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The impact of the virtual integration of assets on pension risk preferences of individuals

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DESIGN PAPER 133

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Abstract

The impact of the virtual integration of assets on pension risk preferences of individuals

Recent pension reforms allow individuals more choice in managing their post-retirement finances. If they actively choose , individuals face complex investment decisions that involve risks and returns of multiple assets and investment portfolios related to their pension savings. To reduce the complexity of these investment decisions and to overcome behavioral biases, it has been suggested that presenting risk-return information in an integrated manner may be helpful. However, evidence for the impact of such aggregation of assets on risk taking by individuals is mixed. Also, such evidence in the context of pension investments is unknown. Therefore, in this paper, we study the impact of integrating multiple assets on risk taking by conducting two experiments, using an interactive simulation tool called the Distribution Builder. In the first experiment, we examined the impact of integrating a fixed income (i.e., monthly income from a state pension) with a risky asset return (i.e., monthly income from an employment-based pension). The results show that respondents can make a consistent decision regardless of whether investments are integrated, as the Distribution Builder allows them to focus on the risk-return distribution. In the second experiment, which investigates the effect of integrating two risky investment products, respondents made different decisions when investment products were integrated compared to the case of not integrating products. Unlike in the first experiment, respondents in the second experiment tended to have difficulty in taking two risky products into account jointly, which resulted in the choice of inefficient portfolios when products were not integrated. However, we found that the degree of respondents' mistakes decreased as they understood the information presented in the Distribution Builder better. Therefore, our findings suggest that the virtual integration of investment products using an interactive tool such as the Distribution Builder can help individuals to determine a desirable risk-return profile for retirement investment portfolios by enabling them to consider all assets jointly. Also, pension companies can develop a tailor-made investment strategy for individuals using the risk-return profile of portfolios that individuals determined in the Distribution Builder.

Samenvatting

Het effect van virtuele investeringsintegratie op de pensioenrisicohouding van individuen

Recente pensioenhervormingen maken het voor individuen vaker mogelijk om hun pensioen-financiën zelf te regelen. Als ze daar voor kiezen worden zij geconfronteerd met complexe beslissingen rondom de risico's en opbrengsten van de diverse investeringen en beleggingsproducten met betrekking tot hun pensioen. Om de complexiteit van deze investeringsbeslissingen te verminderen en mogelijke fouten te voorkomen, is geopperd dat een geïntegreerde presentatie van risico-rendementsinformatie nuttig kan zijn. Echter, eerdere onderzoeksresultaten over het effect van een dergelijke aggregatie van informatie op de keuzes van individuen laten gemengde resultaten zien. Ook is weinig bekend over mogelijke toepassingen op het gebied van pensioenbeleggingen. Daarom bestuderen we in dit paper het effect van het integreren van meerdere beleggingsproducten op het nemen van risico's. We rapporteren de resultaten van twee experimenten met een interactieve tool: de "Distribution Builder". In het eerste experiment onderzochten we de impact van het integreren van een vast inkomen (d.w.z. een maandelijks inkomen uit de AOW) met een risicovolle investering (d.w.z. een maandelijks inkomen uit een DC-pensioen). De resultaten laten zien dat in deze situatie, respondenten een consistente beslissing kunnen nemen, ongeacht of investeringen geïntegreerd of apart worden gepresenteerd. De Distribution Builder helpt ze om zich te concentreren op de totale risico-rendementsverdeling. Het tweede experiment onderzoekt het effect van het integreren van twee verschillende risicovolle beleggingsproducten. Anders dan bij het eerste experiment, hadden de respondenten in het tweede experiment moeite met de gezamenlijke evaluatie van de twee risicovolle producten. Dit resulteerde in de keuze van inefficiënte portefeuilles wanneer de producten niet geïntegreerd waren. De fouten van de respondenten namen af naarmate ze de informatie in de Distribution Builder beter begrepen. Onze bevindingen laten daarom zien dat de virtuele integratie van beleggingsproducten met behulp van een interactieve tool zoals de Distribution Builder individuen kan helpen bij het bepalen van hun gewenste risico-rendementsprofiel. De aanpak stelt hen in staat om meerdere beleggingsproducten gezamenlijk te beschouwen. Zo kunnen pensioenfondsen een op maat gemaakte beleggingsstrategie ontwikkelen voor individuen, door gebruik van de risico-rendementsprofielen die ze zelf bepalen in de Distribution Builder.

1. Introduction

In the Dutch pension system, a transition has been proposed, because of population aging and the changed labor market structures, toward pension plans that shift risks to individual participants during the accumulation phase (i.e., from defined benefit plans to individual or collective defined contribution plans). Proposals to that effect include the development of more individualized pension designs, including tailor-made investment strategies for retirement income (Bovenberg and Nijman, 2017; De Boer, 2019). In such pension designs, individuals can choose the level of risk in the employment-based pension investment in line with their personal preferences, considering their private financial investment holdings, such as savings, stocks, bonds, and real estate. In such a setting, individuals are thus more likely to face complex investment decisions that require pooling the risks and returns of multiple financial assets.

However, this has elicited debate on the increasing freedom of choice in pension investment decisions. While results from polls initiated by the Dutch government in 2014 indicated that more than half of the Dutch population preferred to choose their own investment portfolio and pension premium level (Koenen, 2014), Van Dalen and Henkens (2018) found that most pension holders prefer to leave some decisions with pension funds. Also, recent research has led to skepticism about the ability of individual persons to make such complex investment decisions regarding their retirement savings. According to Benartzi and Thaler (2007) and Van Rooij et al. (2007), individuals tend to be reluctant to take control over their defined contribution (DC) plan because they find it difficult to decide about investment portfolios for retirement. Moreover, literature in behavioral economics has suggested that individuals are prone to make poor investment decisions due to limited cognitive ability, unlike the assumption of modern portfolio theory pioneered by Markowitz (1952). According to mental accounting theory, individuals compartmentalize their investments into mental accounts and evaluate the gain and loss for each mental account separately (Thaler, 1985). Because of this, they tend to ignore other holdings when making an investment decision (Kahneman and Lovallo, 1993), and to ignore the correlation between asset returns in the portfolio diversification even when they notice it (Gubaydullina and Spiwoks, 2015; Kallir and Sonsino, 2009; Kroll et al., 1988). Furthermore, their risk-taking behavior largely depends on how the decision is framed, as this affects the formation of mental accounts (Thaler, 1999; Tversky and Kahneman, 1981).

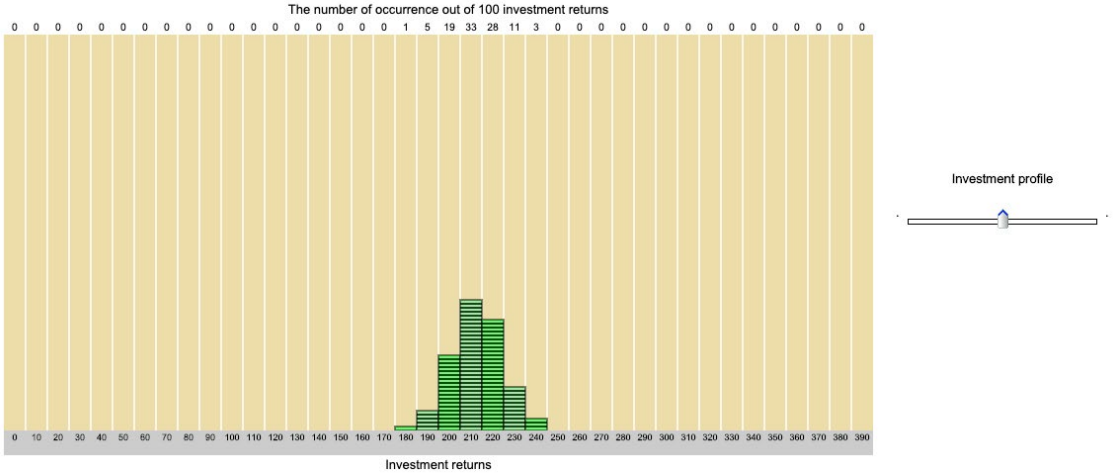
Since individuals are likely to experience difficulties when they need to take multiple financial assets into account jointly, virtual integration of the assets that make up their retirement investment can help them to consider their assets as a single portfolio for retirement wealth and thus lead to better decisions. Various experiments have examined the effects of aggregating information at portfolio level on individual risk-taking behavior. Kaufman and Weber (2013) found that aggregating the return information of one risk-free asset (e.g., a bond) and one risky asset (e.g., an equity) encourages individuals to increase their shares of the risky asset. However, evidence of the effects of aggregation of return information across multiple risky and risk-free assets was not robust among researchers (cf. Anagol and Gamble, 2013; Beshears et al., 2016). Also, these studies have not explored how aggregation across multiple assets affects individual risk-taking behavior under different conditions when it comes to the correlation between asset returns[1]. Most importantly, the effect of aggregating multiple pension products has not been tested yet, although Vlaev et al. (2010) argued that risk preferences are sensitive to the financial context.

We therefore decided to conduct two experimental studies of the impact of virtual integration of multiple asset returns on risk-taking pertaining to an individual person's pension. In each study, we introduced two conditions of integrating asset returns: one without integration and one for a single portfolio with integration of assets. Both conditions were applied with the help of an interactive decision support tool, the *Distribution Builder* (Goldstein et al., 2008), which allows individuals to express their preferences regarding risky investment outcomes, using an intuitive interface. The tool shows the impact of a specific decision on the risks and returns of financial outcomes (Dellaert et al., 2016). In the Distribution Builder, the risk-return information of an investment product is presented graphically, and respondents are asked to select their most preferred risk level of the investment product by moving a slider on a scale as shown in Figure 1. The slider is initially positioned in the middle, and moving the slider to the left indicates reduction of the risk level. The tool automatically presents the distribution of possible outcomes at the risk level corresponding to the position of the slider, through an interactive graph of 100 markers, with each marker representing an outcome that has an equal probability of occurring. The outcomes become distributed more widely, with a higher risk level as presented in the figure. After choosing their preferred risk level, respondents experience the return

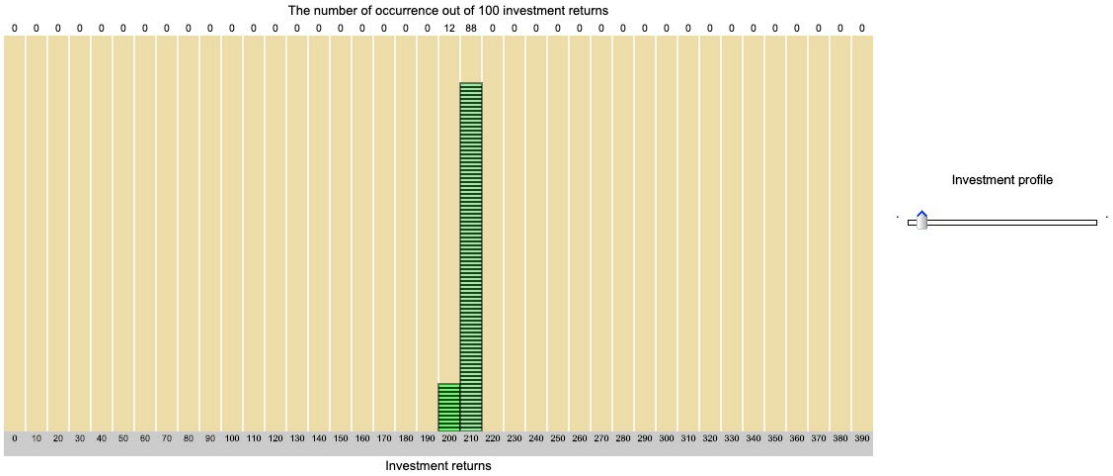
1 Both Anagoal and Gamble (2013) and Beshears et al. (2016) calculated correlations between asset returns from the historical data to simulate investment returns in the experiment. However, they did not report the exact specification of correlations nor did they investigate investors' behaviors by changing correlations.

Figure 1 Example of a Distribution Builder

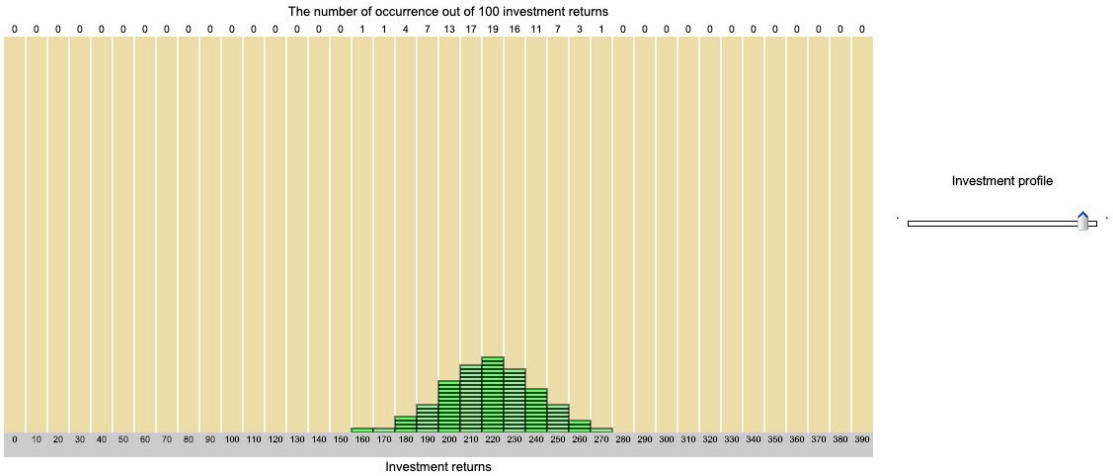
a. Medium risk level as default



b. Reduce the risk level by moving a slider to the left



c. The risk level increases by moving a slider to the right



distribution by observing five randomly sampled returns. This gives them a better understanding of the risk-return profile (Goldstein et al., 2008; Kaufmann et al., 2013).

In experiment 1, we investigated the effect of integrating the returns from the Dutch state pension (in Dutch: *Algemene Ouderdomswet*, commonly referred to as AOW) and the employment-based pension on personal risk-taking behavior. Since people are expected in the Dutch pension system to substitute most of their wages by the sum of AOW pension income and employment-based pension income, they should assess the investment outcomes from both pension income sources together. Because the AOW pension provides a certain baseline income, our first experiment can be seen as a replication of Kaufman and Weber's study (2013), which found a significant effect of aggregating return information of a risk-free asset and a risky asset on personal risk-taking behavior; however, we translate their setup to the pension domain[2]. While respondents in Kaufman and Weber (2013) were asked to allocate investment money between two assets using a slider, in our experiment respondents chose the most preferred risk level of the investment product (i.e., the employment-based pension product, because people have no say on the AOW pension investment). Although the decision task of this paper is different from that of Kaufman and Weber, we expected that respondents would increase their risk-taking level when integrating pension products, as found in previous literature, because they perceive smaller losses as the overall level of the employment-based pension income is added to the AOW pension income.

In experiment 2, we examined the effect of integrating risky investment products on the risk-taking behavior of individuals. Such integration can be essential to help them make better retirement investment decisions, as they are then more likely to consider multiple risky products jointly. This study can also contribute to the body of research of the effect of information aggregation over multiple risky assets, because the evidence to date is not robust (i.e., Anagol and Gamble, 2013; Beshears et al., 2016). However, this study is significantly different from the others. In our study, we assumed a simple case where respondents invest half of their money in each of two risky investment products. Each investment product consisted of a risk-free asset and a risky asset; however, respondents were not aware of this split. Respondents were only told to choose the risk level that they preferred most. This technically determined the weight between the risk-free asset and the risky asset in the investment product.

2 While it could be argued that there is also an inherent risk in the AOW pension, in our communication to respondents in this experiment we followed common practice in current pension advice to present this component as a risk-free income after the AOW pension age.

The other studies, on the other hand, asked respondents to allocate the investment money between four assets directly, but that might make respondents vulnerable to the use of the 1/N heuristics (without paying attention to the return information) due to the complexity of the decision task (Ehm et al., 2018). Therefore, we expected that our experiment would show a significant effect of integrating investment products on a person's risk-taking behavior because respondents were able to focus on the return information. Moreover, unlike previous studies, various conditions were applied regarding the correlation between investment returns to investigate whether this moderates the effect of integrating assets.

The remainder of the paper is as follows. Chapters 2 and 3 describe the experimental design and the results of experiments 1 and 2, respectively. The discussion about results and policy implications are presented in Chapter 4, and Chapter 5 concludes with a summary of results.

2. Integrating risky and risk-free pension income

In the first experimental study, we aim to examine whether the results from earlier studies (i.e., that respondents take more risks when aggregating returns) are replicated in the case of integration of a monthly fixed income from the AOW pension (i.e., a risk-free asset) with a monthly return from an employment-based pension (i.e., a risky asset).

2.1 Experimental design

2.1.1 Experimental conditions

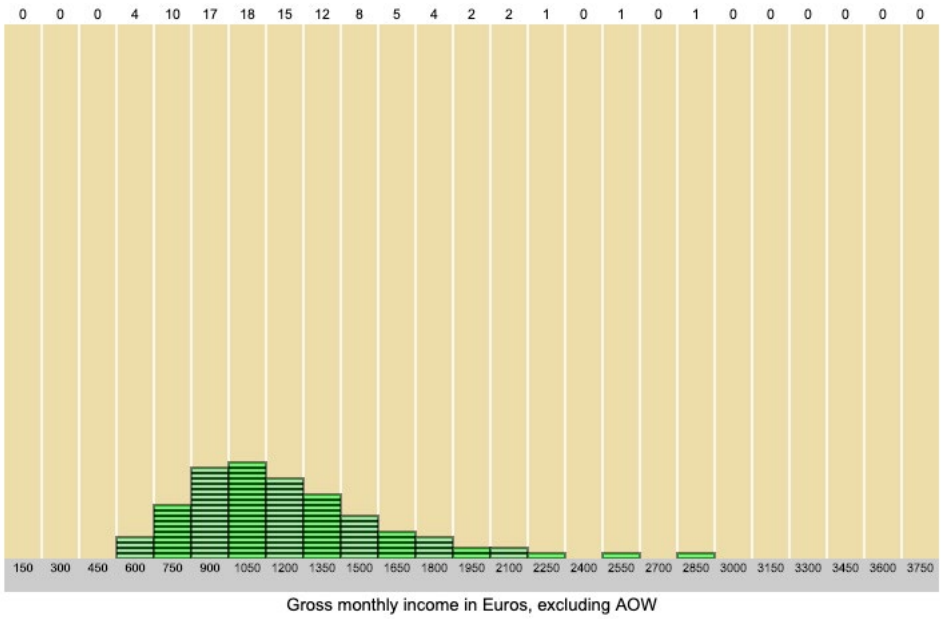
In this study, we introduce two experimental conditions. In the condition without integration (called *the separate condition*), respondents chose their risk levels for the employment-based pensions; the AOW pension incomes were not included in the outcomes that appeared in the distribution builder but were described only verbally (see Figure 2a). In the condition of integration (called the *integrated condition*), the distribution builder also presented the outcomes from combining both pension incomes (see Figure 2b). As a result, the levels of income for the two conditions were different while the shapes of the distribution of income were the same. The monthly incomes from the AOW pensions and the employment-based pensions were simulated based on the ages and incomes that respondents had provided at the beginning of the experiment and on the assumption of a retirement age of 67. To ensure the reliability of the experimental results, we screened out those respondents whose ages or annual incomes were outside of the range of 21 to 65 years and of €15,000 to €300,000, respectively. Respondents who were in the targeted age and income range were randomly assigned to one of the two experimental conditions.

2.1.2 The procedure of the experiment

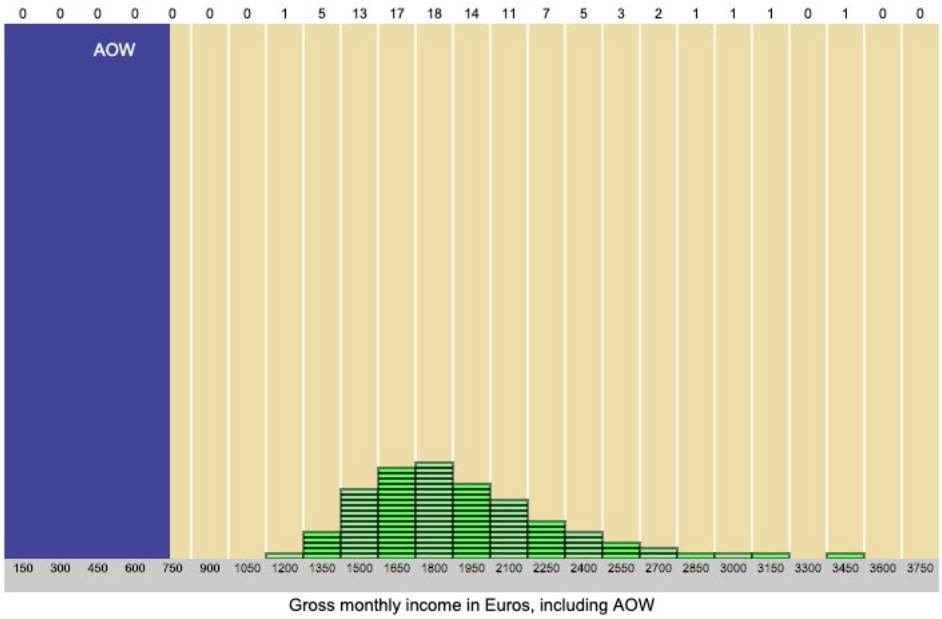
Respondents were invited by means of an email. This contained brief information about the purpose and procedure of the study and a hyperlink to access an online survey. At the start of the survey, all respondents who were willing to participate were asked about their age and their annual income (exact or estimated) to enable screening respondents out and simulating pension incomes. Respondents in the targeted age and income range were randomly assigned to one of two conditions regarding the integration of assets. Respondents were asked to watch an instructional video to help them understand the Distribution Builder. Respondents were then asked to choose their preferred risk level in an investment decision task using the Distribution Builder.

Figure 2 Example of pension income information provided on a distribution builder in experiment 1

a. Separate condition (only presenting employment-based pension income)



b. Integrated condition marking AOW pension income



They were allowed to try as many risk levels as they wanted before making a final decision. However, to ensure that the respondents understood the risk-return profile described in the Distribution Builder, they were asked to go through a trial decision

task first, which forced them to experience at least five possible outcomes before making a final decision.

Upon completion of the tasks for deciding the most preferred risk levels, respondents were asked to answer some characteristics that can impact risk-taking behavior. They were also asked to provide demographic information, such as their gender and level of education (cf. Anagol and Gamble, 2013; Bateman et al., 2016; Kaufmann and Weber, 2013; Van Rooij et al., 2007). The first characteristic measured in this study is the respondents' understanding of the risk-return information presented in the Distribution Builder. The *understanding* score was determined by the combined answers to four questions, which tested whether respondents inferred the risk or expected returns correctly under the given sample distribution, where each correct answer gives one point. The second characteristic is the respondents' cognitive ability, measured on the basis of the cognitive reflection test suggested by Frederic (2005). This assesses whether respondents tend to use cognitive system 1 (involving intuitive thinking and less cognitive effort) or cognitive system 2 (involving conscious reasoning and high cognitive effort). The *cognitive ability* score was measured by the sum of three questions, where each correct answer yields one point. Respondents who are more likely to use cognitive system 2 get a higher score. We then assessed the respondents' knowledge regarding financial problems (*financial literacy*) based on the advanced financial literacy questions developed by Van Rooij et al. (2011). Four questions were used to compute the financial literacy score, adding up points for each correct answer. In addition, the respondents' subjective risk preference scores (*risk preference*) were measured by taking the average of two questions. In the first question, we asked respondents to express their risk preferences regarding the pension investment on a scale of 1 (not willing to take any risk) to 7 (willing to accept substantial risk to potentially earn a greater return), adapted from Kaufman and Weber, 2013. The second question, on the other hand, asked respondents' general preferences for risks on a scale of 1 (not at all willing to bear high risk) to 4 (very willing to bear high risk for earning a high expected return), adapted from Dorn and Huberman (2005) and Anagol and Gambl (2013). Lastly, we measured the respondents' satisfaction on the risk-return distribution presented by the Distribution Builder initially (*satisfaction*) and their expectation of the amount of AOW pension income (*expected AOW income*). All survey questions used in this study are presented in the appendix.

2.1.3 Participants

Respondents were recruited by the market research agency Right Minds from their online panel, during ten days in December 2017. After completing the survey,

Table 1 Descriptive statistics of respondents in experiment 1

	Value	P-value[a]
Age	44.92 ± 13.47	0.81
Annual income	40,133 ± 25,795	0.43
Male	138 (53.1%)	0.40
Schooling		0.13
Primary education	4 (1.5%)	
High school	41 (15.8%)	
Secondary vocational education (MBO)	74 (28.5%)	
Higher vocational education (HBO)	103 (39.9%)	
University education or higher	37 (14.2%)	
Others	1 (0.4%)	
Understanding[b] (Min. 0; Max 4)	2.18 ± 1.11	0.05
Cognitive ability[b] (Min. 0; Max 3)	1.03 ± 1.08	0.10
Financial literacy (Min. 0; Max 4)	2.55 ± 1.08	0.37
Risk preference[c] (Min.1; Max. 5.5)	2.75 ± 1.06	0.68
Satisfaction (7 Likert)	4.67 ± 1.29	0.45
Expected AOW income (€)	1,177 ± 939	0.47

a For testing the significant difference between two groups, t-test for the null hypothesis on the equality of means was used for continuous variables and Chi-square test for equality of proportion for categorical variables.

b Because of the questioning order, the score could be overestimated as respondents had been able to practice with the decision tasks using the Distribution Builder prior to answering.

c Correlation between two items = 0.84; Cronbach alpha = 0.75

respondents were paid €2.35 as compensation for their participation. Table 1 presents the descriptive statistics of their characteristics in experiment 1. Among the 260 respondents whose data were used in the analysis, 125 (48.8%) were assigned to the condition of integration. The last column in the table presents the test result for the significant difference between respondents who were in the integrated condition and those who were in the separate condition. As shown in the table, none of the characteristics except for the understanding score were different between the two groups at a 5% significant level. For the understanding score, respondents who were in the integrated condition showed a higher average score (2.32) than those in the separate condition (2.05). However, this difference might also result from a higher proportion of respondents who had a university level education (20% versus 8.9%).

2.2 Results

2.2.1 The effect of integrating AOW pension income and employment-based pension income

Among the five scales of risk levels, the average value (standard deviation) of the respondents' choice on risk levels was 2.82 (0.09) and 2.81 (0.10) under the integrated condition and the separate condition, respectively. The independent t-test result did not show a significant difference between the two groups (P=0.94). In addition, Figure 3 shows no systemic difference between the two groups in the respondents' choices.

The linear regression result on the risk-taking level of respondents also suggests no significant impact of integrating AOW pension income and employment-based pension income on the risk-taking decisions of respondents on the employment-based pension investment. As shown in Table 2, the variable indicating the integrated condition does not have a significant main effect as well as no interaction between respondents' characteristics. On the other hand, the level of education, financial literacy, and subjective risk preferences of respondents have significant impact on their risk-taking levels. According to Table 2, respondents with higher financial literacy and a preference for higher risks tended to take more risks in the employment-based pension investment regardless of the conditions regarding integration. Also, respondents who only completed high school were more likely to take risks compared to those with a higher vocational education.

Figure 3 Comparison of distributions of risk levels chosen by respondents by conditions on integration

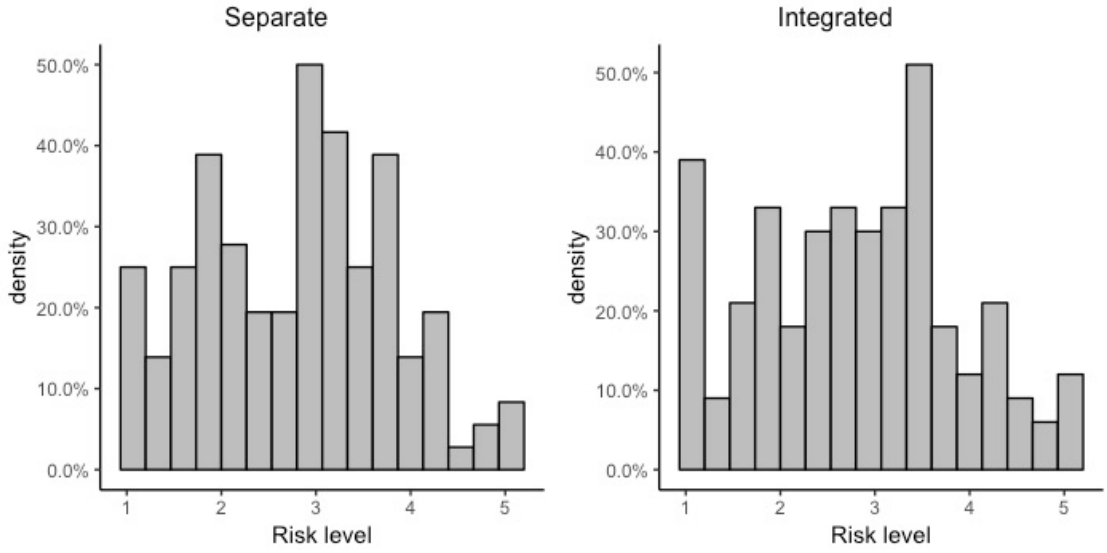


Table 2 Linear regression result on risk-taking level

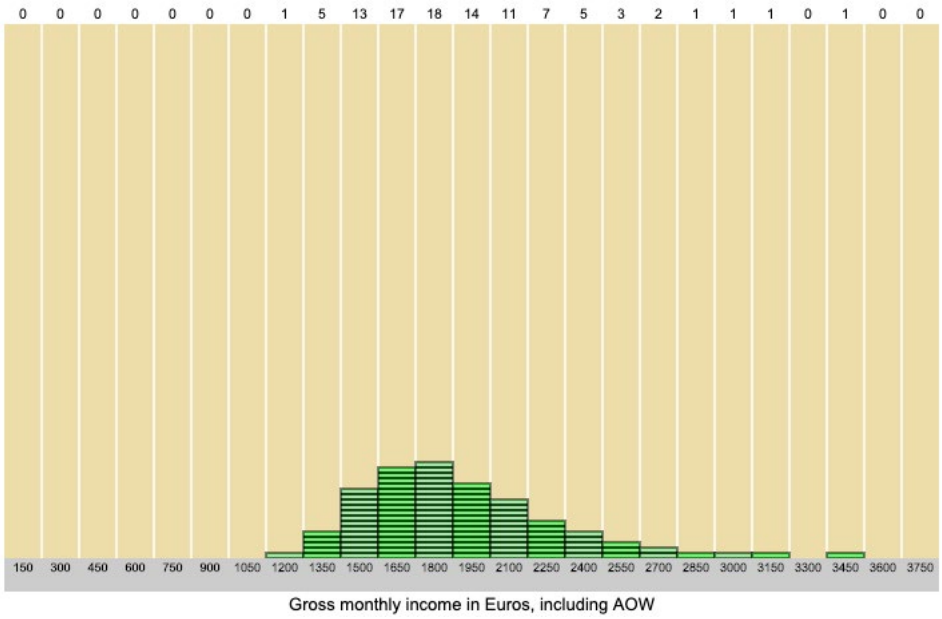
	Coefficient	Standard error
Constant	1.126	1.098
Integration (I)	0.204	0.320
Age	0.001	0.004
Log (income)	−0.103	0.108
Male	0.102	0.092
Schooling (Base: Higher vocational)		
Primary	0.175	0.365
High school	0.308**	0.136
Secondary vocational	0.161	0.113
University or higher	−0.140	0.140
Others	0.823	0.712
Understanding (U)	0.032	0.059
Cognitive ability (C)	0.059	0.064
Financial literacy (F)	0.104*	0.056
Risk preference (R)	0.769**	0.064
Satisfaction	0.001	0.035
Expected AOW	0.002	0.005
Interaction		
I x U	−0.091	0.085
I x C	−0.028	0.089
I x F	−0.020	0.086
I x R	0.036	0.086
Adj. R-squared	0.51	

Note: ** p<0.05; * p<0.1

2.2.2 Testing robustness: the effect of marking the AOW pension income

Since the amount of AOW pension income is marked by a blue bar in the integrated condition as illustrated in Figure 2b, one could argue that our condition is not appropriate for measuring the effect of integrating investment returns. Because the marking isolates the possible range of the employment-based pension in the Distribution Builder, it might have influenced respondents in their decision to segregate the fixed income from the integrated income and, by doing so, weaken the effect of integrating asset returns. We therefore created an additional condition, that income from the AOW pension and the employment-based pension are integrated without highlighting the AOW pension income, as shown in Figure 4. We contrasted this integrated condition with the condition shown in Figure 2b in order to examine whether marking the AOW pension as a separate income component would have an impact on respondents' risk-taking decisions. All other survey questions and experimental procedures were left unchanged from those used for the main experiment.

Figure 4 Integrated condition without marking the AOW pension income



For the additional experiment, 349 respondents were recruited during four days in May 2018. Of these respondents, 182 (52%) were randomly assigned to the integrated condition in which the AOW pension income was not marked, while the rest were assigned to the condition where AOW pension was marked. When comparing background characteristics, all measures except cognitive ability were found to differ insignificantly between respondents in the two conditions. When comparing the respondents' choices on risk levels between the two groups, we found no significant differences either (P=1.00): the average value (standard deviation) of risk levels chosen by respondents was identical under the integrated condition with and without marking the AOW income, namely 2.99 (0.08) in both situations. This shows that our finding of lack of impact of integrating incomes from the AOW pension and the employment-based pension does not depend on the way the AOW pension income is presented in the Distribution Builder. To summarize our findings, respondents experienced no difficulty when combining AOW pension income and employment-based pension income when making a risky investment decision regarding the pension, or at least their average preferred risk levels were not affected.

3. Integrating two risky investments

In the second experimental study, we test the influence of integrating two risky investment products under the paradigm of correlated returns on investments. Although highly relevant in the pension context, the experiment was executed in the domain of "regular" investments.

3.1 Experimental design

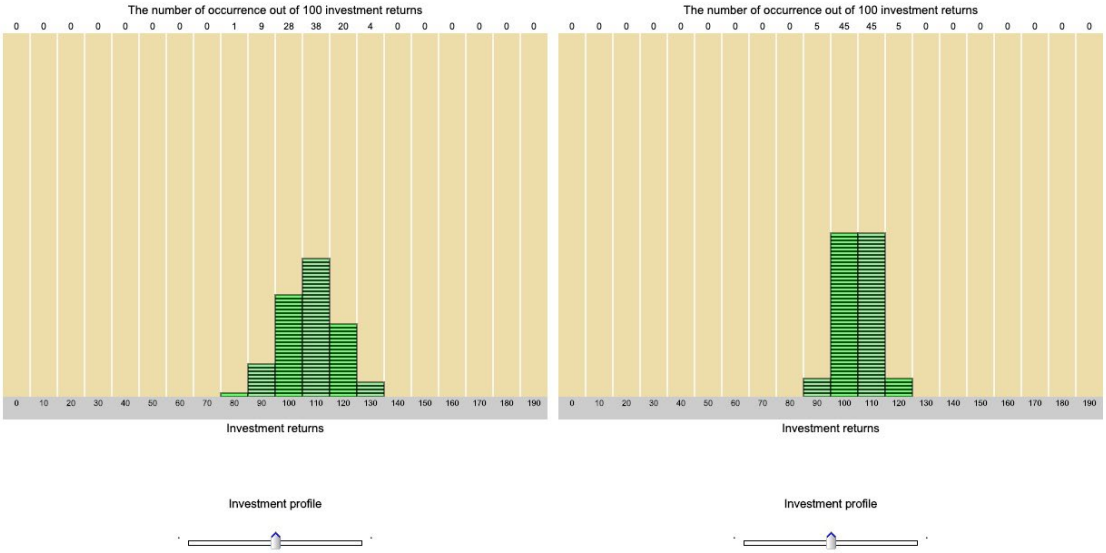
3.1.1 Experimental conditions

Respondents were presented a hypothetical situation in which they had to invest €100 in each of two investment products. To simulate returns on investments, we assumed that the returns of a risky asset engaged in each investment product are normally distributed. The distribution parameters were based on the distribution of annual returns of S&P500 companies from January 1988 to December 2017 (mean: 12.2%; standard deviation: 17.1%; retrieved from Shiller, 2018). More specifically, one asset (engaged in the investment product on the left in Figure 5a) was set to yield a higher expected return but was riskier (mean: 13%; standard deviation: 20%) than the other (mean: 7%; standard deviation 12%). We also specified the return of a risk-free asset as 3%, which is used to construct investment products with various risk levels, based on each of the two assets.

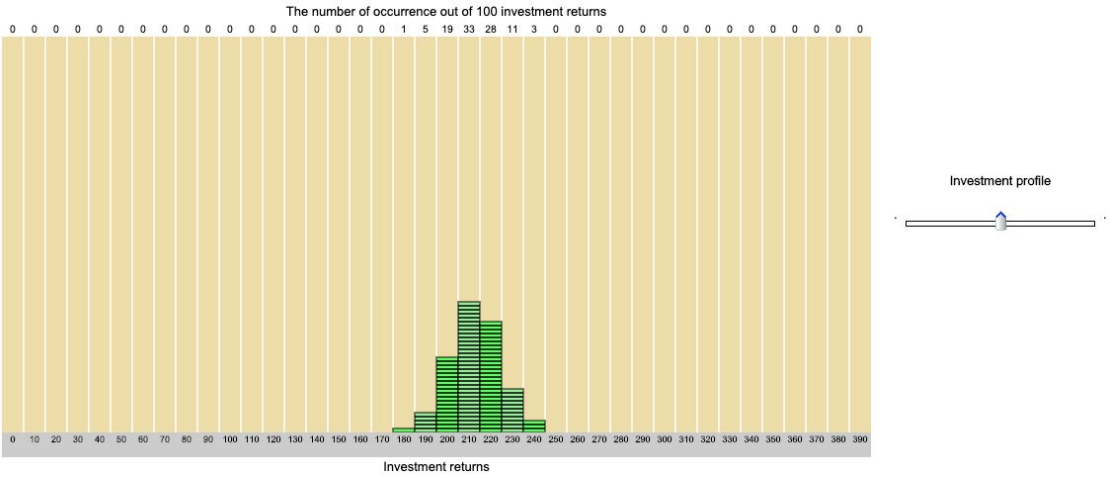
In the condition of no integration (the *separate* condition; see Figure 5a), respondents observed the distribution of returns for each investment product and selected their preferred risk level for the two products separately. They were asked to select their preferred risk level for the two investment products, which implied deciding on the share of a risky asset and a risk-free asset within the product. More specifically, they had to choose the risk of an investment product, ranging from the lowest level by putting full weight on a risk-free asset to the highest level by putting all money in the risky asset. This underlying mechanism, however, was not made explicit to the respondents, nor did they receive a detailed specification of return distributions regarding all assets. Thus, in our setting, respondents could strictly focus on the risk-return information presented in the Distribution Builder, without the need to consider asset weights during the investment decision. This is important as the decision on asset allocations across various asset classes is prone to biases like the 1/n heuristic (Ehm et al., 2018) and might be driven by the selected asset class labels and not by the factual return distribution.

Figure 5 Examples of investment decisions in the separate and integrated condition

a. Separate condition (investment product by product)



b. Integrated condition (efficiently integrated investment product)



On the other hand, in the condition of virtual integration of investments (the *integrated* condition; see Figure 5b), we presented the distribution of returns of an investment product that optimally combines the two risky assets underlying the investment products in Figure 5a, thereby creating a single investment product that achieves the highest Sharpe ratio (i.e., the highest excess returns over the risk-free rate, given a certain amount of risk). By choosing the risk level in the integrated condition, respondents decide how much weight they want to put on a risk-free asset and on the (efficient) combination of risky assets that jointly compose the integrated investment product. Thus, all risk-return profiles (i.e., all possible combinations of the expected return and the standard deviation of investment returns) in the

integrated investment product are on the optimal capital allocation line (CAL) in the risk–return space (see Figure 6). This allows respondents to have the best performance of an investment portfolio and to maximize their utility as suggested by modern portfolio theory (e.g., Lindblom et al., 2017; Markowitz, 1952; Tobin, 1958).[3]

For each of the two conditions that differ with respect to the integration of investments, we also consider three scenarios that differ with respect to the correlation among returns of the assets that underlie the two investment products: i) no correlation (Pearson correlation coefficient $\rho = 0$), ii) a positive correlation ($\rho = 0.6$), and iii) a negative correlation ($\rho = -0.6$)[4]. The correlation coefficient represents the degree of dependence in investment returns between the two investment products. If the correlation coefficient is close to zero (one), realized returns from the two investment products show little (close) relationship. Under the positive correlation, gains from one investment product tend to be matched by gains from the other investment product in the segregate condition; the opposite applies under the negative correlation. In addition, the return distribution for the complete investment portfolio varies by conditions regarding the correlation because the standard deviation of the return distribution depends on the correlation coefficient. Respondents were randomly assigned to one of these three conditions regarding the correlation. Unlike in experiment 1, we now present both conditions of integration to each respondent in a randomized order.

3 This condition was set to comply with Markowitz's approach for portfolio selection. Under this approach, it is suggested, when constructing a portfolio consisting of many risky assets and a risk-free asset, to find the optimal combination of risky assets, and then to build the complete portfolio by mixing a risk-free asset and the optimally combined risky assets with a weight corresponding to the investor's risk preference. The optimal combination of risky assets can be found by maximizing the expected return per unit of risk (i.e., Sharpe ratio). Mixing this optimal combination and a risk-free asset enables investors to have the most risk-efficient portfolio regardless of how much weight they put on the risky assets relative to the risk-free asset. All available portfolios are on the line connecting the risk-free asset profile and the profile of the optimal combination of risky assets in the risk-return space. This yields the optimal CAL. Modern portfolio theory predicts that, on the optimal CAL, investors who prefer a small risk will choose portfolios close to the risk-free asset profile, while those who prefer a high risk will choose the profile of the optimal combination of risky assets .

4 Empirical studies which examined the realized correlation of stock returns found that most correlation coefficients are concentrated on the positive values. For example, Wang et al. (2018) estimated the Pearson correlation coefficient for daily returns of 57 stock markets during the period from 2005 to 2014, which averaged 0.36 with -0.03 and 0.95 as minimum and maximum value, respectively. However, the experimental studies assumed the correlation symmetrically (e.g., -2/3 to 2/3 in Kallir and Sonsino, 2009; and -0.6 to 0.6 in Laudenbach et al., 2017), as done in this paper.

3.1.2 The procedure of the experiment

The experimental procedures were similar to those in experiment 1. Respondents were invited by email with a brief explanation about the study and a link to the online survey. Once respondents agreed to participate, they were assigned to one of three conditions regarding the degree of correlation among the risky assets and asked to watch an instructional video. Respondents then accessed the Distribution Builder tool, where they had to select their preferred risk level in the two investment decision tasks. These tasks considered the integrated and separate conditions that were presented in randomized order. For each choice of the degree of risk that they preferred, respondents had to select a level and to experience a number of draws from the resulting distribution before they could make a final choice. Respondents were also allowed to try as many risk levels as they wanted before their final decision.

After the respondents had completed the decision tasks, we measured their understanding, cognitive ability, financial literacy, and risk preference, as we did in experiment 1. Respondents were asked their age and annual income in the latter part of a survey along with other demographic information, because those values are not needed to simulate investment returns anymore. Additionally, we measured how many respondents were aware of the correlation between investment returns that appeared in the Distribution Builder in each condition regarding the correlation. When return distributions of two hypothetical investment products were presented as separate figures, respondents were asked to predict the outcome of one investment product when the other investment outcome yielded a relatively low outcome (i.e., a loss on the investment). The detailed survey questions are provided in the appendix.

3.1.3 Participants

As in experiment 1, an online survey panel organization recruited more than 600 respondents from their online panel during 18 days in September and October 2018. As in experiment 1, all respondents were paid €2.35 as a reward for the participation, but they were told that one in every 200 respondents would be randomly selected as winners to receive an additional reward based on the investment outcome, drawn from a return distribution chosen by the respondent. More specifically, for each winner, we randomly selected one decision task and drew one outcome from the return distribution chosen in the decision task. Three respondents were chosen as winners and received an additional €211 on average.

Table 3 represents the descriptive statistics of respondents' characteristics in experiment 2. From a total of 476 respondents whose data were used in the analysis, 152 (32%), 158 (33%), and 166 (35%) were assigned to the condition of no correlation,

Table 3 Descriptive statistics of respondents in experiment 2

	Value	P-value[a]
Age	46.80 ± 14.74	0.18
Annual income	43,386 ± 50,813	0.45
Male	244 (51.3%)	0.10
Schooling		0.78
Primary education	4 (0.8%)	
High school	80 (16.8%)	
Secondary vocational education (MBO)	154 (32.4%)	
Higher vocational education (HBO)	157 (33.0%)	
University education or higher	79 (16.6%)	
Others	2 (0.4%)	
Understanding (Min. 0; Max 4)	2.14 ± 0.98	0.17
Cognitive ability (Min. 0; Max 3)	1.11 ± 1.09	0.38
Financial literacy (Min. 0; Max 4)	2.76 ± 1.09	0.05
Risk preference[b] (Min.1; Max. 5.5)	3.15 ± 0.98	0.62

a For testing the significant difference between two groups, t-test for the null hypothesis on the equality of means was used for continuous variables, and Chi-square test for equality of proportion was used for categorical variables.

b Correlation between two items = 0.72; Cronbach alpha = 0.84

positive correlation, and negative correlation, respectively. The last column presents the test results for the significant differences between respondents assigned to the condition of no correlation, those assigned to the positive correlation, and those assigned to the negative correlation. According to Table 3, all characteristics except for the financial literacy score were not different between the three groups of respondents at a 5% significant level.

One notable finding is that the respondents' tendency to notice the correlation between investment returns based on the information presented in the Distribution Builder differs depending on the conditions regarding the correlation. Table 4 presents the distribution of the respondents' answers to the question for the notice correlation score. Under the positive correlation, respondents who notice the correlation correctly will choose the answer "Loss (less than €110)" for the expected return of an investment product when the return of the other investment product was indicated as a loss, while these respondents will choose the answer "Gain (more than €100)" under the negative correlation. According to the table, the percentage of respondents who chose the correct answer in the condition of positive correlation was the lowest. Moreover, the percentages of respondents who chose each answer under the positive correlation show a distribution that is very similar to the case of no correlation. On the other hand, respondents were more likely to notice the correlation correctly under the negative correlation, as shown in Table 4.

Table 4 Distribution of respondents' answers to the question regarding awareness of the correlation

	No correlation	Positive correlation	Negative correlation
Anything possible	55 (36.3%)	56 (35.4%)	47 (28.3%)
Gain (more than €100)	54 (35.5%)	56 (35.4%)	**85 (51.2%)**
Loss (less than €110)	43 (28.3%)	**46 (29.1%)**	34 (20.4%)

Note: Values in bold represent the percentage of respondents who answered correctly under the existence of the correlation.

3.2 Results

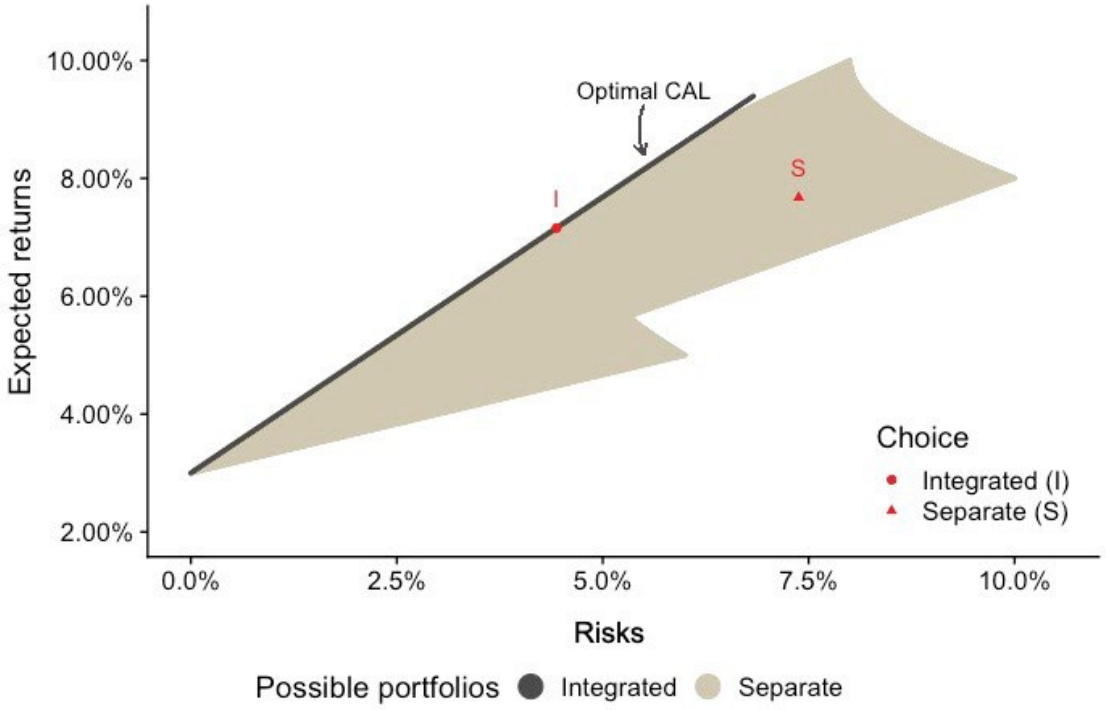
3.2.1 The effect of integrating two investment products

Figure 6 illustrates an example of a respondent's choices in case of a negative correlation. Since the x-axis and y-axis respectively stand for the risks and expected returns of an investment product, every point on the figure indicates a risk-return profile of the product. In the figure, the dark gray line represents all possible risk-return profiles for an investment product that respondents can choose under the integrated condition. This is the optimal CAL as explained earlier. The light gray region, on the other hand, includes all possible risk-return profiles for an investment portfolio consisting of two investment products that respondents can choose under the separate condition. Point I indicates the example of the risk-return profile chosen by a respondent under the condition of integration (an *integrated* choice), while the risk-return profile of the portfolio consisting of two investment products chosen under the condition of no integration (a *separate* choice) is depicted as point S.

To investigate the effect of integrating two investment products, we compared an integrated choice (I) and a separate choice (S) for each respondent in terms of the expected return and risk (i.e., the standard deviation of returns) of the portfolios selected. These differences are denoted as Δ_{μ}^{IS} and Δ_{σ}^{IS}, respectively, and are displayed in Figure 7. Note that Δ_{μ}^{XY} (Δ_{σ}^{XY}) indicates the difference in the expected return (risk) between points X and Y by subtracting the expected return (risk) of point Y from that of point X. Thus, the positive (negative) value of Δ_{μ}^{IS} or Δ_{σ}^{IS}, implies that the respondent tended to select a higher return, higher risk portfolio in the integrated choice than in the separate choice.

When comparing decisions across the separate and integrated conditions, we need to be careful. As shown in Figure 6, all feasible profiles in the condition of integrating investments are on the optimal CAL, while those in the separate condition cover the region below the optimal CAL. Thus, an integrated choice always presents a better performance than a separate choice due to the nature of the experimental

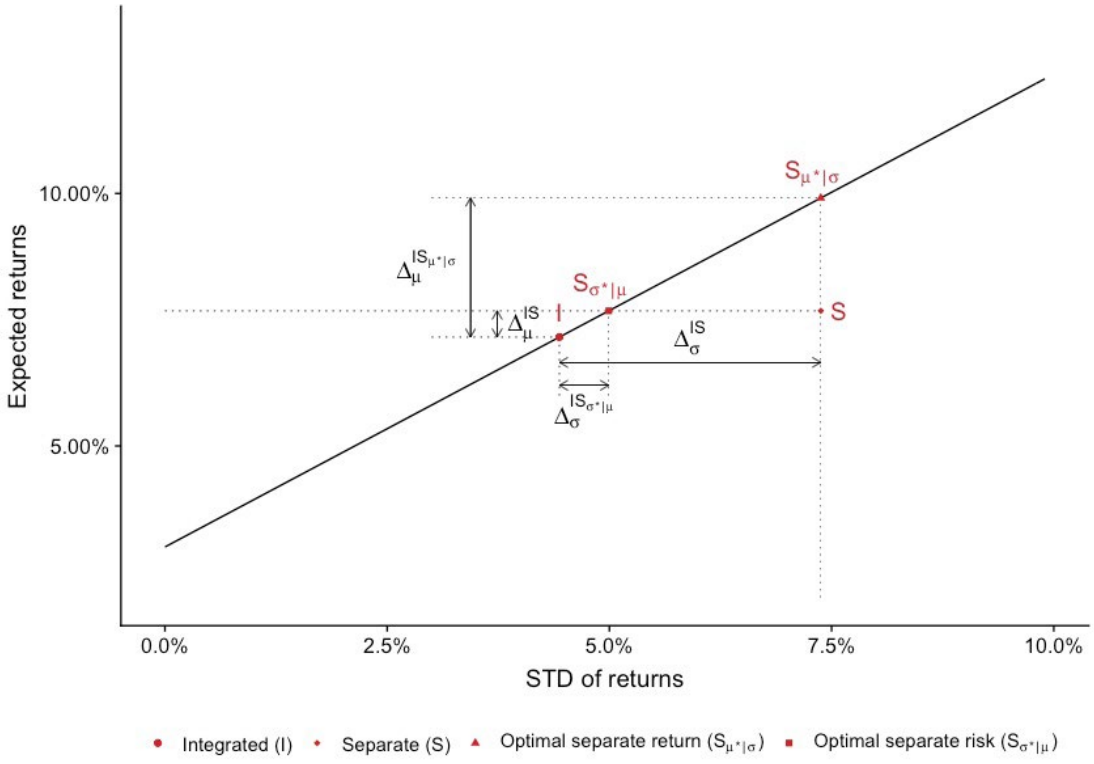
Figure 6 Example of a respondent's choice in case of a negative correlation



manipulation. For this reason, in addition to the direct comparison of choices I and S, we converted the separate choice to the one on the optimal CAL to make a fair comparison with an integrated choice. Two optimally adjusted separate choices were used: the optimal separate return, which gives the best return at the same risk level of the separate choice (i.e., $S_{\mu^*|\sigma}$ in Figure 7) , and the optimal separate risk, which has a minimum risk when the expected return remains the same as the separate choice (i.e., $S_{\sigma^*|\mu}$ in Figure 7). The difference between an integrated choice and the optimal separate choices for each respondent were calculated by subtracting the expected return of $S_{\mu^*|\sigma}$ and risk of $S_{\sigma^*|\mu}$ from those of I, respectively (i.e., computing $\Delta_{\mu}^{IS\mu^*|\sigma}$ and $\Delta_{\sigma}^{IS\sigma^*|\mu}$).

Table 5 compares the average values of the expected returns and risks of portfolios chosen by respondents between the conditions of integration and those of correlation. The expected returns and risks of optimally adjusted separate choices are reported in the fourth column. As shown in Table 5, the respondents' choices differed on average, depending on whether the two investments were integrated or not, regardless of using optimally adjusted separate choices for the comparison. More specifically, respondents on average took more risk in the separate choices than in the integrated choices when there was no correlation between investment returns (the paired t-test result: P<0.005 for both expected return and risk) and when a negative correlation existed (the paired t-test result: P<0.005 when comparing an integrated

Figure 7 Illustration of the difference between an integrated choice (I) and separate choice (S)



choice to either risk of S or expected return of $S_{\mu^*|\sigma}$). On the other hand, on average, respondents took less risk in the separate choices than the integrated choices when a positive correlation in investment returns existed (the paired t-test result: P=0.000 for both expected return and risk).

One notable result is that the expected returns of portfolios separately chosen by respondents have similar values across the conditions of correlation (cf. bold values in Table 5), while the risks of separate choices differ considerably across those conditions (cf. italicized values in Table 5). Since the expected returns of portfolios from separate choices only depend on respondents' decisions on risk levels, while computing risks also requires the value of correlation, this result indicates that respondents were more likely to make similar decisions regardless of the condition of correlation. Thus, respondents tended not to involve the information regarding the correlation between investment returns in their decisions when they chose risk levels of two investments separately, even in case of a negative correlation, where more than half of the respondents were found to recognize the correlation correctly. The ANOVA test result also supports our premise: the condition regarding correlation and respondents' recognition of correlation did not have significant impact on the expected return

Table 5 Overview of the expected returns and risks of respondents' chosen portfolios by conditions

	Integrated (I)	Separate (S)	Optimal separate[a]
No correlation			
Expected return	7.2% (1.6%)	**7.6%** (1.4%)	7.7% (1.4%)
Risk	7.0% (2.7%)	*7.8%* (2.3%)	7.7% (2.3%)
Positive correlation			
Expected return	8.2% (2.1%)	**7.4%** (1.3%)	7.6% (1.4%)
Risk	10.3% (4.2%)	*9.3%* (2.7%)	8.9% (2.3%)
Negative correlation			
Expected return	7.5% (1.5%)	**7.5%** (1.5%)	7.9% (1.6%)
Risk	4.8% (1.6%)	*5.3%* (1.7%)	4.8% (1.6%)

Note: The average values (standard deviation) of respondents' choices are reported.
a For the expected returns and risks of optimal separate choices, the optimal separate return ($S_{\mu^*|\sigma}$) and the optimal separate risk ($S_{\sigma^*|\mu}$) were reported, respectively.

of separate choices (P>0.1 for both main effects and their interaction) and thus on respondents' decisions under the condition of no integration.

For further analysis, we performed a robust linear regression that included respondents' characteristics as explanatory variables. Table 6 presents the estimation results of four regression models that used different dependent variables, to measure the difference between a separate choice and an integrated choice for each respondent as introduced in Figure 7. Thus, integrated choices are compared with separate choices in the first two models and with optimal separate choices in the last two models. All four models show that the respondents' tendency to avoid more risks in the more narrowly framed decision task became salient when there was a positive correlation between investment returns. Also, respondents with higher cognitive ability are more likely to avoid risks when they make separate investment decisions compared to when making integrated decisions. No significant interaction effects were found between the condition regarding the correlation and respondents' characteristics, so these are not reported.

3.2.2 The inefficiency of separate choices

Although the separate choices can never be "better" than the integrated choices, it is interesting to know what drives the differences between actual choices and choices

Table 6 Robust linear regression on the difference between the separate choice and the integrated choice

	(1) Dep.: Δ_{μ}^{IS}		(2) Dep.: Δ_{σ}^{IS}		(3) Dep.: $\Delta_{\mu}^{IS\mu^*\|\sigma}$		(4) Dep.: $\Delta_{\sigma}^{IS\sigma^*\|\mu}$	
	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.
Constant	0.102	1.034	−0.421	1.648	−0.050	1.061	−0.108	1.609
Correlation (Base: No)								
Positive	1.139**	0.168	1.927**	0.267	1.017**	0.172	2.208**	0.261
Negative	0.408**	0.166	0.390	0.264	0.063	0.170	0.718**	0.258
Male	−0.153	0.148	−0.255	0.236	−0.235	0.152	−0.162	0.230
Age	−0.003	0.005	−0.007	0.008	−0.003	0.005	−0.008	0.008
Schooling (Base: Higher vocational)								
Primary	−1.008	0.754	0.045	1.201	−0.944	0.773	0.198	1.173
High school	−0.089	0.210	−0.298	0.335	−0.215	0.216	−0.149	0.327
Secondary vocational	−0.036	0.170	−0.006	0.271	−0.023	0.174	−0.047	0.264
University or higher	0.045	0.206	0.167	0.329	0.066	0.212	0.092	0.321
Others	−1.355	1.060	−2.410	1.690	−1.234	1.088	−2.510	1.651
Log (income)	−0.045	0.100	−0.023	0.160	−0.028	0.103	−0.046	0.156
Understanding	0.022	0.073	0.008	0.116	0.019	0.074	0.017	0.113
Cognitive ability	0.146**	0.070	0.214*	0.111	0.149**	0.072	0.213*	0.109
Financial literacy	−0.104	0.069	−0.161	0.110	−0.112	0.071	−0.137	0.107
Risk preference	0.093	0.072	0.178	0.114	0.095	0.074	0.157	0.112
Adj. R-squared	0.09		0.08		0.08		0.10	

Note: ** p<0.05; * p<0.1
In Models 1 and 2, the dependent variables measured the difference between a separate choice and an integrated choice for each respondent in terms of expected returns and risks, respectively. The differences in expected returns and risks between optimally adjusted separate choices and integrated choices were used in Model 3 and 4, respectively.

that are efficient in the sense that the chosen portfolio is on the efficient market frontier. The inefficiency of separate choices was measured in two ways: "loss of returns" and "excessive risk." Loss of returns measures how much return respondents lose in the separate choice compared to the optimal risk-return profile with the same risk level. This is done by computing $-\Delta_{\mu}^{SS\mu^*|\sigma}$, as shown in Figure 8. On the other hand, the excessive risk captures how much excessive risk they take in the separate choice compared to the optimal risk-return profile with the same expected return. This is done by subtracting S from $S_{\sigma^*|\mu}$ (i.e., $\Delta_{\sigma}^{SS\sigma^*|\mu}$ in Figure 8).

Table 7 presents the average values of the loss of returns and excessive risk by conditions of correlation. According to the table, respondents chose significantly more inefficient portfolios in the case of correlation compared to the case of no correlation (P<0.01).

Figure 8 Illustration of the difference between a separate choice (S) and optimal separate choices

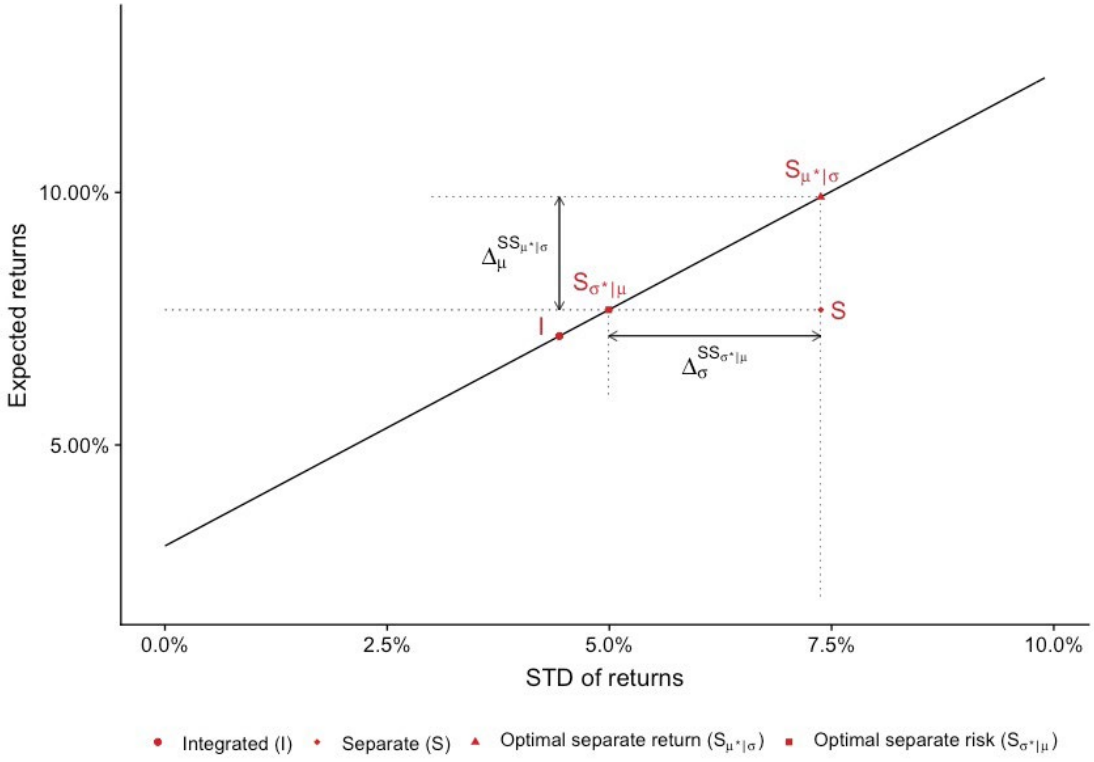


Table 7 Overview of the loss of returns and excessive risk by conditions of the correlation

	Loss of returns	Excessive risk
No correlation	0.060 % (0.113 %)	0.099 % (0.188 %)
Positive correlation	0.196 % (0.106 %)	0.391 % (0.212 %)
Negative correlation	0.433 % (0.579 %)	0.463 % (0.618 %)

The regression results in Table 8 also support the finding in Table 7. Respondents are likely to choose more inefficient portfolios in the situation of a correlation between the returns of the multiple investment options. Furthermore, respondents who are younger and prefer more risks are likely to choose more inefficient portfolios when they choose the risk-taking level by individual investment. Only one interaction effect was found to be significant, namely the interaction between the condition of negative correlation and respondents' level of understanding about the information presented in the Distribution Builder. This result suggests that, in the negative correlation, respondents who have a better understanding of the interface during the experiment are less likely to make a mistake.

Table 8 Robust linear regression on the loss of returns and excessive risks

	(1) Dep.: Loss of returns		(2) Dep.: Excessive risks	
	Coeff.	Std.	Coeff.	Std.
Constant	−0.013	0.088	−0.021	0.138
Correlation (Base: No)				
Positive (P)	0.171**	0.034	0.345**	0.054
Negative (N)	0.296**	0.031	0.305**	0.049
Male	−0.005	0.012	−0.008	0.019
Age	−0.001*	0.000	−0.001*	0.001
Schooling (Base: Higher vocational)				
Primary	0.039	0.062	0.066	0.098
High school	0.018	0.017	0.037	0.027
Secondary vocational	0.008	0.014	0.007	0.022
University or higher	−0.019	0.017	−0.037	0.027
Others	−0.031	0.088	−0.031	0.138
Log (income)	0.001	0.008	0.002	0.013
Understanding (U)	−0.000	0.010	−0.001	0.016
Cognitive ability	0.002	0.006	0.005	0.009
Financial literacy	0.004	0.006	0.011	0.009
Risk preference	0.018**	0.006	0.028**	0.009
Interaction term				
P x U	−0.008	0.014	−0.013	0.023
N x U	−0.067**	0.014	−0.053**	0.021
Adj. R-squared	0.20		0.28	

Note: ** p<0.05; * p<0.1

4. Discussion and implications for the pension domain

The main findings of experiments 1 and 2 are summarized in Table 9.

In experiment 1, we found that integrating AOW pension income and employment-based pension income did not change respondents' risk-taking decisions, contrary to our expectation based on the finding of Kaufman and Weber (2013). Our finding implies that respondents' decisions on the risks of pension investments were not affected by the inclusion of AOW pension income. However, this does not necessarily imply that respondents are capable of making a pension investment decision when considering all pension products jointly as a general portfolio. On the contrary, our finding suggests that respondents can make a choice that is relatively free from cognitive biases in an appropriately framed decision task. In the study of Kaufman and Weber (2013), respondents were allowed to choose a risk-taking level using a slider similar to the one in our study, but the decision tasks were framed in

Table 9 Summary of findings of experiments 1 and 2

	Experiment 1	Experiment 2
Integrating investment products	• Risk-free investment product (AOW pension) • Risky investment product (employment-based pension)	• Two risk investment products (one gives a higher expected return but is riskier than the other)
Experimental conditions	• Virtual integration (Separate/Integrated)	• Virtual integration (Separate/Integrated) • Correlation between investment returns (no/positive/negative correlation)
Results	• No significant effect of integrating investment products on risk-taking level was found	• Virtual integration has a significant effect on respondents' risk-taking level. • The effect of integration on the risk-taking level significantly differs depending on the conditions regarding the correlation. • Respondents tended to ignore the correlation between investment returns when they made investment decisions separately. • When respondents had to make investment decision separately, they tended to choose significantly more inefficient portfolios in the case of correlation compared to the case of no correlation.
Implications	• Using a Distribution Builder helps investors to avoid behavioral biases.	• Because investors tend to fail to take different investment products into account properly, pension providers can help retail investors by combining products to facilitate decisions on (joint) portfolio risk and return.

terms of asset allocation by labeling the risk levels as a relative weight of risky assets in the investment. On the other hand, the decision tasks in our study were framed as the decision on the volatility of investment returns, by not presenting detailed information regarding the asset weight. According to Ehm et al. (2018), investors tend to pay more attention to the risk–return distribution and to make a more consistent risk-taking decision when the asset weights are not given compared to the case where information of asset weights is provided. Thus, respondents in experiment 1 might make a risk-taking decision based on a more accurate feeling about the risk–return distribution and, by doing so, be able to avoid potential biases. We therefore suggest that pension providers apply an interactive tool such as the Distribution Builder to support customers in deciding the best pension product, in accordance with their preferred risk-taking level in the DC plan or even more individualized pension plan. Customers should not be asked to decide about the precise asset allocation, as this is best handled by the financial experts.

In experiment 2, respondents made significantly different decisions when investment products were integrated compared to the case of not integrated products. This shows that respondents find it difficult to take two risky investment products into account jointly due to the complexity of pooling the risks and returns, even though the decision tasks were framed such as to help respondents to understand the risk–return profiles, similar to experiment 1. Also, we found that respondents tended to ignore the correlation between investment returns when deciding on risk-taking levels of investment products separately, even though they were sometimes able to notice the correlation, especially in the case of negative correlation. These findings imply that respondents tend to use separate mental accounts for two investment products when products are not integrated, despite the fact that the Distribution Builder allowed respondents to observe the risk–return profiles of each investment product side by side. It suggests that putting return information of all asset holdings of a customer together in a platform for financial advice is not enough to help customers to manage their retirement finances. We conclude that investors fail to properly account for correlation among investment returns. Hence, they are not able to construct an efficient portfolio of investment products when having to make a decision about each investment product separately.

Respondents were most likely to make mistakes when investment products generated correlated returns, because of the respondents' tendency to ignore correlation. Suppose that a typical investor wants to invest a certain amount of money in two investment products for retirement purposes (thus intending to hold the investment products for many years). Assuming that this investor has a portfolio that presents

the average expected return and risk of separate choices as shown in Table 5 after making separate decisions for each investment product, the investor will then lose 0.06% of his investment money on average after one year because of having chosen an inefficient portfolio even though there is no correlation between investment returns. The loss of expected returns due to the mistake in the separate investment decision increases as the investor holds the investment portfolio longer: for instance, the investor will lose about 0.4% of his investment money after five years. When two investment products have correlated returns, the loss of returns due to the mistake will be substantially greater than in case of no correlation. The investor will lose 0.20% and 0.43% of his investment money on the two products after one year and 1.31% and 2.91% after five years in the situation of a positive and a negative correlation, respectively. Since the amount of investment money for retirement purposes is usually considerable, the loss of investment return due to the mistake would be also significant. For example, assuming €100,000 as investment money, the investor loses €200 in the first year, increasing to €1,310 after five years in the case of a positive correlation. Also, as the investor tends to take excessive risks in the separate investment decision, the chance of losing money (i.e., the probability of negative returns) increases by 0.3%, 1%, and 2% in the situations of no, positive, and negative correlation, respectively. Therefore, to help investors to make better decisions on tailor-made investment portfolios for retirement purposes, it is advisable that pension companies provide investors the chance of determining a desirable risk-return profile at a single portfolio level, by virtually integrating the investment products held by investors.

Additionally, even though it is not feasible for companies to virtually integrate all investment products, applying the decision interface used in this study to each investment decision would serve investors well. Based on the results in Table 8, the degree of respondents' mistakes in the separate investment decision does not depend on their cognitive ability or financial literacy, which has been considered as drivers of poor financial decision-making (e.g., Calvet et al., 2009; Van Rooij et al., 2007). Instead, respondents' understanding of the information presented in the Distribution Builder leads to significantly better decisions. This finding suggests that investors do not need sophisticated understanding and knowledge of mathematics to make a better investment decisions when asked to decide a risk level using an interactive tool that presents a risk-return distribution graphically, such as used in this study. Since the Distribution Builder allows investors to perceive the risk-return distribution of investment products intuitively, providing sufficient instruction and practice with the tool will help investors in their decisions.

We can summarize the key messages of this paper as follows. Virtual integration of investment products by pension providers or financial advice platforms can support individuals in making decisions about their personal pension portfolios. The results of experiment 2 show that complete freedom of individuals to make decisions per investment product tends to lead to mistakes. Thus, it is difficult for individual persons, even when financially literate, to decide on an adequate investment portfolio. However, by letting them choose the most preferred risk–return profile in a virtually integrated portfolio using an interactive tool, they can make decisions that solely depend on their risk preference. This helps overcome potential behavioral biases such as correlation neglect. Pension providers can develop an investment strategy which fits the assessed risk preference. Thus, integrated pension portfolio communication and options will allow individuals to benefit from freedom of choice, while protecting them from potentially severe losses due to misjudgment in integrating different investment funds.

5. Conclusion

This paper investigated the effect of virtual integration of assets involved in retirement investments in the Netherlands, using an interactive tool called the Distribution Builder, on decisions by individuals regarding investment risks. When integrating AOW pension income (i.e., a risk-free asset) and employment-based pension income (i.e., a risky asset), we found that respondents' decisions were not affected by whether or not the two pension incomes were integrated. This can be explained by the fact that the Distribution Builder enabled them to focus on the risk-return distribution. On the other hand, respondents' risk-taking decisions when two risky investment products were integrated were significantly different from the case of not integrating products. Our study also showed that, when respondents were asked to make investment decisions for two risky investment products separately, they were likely to choose suboptimal portfolios by not taking the correlation among the returns on the two products into account. Therefore, virtual integration of investment products using an interactive tool, such as the Distribution Builder, is recommended when individuals need to make decisions on their level of risk-taking across multiple investment products. Pension providers can help their customers to consider all financial products that they hold, by integrating them into a single tailor-made retirement investment portfolio.

There are opportunities for future research. Firstly, future research could investigate the robustness of the outcome of experiment 1. In experiment 1, this paper found no significant impact of virtual integration of AOW income and employment-based pension income, which is not consistent with the finding of Kaufmann and Weber (2013). We argued that not framing respondents' decisions as asset allocation tasks, unlike Kaufmann and Weber (2013), helps respondents to avoid behavioral bias. However, there is a possibility that respondents may react differently when the way of presenting a distribution of investment returns changes, even though the framing of decision tasks remains the same. Furthermore, integrating in the format of a Distribution Builder not only financial risks but also political risks regarding the AOW pension could be examined in future research.

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Appendix

A. Survey questions

Both the questions in Dutch and in English are provided in this appendix. We italicized the correct answers for questions if feasible.

A.1 Understanding score

[Dutch]

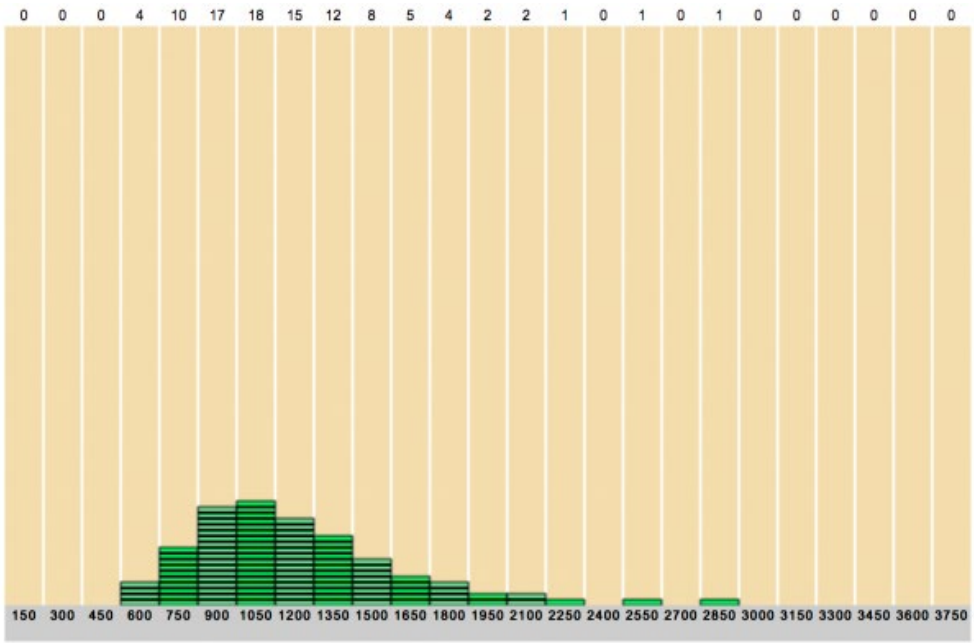
We zouden graag weten of de tool helemaal duidelijk was. Hieronder staan dan ook enkele vragen over de investeringssimulator.

Stelt u zich voor dat de investeringen van uw pensioenvermogen leiden tot de volgende verdeling van uw inkomen per maand.

[English]

We would like to know whether you clearly understand the information presented in the tool. Please answer the following questions about the investment simulator.

Imagine that the investments of your pension equity will give you a monthly income following the distribution in the figure below.



[Dutch]
Q1. Wat is de kans dat u €2400 of meer per maand ontvangt?
- Deze kans is groter dan 10% (10 per 100)
- *Deze kans is kleiner dan 10% (10 per 100)*

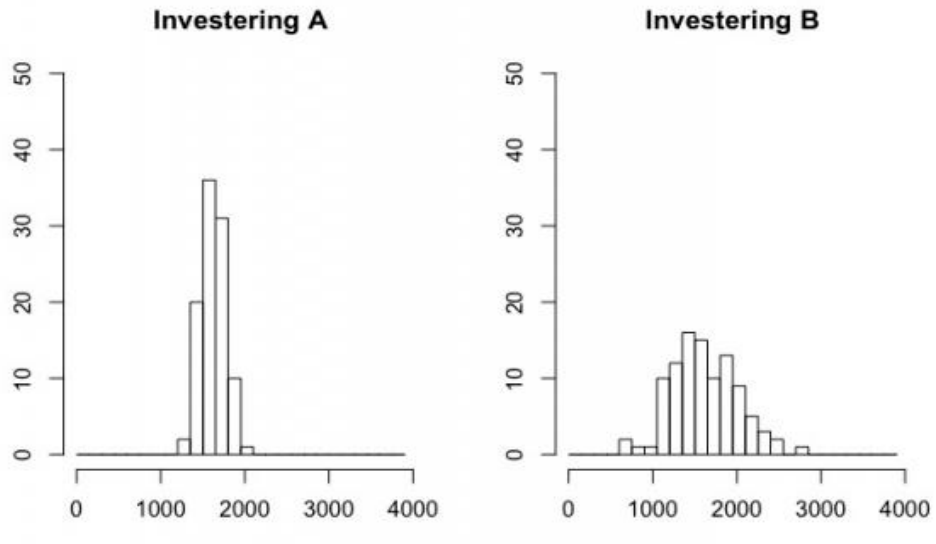
Q2. Wanneer de hoeveelheid risico bij de beleggingen wordt verminderd, dan zal de kans dat u €1500 of meer per maand ontvangt...
- stijgen
- *dalen*
- hetzelfde blijven

[English]
Q1. What is the probability that you will receive €2,400 or more per month?
- The chance is higher than 10% (10 per 100 cases)
- *The chance is less than 10% (10 per 100 cases)*

Q2. When the risk level of the investment is reduced, what would the probability that you will receive €2,400 or more per month be?
- The chance will increase
- *The chance will decrease*
- The chance will stay the same

[Dutch]
Verschillende manieren van investeren leiden tot verschillende mogelijke uitkomsten. Hieronder ziet u het resultaat van twee verschillende investeringen.

[English]
Please note that different investment decisions lead to different investment incomes. In the figure below, you will see the return distribution of two different investments.

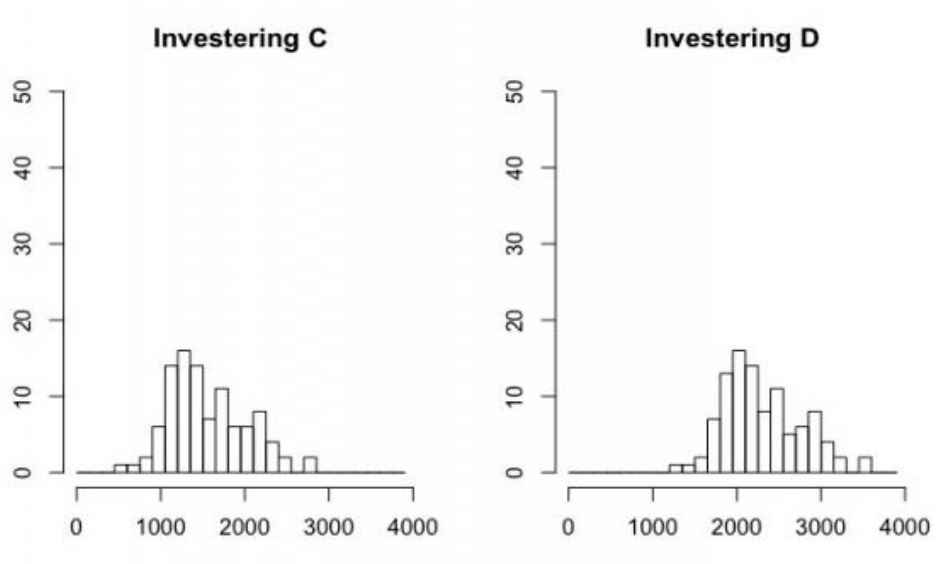


[Dutch]
Q3. Welke investering leidt tot de meeste onzekerheid over het uiteindelijke inkomen?
- Investering A
- *Investering B*
- Dit is hetzelfde voor beide

[English]
Q3. Which investments will give you the most uncertain income?
- Investment A
- *Investment B*
- No difference between both investments

[Dutch]
Verschillende manieren van investeren leiden tot verschillende mogelijke uitkomsten. Hieronder ziet u het resultaat van twee andere investeringen.

[English]
Please note again that different investment decisions lead to different investment incomes. In the figure below, you will see the return distribution of two different investments.



[Dutch]
Q4. Welke investering leidt (gemiddeld genomen) tot het hoogste inkomen?
- Investering C
- *Investering D*
- Dit is hetzelfde voor beide

[English]
Q4. Which investments will give you the highest income?
- Investment C
- *Investment D*
- No difference between both investments

A.2 Cognitive ability score

[Dutch]
De volgende drie vragen gaan over analytische vaardigheden. Beantwoord alstublieft de volgende vragen.

Q5. Een racket en een bal kosten samen € 1.10. Het racket kost € 1.00 meer dan de bal. Wat kost de bal?
A: De bal kost __ cent. (*5 cents*)

Q6. Als het vijf machines vijf minuten kost om vijf producten te maken, hoelang doen honderd machines er dan over om honderd producten te maken?
A: De machines doen er __ minuten over. (*5 minutes*)

Q7. In het midden van een vijver groeit een waterlelie. De waterlelie verdubbelt elke dag in oppervlakte. Als het 48 dagen duurt om de vijver volledig te bedekken door de waterlelie, na hoeveel dagen is de helft van de vijver bedekt door de waterlelie?
A: Na __ dagen. (*47 days*)

[English]
We would like to know your analytical skills. Please answer the following questions.

Q5. A racket and a ball cost €1.10 in total. The racket costs €1.00 more than the ball. How much does the ball cost?
A: The ball costs __ cents. (*5 cents*)

Q6. If it takes five machines five minutes to make five widgets, how long would it take one hundred machines to make one hundred widgets?
A: It takes __ minutes. (*5 minutes*)

Q7. 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?
A: It takes __ days. (*47 days*)

A.3 Financial literacy score

[Dutch]

De volgende vier vragen gaan over financiële kennis. Beantwoord alstublieft de volgende vragen.

Q8. Welke van de volgende beweringen is correct? Als iemand de aandelen van bedrijf B koopt op de aandelenmarkt...

- *Dan bezit hij een gedeelte van bedrijf B*
- Dan heeft hij geld uitgeleend aan bedrijf B
- Dan is hij verantwoordelijk voor de schulden van bedrijf B
- Geen van allen

Q9. Wanneer er gekeken wordt naar de opbrengsten over een langere periode (bijvoorbeeld 10 of 20 jaar), welke belegging zal het meeste opbrengen?

- Spaarrekening
- Obligaties
- *Aandelen*
- Ik weet het niet

Q10. Welke belegging zal normaal gesproken het meeste fluctueren in waarde?

- Spaarrekening
- Obligaties
- *Aandelen*
- Ik weet het niet

Q11. Wanneer een investeerder zijn geld spreidt over verschillende beleggingsinstrumenten dan zal het risico om geld te verliezen...

- Stijgen
- *Dalen*
- Hetzelfde blijven
- Ik weet het niet

[English]
We would like to test your financial knowledge. Please answer the following questions.

Q8. If someone buys the stock of firm B in the stock market, which of the following statements is correct?
- *He owns part of firm B*
- He has lent money to firm B
- He is liable for B's debts
- None of above statements are correct

Q9. Considering a long-time period (e.g. 10 or 20 years), which asset normally gives the highest return?
- Savings accounts
- Bonds
- *Stocks*
- Don't know

Q10. Normally, which asset displays the highest fluctuation over time?
- Savings accounts
- Bonds
- *Stocks*
- Don't know

Q11. When an investor spreads his money across different assets, the risk of losing money:
- Increases
- *Decreases*
- Stays the same
- Don't know

A.4 Risk preference score

[Dutch]

Q12. Geeft u alstublieft aan hoeveel risico u zou willen nemen met uw pensioeninvesteringen.

- 1 (Ik wil geen enkel risico lopen)
- 2
- 3
- 4
- 5
- 6
- 7 (Ik wil redelijk veel risico lopen voor een grotere kans op een hoger rendement)

Q13. Kies uit de onderstaande opties de beschrijving die uw risicovoorkeur het beste weergeeft.

- Ik loop echt niet graag veel risico als ik daar een hoge te verwachten beloning voor krijg (1)
- Ik loop niet graag veel risico als ik daar een hoge te verwachten beloning voor krijg (2)
- Ik loop graag veel risico als ik daar een hoge te verwachten beloning voor krijg (3)
- Ik loop heel graag veel risico als ik daar een hoge te verwachten beloning voor krijg (4)

[English]

Q12. Please indicate how much risk you would like to take with your pension investments.

- 1 (not willing to take any risk)
- 2
- 3
- 4
- 5
- 6
- 7 (willing to accept substantial risk to potentially earn a greater return)

Q13. Please choose the one sentence that best characterizes your risk preferences.

- x
- I am unwilling to take a high risk even if I get a high expected return for it (2)
- I am willing to take a high risk if I get a high expected return for it (3)
- I am very willing to take a high risk if I get a high expected return for it (4)

A.5 Satisfaction score

[Dutch]
Hierboven ziet u een mogelijke verdeling van uw pensioeninkomen in de pensioen-simulator. We zouden graag weten wat u van deze inkomensverdeling vindt.

[English]
You can see a possible distribution of your pension income in the figure below. We would like to know what you think of this distribution.

[Presenting a screenshot for the return distribution presented by the distribution initially, which was simulated based on respondents' ages and incomes assuming the medium risk level as default]

[Dutch]
Q14. Hoe tevreden bent u met de hoogte van uw pensioenuitkering in bovenstaande situatie?

- 1 (Zeer ontevreden)
- 2
- 3
- 4
- 5
- 6
- 7 (Zeer tevreden)

[English]
Q14. How satisfied are you with your pension income in the above situation?

- 1 (Very dissatisfied)
- 2
- 3
- 4
- 5
- 6
- 7 (Very satisfied)

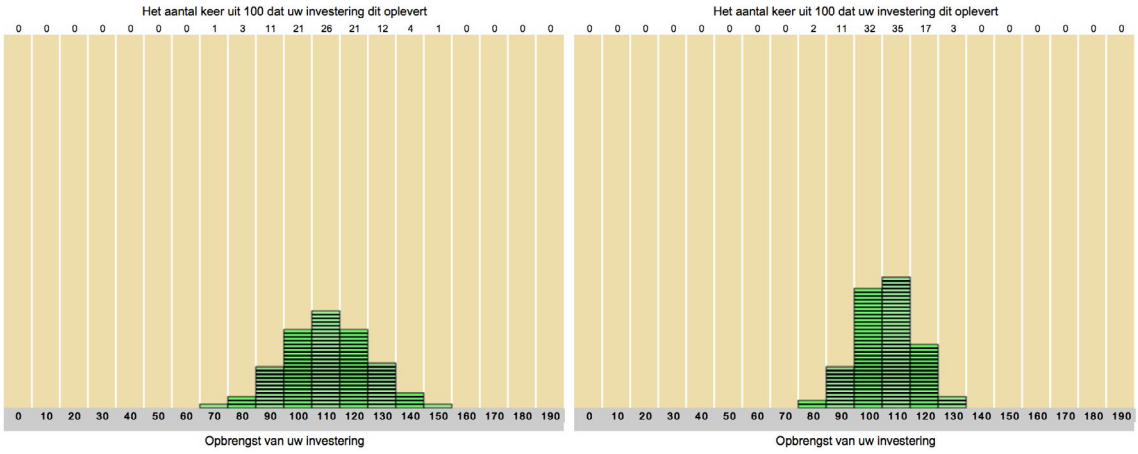
A.6 Notice correlation

[Dutch]

Stelt u zich voor dat de investeringen van uw vermogen leiden tot de volgende verdeling van opbrengsten. Gegeven dat de uitkomst van fonds A € 70 is.

[English]

Imagine that your investment decisions will give you returns following the distributions in the figure below. Suppose that you receive €70 from the investment product on the left.



[Dutch]

Q15. Wat denkt u dat de uitkomst zal zijn van fonds B?

- minder dan € 110,–
- meer dan € 100,–
- Het kan van alles zijn

[English]

Q15. How much do you think you will receive from the investment product on the right?

- Less than €110
- More than €100
- Anything possible

B. Distributions of respondents' choices in experiment 2

B.1 Distributions of respondents' choices under the condition of integration and under the separate condition

Figures 9 and 10 show the distribution of respondents' choices on expected returns and risks, respectively. Respondents' choices under the integrated condition (i.e., integrated choices) and those under the separate condition (i.e., separate choices) are presented on the graphs in the first and second column of the two figures, respectively. The graphs in the third column show the distribution of differences between a separate choice and an integrated choice for each respondent. As shown in the figures, respondents' decisions on the expected returns in separate choices show a similar distribution between conditions regarding correlation, unlike the case of risks or integrated choices. This supports our suggestion from Table 5 that respondents tended to ignore the correlation and make similar decisions when investment products were not integrated.

In addition, we computed the Kendall rank correlation coefficients between the separate choices and integrated choices in terms of the expected mean and the risk. These coefficients indicate the tendency of respondents choosing similar risk-return profiles in the separate and integrated conditions in terms of ranks of the relative riskiness within respondents' choices. Regardless of the condition regarding correlation, there are significant positive correlations (at a 5% significant level) between respondents' integrated choices and separate choices (Kendall's > 0.4 for no correlation; Kendall's > 0.35 for positive correlation; Kendall's > 0.27 for negative correlation). This implies that respondents who chose relatively risky risk-return profiles under the separate condition tended to likewise choose relatively risky risk-return profiles under the integrated condition.

Figure 9 Distribution of respondents' choices on expected returns of portfolios by conditions regarding integration and correlation

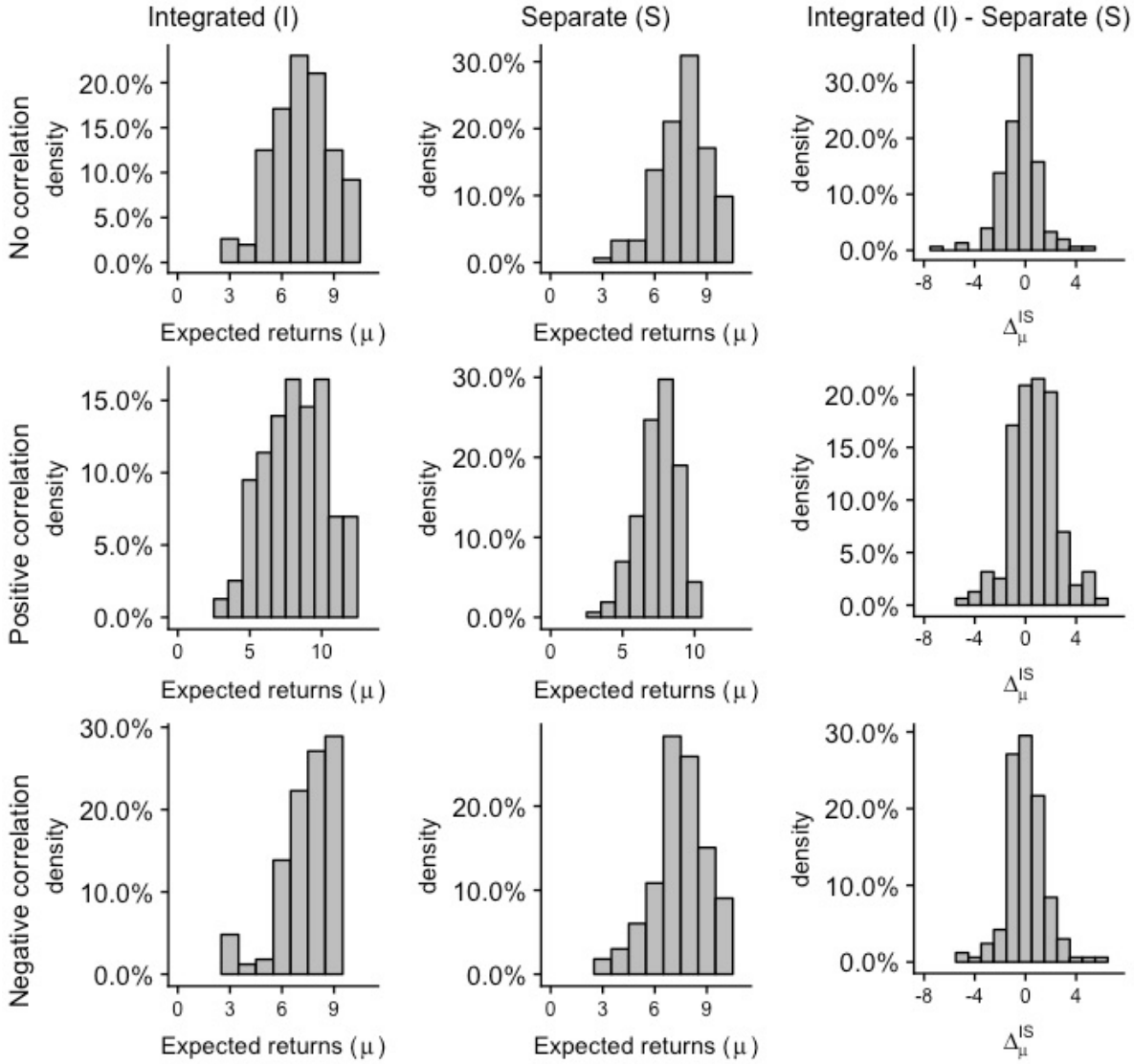
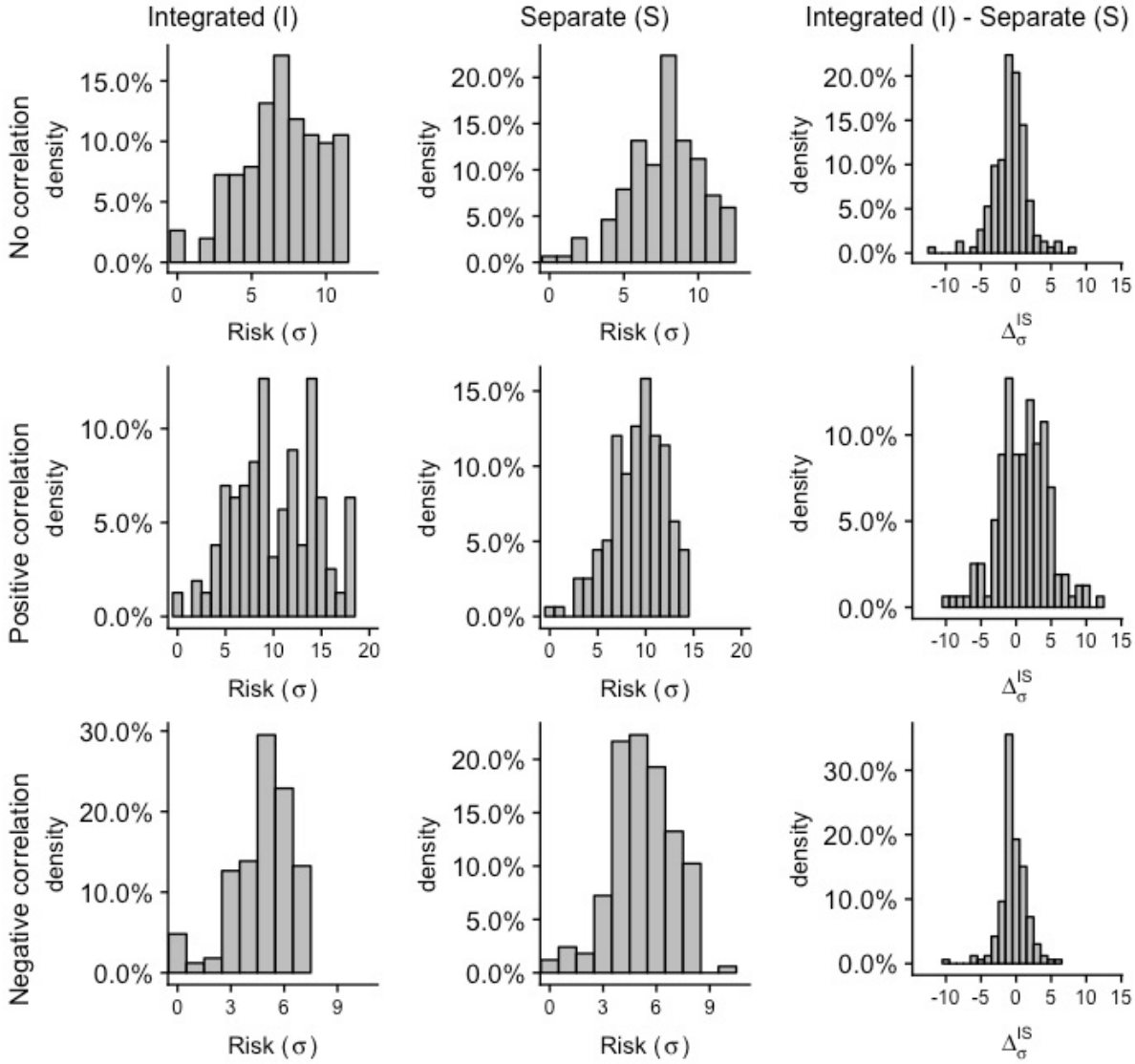


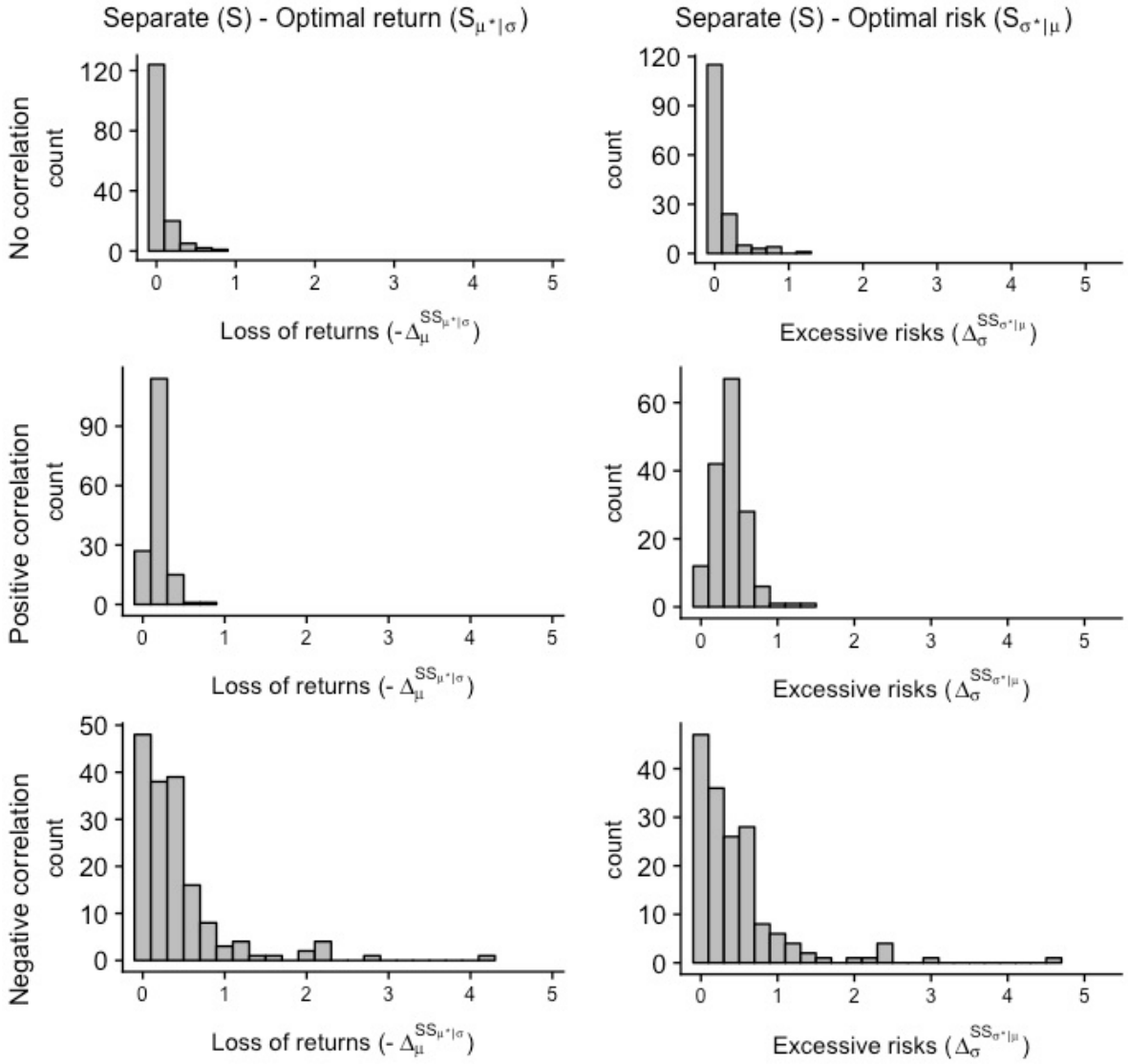
Figure 10 Distribution of respondents' choices on risks of portfolios by conditions regarding integration and correlation



B.2 Distributions of the inefficiency of risk-return profiles chosen by respondents under the condition of no integration

Figure 11 shows the distribution of losses of returns and excessive risks taken by respondents for each condition regarding correlation. As shown in the figure, higher percentages of respondents tended to have inefficient risk-return profiles when there is a correlation between investment products.

Figure 11 Distribution of inefficiency of portfolio chosen by respondents in the separate decision task compared to conditions regarding correlation



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