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Portfolio Composition and Investors' Trading Patterns toward 1/N*

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Abstract: We explore how an understudied factor, portfolio composition, affects investors' trading preferences and whether it is associated with the Disposition Effect. Behavioral lab experiments reveal predictable trading patterns depending on salient holding amounts in the portfolio, and the latter's association with the amount subjects were asked to sell. E.g., when instructed to sell $600 subjects tend to make simple trades, like 2X$300, or 4X$150, particularly if portfolio composition highlighted such amounts. These biased trades are inconsistent with portfolio theory, bringing the portfolio toward 1/N. Portfolio managers should be aware of such trading patterns since they may be sub-optimal by modern portfolio theory.

Keywords: Portfolio theory; Behavioral finance; Prospect theory.

JEL Classifications: D1, G1.

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1. Introduction and motivation

The patterns by which investors trade in financial markets attracted much research attention since the inception of modern portfolio theory, with the seminal contributions of Markowitz (1952), Sharpe (1964) and Lintner (1965). Rationally, investors should have formed optimal portfolios and trade over time in ways that maintain the optimal structure under the mean-variance framework. Yet, behavioral research found a number of persistent deviations from the rational assumption. For one, Shefrin and Statman (1985) attributed

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the term "Disposition Effect" (DE) to the phenomenon where investors tend to sell winning stocks early while keep holding losing stocks. They hypothesized that DE stems as a combination of various psychological factors, including the loss aversion property of Prospect Theory (PT, Kahneman and Tversky, 1979; Tversky and Kahneman, 1974), mental accounting, regret avoidance, and self-control.

Following Shefrin and Statman, Odean (1998) analyzed about 10,000 discount brokerage accounts and supported Shefrin and Statman's conclusions in real trades. Relevant for our study, Odean explored Lakonishok and Smidt's (1986) argument whereby DE might be related to trading volume through portfolio rebalancing, as investors would presumably sell winners to restore optimal diversification. Consistent with modern portfolio theory, Odean hypothesized that rebalancing is associated with selling only part of the position, not the entire holding, i.e., "proportional rebalancing". Based on the proportional rebalancing criterion, Odean's tests revealed that DE remains after eliminating sales of partial positions, thus concluding that portfolio rebalancing does not cause DE.

The voluminous subsequent research on DE almost neglected the study of possible interactions between portfolio composition and DE, including prominent theoretical contributions like Barberis and Xiong (2009), or prominent experimental papers like Weber and Camerer (1998). While most of the research focused on investor's reference point in a single stock setup, ignoring portfolio composition, to the best of our knowledge only Be'eri et. al (2019) used a multi-stock setup to study gender differences in DE. Investors' preference for simple and small portfolio compositions was recognized in the literature, as in Benartzi and Thaler (2001), who document that investors allocate their wealth across assets using the naive 1/*N* rule. Additionally, Huberman and Jiang (2006) find that participants tend to invest in only a small number of the funds offered to them, and that they tend to allocate their contributions evenly across the funds that they use, with this tendency weakening with the number of funds used.

We add to the literature in two aspects. First, by studying the patterns by which investors trade toward a uniform allocation, 1/N, in a multi-asset setup. Second, we explore whether these trades are related to DE. One economic rationale for replacing the single stock approach with multiple assets in a portfolio is the presence of fixed transaction costs. Straightforwardly, fixed transaction costs rationalize minimizing the number of different stocks being traded, thus justify selling entire positions or a few blocks. An additional economic rationale is reducing trading frequency, as shown by Constantinides (1986). Indeed, Barberis and Xiong (2009) acknowledge that proportional rebalancing is more intellectually demanding than selling entire positions. We endorse this comment, thus consider it a type of a "psychological fixed transaction cost". Psychological fixed transaction costs may include cognitive load, task complexity, and time spent throughout the decision-making process.

An additional motivation to explore investors' selling decisions in multi-assets portfolios is to reflect reality; for example, Goetzmann & Kumar (2008) report that about 70% of investors hold five or fewer stocks, and this is not a new finding (e.g., Levy, 1978). By modern portfolio theory, a portfolio smaller than 30-40 stocks is not well diversified, with psychological burden often mentioned as one of the reasons for the departure from rational choice. By acknowledging those behavioral implications on portfolio rebalancing, our study is the first to test directly the relevance of portfolio composition on investors' trades.

Our study focuses on manipulating portfolio composition, evaluating its impact on investors' trading patterns, and we study whether those trades are related to DE. We find that in the presence of multiple assets in their portfolios, subjects tend to trade simple fractions toward achieving simple portfolio forms. For instance, when asked to sell $600, subjects prefer selling 2X$300, 3X$200 and the like, and they sell from those stocks whose values feature such positions, like $1,200 or $1,300, respectively. We denote these trades "meta-positions", as they involve changing investors' positions in simple fractions far more frequently than trading the rational amounts that portfolio theory prescribes. Subjects trade with and against the disposition effect in order to achieve the simple portfolio form of 1/N, therefore we are doubtful whether DE matters in this setting.

In the reminder of this paper Section 2 presents the experimental study and the instructions subjects have received, Section 3 lists the quantitative results and presents the quantitative analysis. Section 4 concludes.

2. Experimental Study and Instructions

We designed a laboratory experiment for which 180 undergraduate students were recruited (57% woman, average age 27) from a private college in Israel. They participated in the study as part of their course requirements. Subjects were randomly assigned to one of six manipulation-checks and tested individually. Participants were asked to fill in questionnaires in a between-subject design setup. Participants could read the instructions, although those were read to them by the laboratory manager. Each manipulation check was presented to subjects by a table with four stocks and one riskless bond. Stock names were pre-selected: A, B, C, and D, to avoid attachment to personal selection and regret avoidance. To encourage participants to engage the task seriously, they were told that those with the best results would win valuable prizes such as an internet camera, wireless mouse, etc. The unit count of shares and the bond in the portfolio were indicated in a table, together with purchase prices, and the initial holding values. The purpose of the experiment and details about the prizes were delivered verbally and individually. Above the table, subjects read the following instruction (emphasis in origin,).

"Hello,
Assume that a week ago you purchased shares of the following companies to your investment portfolio. In addition, you purchased a riskless bond:"

At the bottom of the table, subjects could see their total portfolio value (in this example, 4,850). An example for one such table is presented in Table 1.

Table 1: Example of "last week" portfolio composition in a questionnaire

Company name	*Number of shares*	*Stock Purchase price*	*Value of holdings ($)*
A	100	9	900
B	100	8.5	850
C	100	10	1,000
D	100	11	1,100
Riskless bond	*Number of bonds*	*Bond purchase price*	*Value of holdings ($)*
E	100	10	
		Total portfolio value:	1,000 4,850

Table 1 was followed by this sentence:

"Since the time of purchase and until yesterday, no news were published concerning your stocks or the bond, and yesterday the following prices were recorded in the stock exchange:"

Below this statement, subjects found Table 2, and the subsequent instructions,

Table 2: Example of "yesterday" portfolio composition in a questionnaire

Company name	*Number of shares*	*Stock Purchase price*	*Value of holdings ($)*	*Please write the value of the stock/bond after change*
A	100	6	600	
B	100	11	1,100	
C	100	11.5	1,150	
D	100	12.5	1,250	
Riskless bond	*Number of bonds*	*Bond purchase price*	*Riskless bond*	
E	100	10.5	1,050	
			Total portfolio value	5,000

"Assume that you must sell assets from your portfolio amounting to $600 in order to finance your other expenses (you may sell shares of one company, or more. You may sell any quantity of the bond, with or without selling shares, at any amount). Please indicate in the right-most column from which stocks or bond you wish to sell *(Note: write only where you have made a change, leave other rows empty)"*

Subjects wrote their holdings in the right-most column of Table 2, from which we could compute the changes in positions (trades). Those trades were analyzed and compared to "yesterday" portfolio composition, as it appears in the second column from the right. The above example is drawn from the third manipulation check; the other questionnaires differ only with respect to purchasing and "yesterday" prices, as detailed in Tables 3 to 8. It should be noted that subjects were free to hypothesize a rational process for the stock prices, like mean reversion or mispricing (as the asset value changes irrespective of news). As we show next, the presence of any rational explanation cannot mitigate the implications of our results because we conduct the mirror of any experiment and show that if DE is supported under one experiment, it is negated under the mirror experiment. Thus, any rational explanation would be countered by the data.

3. Results and analysis

We distinguish between stocks whose price increased ("winning stocks"), and stocks whose price declined ("loosing stocks"), in each manipulation check, and compare actual sales with "expected sales". Following Odean (1998), we hypothesize that if subjects act in accordance with modern portfolio theory, "expected sales" of the $600 would be proportional to the value of each stock and the bond in the portfolio. Alternatively, we compute "expected sales" as a uniform value from each asset, representing a simplified 1/N rule. To highlight the importance of portfolio composition, we focus on portfolio compositions that feature positive and/or negative deviations from uniform holdings, seeking for trading patterns consistent or against the disposition effect. We are interested in salient deviations and/or holdings, particularly those that attract the subject to 600, or its simple fractions (e.g., 150+450, 2X300, or 3X200). Trades that involve 600 or its simple fractions are denoted henceforth "meta-positions". The term "meta-position" aims to emphasize the higher-order importance of trading simple fractions, over and above rational values that need not be salient or involve simple fractions.

If the entire amount, $600, was sold from a single asset, we denote the trade "1st order meta-position". Similarly, if the $600 were sold by only two simple fractions of $600 we denote the trade "2nd order meta-position". 2nd order meta-position trades are the following fractions: 100, 300, 400, 450, or 500, as well as 150, if it was not part of 4X150 trade, and 200, if it was not part of a 3X200 trade. In case trades were 3X200 we assigned them into "3rd order meta- position". If subjects traded 4X150 the trade is denoted "4th order meta-position". The tests will highlight whether trading meta-positions is stronger or weaker than trading in accordance with rational portfolio theory.

Table 3, and the following similar tables, show portfolio composition before and after prices have changed at the top section; the next section shows the average amount sold from each asset and the expected sell amount by proportion of value (600/5=120 in all cases, thus not presented); the third section shows the actual portfolio chosen, and the portfolio that would have resulted if sales were proportional to value, or uniform. The column labeled "STD" ("Average") measures the standard deviation (average) of the values in the relevant row across the four stocks and the bond. A single (double) asterisk represents deviation from expected value at 5% (1%), single sided *t*-test.

The row labeled "Trade intensity" measures the proportion of non-zero sales, out of 30 subjects, thus identifying the stocks subjects have traded most actively. The last section shows the fraction of non-zero sales that occurred at each meta-position level, and non-meta-position transactions. By definition, the sum of all those fractions equals "Trade intensity".

Table 3 shows the simplest case: stocks A and B increased in value, while C and D declined. The bond increased 5% in all experiments. Clearly, subjects sold from stock A, which increased from $400 to $600, an amount significantly higher than expected under the proportional assumption (p<1%), and under the uniform assumption (p<5%). This finding is consistent both with the disposition effect, because stock A is a "winner", and with the meta- position hypothesis, as trading $600 is the simplest way to execute the trade. Nevertheless, subjects *did not* sell significantly higher amounts from stock B, also a winner, and they sold *significantly less* (p<5%) than the proportional expectation from the bond, a winner as well. This indicates preference to selling the simple meta-position of $600, rather than investing time and mental effort in "complex" computations and decisions.

Table 3: Manipulation check #1
Highlighting winning stock "A" as smallest holding, and Meta-position 1st order

	STD	*Average*	*A*	*B*	*C*	*D*	*Bond*
Pre price changes	248	870	400	850	1,000	1,100	1,000
Post price changes	177	910	600	1,100	850	950	1,050
Actual sold	62	120	238	113	85	102	62
Expected sales	23	120	79	145	112	125	138
Actual portfolio	230	790	362	987	765	848	988
E. portfolio, % sales	154	790	521**	955	738	825	912*
E. portfolio, uniform sales	177	790	480*	980	730	830	930
Trade intensity			53%	37%	33%	33%	17%
Meta-position 1st order			30%	10%	3%	7%	7%
Meta-position 2nd order			17%	13%	13%	13%	7%
Meta-position 3rd order			3%	7%	7%	3%	0%
Meta-position 4th order			3%	7%	7%	7%	3%
Non meta-position trades			0%	0%	3%	3%	0%

Another finding worthy highlighting is that meta-position sales of the 2nd order are most dominant in stocks B, C, and D, (13%), while meta-position sales of the 1st order is dominant in stock A (30%). This latter finding may be attributed to either the exact match of $600 to stock A's value in the portfolio, or to the fact that stock A's value is smallest among the others. While the first explanation is associated with the saliency of "600", the latter explanation may be the result of striving to achieve a simple portfolio of 3, rather than handling 4 stocks in the portfolio. To control for these effects and gain more insight on their relative importance, Table 4 also features a non-uniform portfolio, with two winners (A, B) and two losers (C, D), yet stock B's value is salient at 1,600.

Table 4: Manipulation check #2
Highlighting winning stock "B" as highest holding, and Meta-position 1st order

	STD	*Average*	*A*	*B*	*C*	*D*	*Bond*
Pre price changes	287	1,160	700	1,400	1,500	1,200	1,000
Post price changes	205	1,200	1,050	1,600	1,150	1,150	1,050
Actual sold	66	120	83	248	80	70	118
Expected sales	20	120	105	160	115	115	105
Actual portfolio	147	1,080	967	1,352	1,070	1,080	932
E. portfolio, % sales	184	1,080	945	1,440	1,035	1,035	945
E. portfolio, uniform sales	205	1,080	930	1,480*	1,030	1,030	930
Trade intensity			30%	57%	30%	23%	37%
Meta-position 1st order			7%	33%	7%	7%	13%
Meta-position 2nd order			3%	10%	7%	3%	0%
Meta-position 3rd order			7%	7%	0%	0%	7%
Meta-position 4th order			13%	7%	17%	13%	17%
Non meta-position trades			0%	0%	0%	0%	0%

Subjects sold significantly more than expected values from stock B, (p(uniform) <5%), which also features the most dominant meta-position sales of the 1st order (33%). Note that although stock A increased 50%, the most prominent winner, subjects sold it less than the expected amount (83 vs. 105), but they sold more than expected from stock B (248 vs. 160), although it only increased about 14%. Evidently, this finding is not consistent with DE. Further note that meta-positions of the 4th order (4X150) are most prevalent in A, C, D, and the bond, because their values attract attention to the "150" meta-position. Thus, while Table 4 weakly supports DE as subjects sold from the winning stock B, it also highlights the role of meta- positions.

Table 5 features three winners (B, C, D) and one losing stock, A, which declined in value 30%, from 900 to the 1st order meta-position 600. Subjects' average trades are significantly *against the disposition effect*: although stock A is a losing stock, it was sold significantly more than expected, by both reference expectations (p<1%). This finding highlights the greater importance that subjects assign to salient meta-position trades over keeping losers, as the disposition effect would suggest. Further, contrary to the disposition effect, subjects sold significantly less than expectations, by both measures, from the winning stocks B and C.

Table 5: Manipulation check #3
Highlighting losing stock "A" as smallest holding, and Meta-position 1st order

	STD	*Average*	*A*	*B*	*C*	*D*	*Bond*
Pre price changes	87	970	900	850	1,000	1,100	1,000
Post price changes	225	1,030	600	1,100	1,150	1,250	1,050
Actual sold	75	120	265	63	68	113	90
Expected sales	26	120	70	128	134	146	122
Actual portfolio	293	910	335	1,037	1,082	1,137	960
E. portfolio, % sales	199	910	530**	972*	1,016*	1,104	928
E. portfolio, uniform sales	225	910	480**	980*	1,030*	1,130	930
Trade intensity			60%	23%	27%	37%	27%
Meta-position 1st order			37%	3%	3%	7%	7%
Meta-position 2nd order			3%	7%	3%	10%	10%
Meta-position 3rd order			17%	7%	10%	13%	3%
Meta-position 4th order			3%	7%	7%	7%	3%
Non meta-position trades			0%	0%	3%	0%	3%

Table 6 shows results of an experiment with two winning stocks, (A, D), and two losing stocks, (B, C). Stock B declines 20%, to 1,600, highlighting the meta-position value "600". Consistent with the previous finding and *against* the disposition effect, stock B was sold significantly more than the uniform expectation ($p<5\%$). Stock D was sold significantly less than both expected values ($p<5\%$), in spite of being a winner, against the disposition effect.

Table 6: Manipulation check #4
Highlighting losing stock "B" as highest holding, and Meta-position 1st order

	STD	*Average*	*A*	*B*	*C*	*D*	*Bond*
Pre price changes	445	1,280	700	2,000	1,500	1,200	1,000
Post price changes	204	1,220	1,050	1,600	1,150	1,250	1,050
Actual sold	66	120	95	248	90	63	103
Expected sales	20	120	103	157	113	123	103
Actual portfolio	153	1,100	955	1,352	1,060	1,187	947
E. portfolio, % sales	184	1,100	947	1,443	1,037	1,127*	947
E. portfolio, uniform sales	204	1,100	930	1,480*	1,030	1,130*	930
Trade intensity			33%	57%	30%	23%	27%
Meta-position 1st order			7%	30%	7%	3%	13%
Meta-position 2nd order			17%	20%	17%	3%	7%
Meta-position 3rd order			3%	0%	0%	3%	3%
Meta-position 4th order			7%	7%	7%	7%	0%
Non meta-position trades			0%	0%	0%	7%	3%

Trade intensity is highest in stock B, with highest 1st and 2nd order meta-position sales. Further, the presence of "50" in all other stocks and the bond resulted in higher 4th order meta- position (4X150), than 3rd order meta-positions. This finding highlights the notion that investors are attracted to simple decision rules, and these are state-dependent. In our case, portfolio composition appears to be more important than the disposition effect.

In Table 7 and in Table 8 the post-price-changes vector of security prices is identical (second line from top), but the roles of winners and losers are switched. In Table 7 stocks A and D are winners, and in Table 8 they are losers, with B and C obtaining the opposite roles. Stocks B and C feature meta-position values of the 2nd order, "450" and "150".

Table 7 shows that while B is a losing stock, it was sold significantly more than both expectations (p(proportional)<5%, p(uniform)<1%), against the disposition effect but consistent with meta-position trade of the 2nd order. Stock C was sold significantly less than expected, consistent with the disposition effect but against meta-position trade of the 2nd order. While stock B was most intensively traded (67%), the second most active stock was D. We explain the findings related to stocks C and D by subjects' tendency to obtain about uniform holdings across stocks: after selling some of stock B, possibly to $1,000, stock D is the biggest holding ($1,250), thus selling on average 140 of it brings the portfolio close to uniform. While this tendency toward 1/N appears to be relevant, it is unclear at this stage how important it is compared with meta-position trades, and the disposition effect.

Table 7: Manipulation check #5
Examining more balanced portfolio: Total holdings in the losing stocks was higher

	STD	*Average*	*A*	*B*	*C*	*D*	*Bond*
Pre price changes	329	1,200	700	1,600	1,500	1,200	1,000
Post price changes	150	1,190	1,050	1,450	1,150	1,250	1,050
Actual sold	62	120	90	232	60	140	78
Expected sales	15	120	106	146	116	126	106
Actual portfolio	96	1,070	960	1,218	1,090	1,110	972
E. portfolio, % sales	135	1,070	944	1,304*	1,034*	1,124	944
E. portfolio, uniform sales	150	1,070	930	1,330**	1,030**	1,130	930
Trade intensity			33%	67%	30%	53%	20%
Meta-position 1st order			7%	13%	0%	10%	10%
Meta-position 2nd order			7%	33%	10%	20%	0%
Meta-position 3rd order			10%	7%	7%	10%	7%
Meta-position 4th order			10%	13%	13%	13%	3%
Non meta-position trades			0%	0%	0%	0%	0%

Interestingly, Table 8 shows that while stocks B and C were switched from being losers to being winners, stock B was sold less intensively than it was sold in Table 7 (against DE), thus significantly different only from the proportional expectation. Stock C was sold more intensively (average 85 vs. 60), presumably because in Table 8 it was a winner, yet this gap is not significant. Lastly, stock C was traded more intensively in Table 8 than in Table 7, 47% vs. 30%, mostly at 2nd order meta-position, which, together with the smaller amount sold from stock D appear to be consistent with DE. These gaps are not significant, yet may indicate on possible future research paths.

Table 8: Manipulation check #6
Examining more balanced portfolio: Total holdings in the winning stocks was higher

	STD	*Average*	*A*	*B*	*C*	*D*	*Bond*
Pre price changes	148	1,150	1,200	1,150	1,000	1,400	1,000
Post price changes	150	1,190	1,050	1,450	1,150	1,250	1,050
Actual sold	51	120	103	218	85	115	78
Expected sales	15	120	106	146	116	126	106
Actual portfolio	105	1,070	947	1,232	1,065	1,135	972
E. portfolio, % sales	135	1,070	944	1,304	1,034	1,124	944
	150	1,070	930		1,030	1,130	930
E. portfolio, uniform sales				1,330*			
Trade intensity			37%	63%	47%	50%	23%
Meta-position 1st order			13%	10%	3%	7%	7%
Meta-position 2nd order			3%	37%	27%	17%	10%
Meta-position 3rd order			0%	0%	3%	3%	3%
Meta-position 4th order			3%	7%	7%	7%	3%
Non meta-position trades			17%	10%	7%	17%	0%

4. Conclusions

Experimental studies of the patterns by which investors trade in the stock market often assume a single asset setup. This paper presents behavioral laboratory results aimed to examine what roles would stocks' relative values (saliency) play in investors' selling decisions in the realistic and prevalent case where investors hold more than one stock in their portfolio. In addition, we explore whether having multiple stocks in investors' portfolios is associated with the disposition effect, which is an aspect that, to our best knowledge, was tested only by Be'eri et. al (2019). The approach we propose is novel, as it traces the patterns by which investors trade toward achieving uniform portfolio holdings. While investors' tendency to hold uniform portfolios was reported in the literature, we add to the literature by showing that the way to get to uniform portfolios is predictable on behavioral grounds. Apparently, portfolio managers should be aware of this behavioral phenomenon, either filtering clients' trading orders, or noticing the same patterns as they trade for their clients, in both cases a client's portfolio might be tilted away from an optimal structure.

Our findings highlight the important role that portfolio composition plays in investors' selling decisions. We coin the term "meta-position" to represent easily computable trades and show that simple computations are more important than the disposition effect throughout the decision-making process. In fact, the disposition effect appears irrelevant in our setting.

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