should not affect reality…

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