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What is Risk to Managers?

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Abstract

We systematically examine which characteristics of a business opportunity – such as the likelihoods of potential gains and losses – affect managers' perception of risk and attractiveness. In an online experiment with a sample of 4,287 managers from small- and medium-sized enterprises in Denmark, we present participants with a hypothetical investment prospect in a business context, and elicit their perception of risk associated with the project and their perception of the investment's attractiveness. The experimental data is merged with a set of background variables on the company, which allows controlling for firm-specific effects. We find that risk perception is driven by the likelihood and the return associated with the worst-case scenario as well as the size of the required investment. Managers' perception of attractiveness is affected not only by the worst-case scenario but also by the characteristics of the base-case and the best-case outcomes. Furthermore, we provide evidence that managers' perception of the project's attractiveness is significantly affected by their individual-level risk preferences and the interaction effect with risk perception. This implies that not only the characteristics of the different scenarios but also individuals' risk preferences play an important role when assessing the attractiveness of a business opportunity.

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Introduction

Risk is of paramount importance in many economic decisions, including the decisions made by business managers to pursue or turn down business investments. Despite its key role in economic and managerial decision-making, there is a lack of agreement as to how risk should be defined (Brachinger and Weber, 1997). Several contributions point towards a mismatch of common definitions of risk and the way people *perceive* risk (see, e.g., March and Shapira, 1987; Weber and Milliman, 1997; Holzmeister *et al.*, 2020; Zeisberger, 2021). Therefore, it seems highly relevant for researchers to understand *(i)* which business opportunity parameters drive managers' risk perceptions, and *(ii)* how risk perceptions and parameters associated with risk perception affect the perceived attractiveness of an investment opportunity. Management research has been quite fragmented on the first question and virtually silent on the second. In this paper, we seek to consolidate and advance the literature using a large-scale experiment in which business managers were asked to assess the risk and the attractiveness of hypothetical investment scenarios that were varied on parameters that previous contributions had identified as drivers of risk perception.

An integral contribution to the management literature was the paper by March and Shapira (1987). The article synthesizes the evidence put forward by a study by Shapira (1986), relying on interviews with 50 American and Israeli executives, and McCrimmon and Wehrung (1986), relying on interviews with 129 executives in Canadian and American firms as well as survey responses from 509 executives from these countries. The synopsis by March and Shapira (1987) suggests that the processes that induce risk-taking in a business context do not align with classical decision theory, which predicts that choice involves a calculation and trade-off between the expected return (mean) and risk (variance) of the probability distributions over potential outcomes. Furthermore, March and Shapira (1987) highlight that the conception of risk as variance does not prevail in real managerial life. Three key findings in relation to managerial risk conception stand out. First, both studies (i.e., Shapira, 1986, and McCrimmon and Wehrung, 1986) suggest that positive outcomes associated with managerial decisions are not considered important aspects of risk. This implies that, in assessing risk, managers tend to neglect a potentially significant part of the variation in outcomes. Second, the respective probabilities of potential outcomes only appeared to be a risk factor for some managers, and even for those the

magnitudes of the negative outcomes were more salient. For instance, Shapira (1986) found that when asked to evaluate uncertain prospects, 80% of managers requested information about the "worst outcome" or "maximum loss." Third, managers expressed uncertainty about the possibility of quantifying risk as a single construct. Most felt that risk ought to be quantified but also noted that this was not what they did it in order to evaluate risk.

Since the contribution by March and Shapira (1987), the progress made in understanding risk perception and the importance of risk conception for a firm's risk-taking has been limited primarily to conceptual work drawing on previous papers in a somewhat piecemeal manner. Most notable in this vein are papers, which have as one of several foci the provision of one overarching definition of risk. Pablo and Sitkin (1992) define risk as "the extent to which there is uncertainty about whether potentially significant and/or disappointing outcomes of decisions will be realized." Mullins and Forlani (2005), drawing on psychological insights from Yates and Stone (1992), argue that the risk construct reflects three underlying facets: *(i)* the presence of potential losses, *(ii)* the significance of these losses, and *(iii)* the uncertainty about these losses. With this construct of risk in mind, Mullins and Forlani (2005) propose that – while the chance for gains is what motivates actors to engage in risk taking – "risk itself [..] involves the likelihood of realizing some magnitude of loss." Finally, Sanders and Hambrick (2007) define risk as "the degree to which potential outcomes associated with a decision are consequential, vary widely, and include the possibility of extreme loss." Each of these three contributions adds certain aspects beyond the definition of risk put forward by March and Shapira (1987). Pablo and Sitkin (1992) stress the importance of disappointment; Mullins and Forlani (2005) highlight positive outcomes as being utterly unimportant to risk as seen from a psychological perspective; and Sanders and Hambrick (2007) direct our attention to consequentiality which is deemed to be present when outcomes "have the potential to alter – positively or negatively – the health and vitality of a manager's firm." Furthermore, Sanders and Hambrick (2007) argue that "a given choice alternative might be very risky on one dimension but not so risky on another" and thus indirectly challenge March and Shapira's (1987) interpretation of the magnitude of the worst possible outcome as being almost the only aspect of importance to managerial risk assessment.

The above account demonstrates that – despite excellent empirical and conceptual work in various disciplines concerned with the notion of risk – there seems to be more to be learned about managers' conception of risk and its impact on managerial decision-making. In particular, we consider the following research question as being only partially answered in prior literature:

RQ-1: Which attributes of a business project drive managers' perception of risk and investment preferences?

Furthermore, we note that prior contributions have largely ignored the link between risk perception and the attractiveness of business opportunities and entirely ignored the role of the manager's individual-level risk preferences in this link. Yet, it appears intuitively evident that risk tolerant managers would be less likely to be scared off by opportunities that appear risky. Therefore, we contribute to the literature by addressing the following research question:

RQ-2: How do perceived business project risk and managers' individual-level risk tolerance translate into investment preferences?

While we are well aware that the two questions have been touched upon – at least tangentially – in the strategic management literature and in other disciplines, we believe there is a need to address these questions in a more comprehensive and comparative manner.

We address our two research questions via an online experiment in which 4,287 managers of small- and medium-sized enterprises (SMEs) in Denmark assess the risk and the attractiveness of a hypothetical investment opportunity. These business projects are scaled by firm size and vary across managers in terms of the required size of the investment and the time with income from the investment, and four parameters (including the investment's net loss/gain, the yearly internal rates of return (IRR), the number of years to break-even (B/E), and the likelihoods of outcomes) associated with one of three scenarios (worst case, base case, and best case).

Our experiment provides a number of interesting insights. First, managers' risk perception of an investment opportunity, on average, increases with the size of the required investment, indicating that managers do not only take into consideration relative measures, but also integrate the business opportunity's absolute stake into

their assessment. Second, we find that managers' conception of risk is strongly related to the potential downsides associated with the project, but not its upsides: In line with the previous literature, we find that both higher likelihoods and higher magnitudes (IRR) of the worst-case outcome induce managers to perceive business opportunities as more risky. Notably, however, the interaction between the two latter variables turns out not to be systematically related to risk perception, challenging expectation-based conceptions of risk. Third, managers' assessment of the project's attractiveness significantly correlates with their perception of risk. Yet, the impact of the various project attributes turns out not to be symmetric: While managers' perception of the project's attractiveness is not affected by the size of the required investment, it does not only relate to the returns and likelihood of the worst-case scenario, but also to the returns and likelihoods of the base-case and best-case scenarios. Fourth, we provide evidence that the managers' individual-level risk preferences play a significant role for the perception of attractiveness, and therefore affect attractiveness judgments not only via the interaction with perceived riskiness. This suggests that risk tolerant managers, on average, perceive investment opportunities to be more attractive than risk averse managers do, even when the risk of the business opportunity is perceived to be small.

Methods

To address our research questions, we conducted a large-scale unincentivized online experiment with managers from small- and medium-sized enterprises (SMEs) in Denmark. Experimental participants were presented with a hypothetical business opportunity, varying in several key attributes that may enter managers' assessment of risk and attractiveness of the business opportunity. In particular, managers faced an investment project with three scenarios (worst-case, base-case, and best-case), for which they were informed about the size of the initial investment and the time with income from the investment. For each of the three scenarios, participants were informed about four key performance indicators: *(i)* the likelihood of the scenario, *(ii)* the net loss or gain from the investment, *(iii)* the yearly internal rate of return (IRR), and *(iv)* the number of years to break-even (B/E). Each participant received information about the same variables but with randomly drawn values (within a pre-specified range), giving rise to researcher-controlled variation in

explanatory variables. Importantly, the estimates of the key characteristics were scaled by a firm size factor – based on the company's gross profits and its total equity, obtained from the company's financial statements – to ensure that the investment project is at reasonable stakes. The estimated values were chosen in such a way that they could strike a satisfactory balance between wide variation in the variables and managers still perceiving the values as being within the range relevant for their managerial decision-making. Table 1 summarizes the parametrization used in the online experiment. An example of how the parameterization translates into a particular investment opportunity faced by a random participant in the sample is presented in Table A1 in the Appendix.

Table 1. Parametrization of the three scenarios of the investment project presented to participants in the online experiment. All parameters determining the business opportunity's attributes (i.e., s, t, p_i, and r_i) – as defined in the table – were randomly drawn from uniform distributions. The scenarios were scaled by a factor (f), based on the gross return and total equity obtained from the company's accounting data, ensuring that the investment opportunity faced by managers is at reasonable stakes.

	Worst Case (i=1)	*Base Case (i=2)*	*Best Case (i=3)*
Investment size (I)	$I = s \cdot f$ with $s \in \{1\%, 2\%, \ldots, 100\%\}$ and $f = 0.25 \cdot$ gross return $+ 0.25 \cdot$ total equity		
Time frame (t)	$t \in \{2, 3, \ldots, 10\}$ (indicated as ranges, starting in 2020 or 2021)		
Likelihood (p_i)	$p_1 \in \{5\%, 10\%, \ldots, 55\%\}$ $(p_1 < p_2)$	$p_2 \in \{40\%, 45\%, \ldots, 70\%\}$ $(p_2 > p1 \wedge p_2 > p_3)$	$p_3 \in \{5\%, 10\%, \ldots, 55\%\}$ $(p_3 < p_2)$
Net loss/gain (π_i)	$\pi_1 = r_1 \cdot I$ with $r_1 \in \{-0.95, -0.90, \ldots, -0.25\}$	$\pi_2 = r_2 \cdot I$ with $r_2 \in \{0.010, 0.011, \ldots, 0.100\}$	$\pi_3 = r_3 \cdot I$ with $r_3 \in \{0.11, 0.12, \ldots, 0.75\}$
Rate of return (irr_i)	$irr_1 \in \{-83\%, -82\%, \ldots, -4\%\}$ (determined by π_1, I, and t)	$irr_2 \in \{3\%, 4\%, \ldots, 20\%\}$ (determined by π_2, I, and t)	$irr_3 \in \{15\%, 16\%, \ldots, 133\%\}$ (determined by π_3, I, and t)
Break-even (b_i)	b_1 = "n.a."	$b_2 \in \{1.5, 1.6, \ldots, 9.1\}$ (determined by π_2, I, and t)	$b_3 \in \{0.6, 0.7, \ldots, 5.4\}$ (determined by π_3, I, and t)

Each manager faced a single hypothetical investment opportunity but was shown this opportunity twice: once to indicate how *risky* they perceive it to be, and once to indicate how *attractive* they perceive it to be. The order of the two questions was randomized to counter potential order effects (see, e.g., Carlsson *et al.*, 2012). On

both screens, the information about the business project was preceded by the preamble "Please look at the information below and consider how [risky/attractive] the investment – which is to take place this year – is to your company in its current economic situation". Managers' risk perception was elicited using the question: "How risky is this opportunity for your company?" to be answered on a Likert scale ranging from 1 ("not risky at all") to 7 ("very risky"). Managers' perception of the project's attractiveness was elicited using the question: "How attractive is this opportunity for your company?" to be answered on a Likert scale ranging from 1 ("not attractive at all") to 7 ("very attractive").

We ask managers to assess the project's attractiveness to proxy investment preferences – instead of asking directly about how likely the company would be to invest in the opportunity – to avoid that respondents were inclined to factor in how likely the company would be to face such an opportunity if the likelihood of investing appeared explicitly in the question. Thus, from a methodological point of view, the design of our study joins the rank of a respectable body of literature on perceived risk and perceived benefits (see, among others, Alhakami and Slovic, 1994; Slovic *et al.*, 2004; Keller *et al.*, 2006; Slovic and Peters, 2006; Holzmeister *et al.*, 2020).

The experiment was part of a larger survey on corporate investment decisions and subsequent management of investments undertaken, which contained a total of 72 questions, with only a small subset pertaining to the research questions addressed in this paper. Most of the items were collected primarily for the purpose of developing a practical online investment management tool, which was requested by the funding body. The survey was conducted in Danish. The full survey is available upon request. Apart from the managers' risk perception and investment preferences, the only variable that enters this study is a proxy for managers' individual-level attitude towards risk. In particular, we elicited the participants' risk preferences using the question "Please indicate how willing or unwilling you are personally, in general, to take risks?" to be answered on a Likert scale from 1 ("Completely unwilling to take risk") to 7 ("Very willing to take risk"), introduced by Dohmen *et al.* (2011).[1]

[1] In addition, we elicited participants' attitude towards risk using the multiple price list procedure introduced by Holt and Laury (2002). In particular, participants were asked to indicate whether they prefer a safe lottery (paying 2,000 DKK with p and 1,600 DKK with 1-p) or a risky lottery (paying 3,850 DKK with p and 100 DKK with 1-p) for varying probabilities $p \in \{0.10, 0.20, \ldots, 1.00\}$. Risk preferences elicited using this procedure serve as a robustness check for the survey-based proxy of participants' risk preferences.

We aimed to send the survey to the entire population of established small- and medium-sized enterprises (SMEs) in Denmark. We thus selected all Danish limited liability companies that were at least five years old, were not holding companies, were not within the financial sector, were not part of a larger group, and had executives who were not involved in other companies (as otherwise it might introduce confusion about which company their answers should pertain to). This resulted in an eligible sample of 19,759 companies.

The company-specific link to the survey was sent directly to one executive of the 19,759 Danish SMEs. The link was distributed via the personal *e-boks*, a strictly personal government-granted e-mail, to all individuals in the pool. Statistics Denmark (the Danish governmental statistical bureau) performed the matching of companies and executives as well as the distribution of the survey links to participants. Upon completion of the online survey, the data was merged with information obtained from the financial database *Orbis*, allowing us to control for company size via a company's total assets, shareholder funds (i.e., total equity), gross profits, and the number of employees. For the survey items of relevance to this paper, we received 4,287 responses, implying a response rate of 21.7%.[2] Descriptive statistics on the control variables and an analysis of selection effects of managers into the experiment are provided in Appendix B.

Results

Observation 1. Managers' risk perception is significantly driven by the size of the required investment and by downside measures. In particular, perceived risk is significantly related to the likelihood and the magnitude (IRR) of the project's worst-case outcome. Perceived risk and perceived attractiveness are strongly negatively associated. Yet, managers' perceived attractiveness does not relate to the size of required investment, and it is not only affected by the worst-case scenario but also by a project's base-case and best-case outcomes.

[2] While participants' perception of risk and attractiveness of the business opportunity was elicited at the very beginning of the survey, the question on individual-level risk preferences and the multiple price list (Holt and Laury, 2002) were presented towards the end of the experiment. Since survey items in-between required participants to describe their business activities in an open-ended format, attrition rates were relatively high. A total of 3,041 participants completed the self-reported measure on risk preferences; 2,537 also completed the multiple price list task.

Support. Figure 1 shows the (standardized) coefficient estimates of a linear regression of risk perception and *un*attractiveness[3] ratings on the various project attributes that were exogenously varied in the experimental setup, controlling for the company's total assets, shareholder funds, gross profit, and number of employees. Non-standardized estimates of the regressions are provided in models (1) and (2) in Table C1 in the Appendix.

First, we report a significantly positive effect of the size of the required investment on risk perception:[4] On average, an increase by one standard deviation in (the log of) the required investment induces an increase of 0.168 standard deviations ($se = 0.018$, $p < 0.001$) in risk perception. We deem this result striking, as it indicates that managers do not only consider relative measures, but are also concerned about absolute stakes. As such, this result is well in line with the notion of "consequentiality" as put forward by Sanders and Hambrick (2007): risk is associated with the extent to which a company's health and vitality is potentially affected. Moreover, the results presented in Figure 1 indicate that managers' risk perception is significantly related to the likelihood of the worst-case scenario, which – by design of the experimental task – coincides with the probability to incur losses. An increase in a business opportunity's loss probability of one standard deviation, on average, implies that the project is perceived being 0.138 standard deviations more risky ($se = 0.021$, $p < 0.001$). Although somewhat smaller in terms of the effect size, we find that the internal rate of return (IRR) of the worst-case scenario explains a significant share of the variation in managers' risk perception. On average, an increase by one standard deviation in the worst-case IRR (i.e., a less negative outcome) is associated with a decrease in risk perception by 0.082 standard deviations ($se = 0.015$, $p < 0.001$). Notably, neither the IRR associated with both the base-case and the best-case scenarios, nor the likelihood of the best-case scenario are significantly related to participants' perception of business risk. In line with previous findings (see, e.g.,

[3] Please note that – for the sake of comparability of effects – we use the reverse-coded survey response on managers' perception of the project's attractiveness as a measure of the project's unattractiveness. Without altering the economic content of the measure, we consider unattractiveness (instead of attractiveness) as the dependent variable in our analyses, to align the signs of effects associated with perceived risk and our proxy of investment propensity.

[4] Note that the regression analysis controls for several firm size related measures, as the effect of absolute measures might be confounded otherwise. In particular, the regression controls for the company's total assets, shareholder funds, gross profit, and number of employees. Since the size of the initial investment is based on a company's total assets and gross profit, the effect is assumed to be properly adjusted.

Brachinger and Weber, 1997; Holzmeister *et al.*, 2020; Zeisberger, 2021), these results indicate that risk perception is primarily driven by downside risk measures. Moreover, we do not find evidence that managers' perception of risk is related to the duration of the project or the years to break-even (B/E).

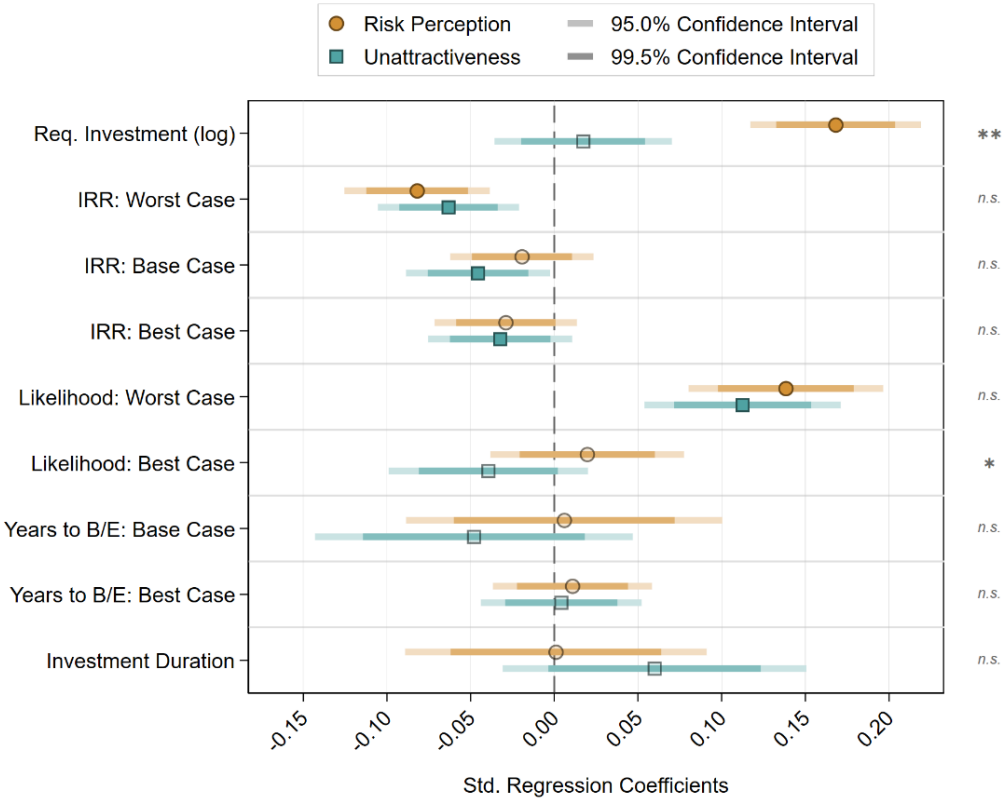

Figure 1. Effects of business project attributes on managers' risk perception and unattractiveness ratings. The figure shows standardized coefficient estimates based on ordinary least squares regressions of managers' risk perception and unattractiveness ratings on various project attributes (controlling for the company's total assets, shareholder funds, gross profit, and number of employees). Error bars indicate 95% and 99.5% confidence intervals based on robust standard errors. Standardized regression estimates are reported in models (1) and (2) in Table C1 in the Appendix. Significance indicators on the right refer to differences between coefficient estimates after seemingly unrelated regressions as reported in model (3) in Table C1 in the Appendix; $^{n.s.}$ not significant, * $p < 0.05$, and ** $p < 0.005$.

Given these results, the question whether and to which extent the likelihoods and the IRR interact with one another arises naturally. In a supplementary analysis (reported in Table D1 in the Appendix), we regress managers' risk perception on the (exogenous) variation in the business opportunity's worst-case outcome, the probability with which this outcome is expected to be realized, and the interaction be-

tween these two factors. Corroborating the results reported above, we find a significantly positive main effect of the likelihood of the worst-case outcome (i.e., the loss probability; $b = 0.133$, $se = 0.021$, $p < 0.001$) and significantly negative main effect of the worst-case scenario's IRR ($b = -0.079$, $se = 0.015$, $p < 0.001$). Strikingly, however, we do not find evidence for the interaction term between the likelihood and the magnitude of losses being statistically different from zero ($b = 0.006$, $se = 0.015$, $p = 0.701$; see Model (2) in Table D1 in the Appendix).[5] This result indicates that managers in our sample do not seem to systematically factor in the *expected outcomes*, but rather treat likelihoods and outcomes *separately*. The overarching pattern, thus, remains unchanged: What clearly matters in terms of what is considered being risky are the probability to incur losses and the magnitude of potential losses. In turn, this finding challenges the conceptualization of risk measures based on expectations, such as, e.g., variance, expected loss, or expected shortfall. These results are in line with previous findings reported in the literature (see, e.g., Holzmeister *et al.*, 2020).

Turning to managers' perception of a project's unattractiveness, we find that their perception – as to be expected – is positively correlated with their perception of project risks (Spearman rank correlation: $\rho_S = 0.159$, $p < 0.001$; $n = 4{,}287$). Although assessments of risk and unattractiveness are strongly correlated, the impact of the project attributes turns out not to coincide for the two dependent variables. First, we do not find evidence that managers' assessment of unattractiveness is systematically affected by (the log of) the required investment ($b = 0.017$, $se = 0.019$, $p = 0.360$); the coefficient estimate of required investment turns out being significantly larger for risk perception as compared to unattractiveness. Second, we report that the impact of downside measures on unattractiveness ratings is comparable to the effect on risk perception (likelihood of the worst-case scenario: $b = 0.112$, $se = 0.021$, $p < 0.001$; IRR of the worst-case scenario: $b = -0.063$, $se = 0.015$, $p < 0.001$). While – as compared to the effects on risk perception – the effect of these two downside measures tend to be slightly less pronounced, the coefficient esti-

[5] Likewise, we do not find any evidence for significant interaction effects of likelihoods and magnitudes of both the base-case and the best-case outcomes. Moreover, the significant main effects of the downside measure (i.e., likelihood and IRR of the worst-case outcome) turn out to be highly robust when considering the base-case or best-case measures at the same time; for details, please refer to Table D1 in the Appendix.

mates do not significantly differ between the two models. However, unlike managers' risk perception, assessments of unattractiveness are also significantly driven by a project's upside potential. In particular, we report negative effects for IRR of both the base-case (b = –0.046, se = 0.015, p = 0.003) and the best-case scenario (b = –0.032, se = 0.015, p = 0.035); the effect of the likelihood of the best-case scenario turns out to be negative but does not significantly differ from zero (b = –0.039, se = 0.021, p = 0.063).[6] Although the effects of base-case and best-case measure suggest that the extent to which a project is deemed attractive does not only depend on the potential downsides, the coefficient estimates for unattractiveness ratings do not differ significantly from the estimates for managers' risk perception.

Overall, our findings appear to be in line with the findings by Slovic (1967) and Slovic and Lichtenstein (1968), arguing that perceived risk and perceived benefits are shaped by people's beliefs about the relative importance of probabilities and outcomes, and their inability to translate these beliefs into judgments when processing information. The results of their experiments suggest that people's conception of risk is predominantly determined by a prospect's downside probability whereas attractiveness judgments are affected by upside potentials.

Observation 2. Managers' perception of the project's attractiveness is inversely related to their perception of risk. Moreover, attractiveness ratings are significantly driven by their individual-level risk preferences, and the interaction of risk preferences with the perception of risk associated with the investment opportunity.

Support. In line with a consistently observed pattern in the previous literature, we report that managers' perception of unattractiveness is positively related to their perception of project risk (b = 0.191, se = 0.021, p < 0.001; see model (1) in Table C2 in the Appendix). Alhakami and Slovic (1994) argue that the inverse relationship between perceived risk and perceived benefit is due to a confounding of risk and benefit in people's minds. In particular, they argue that the inverse relation between

[6] As for the analysis on drivers of risk perception, we conduct supplementary analyses to examine potential interaction effects of likelihoods and magnitudes of outcomes associated with the three scenarios to infer effects pointing towards expectation-based risk and attractiveness assessments. Actually, we do not find any interaction effects between likelihoods and magnitudes of returns associated with any of the three scenarios, while the main effects of the respective measures turn out to be robust. The corresponding analyses are summarized in Table D1 in the Appendix.

perceived risk and perceived benefit might be an "interesting manifestation" of the halo effect (Thorndike, 1920). People's judgement tends to be governed by their perceptions and impressions of general aspects – i.e., particular characteristics are considered representative whereas other facets, which are considered secondary, are eclipsed. Relatedly, Finucane *et al.* (2000), Slovic *et al.* (2004), Keller *et al.* (2006), and Slovic and Peters (2006) propose that the inverse relationship between perceived risk and perceived benefit occurs due to people relying on affect and availability when judging risk and benefits.

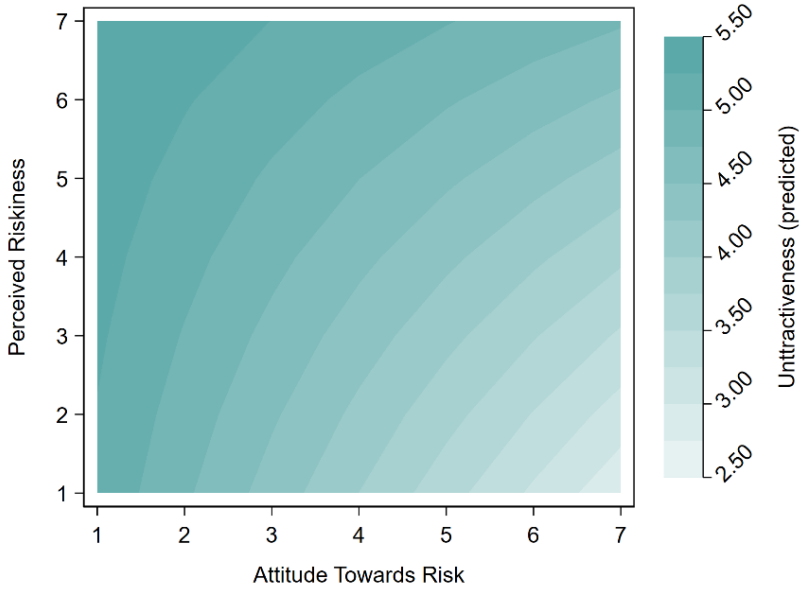

Figure 3. Contour plot of predictive margins of managers' unattractiveness ratings conditional on their individual-level attitudes towards risk and the perception of risk. Estimates (unstandardized) are based on ordinary least squares regressions of managers' perceived unattractiveness on perceived riskiness, their individual-level risk preferences, and the interaction term thereof. The corresponding regression estimates are provided in model (2) in Table C2 in the Appendix.

Weber *et al.* (1992) test various conceptualizations of the potential relationship between risk and attractiveness assessments. Their findings tend to rule out the common mediator hypothesis; rather, their results support the notion that risk and attractiveness are distinct accessible psychological constructs. Yet, perceived attractiveness may well be interrelated with perceived risk, and various moderators may influence both constructs. A decision-maker's individual-level risk preferences appear to be an intuitively reasonable candidate for such a moderator. Relating to this conceptualization of risk and attractiveness, we contribute by providing evidence

for unattractiveness ratings being significantly negatively affected by managers' individual-level risk preferences ($b = -0.263$, $se = 0.023$, $p < 0.001$; see model (1) in Table C2 in the Appendix). Although one might be inclined to hypothesize that risk perceptions are interrelated with risk preferences, managers' perception of risk turns out not to be significantly related to their individual-level risk preferences (Spearman rank correlation: $\rho_S = -0.000$, $p = 0.979$; $n = 3{,}041$). Yet, the question whether attractiveness perceptions are affected by the interaction effect of risk perception and risk preferences arises naturally.

Figure 2 depicts the predictive margins of managers' assessment of the project's unattractiveness (based on a linear regression model; see model (2) in Table C2 in the Appendix) subject to the (endogenous) variation in individual-level risk preferences and perceived risk associated with the project. Strikingly, Figure 2 reveals that the contour levels of the predictions are clearly concave, indicating that managers' assessment of a project's unattractiveness is governed by a significant interaction effect between risk perceptions and individual-level risk preferences ($b = 0.047$, $se = 0.013$, $p < 0.001$; see model (2) in Table C2).[7] The less risk tolerant a manager is *and* the more risky she perceives the project to be, the more unattractive the project is perceived to be. This effect gives rise to the following observation: On average, managers who are highly risk averse tend to perceive the project relatively unattractive *per se*, irrespective of the extent to which the project is perceived to be risky or not. Likewise, whenever a project is perceived to be highly risky, it is deemed relatively unattractive, with only a small moderating impact of the manager's individual-level attitude towards risk. We deem this result of particularly high relevance, as it indicates that managerial decision-making processes seem to be not only affected by subjective conceptions of objective attributes of business opportunities, but are also governed by a manager's individual-level *risk preferences*.

[7] Notably, these effects turn out to be qualitatively highly robust if we replace the self-reported measure of risk preferences by the number of risky choices participants made in the multiple price list (Holt and Laury, 2002). In particular, we find a significant interaction effect of revealed risk preferences elicited using the price list setting and managers' perception of risk ($b = 0.035$, $se = 0.009$, $p < 0.001$) and a significant main effect of the number of risky choices ($b = -0.212$, $se = 0.042$, $p < 0.001$) on manager's assessment of attractiveness. Please refer to Table C2 in the Appendix for details.

Discussion and Conclusion

This study contributes to the highly relevant research area of studies examining behavioral aspects of managerial decision-making, initiated by March and Shapira (1987). Using a unique large-scale online experimental research design that allows for a systematic delineation of the effects associated with various attributes of a business opportunity, potentially affecting risk perception and investment preferences, our study consolidates and advances the literature by providing a more comprehensive understanding of how managers perceive risk and attractiveness in a business context.

Our results suggest that the processes that result in judgements of a business project's risk and attractiveness are somewhat detached from the classical processes of choosing among alternative actions based on evaluating the trade-off between the mean (expected value) and variance (risk) of the probability distributions over possible outcomes. We find that managers' conception of risk is strongly related to the potential downsides associated with the project, but not its upsides. Both, higher likelihoods and higher magnitudes (IRR) of the worst-case outcome, induce managers to perceive business opportunities as being more risky. The impact of the likelihood of the worst-case outcome on managers' risk perception is noteworthy, as previous studies provide mixed evidence on likelihoods as a risk measure. One the one hand, there are indications in Shapira (1986), MacCrimmon and Wehrung (1986), Slovic 1967, and Fischhoff *et al.*, 1978 that individuals do not trust, do not understand, or simply do not use likelihood estimates when assessing risk. On the other hand, more recent findings suggest that likelihood estimates – particularly the probability of incurring losses – strongly affect decision-maker's perception of risk (e.g., Holzmeister *et al.*, 2020 and Zeisberger, 2021). Moreover, we find that the interaction between likelihoods and IRRs turns out not to be systematically related to risk perception, suggesting that the likelihoods of outcomes and their values enter managers' perception of risk independently, rather than as their products (Slovic *et al.*, 1987; Holzmeister *et al.*, 2020).

We find that manager's risk perception increases with the size of the required investment, which indicates that managers also integrate the business opportunity's absolute stake into their risk assessment. Managers therefore seem to consider the

consequential outcomes when assessing the risk of a business opportunity. Interestingly, most researchers omit consequential outcomes in conceptualizing risk taking (Sanders and Hambrick, 2007) or treat it as a relatively complete indicator of risk taking (Hoskisson *et al.*, 1993; Lee and O'Neill, 2003).

Turning to investment preferences, we find that managers' perception of attractiveness is inversely related to their risk perception. This supports that risk and benefits are negatively correlated in managers' mind and assessments, but is contrary to hazardous activities in the world where high-risk activities tend to have greater benefits than do low-risk activities (Fischhoff *et al.*, 1978; Alhakami and Slovic, 1994). When assessing the attractiveness of the project, managers do not only rely on returns and likelihoods of the worst-case scenario, but also the returns of the base-case and best-case outcomes. Furthermore, novel insights on individual-level risk preferences suggest that risk tolerant managers perceive investment opportunities to be more attractive than risk intolerant managers. The latter result suggests that the relative underweight of strategic management research on *risk preferences* relatively to research on *risk perception* and the definition of risk is unmerited.

Our results have important implications for how we understand and teach managerial decision-making. Currently, there seems to be a gap between how we teach our students in assessing a business opportunity and how managers actually perceive it. In general, managers seem to rely on simpler measures than suggested by decision theory, which typically relies on variance as a measure of risk. Given that managers do not seem to perceive variance as the defining moment of risk, measures focusing on the likelihood and return of the worst-case outcome should be given more attention in the literature. Furthermore, decision theory relies on expected values as a measure for decision-making. Managers in our sample, however, seem to rely on single moments such as the likelihood and the IRR for each scenario separately. This suggests that there might be possibilities for challenging managerial perspectives through direct training in decision theoretic approaches to the assessment of business opportunities.

The fact that managers tend not to follow decision theoretic approaches raises the question whether those managers as a result make sub-optimal decisions. In other words, would managers make better decisions if they followed the procedures put

forward by standard decision theory rather than simple measures or some heuristics (rule of thumbs)? Are certain types of investments more suitable for simpler measures? Answering these and related questions seems to promise valuable insights not only for academics but also for managers. Thus, a fruitful avenue for future research is to address such questions.

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Appendices

What is Risk to Managers?

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Appendix A. Details on the Experiment

Table A1. Example of a hypothetical investment opportunity as shown to survey participants. For a detailed description of the parametrization and range of the various attributes, please refer to the description in the main text. The IRRs presented to the participants were based on the assumption that the initial cash outflow (*size of initial investment*) took place in 2019 (at the time of the survey) while cash inflows – *size of initial investment* (recouped) + *Net loss (-) or gain (+)* – were evenly spread out over the *time period with income from the investment*. Thus for instance the base case IRR below results from the following cash flows $t_0 = -13{,}000{,}000$, $t_{1\text{-}3} = (13{,}000{,}000+4{,}300{,}000)/3$. Information about these underlying IRR assumptions were not presented to respondents as it was deemed sufficiently complex to divert their focus from the task at hand.

	Worst Case	***Base Case***	***Best Case***
Size of initial investment	DKK 13,000,000	DKK 13,000,000	DKK 13,000,000
Net loss (-) or gain (+) from the investment	DKK –3,900,000	DKK 4,300,000	DKK 21,000,000
Yearly return (IRR)	–16%	16%	69%
Time period with income from the investment	2020–2022	2020–2022	2020–2022
Number of years until break-even	n.a.	2.3	1.1
Likelihood of scenario	10%	70%	20%

Appendix B. Recruitment and Register Data

Table B1. Descriptive statistics on firm-specific covariates used as control variables in all analyses, separated for experimental participants (Respondents) and managers in the population who did not participate in the study (Non-Respondents). Total assets, shareholder funds (i.e., total equity), and gross profits are measured in DKK 1,000,000. Means and standard deviations (SD) as well as medians and inter-quartile ranges (IQR) are provided. The right-most column indicates the results of two-sample *t*-tests using Welch's approximation to adjust for unequal variances.

	Respondents		**Non-Respondents**		
	Mean (SD)	*Median (IQR)*	*Mean (SD)*	*Median (IQR)*	*t-Statistic (p-value)*
Total assets	24.11 (45.77)	8.39 (18.34)	20.01 (40.67)	6.96 (14.25)	5.305 (< 0.001)
Shareholder funds	9.49 (21.78)	2.97 (6.79)	7.61 (21.91)	2.33 (5.56)	5.000 (< 0.001)
Gross profits	13.33 (21.29)	6.39 (10.45)	11.05 (18.63)	5.39 (8.03)	6.359 (< 0.001)
Number of employees	22.93 (32.65)	12.00 (17.00)	19.54 (28.40)	10.00 (13.00)	6.175 (< 0.001)
Observations	4,287		15,472		

Appendix C. Supplementary Tables

Table C1. Regression analyses of perceived riskiness (1) and perceived unattractiveness (2) on the various attributes of the business project varied in the experiment. Estimates (standardized) are based on ordinary least squares regressions. *Controls* include the company's total assets, shareholder funds (i.e., total equity), gross profits, and the number of employees. Model (3) reports the differences between models (1) and (2) as based on seemingly unrelated regressions. Robust standard errors are provided in parentheses. * $p < 0.05$, ** $p < 0.005$.

	(1) Perceived Riskiness	(2) Perceived Unattract.	(3) Difference (1) – (2)
Req. Investment (log)	0.168**	0.017	0.151**
	(0.018)	(0.019)	(0.024)
IRR: Worst Case	–0.082**	–0.063**	–0.019
	(0.015)	(0.015)	(0.020)
IRR: Base Case	–0.019	–0.046**	0.026
	(0.015)	(0.015)	(0.021)
IRR: Best Case	–0.029	–0.032*	0.003
	(0.015)	(0.015)	(0.020)
Likelihood: Worst Case	0.138**	0.112**	0.026
	(0.021)	(0.021)	(0.028)
Likelihood: Best Case	0.020	–0.039	0.059*
	(0.021)	(0.021)	(0.027)
Years to B/E: Base Case	0.006	–0.048	0.054
	(0.034)	(0.034)	(0.044)
Years to B/E: Best Case	0.011	0.004	0.007
	(0.017)	(0.017)	(0.022)
Investment Duration	0.001	0.060	–0.059
	(0.032)	(0.032)	(0.043)
Constant	0.007	0.035	
	(0.020)	(0.020)	
Controls	*yes*	*yes*	
Observations	4287	4287	
Adjusted R^2	0.044	0.027	

Table C2. Regression analyses of managers' assessment of project attractiveness on perceived risk, individual-level risk preferences, and the interaction term thereof. Estimates (non-standardized) are based on ordinary least squares regressions. *Controls* include the company's total assets, shareholder funds (i.e., total equity), gross profits, and the number of employees. Robust standard errors are provided in parentheses. * $p < 0.05$, ** $p < 0.005$.

	(1) Perceived Unattract.	(2) Perceived Unattract.	(3) Perceived Unattract.	(4) Perceived Unattract.
Perceived Riskiness	0.191**	0.002	0.270**	0.122*
	(0.021)	(0.053)	(0.024)	(0.045)
Attitude Towards Risk	–0.263**	–0.437**		
	(0.023)	(0.058)		
Perceived Riskiness		0.047**		
# Attitude Towards Risk		(0.013)		
Attitude Towards Risk (Holt/Laury)			–0.078**	–0.212**
			(0.013)	(0.042)
Perceived Riskiness				0.035**
# Attitude Towards Risk (Holt/Laury)				(0.009)
Constant	4.916**	5.607**	3.705**	4.263**
	(0.138)	(0.237)	(0.128)	(0.203)
Controls	*yes*	*yes*	*yes*	*yes*
Observations	3041	3041	2537	2537
Adjusted R^2	0.077	0.083	0.077	0.085

Appendix D. Supplementary Analyses

Table D1. Regression analyses of perceived risk (models (1) and (2), respectively) and perceived unattractiveness (models (3) and (4), respectively) on the likelihood of the scenarios, the internal rate of return (IRR), and their interaction terms. Estimates (standardized) are based on ordinary least squares regressions. *Controls* include the company's total assets, shareholder funds (i.e., total equity), gross profits, and the number of employees. Robust standard errors are provided in parentheses. * $p < 0.05$, ** $p < 0.005$.

	(1) Perceived Riskiness	(2) Perceived Riskiness	(3) Perceived Unattract.	(4) Perceived Unattract.
IRR: Worst Case	–0.075**	–0.079**	–0.057**	–0.061**
	(0.015)	(0.015)	(0.015)	(0.015)
Likelihood: Worst Case	0.115**	0.133**	0.151**	0.110**
	(0.016)	(0.021)	(0.016)	(0.021)
IRR: Worst Case	0.005	0.006	0.007	0.007
# Likelihood: Worst Case	(0.015)	(0.015)	(0.015)	(0.015)
IRR: Base Case	0.004		0.070	
	(0.083)		(0.083)	
Likelihood: Base Case	–0.139		0.302	
	(0.162)		(0.162)	
IRR: Base Case	–0.045		–0.217	
# Likelihood: Base Case	(0.149)		(0.149)	
IRR: Best Case		–0.029		–0.036*
		(0.015)		(0.015)
Likelihood: Best Case		0.018		–0.041
		(0.021)		(0.021)
IRR: Best Case		–0.004		–0.011
# Likelihood: Best Case		(0.015)		(0.015)
Constant	0.018	–0.058**	–0.139	0.029
	(0.091)	(0.019)	(0.091)	(0.019)
Controls	*yes*	*yes*	*yes*	*yes*
Observations	4287	4287	4287	4287
Adjusted R^2	0.026	0.026	0.026	0.024

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Jeppe Christoffersen, Felix Holzmeister, Thomas Plenborg

What is Risk to Managers?

Abstract
We systematically examine which characteristics of a business opportunity - such as the likelihoods of potential gains and losses - affect managers' perception of risk and attractiveness. In an online experiment with a sample of 4,287 managers from small- and medium-sized enterprises in Denmark, we present participants with a hypothetical investment prospect in a business context, and elicit their perception of risk associated with the project and their perception of the investment's attractiveness. The experimental data is merged with a set of background variables on the company, which allows controlling for firm-specific effects. We find that risk perception is driven by the likelihood and the return associated with the worst-case scenario as well as the size of the required investment. Managers' perception of attractiveness is affected not only by the worst-case scenario but also by the characteristics of the base-case and the best-case outcomes. Furthermore, we provide evidence that managers' perception of the project's attractiveness is significantly affected by their individual-level risk preferences and the interaction effect with risk perception. This implies that not only the characteristics of the different scenarios but also individuals' risk preferences play an important role when assessing the attractiveness of a business opportunity.

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