Arbeitskreis Quantitative Steuerlehre
Quantitative Research in Taxation – Discussion Papers

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arqus Discussion Paper No. 222

October 2017

www.arqus.info

ISSN 1861-8944

Tax Loss Offset Restrictions and Biased Perception of Risky Investments

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Abstract: We investigate how tax loss offset restrictions affect an investor's evaluation of risky investments under bounded rationality. We analytically identify behavioral tax effects for different levels of loss offset restrictions, tax rate and prospect theoretical biases (loss aversion, probability weighting and reference dependence) and find tax loss offset restrictions significantly bias investor perception, even more heavily than the tax rate. If loss offset restrictions are rather generous, investors are very loss averse or assign a huge weight to loss probabilities, taxation is likely to increase the preference value of risky investments (behavioral tax paradox). Surprisingly, the identified significant perception biases of tax loss offset restrictions occur under both high and low tax rates and thus are relatively insensitive to tax rate changes. Finally, we identify huge differences in behavioral tax effects across countries indicating that tax loss offset restrictions crucially determine the perceived tax quality of a country for risky investments. Our analysis is relevant for policy makers discussing future tax reforms as well as for investors assessing risky investment opportunities.

Keywords: asymmetric taxation, investment decisions, loss offset restrictions, perception bias, risk-taking, tax effects, tax losses, prospect theory, behavioral taxation

JEL Classification: D81, D91, H21, H25

Acknowledgments: The authors gratefully acknowledge very helpful comments from James Alm, Harald Amberger, Tobias Bornemann, Eva Eberhartinger, Christina Elschner, Michael Ebert, Vanessa Flagmeier, Thomas Hoppe, Martin Jacob, Erich Kirchler, Thomas Kourouxous, Jens Müller, Regina Ortmann, Benjamin Oßwald, Thomas Pfeiffer, Martina Rechbauer, Stefan Reichelstein, André Uhde and the participants of the Accounting Research Seminar at the Vienna University of Economics and Business in January 2017, the Annual Meeting of the Ausschuss Unternehmenstheorie und –politik in May 2017, the Research Seminar of the Department of Applied Psychology: Work, Education, Economy at the University of Vienna, the 7th Conference on Current Research in Taxation at the Vienna University of Economics and Business in July 2017 and the NoCeT Seminar and Seminar of the Department of Accounting, Auditing and Law at NHH Norwegian School of Economics in Bergen in August 2017. An earlier version of this paper is included in Mehrmann (2017) and has been completely rewritten and substantially extended by the authors. Caren Sureth-Sloane gratefully acknowledges support by the German Research Foundation (DFG SU 501/4-2).

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1 Introduction

We study the effects of tax loss offset restrictions on the evaluation of risky investments under bounded rationality of decision makers and find loss offset restrictions being a crucial determinant, even more important than tax rates. We address an important research gap as the prevalence of remarkable loss offset restrictions across countries is deemed to be an important factor effectively preventing the tax-deductibility of losses and thereby impairing risky investment. In addition to restrictions in time, many countries have implemented further restrictions in the amount of yearly tax loss offsets.[1]

We know from Domar and Musgrave (1944) that a complete loss offset (symmetrical taxation of gains and losses) increases a risk-averse investor's propensity to carry out risky investments in portfolio selection settings, while loss offset restrictions (asymmetrical taxation of gains and losses) induce ambiguous effects.[2] In loss-making investments, the tax authority shares the risk if tax losses can be offset. If the loss offset opportunities are sufficiently large, the benefit from tax refund on tax losses prevails. As a consequence, rising tax rates increase the value of a risky investment (so-called tax paradox, Schneider 1992, p. 246). Related approaches, like real option models, support this finding (Panteghini 2001, Niemann and Sureth 2004 and 2013, Gries, Prior and Sureth 2012).

However, empirical evidence on corporate investment responses to loss offset restrictions is mixed and can only partially be explained by theoretical models. Langenmayer and Lester (2017) find risk-taking positively related to the length of tax loss periods. They further show that the sign of the tax rate effect on risky investment depends on firm-specific expectations of future loss recovery. Ljungqvist, Zhang and Zuo (2017) find that firms reduce risky investments in response to tax increases, but fail to provide evidence for a corresponding sensitivity to tax cuts as theory suggests. Devereux, Keen and Schiantarelli (1994) investigate the effects of intertemporal loss offset restrictions and surprisingly find that including tax asymmetries does not improve the predictive power of a model to explain corporate investment decisions. However, Dreßler and Overesch (2013) find evidence that in industries with a high probability to face losses firms respond negatively to tax loss offset restrictions when making investment decisions. Also, Bethmann, Jacob and Müller (2016) find that less restrictive loss offset regulations increase investments of loss firms.

Notably, all of these studies build on neoclassical economics and assume a perfectly rational decision maker, which is empirically questionable. Studies based on real data show that such rationality can be rarely observed; instead, decision-making in a wide range of situations systematically deviates

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[1] Cf. Appendix A for an overview of tax loss offset restrictions over time in various countries and their economic relevance.

[2] The effects of loss offset restrictions on investment decisions under rational choice have already been comprehensively discussed in the literature. Cf., e.g., Mossin (1968), Näslund (1968), Feldstein (1969), Stiglitz (1969), Russell and Smith (1970), Allingham (1972), Sandmo (1989), Eeckhoudt, Gollier and Schlesinger (1997), Niemann (2004).

from fundamental rationality postulate (Allais 1953, Ellsberg 1961, Kahneman and Tversky 1979, Tversky and Kahneman 1992).

We analyze the effects of tax loss offsetting on the evaluation of risky investments by decision makers who behave in line with the tenets of prospect theory,[3] for example, private individual investors, sole proprietors or owner-managers in owner-managed firms.[4] The application of prospect theory allows us to depict investor behavior and risk-taking more accurately than rationality-based expected utility theory by accounting for behavioral aspects (Kahneman and Tversky 1979, Tversky and Kahneman 1992). Based on this theory, loss offset restrictions interact with the psychological imbalance of investors assigning more weight to a loss than to a correspondingly large gain.

We are the first to include all three crucial and fundamental characteristics of prospect theory, namely loss aversion, probability weighting and reference dependence and study their impact the assessment of risky investment. Previous literature, in particular, Fochmann and Jacob (2015) limit their focus on loss aversion as one of the core elements of prospect theory, abstracting from other psychological determinants of behavior,[5] As shown by Langer and Weber (2005), statements on the attractiveness of (repeated) lotteries originally gathered purely with regard to loss aversion only apply to a limited extent given investors with different risk profiles. The authors show that ignoring probability weighting under certain circumstances can even lead to conclusions that are not compatible with loss aversion. Not least, integrating different reference levels in a tax impact analysis also promises elucidating findings as the decision maker's (perceived) gain or loss from the investment is not (necessarily) consistent with the taxable base. As there is evidence for both the 'flawed' handling of probabilities, i.e., probability weighting, and the choice of reference point having a major effect on investment behavior (Langer and Weber 2005, Kanbur, Pirttilä and Tuomala 2008, Hlouskova and Tsigaris 2012, Hlouskova et al. 2014), models that abstract from these aspects assume decisions that deviate from observed investor behavior.

Second, we analytically identify general behavioral neutral loss offset factors.[6] These factors serve as yardsticks in our analyses of the distortive power of the interplay of tax rates and loss offset restrictions. Moreover, we determine tax effects for different levels of loss offset restrictions, tax rates and prospect theoretical biases.

[3] When we use the term 'prospect theory', it refers to cumulative prospect theory that succeeded the original version of the theory.

[4] A large proportion of firms are owner-managed. For example, Jacob and Michaely (2017) use Swedish individual income tax information and find that 90% of firm's shares are owned by active owners.

[5] In their model, Fochmann and Jacob (2015) abstract from an investor-specific transformation of probabilities. In addition, the authors assume (implicitly) a zero investment as a reference point and thus exclude a positive (taxable) yield as the reference point.

[6] A neutral tax system in this respect can thus be used as a benchmark when assessing tax systems. This idea builds on the literature on neutral tax systems that have been addressed under rational choice theory and certainty by, e.g., Brown (1948), Samuelson (1964), and Johansson (1969), under uncertainty by MacKie-Mason (1990) and Bond and Devereux (1995), under uncertainty and risk aversion by, e.g., Niemann and Sureth (2004).

In contrast to prior theoretical literature, we find that taxation of gains and losses leads to ambiguous tax effects, even under complete loss offset, for investors with bounded rationality. Moreover, we show that tax loss offset restrictions significantly bias the assessment of risky investments, even more heavily than the tax rate. If loss offset regulations are rather generous, investors are very loss averse or assign a huge weight to loss probabilities then taxation is likely to increase the preference value (behavioral tax paradox). These results are driven by behavioral features as loss aversion and probability weighting and are in contrast to rational decision-making. Surprisingly, we find that the identified significant perception bias of tax loss offset restrictions occurs under both high and low tax rates and is thus relatively insensitive to tax rate reforms.

Our model theoretically describes effects found in laboratory experiments as the mentally overestimation of losses or loss offset opportunities in Fochmann, Kiesewetter and Sadrieh (2012) or Fahr, Janssen and Sureth (2014) and Amberger, Eberhartinger and Kasper (2016). Thus, we provide a descriptive model for the yet unexplained experimental evidence for tax-induced biased perception of risky investments. Moreover, we determine country-specific tax effects on the basis of reported tax regulations. We find huge differences in prospect theoretical tax effects across countries indicating that tax loss offset restriction crucially determine the tax quality of a country for risky investments.

These findings are an important step towards evaluating tax effects on investment and risk-taking under bounded rationality. Our study sensitizes for the high relevance of loss offset restrictions in discussions on future tax reforms and helps to develop suggestions accounting for behavioral economics on how tax regulations should be designed. Our analysis also provides useful support for investors to better gauge, assess and even avoid the effects of taxation and psychological biases when making decisions. Testing our findings in laboratory experiments may be a fruitful avenue for future research.

Hitherto, there is only limited accounting, economic and psychological research on taxation using behavioral economic models. This is particularly astonishing, as prospect theory has been established for several decades and long been found to have empirical relevance for taxation issues (Chang, Nichols and Schultz 1987 and Robben et al. 1990). Only few studies examine tax effects using prospect theory. Kanbur, Pirttilä and Tuomala (2008) deduce an optimal income tax in their theoretical model study to, taking into account the moral hazard problem. The authors show that an optimal tax system differs above and below the reference point. Hlouskova and Tsigaris (2012) and Hlouskova et al. (2014) use a model framework based on prospect theory to analyze the effect of a proportional capital income tax on portfolio decisions. The key finding in both papers is that tax-induced reactions depend on the reference point. Falsetta and Tuttle (2011) investigate in an experimental study how expecting a tax refund or an additional tax payment affects investment decisions that themselves do not have any tax consequences. They find that subjects who were entitled to claim a tax refund take significantly less risk than those who have to pay an additional tax. Falsetta, Rupert and Wright (2013) analyze experimentally whether the timing of a change to capital income tax affects risk-taking. They find a reduction in tax significantly increases risk-taking if the reform is introduced gradually. Conversely, a tax increase causes decreases risk-taking, if the reform is implemented in a single measure. These studies provide evidence for investors assigning more weight to specific tax issues in their risk-taking decisions than predicted by rational choice theory.

Our study scrutinizes loss offset restrictions and how they bias the evaluation of risky investments. It is related to Fochmann and Jacob (2015). They use a utility-based investment model to determine tax rates that would ensure a balance of prospect theoretical preferences regarding the tax treatment of a gain and a correspondingly high loss. Assuming loss aversion in a prospect theoretical sense, they show numerically that under symmetrical taxation of gains and losses preferences for a tax refund for losses are overestimated in comparison to tax payments for gains. They find that the degree of tax asymmetry that eliminates this behavioral bias depends on the investors' risk attitude and their degree of loss aversion. We extend their approach by including all three fundamental characteristics of prospect theory, loss aversion, probability weighting and reference dependence, and studying country-specific behavioral biases.

The remainder of the paper is organized as follows. In Section 2, we introduce our prospect theoretical decision model. We apply our model within a baseline scenario and are able to show the significant impact of loss offset restrictions on the assessment of risky investments in Section 3. The subsequent sensitivity analyses in Section 4 then enable us to investigate the behavioral value drivers and the robustness of our results. In Section 5, we summarize our main results and conclude.

2 Model

We assume an investor is evaluating a risky investment with a state-dependent yield $\tilde{x}$ in a one-period model.[7] The realization of the stochastic binary variable $\tilde{x}$ is x^+ in the good state of nature and x^- in the bad state of nature. In case of the good state of nature that occurs with a probability p with $p \in [0,1]$, the return x^+ exceeds the aspiration level, benchmark return or reference return x_{ref}. In the bad state of nature, which occurs with the probability $(1-p)$, the return remains below the reference return and thus is $x^- < x_{ref}$. This setting allows us to account for both the investor's risk attitude and loss aversion.

We assume, that the reference point x_{ref} is an exogenously given parameter. When evaluating the risky investment opportunity A, the investor may also be guided by a reference return of $x_{ref} \geq 0$. If $x > x_{ref} \geq 0$, the investor enjoys a "gain"; if $x < x_{ref}$, the investor suffers from a "loss". A reference

[7] We do not model firm decisions explicitly. However, we expect that in group decisions the perception bias is likely to be less profound, especially in heterogeneous groups, but does not vanish (Lejarraga and Müller-Trede 2017, also Chen, Williamson and Zhou 2012). Consequently, our findings also help to describe the assessment of risky investments in firms qualitatively even though the size of the tax effects might be smaller under group decisions.

point could be given by the status quo or a (positive) minimum yield that the investor currently expects based on market conditions. Figure 1 provides a numerical example for both $x_{ref} = 0$ and $x_{ref} > 0$.

[Insert Figure 1 here]

Here, tax gains are subject to the tax rate τ with $\tau \in (0, 1)$. Losses are tax-deductible at the tax rate $\tau_l = \theta\tau$ with $\theta \in [0, 1]$. The parameter θ captures the fraction of tax losses that can be offset and is therefore a measure of the degree of tax asymmetry. If $\theta = 1$ tax losses can be completely offset, if $\theta < 1$, then the loss offset is restricted. We see how a positive reference point decreases the pre- and post-tax "gain" while the tax gain remains unchanged. Furthermore, we see that the pre- and post tax "loss" increases for increasing reference points aggravating the relevance of "losses" and the behavioral implications of losses. Given these assumptions, the decision on the risky investment A in the pre-tax case is given by

$$A = (x^- - x_{ref}, 1 - p; x^+ - x_{ref}, p). \tag{1}$$

Thus, the risky investment opportunity will generate a "loss" of $x^- - x_{ref}$ with a probability of $1 - p$, whereas the investor will receive a "gain" of $x^+ - x_{ref}$ with probability p.

For simplicity and without loss of generalizability,[8] we assume

$$|x^-| = x^+ = x$$

and thus in the following

$$0 \leq x_{ref} < x^+ \quad \text{and} \quad x^- < 0 \leq x_{ref}.$$

The decision maker uses the following prospect theoretical preference value Φ as a benchmark for assessing the risky investment project:

$$\Phi = \sum \pi(p) \cdot v(\Delta x). \tag{2}$$

$\pi(p)$ is the subjective probability weighting function and $v(\Delta x)$ the value function both determined by Tversky and Kahneman (1992) from empirical data.

$$v(\Delta x) = \begin{cases} \left(x^+ - x_{ref}\right)^\alpha, & 0 \leq x_{ref} \leq x^+, 0 < \alpha \leq 1, \\ -\lambda\left(-\left(x^- - x_{ref}\right)\right)^\beta, & x^- < x_{ref}, 0 < \beta \leq 1, \lambda > 1. \end{cases} \tag{3}$$

8 If we abstract from the assumption $|x^-| = x^+ = x$, scenarios with bad states of nature can be characterized by $0 < x^- < x_{ref}$. In this case, it is useful to split the loss domain into two subparts for tax purposes to be able to distinguish between perceived losses and tax losses. Then, outcomes of $\tilde{x}$ below the reference point are considered as unattractive (pre-tax "loss") for the investor and the investors will abstain from carrying out this investment. Against this background, assuming $|x^-| = x^+ = x$ does not imply a loss in generalizability.

The parameter λ serves to measure loss aversion. For all λ with $\lambda > 1$ the decision maker is loss averse. The parameters $\alpha, \beta \in (0,1]$ co-determine the level of risk aversion (α for gains) or risk seeking (β for losses).[9] If $\alpha = \beta = 1$, the value function implies risk neutrality.

The function for the first interval describes the domain of perceived gains while the second interval captures the domain of perceived losses (Figure 2).

[Insert Figure 2 here]

The probability weighting function is given by (Tversky and Kahneman (1992), p. 309)[10]

$$\pi(p) = \begin{cases} \pi^+(p) = \dfrac{p^\gamma}{(p^\gamma + (1-p)^\gamma)^{\frac{1}{\gamma}}}, & x^+ \geq x_{ref}, 0 < \gamma \leq 1, \\ \pi^-(p) = \dfrac{p^\delta}{(p^\delta + (1-p)^\delta)^{\frac{1}{\delta}}}, & x^- < x_{ref}, 0 < \delta \leq 1. \end{cases} \tag{4}$$

The parameters $\gamma,\ \delta \in (0,1]$ determine to what extent a decision maker differentiates between gain and loss probabilities and to what extent subjective probability weight deviate from objective probabilities. If $\gamma,\ \delta = 1$, gain and loss probabilities are equally weighted and probability weighting is linear, meaning that objective and subjective probabilities are identical. In this case, we set $\pi(p) = p$. For values of $\gamma,\ \delta < 1$, the function is inverse S-shaped (Figure 3).

[Insert Figure 3 here]

The shape plotted in Figure 3 illustrates that investors overestimate small probabilities, but underestimate mid-range and large probabilities (Tversky and Kahneman 1992).

We assume that shifting the reference point in the investor's decision-making process does not affect the probability weighting, the value function or the degree of loss aversion.[11]

From the given set of assumptions and equations (1) to (5) we obtain as the pre-tax preference value of the risky investment project

$$\Phi = \frac{p^\gamma \left(x - x_{ref}\right)^\alpha}{(p^\gamma + (1-p)^\gamma)^{\frac{1}{\gamma}}} + \frac{(1-p)^\delta(-\lambda)\left(-\left(-x - x_{ref}\right)\right)^\beta}{(p^\delta + (1-p)^\delta)^{\frac{1}{\delta}}}. \tag{5}$$

The decision maker refers to the pre-tax preference value Φ in equation (5) as the basis for their assessment. The higher it is, the more attractive the investment is for them.

[9] The investor's overall attitude to risk does not only depend on the curvature of the value function curve, but also on probability weighting.

[10] Within the model chosen here, no more than two non-zero outcomes can occur; cumulative probabilities are therefore irrelevant.

[11] Bleichrodt, Pinto and Wakker (2001, p. 1502) make a similar assumption in their experimental study.

Taxation can substantially affect the value function and thereby the preference value.[12] The cash flow generated by the investment determines the tax base. The tax base depends on the state of nature, i.e., x^+ in a good state of nature and x^- in a bad state of nature. Positive tax bases are subject to the tax rate τ, losses are tax-deductible at the tax rate $\tau_l = \theta\tau.$ As tax losses might have to be carried backward or forward due to loss offset restrictions, the loss offset might take several years or even (partially) expire. In the following, the loss offset coefficient θ can be interpreted as the tax loss offset ratio in present value terms reflecting the present value of the future loss offset potential indicated by tax regulations. Later, we can also broaden the scope of θ and interpret it as a parameter that also captures limitations in loss offset that are due to economic reasons, like insufficient offsetting capacity because of low or missing positive tax income in pre- or post-loss periods. We assume, that if gains and losses are taxed symmetrically, then $\theta = 1$. If $\theta < 1$, this parameter captures deviations from a complete and immediate loss offset that are due to both timing restrictions (loss carryforwards) and size restrictions (maximum loss offset amounts). The smaller θ, the more restrictive the loss offset possibilities and the more uneven the taxation of gains and losses. If $\theta = 0$, tax losses forfeit completely. Furthermore, we assume that the tax on gains or the tax refund for losses are anticipated by investors and thus influences the (post-tax) preferences.[13] This assumption is in line with findings in experimental studies that provide evidence that investors include taxes in their investment calculations (Fochmann, Kiesewetter and Sadrieh 2012, Fochmann and Wolf 2015).

To analyze and evaluate the effects of different loss offset patterns on the assessment of risky investments, we need to establish a suitable benchmark. We use the following difference between the post-tax and pre-tax preference value $\Delta\Phi$ as a criterion for the assessment of tax-induced effects

$$\Delta\Phi = \Phi_\tau - \Phi, \tag{6}$$

where Φ_τ represents the post-tax preference value. For the investment under consideration, the expression $\Delta\Phi$ denotes the change in evaluation caused by taxation.

Taking into account the reference point and how it is handled from a fiscal and psychological perspective, allows for two possible post-tax results. In the following we assume, that the decision maker assesses the investment based on $x_{ref,\tau} = x_{ref}$. Thus, we assume that the reference point remains unaffected by taxation. This scenario applies if the reference investment remains tax-exempt or is only taxed at a very low level compared to the project being assessed and is thus perceived as unchanged in the assessment process. An alternative explanation for taxes not changing the reference point in the mind of the investor can be due to a less salient form of taxation of the reference object. This could originate, for example in a dual income tax system that taxes financial assets, unlike real assets, at source and often only at a very low level. Such systems are prevalent around the world (e.g.,

[12] While taxation affects the value function, probability weighting is independent of the series of payments from an investment and therefore remains unaffected by taxation. Consequently, the following discussion of tax model assumptions relates exclusively to the value function.

[13] We assume that the tax rate itself is included undistorted in the prospect theory value function. Also, Hlouskova and Tsigaris (2012, p. 559), and Fochmann and Jacob (2015) implicitly make this assumption.

in many European and Asian countries). It is possible that investors under such tax systems are not consciously aware of the taxation of the income from financial investment. Moreover, irrespective of the taxation of income from financial investments, investors might abstract from taxation when determining their aspiration level and therefore do not include it in their valuation of the reference point. Then, the investor assesses the post-tax investment project by[14]

$$A_\tau = (x^-(1-\theta\tau) - x_{ref}, 1-p; x^+(1-\tau) - x_{ref}, p). \tag{7}$$

The resulting post-tax preference values Φ_τ for the investment is given by[15]

$$\Phi_\tau = \frac{p^\gamma \left(x(1-\tau) - x_{ref}\right)^\alpha}{\left(p^\gamma + (1-p)^\gamma\right)^{\frac{1}{\gamma}}} + \frac{(1-p)^\delta (-\lambda)\left(-\left(-x(1-\theta\tau) - x_{ref}\right)\right)^\beta}{\left(p^\delta + (1-p)^\delta\right)^{\frac{1}{\delta}}}. \tag{8}$$

From equations (5) and (8) we can easily determine $\Delta\Phi$. Here, $\Delta\Phi < 0$ implies a tax-induced reduction in the preference value, whereas $\Delta\Phi > 0$ denotes a tax-induced increase in the preference value. In both cases, taxation can affect investment behavior. Only if $\Delta\Phi = 0$, does taxation not alter the preference value and the evaluation of a risky investment project remains unaffected. With this in mind, we categorize and assess the effects of taxation as displayed in Table 1.

[Insert Table 1 here]

To enhance the understanding of the overall tax-induced effects and subsequent analysis, it is helpful to distinguish between the effects of gain taxation and those resulting from loss taxation. To do this, we split equation (6) into two parts.

$$\Delta\Phi = \Delta\Phi(Gain) + \Delta\Phi(Loss). \tag{9}$$

The first summand represents the difference in evaluation due to potential gain taxation. In the event of a gain, the investor has to pay taxes of $\tau\, x$ and suffers from a decline in preference value, i.e., preference for the gain decreases as a result of the taxation, $\Delta\Phi(Gain) < 0$. The opposite occurs in the event of a loss. A tax-relevant loss leads to a tax refund of $\theta\tau x$, which induces an increase in the preference value, $\Delta\Phi(Loss) > 0$. The overall tax effect on the assessment of the risky investment comprises both components, so that, depending on which effect is predominant, $\Delta\Phi$ can be both positive and negative. If the value-increasing effect of the tax refund in the event of a loss is predominant, then taxation increases the attractiveness of the investment. However, if the value-reducing effects

[14] A second possible operationalization of taxes is that levying taxes also changes the reference point in the decision maker's calculation. In this case, using superscript var, we set $x_{ref,\tau} = x_{ref}(1-\tau)$. and we obtain for the post-tax risky investment $A_\tau^{var} = (x^-(1-\theta\tau) - x_{ref}(1-\tau), 1-p; x^+(1-\tau) - x_{ref}(1-\tau), p)$.

[15] Correspondingly, we obtain $\Phi_\tau^{var} = \frac{p^\gamma\left((x-x_{ref})(1-\tau)\right)^\alpha}{(p^\gamma+(1-p)^\gamma)^{\frac{1}{\gamma}}} + \frac{(1-p)^\delta(-\lambda)\left(-\left(-x(1-\theta\tau)-x_{ref}(1-\tau)\right)\right)^\beta}{(p^\delta+(1-p)^\delta)^{\frac{1}{\delta}}}$ for a tax-sensitive post-tax reference point. We have conducted a battery of analyses under such a tax-sensitive reference point, which are available upon request.

from taxation in the event of a gain are predominant, the taxation reduces the attractiveness of the investment project.

3 Baseline Scenario

3.1 General Assumptions

Because of the large number of influencing factors determining investment and risk-taking behavior, identifying and assessing the tax-induced effects on the evaluation of investments using a prospect theory model framework is complex. Both the value function and probability weighting function are investor-specific and depend on numerous parameters. To gain an overview of the many interdependencies we construct a baseline scenario that serves as the starting point for the analytical and partially numerical analysis. This scenario already provides interesting insights into yet undescribed effects.

Within the baseline scenario, we assume that the investor measures the success of an investment using a reference project with a yield of zero ($x_{ref} = 0$). Such a scenario is plausible in periods of low interest rates, for example, when investors cannot generate any (secure) alternative returns. However, it is also possible that the investor has no positive (or negative) expectations regarding the investment outcome for other (psychologically motivated) reasons.[16] Both good and bad states of nature occur with identical probability. Thus, as an alternative intuition, assuming $x_{ref} = 0$ can also be interpreted as an endogenously determined reference point that is equal to the expected value of the possible outcomes. We initially abstain from any subjective probability weighting but include it in the second step of the analysis.[17] We assume that losses are completely tax-deductible ($\theta = 1$) or the investor faces loss offset restrictions ($\theta < 1$). Table 2 summarizes the assumptions of the baseline scenario.

[Insert Table 2 here]

Initially, we disregard subjective distortions of the probabilities ($\gamma = \delta = 1$), meaning that $\pi^+(p) = \pi^-(p) = p = 0.5$. Abstracting from the probability transformations in the first step enables us to isolate the value function's effects and analyze its characteristics in detail. Hence, we can draw conclusions about which tax-induced effects are solely due to loss aversion and the different sensitivities in the domains of gains and losses. Based on these assumptions, the investor generally has a pre-tax investment opportunity with $A = (-x, 0.5; x, 0.5)$ and post-tax of $A_\tau = (-x(1-\theta\tau), 0.5; x(1-\tau), 0.5)$. For the pre-tax preference value from equation (5) we obtain

$$\Phi = 0.5\, x^\alpha - 0.5\, \lambda x^\beta \qquad \text{for} \quad x_{ref} = 0, \gamma = \delta = 1, p = 0.5. \tag{10}$$

[16] For example, the investor may be forced to make the risky investment for operational reasons, and an alternative investment with a positive minimum interest rate is therefore not available when the investor is assessing the project.

[17] If the probability weighting is not included, our baseline scenario corresponds widely to the model of Fochmann and Jacob (2015) except for the way we model loss offsetting using loss offsetting factors.

As we assume in the baseline scenario $x = x_{ref} = 0$, we obtain correspondingly

$$\Phi_\tau = 0.5\,\big(x(1-\tau)\big)^\alpha - 0.5\,\lambda\big(x(1-\theta\tau)\big)^\beta \quad \text{for} \quad x_{ref} = 0, \gamma = \delta = 1, p = 0.5. \tag{11}$$

3.2 Absence of Tax Loss Offset Restrictions

If gains and losses are taxed symmetrically ($\theta = 1$), from equation (11) we obtain a post-tax preference value of

$$\Phi_{\tau,sym} = 0.5\,\big(x(1-\tau)\big)^\alpha - 0.5\,\lambda\big(x(1-\tau)\big)^\beta \quad \text{for} \quad x_{ref} = 0, \gamma = \delta = 1, p = 0.5, \theta = 1. \tag{12}$$

Because of the decision maker's loss aversion ($\lambda > 1$), the preference values in this situation with gain and loss of identical size are negative. The investor would therefore not carry out this investment project. However, it is useful to study this scenario with identical gain and loss. It allows us to isolate the prospect theoretical drivers of investment behavior from each other. It enables us to disentangle the complex interdependencies of risk attitude, loss aversion and probability weighting and (later) reference dependence with regard to the effects of loss offsetting patterns on the evaluation of a risky investment.[18]

In the following, we refer to equation (12) and the relation of the pre- and post-tax preference value to assess and interpret the tax effects on investments. Comparing the equations (10) and (12) generates a tax-induced difference in preference value of

$$\Delta\Phi_{sym} = \underbrace{0.5\,x^\alpha\big((1-\tau)^\alpha - 1\big)}_{\substack{<0 \\ \text{effect from taxes on gain}}} \underbrace{-0.5\,\lambda x^\beta\big((1-\tau)^\beta - 1\big)}_{\substack{>0 \\ \text{effect from tax refund on loss}}} \gtreqless 0. \tag{13}$$

The first summand in equation (13) captures the decrease in preference value resulting from gain taxation, contrasting with the increase in preference value resulting from a tax refund in the event of a loss captured in the second summand. It is not clear whether the tax-induced difference in preference value that is key to the overall effect, $\Delta\Phi_{sym}$, is positive or negative; the sign depends on the interplay of the investor's attitude towards risk, measured by α and β, and their loss aversion, measured by λ. The direction of the effect is only clear if the value function for losses is at least as steep as the one for gains, hence $\alpha \leq \beta$, and if $\lambda > 1$. Under these conditions, i.e., if the risk attitude parameter in the domain of losses is either equal to the risk attitude parameter in the domain of gains or closer to risk neutrality and as we assume the investor to put more weight on losses compared to gains, the increase in preference value due to the tax refund in a bad state of nature is always greater than the decrease in preference value caused by paying tax in a good state of nature. Consequently, $\Delta\Phi_{sym} > 0$.

[18] We expect the results deduced in the following to hold in scenarios with gains exceeding losses such that $\Phi_{\tau,sym} > 0$. We conducted some numerical simulations for a gain that is greater than the loss, which provides evidence for this expectation. Thus, investigating tax effects for symmetrical gains and losses contributes significantly to the understanding of investment behavior under bounded rationality.

However, if an investor's value function for gains is steeper than that for losses, i.e., $\alpha > \beta$, the decrease in preference value due to taxation of gains is comparatively higher. This effect counteracts the significant decrease in preference value resulting from loss aversion in case of a tax refund for a loss. If there is a large enough difference between α and β, so that the first effect exceeds the second, the symmetrical treatment of tax gains and losses will reduce the preference value compared to its evaluation without taxes, i.e., $\Delta\Phi_{sym} < 0$. The difference between α and β is sufficiently large, if

$$\lambda < \lambda^* = \frac{x^\alpha - (x - \tau x)^\alpha}{x^\beta - (x - \tau x)^\beta}. \tag{14}$$

Correspondingly, we obtain the preference value-increasing tax effect if

$$\lambda > \lambda^* = \frac{x^\alpha - (x - \tau x)^\alpha}{x^\beta - (x - \tau x)^\beta} \tag{15}$$

applies for $\alpha > \beta$ (*behavioral tax paradox*). Table 3 summarizes the effects of symmetrical taxation of gains and losses.

[Insert Table 3 here]

These findings can be summarized as follows:

Finding 1a: *If investors are at least as risk-averse in the domain of gains as they are risk-seeking in the domain of losses ($\alpha \leq \beta$), i.e., the value function for losses is at least as steep as it is for gains, and $\gamma = \delta$, symmetrical taxation of gains and losses increases the attractiveness of a risky investment for loss averse investors ($\lambda > 1$) compared to an evaluation without taxation.*

Finding 1b: *If investors' loss aversion exceeds a critical value λ^* ($\lambda > \lambda^*$) and $\gamma = \delta$, symmetrical taxation of gains and losses increases the attractiveness of a risky investment compared to an evaluation without taxation (behavioral tax paradox).*

The question which of the possible effects occurs in reality for lower levels of loss aversion with greater probability can be estimated using empirical data. The median decision maker, characterized above as $\alpha = \beta = 0.88$, benefits from a symmetrical tax because the risky investment is more attractive due to the taxation. Köbberling and Wakker (2005, p. 121) show that the value function for gains is steeper than that for losses ($\alpha < \beta$). As empirical evidence in this respect is (so far) unequivocal, it should always follow that $\alpha \leq \beta$[19], as long as the opposite is not explicitly indicated.

Furthermore, the post-tax preference function and therefore the difference between the pre- and post-tax preference values $\Delta\Phi_{sym}$ increases with the (flat) tax rate.

$$\frac{\partial \Delta\Phi_{sym}}{\partial \tau} > 0 \quad \text{for} \quad \lambda > 1. \tag{16}$$

[19] This is in line with Fochmann and Jacob (2015), who also restrict their analysis to scenarios with $\alpha \leq \beta$.

From equation (16) we obtain Finding 1c.

Finding 1c*: The higher the (flat) tax rate, the greater the increase in attractiveness of a risky investment for loss averse investors ($\lambda > 1$) and $\gamma = \delta$ when gains and losses are taxed symmetrically.*

To use the definition coined by Schneider (1992), this situation constitutes a tax paradox, as the perceived value of the risky investment increases with the tax rate. The traditional tax paradox is caused by the interest rate effect. In our prospect theoretical model, in addition to the full loss offset, the tax paradox is due to a behavioral economics effect: The higher the tax rate, the greater the preference gain due to the tax refund in the event of a loss. Even though the preference value reduction due to the taxation of a gain also increases with the tax rate, the opposing effect from the tax refund is stronger because of loss aversion. As a loss-averse decision maker overweights the tax authority's loss participation compared to its gain participation in the case in which losses can be fully offset in a country with high taxation, the decision maker rates a risky investment higher than in a low-tax country (tax haven). This finding is surprising, as it implies that the tax authorities can increase the (perceived) attractiveness of risky investments by increasing taxes and simply treating positive and negative tax bases symmetrically. Thus, a complete loss offset implies an overall perceived tax benefit from risky investments because of the behavioral perception bias in favor of the tax refund on losses of loss-averse investors.

Domar and Musgrave (1944) come to a similar conclusion. The authors show that an investor's willingness to make risky investments can increase if the tax authorities participate fully in losses. However, the authors' conclusion has completely different roots compared to our Finding 1c. While the prescriptive model by Domar and Musgrave (1944) shows that tax-induced restructuring in the investment portfolio increases risk-taking, our result is driven by the asymmetric psychological weighting of tax payments and tax refunds, describes the impact of taxes on the relative attractiveness of risky investments and originates in a descriptive model analysis.

3.3 Tax Loss Offset Restrictions

If the tax loss offset is restricted ($\theta < 1$), we obtain from the post-tax preference value in equation (11) $\Phi_\tau = \Phi_{\tau,asym}$ and the tax-induced difference in preference value of

$$\Delta\Phi_{asym} = 0.5\, x^\alpha((1-\tau)^\alpha - 1) - 0.5\, \lambda x^\beta\big((1-\theta\tau)^\beta - 1\big) \gtreqless 0. \tag{17}$$

If tax loss offset is restricted, the direction of the tax effect on preference value ambiguous. In contrast to a tax system with a complete loss offset, this ambiguity remains even if we assume $\alpha \leq \beta$. Loss offset restriction reduce the behavioral perception bias in favor of losses. As a consequence, the perceived benefit from the tax loss offset may not overcompensate the perceived value reduction by gain taxation. Depending on the level of tax loss offset, measured by θ, $\Delta\Phi_{asym}$ may be positive or negative or even equal to zero. Therefore, we can determine a loss offset factor of θ^*, for which the preand post-tax preference values are identical.[20] If investors are able to offset losses at a ratio of $\theta = \theta^*$, taxation does not alter the evaluation of a risky investment.

Risk-taking remains unaffected by taxation if

$$\theta^* = \frac{1 - \left(\frac{x^{-\beta}\left((1-\tau)^\alpha x^\alpha - x^\alpha + \lambda x^\beta\right)}{\lambda}\right)^{\frac{1}{\beta}}}{\tau}. \tag{18}$$

However, this threshold depends on all risk-taking parameters (α, β, λ) under prospect theory. If $\theta > \theta^*$, the value-increasing effects of the tax refund predominate, and the decision maker evaluates the tax effect as $\Delta\Phi_{asym} > 0$. For $\theta < \theta^*$ the value-reducing effects of the restrictive loss offset regulations predominate so that taxation reduces the preference for the investment ($\Delta\Phi_{asym} < 0$).

Finding 2 summarizes the effects identified under tax loss offset restrictions.

***Finding 2**: Whether taxation increases, decreases or has a neutral effect on the investor's preference value depends on the level of loss offset restrictions. If the loss offset factor θ exceeds a specific level θ^* ($\theta > \theta^*$), a positive, value-increasing tax effect on the preference value occurs and increases in the tax rate. If the loss offset factor is lower than the threshold θ^* a negative, value-reducing tax effect occurs and increases in the tax rate.*

Obviously, tax loss offset restrictions are important if investors behave in line with prospect theory.

By contrast, if $\alpha = \beta = \lambda = 1$ and $\gamma = \delta = 1$, and we thus abstract from all behavioral aspects, the neutral loss offset factor collapses to $\theta^* = 1$. This is the well-known result: under risk neutrality and in absence of behavioral aspects the assessment of risk projects remains undistorted under a full and complete loss offset. Then, loss offset restrictions uniformly reduce the (perceived) value a risky investment.

3.4 Numerical Analyses of Tax Parameters

We supplement our analytical study by numerical examples to improve the interpretation of the identified behavioral results and advance knowledge on the relative importance of tax rate effects in comparison to effects from tax loss offset restrictions. We choose parameters that fit the decision-making behavior observed in reality. The numerical starting position is therefore the median investor's parameter values for the value function determined by Tversky and Kahneman (1992, p. 309). The second step then takes into account the probability weighting of the median investor.

Table 4 lists these parameter characteristics.

[Insert Table 4 here]

[20] Cf. also Fochmann and Jacob (2015), who analyze the characteristics of this neutral level of tax loss offset regulations.

The value function of the median decision maker is characterized by symmetrical risk attitudes in the domain of gains and losses, i.e., $\alpha = \beta = 0.88$. In line with prior findings, we assume that this specific type of investor assigns 2.25 times more weight to losses than to gains. In addition, medium probabilities are underweighted, with the weighting factor for the possible gain being $\gamma = 0.61$, below the weighting factor of $\delta = 0.69$ for the loss.

Experimental studies provide evidence for risk aversion and risk seeking parameters between 0.77 and 1.0 and probability weighting factors from 0.3 to 0.7 (e.g, Tversky and Kahneman 1992, Tversky and Fox 1995, Abdeallaoui 2000, Bleichrodt and Pinto 2000, Kilka and Weber 2001).[21]

As already analytically determined, we show in Figure 4 preference values of the median decision maker before and after taxation in the absence of tax loss offset restrictions depending on the level of the (flat) tax rate for $x = 100$.

[Insert Figure 4 here]

We see that for all tax rates, $\Delta\Phi_{sym} > 0$ applies. The difference between the pre- and post-tax preference values $\Delta\Phi_{sym}$ increases in the (flat) tax rate.

We illustrate the corresponding preference values for the median decision maker under tax loss offset restrictions in Figure 5. This figure depicts the preference values before and after taxes as a function of the tax rate τ. We consider two tax systems that have different levels of restrictions in loss offsetting and (correspondingly high) gains. One system is characterized by 90% of losses being tax deductible ($\theta = 0.9$), while 10% are non-tax deductible. In this case, the change in the preference value is positive ($\Delta\Phi_{asym} > 0$), i.e., taxation increases the attractiveness of the investment despite the tax offset restrictions applied. The 'harsher' system only permits 20% of losses to be tax deductible ($\theta = 0.2$), while 80% of the deficit remains unrecognized for tax purposes. In this case, we find $\Delta\Phi_{asym} < 0$. The higher the tax, the greater this value-reducing effect.

[Insert Figure 5 here]

A numerical view on the neutral loss offset factors for the median decision maker provides additional interesting insights. Table 5 shows the neutral loss offset factors θ^* for different levels of taxation.

[Insert Table 5 here]

If losses in relation to gains are subject to taxation in precisely this weighting, the value-increasing effects of the comparatively higher evaluation of the tax refund due to loss aversion perfectly balances out the value-reducing effects of the loss offset restriction. A closer look at the data shows that for all neutral loss offset factors $\theta^* < 0.5$ applies. This finding implies, as a rule of thumb, that the median decision maker always rates an investment after taxes better than before if at least 50% of losses can be effectively offset (*behavioral tax paradox*). This finding applies for all levels of taxation.

[21] Cf. also Appendix B.

***Finding 3**: For the median decision maker, the attractiveness of a risky investment increases in the tax rate τ despite the application of loss offset restrictions, as long as at least half of a tax loss can be offset* $(0.5 < \theta \leq 1)$.

The second finding displayed in Table 5 is less evident; for all numerically analyzed levels of taxation, ranging from 10% to almost full taxation of gains of 99%, the critical values for θ^* only differ by less than 4 percentages points. If the potential gain of a risky investment is taxed at 10%, then $\theta^* = 44.8\%$. If the potential gain from an investment is subject to a tax rate of 99%, the neutral level of loss offset is $\theta^* = 48.3\%$ and is thus only marginally higher than under a very low level of taxation.

***Finding 4**: The level of taxation τ only marginally affects the level of the neutral loss offset factor θ^*, i.e., while variations in the tax rate τ hardly change investors' evaluation of a risky investment, their evaluation is very sensitive to changes in tax loss offset restrictions* (θ).

While variations in the tax rate hardly change the evaluation of underlying risky investment, this evaluation is very sensitive to change in tax loss offset regulations. If a tax authority of a country with high taxes wishes to neutralize the value-increasing effects of loss aversion, they effectively need to implement investor-specific loss offset restrictions. For investors with similar preferences, they have to apply preference-specific loss offset regulations that are more or less independent of the level of the tax rate.

Finding 4 is illustrated below in Figure 6. It shows the preference values of the median decision maker for $x = 100$ depending on the level of loss offset restrictions. We see clearly that the neutral loss offset factor θ^* for all tax rates on gains is more or less identical; for both a high level of taxation (long-dashed function, $\tau = 0.9$) and a low level of taxation (short-dashed function, $\tau = 0.2$), the intersections of the post-tax indifference curves are at approximately the same level as the pre-tax function.

[Insert Figure 6 here]

It is interesting to have a look at the effect of taxes on the country-specific loss offset factors accounting for the national tax rates and loss offset restrictions (Figure 7). This figure displays country-specific tax loss offset quotas for individual taxpayers (private investors) based on both the countries' statutory tax rate and loss offset restriction in time and amount.

[Insert Figure 7 here]

These quotas indicate that high statutory tax rates are likely to be associated with low tax loss offset restrictions (for example, Sweden) while low tax rates go in line with restrictive tax loss offset regulations (for example, Bulgaria). At first sight, this pattern suggests that in many high-tax countries the negative signal to investors from a high tax rate is compensated by generous loss offset regulations. Against this backdrop, we expect that both tax rate levels and tax loss offset restrictions are likely to matter in decision-making, in particular in decision-making on risky and thus often temporarily loss generating investments. Looking at such real data reveals huge deviations from the neutral tax loss offset factor θ^*. These deviations differ both in size and sign across countries. Hence, we expect considerable variation in the degree of tax-induced distortions of the assessment of the risky investments. The tax effects on the preference value are displayed on the left side of Figure 8. In many countries, we find that the tax system negatively affects the preference values, particularly, in many Eastern European countries.

[Insert Figure 8 here]

By contrast, in most OECD countries, for the median decision maker the tax system enhances the preference value. To be able to compare these values with the corresponding outcome for the expected utility we abstract from risk aversion and assume $\alpha = \beta = 1$. If we compare the tax effect on the prospect theoretical preference value (left graph in Figure 8) and on the expected utility of a risk-neutral investor (right graph in Figure 8), we realize that neglecting behavioral aspects often leads to a significant underestimation of the tax effects and moreover, often an underestimation of the post-tax preference value, which might imply underinvestment. By contrast, under the given set of assumptions the risk-averse investor experiences, as we expected, tax induced reductions in the expected utility from the risky investments because of the symmetry in the gains and loss profile in combination with loss offset restrictions.[22]

We now vary, within reasonable limits, the individual behavioral parameters determining the preference function (α, β and λ for the investor's risk attitude and loss aversion, γ, δ for the probability weighting and x_{ref} for the reference point) and assess their impact on the conclusions reached in the baseline scenario.

4 Sensitivity Analyses of Behavioral Parameters

4.1 Risk Attitude and Loss Aversion

We analyze how a variation in the curvature of the value function affects the Findings 1a, 1b, 2 and 4 reached in the baseline scenario. The curvature is determined by the parameters for risk aversion α, risk seeking β and level of loss aversion λ.

As the value function in the domain of gains is unaffected by loss offsetting regulations, varying α leads to uniform conclusions irrespective of loss offset restrictions. The following applies[23]

$$\frac{\partial \Delta \Phi_{sym}}{\partial \alpha} = \frac{\partial \Delta \Phi_{asym}}{\partial \alpha} < 0. \tag{19}$$

[22] We find a corresponding pattern of negative tax effects for risk neutral investors. However, the tax effects under risk neutrality are considerably larger than under risk aversion because risk sharing with the government weigh less.

[23] This uniform relationship applies to $x \geq 1$. Cf. Appendix C.

The less risk averse the decision maker and thus the less steep the value function in the domain of gains, the greater the decrease in preference value due to gain taxation. For $\Delta\Phi > 0$, this value-reducing effects of taxation decreases as an investor becomes less risk averse ($\alpha \to 1$). For $\Delta\Phi < 0$, the argumentation is thus reversed. In this case, the value-reducing effects of taxation become greater as an investor becomes less risk averse.

We find the value-increasing effect in the absence of loss offset restrictions determined in Finding 1a becomes greater as the decision maker becomes less risk averse in the domain of gains. Findings 1b and 2 remain unchanged. The effects of asymmetrical taxation of gains and losses are ambivalent and depend on the level of loss offset restrictions as the value function increases due to a tax loss induced tax refund in the domain on losses while it is unaffected in the domain of gains. Figure 9 illustrates these relationships for the median decision maker and for $x = 100$ and $\tau = 0.3$.

[Insert Figure 9 here]

If the taxation system has few loss offset restrictions ($\theta = 0.9$), then taxation (and a completely symmetrical system) increases the perceived value of a risky investment. By contrast, in a system with very strict loss offset regulations ($\theta = 0.2$), the pre- and post-tax preference functions intersect. There is then a critical value α^* that marks the border between tax-induced increases and decreases in perceived value. In the example calculation, this value is $\alpha^* = 0.74$. For $\alpha < \alpha^*$ the value-increasing effects are predominant, and for $\alpha > \alpha^*$, the value-reducing effects are predominant. This critical value decreases as the tax system becomes more restrictive. Then, the probability that the attractiveness of risky investments will be reduced by taxation is increased. The opposite applies for a given tax system; as a result of taxes, investors will rate an investment higher, the more risk averse they are.

Finding 4, derived numerically, can be confirmed for a variation of α. We can determine a neutral loss offset parameter θ^* for each risk aversion level which, surprisingly, is rather insensitive to tax rate changes. However, θ^* is very sensitive to the investor's level of risk aversion in the domain of gains. We find[24]

$$\frac{\partial\theta^*}{\partial\alpha} > 0. \tag{20}$$

Table 6 shows the values θ^* for different levels of α and τ.

[Insert Table 6 here]

Although the values for different levels of taxation do not vary much (Finding 4), they vary considerably depending on the level of α. The lower α, the more risk averse a decision maker is and therefore the lower the neutral loss offset rates. If a decision maker acts in an almost risk neutral manner in the domain of gains ($\alpha = 0.99$), the neutral loss offset rate is approximately 80% for all levels of taxation. If up to 80% of losses can therefore be effectively offset, the decision maker does not adjust

[24] This uniform relationship applies when $\alpha \leq \beta$ and $x \geq 1$. Cf. Appendix C.

the evaluation of the investment in response to taxation. However, to prevent very risk averse investors ($\alpha \leq 0.5$) from changing their evaluation of the investment, losses must remain almost irrelevant for tax purposes. The economic intuition behind this is as follows. A decision maker who is very risk averse in the domain of gains ascribes hardly any value to the tax they have to pay in a good state of nature. In contrast, plenty of value is ascribed to a tax refund received in the event of a loss. To offset this imbalance in the preference value calculation, the tax refund in the loss scenario needs to be very low, i.e., reduced to approximately zero.

In contrast, for the risk-seeking parameter β in the domain of losses, we find the first order partial derivatives consistently positive, for both symmetrical and asymmetrical taxation of gains and losses:[25]

$$\frac{\partial \Delta \Phi_{sym}}{\partial \beta} > 0 \tag{21}$$

and

$$\frac{\partial \Delta \Phi_{asym}}{\partial \beta} > 0. \tag{22}$$

The less risk seeking the decision maker is in the domain of losses, the more highly they value the tax refund received from the tax authorities in the event of a loss and therefore the higher (smaller) the positive (negative) difference in preference value resulting from the taxation. For Finding 1a, this relationship implies that a symmetrical tax system increases the attractiveness of the risky investment by less as the decision maker becomes more risk seeking in the domain of losses. Figure 10 illustrates the preference values of the risky investment depending on the level of risk seeking in the domain of gains for $x = 100$ and $\tau = 0.3$. The remaining parameters correspond to the values of the median decision maker.

[Insert Figure 10 here]

Figure 10 shows that the pre- and post-tax preference values increase as β decreases. The more risk seeking a decision maker is, the smaller their disutility in the preference value from the (potential) loss and therefore the higher their preference values with regard to the risky investment.[26] It is also obvious that Finding 2 can be confirmed. The effect of an asymmetrical tax system on the attractiveness of the risky investment depends on the possibility of offsetting the losses through taxation.

Finding 4 is also confirmed for a variation of the parameter β, as long as the level of taxation is almost irrelevant to the extent of the neutral loss offset rate θ^*, as shown in Figure 10. The neutral tax offset rate, however, depends on the level of risk seeking in the domain of gains. The more risk seeking an investor is, the less weight the tax refund has in the event of a loss and therefore the higher the neutral loss offset rate:

[25] This uniform relationship applies when $x \geq 1$. Cf Appendix C.

[26] For a certain level of risk seeking, the investment becomes so attractive that it would actually be taken up.

$$\frac{\partial \theta^*}{\partial \beta} > 0. \tag{23}$$

The degree of loss aversion λ scales the effect from the risk-seeking parameter β and thus determines the overall impact of risk and loss aversion on the tax effect. Although Kahneman and Tversky (1979) determined a loss aversion co-efficient of $\lambda = 2.25$ for the median decision maker, this value depends significantly on the type of investor. There is evidence that investors become less loss averse the higher their level of education. Conversely, the level of loss aversion increases with age, income and wealth (for example, Gächter, Johnson and Herrmann 2007).[27] The more loss averse the investor, the lower the preference for the investment, as greater loss aversion causes a higher disutility from the potential loss. As a result, the increase in preference value from a tax refund is greater, the more loss averse the investor is. A positive (negative) difference in preference value created by taxation increases (falls) with increasing λ:[28]

$$\frac{\partial \Delta\Phi_{sym}}{\partial \lambda} > 0 \tag{24}$$

and

$$\frac{\partial \Delta\Phi_{asym}}{\partial \lambda} > 0. \tag{25}$$

The more heavily losses weigh for an investor, the more a tax increases the value of an investment in absence of loss offset restrictions. Correspondingly, under loss offset restrictions, taxes lessen the devaluation of an investment the more weight the investor assigns to losses (Findings 1a, 1b and 2). Figure 11 illustrates the effect correlations for different values of λ, by way of example when $\alpha = \beta = 0.88$ and when $x = 100$ and $\tau = 0.3$. In addition to the pre-tax preference values as a benchmark, this figure displays the preference values for a complete loss offset ($\theta = 1$) and those for a weakly restricted (here: $\theta = 0.9$) and a strongly restricted loss offset (here: $\theta = 0.2$).

[Insert Figure 11 here]

The neutral loss offset factors for this numerical example are listed in Table 7.

[Insert Table 7 here]

The level of the neutral loss offset factor hardly changes depending on the level of the gain taxation rate but falls in line with the decision maker's growing aversion to potential losses:[29]

$$\frac{\partial \theta^*}{\partial \lambda} < 0. \tag{26}$$

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[27] Cf. also Klapper, Ebling and Temme (2005) on this correlation; differences in the level of loss aversion between consumer groups cannot be explained by sociodemographic factors.

[28] Cf. Appendix C.

[29] Cf. Appendix C.

For every intensity level of loss aversion, there is a resulting neutral loss offset factor of θ^*, that can be (approximately) calculated using the following correlation:

$$\theta^* \cong \frac{1}{\lambda}. \tag{27}$$

Therefore, if a decision maker has the attitude towards risk of a median decision maker and the level of their loss aversion is known, the effects of a given tax system on the attractiveness of an investment can be easily calculated using equation (27). If losses amounting to λ^{-1} can be effectively deducted, the taxation increases the perceived value; if not, it decreases it.

To illustrate the relatively high impact on the tax effect arising from the level of loss aversion and loss offset restrictions we have plotted the relative responsiveness of the tax effect on the preference value to a relative change in the tax rate (tax rate elasticity of the tax effect) as functions of various levels of the risk attitude and loss aversion parameters (Figure 12).

[Insert Figure 12 here]

We clearly see a low responsiveness towards the risk attitude but a rather high sensitivity of the elasticity towards the level of loss aversion and the loss offset factor.

Finding 5*: Investors' evaluation of a risky investment is very sensitive to loss aversion* (λ) *while it is less responsive to investors' risk attitude* (α, β).

4.2 Probability Weighting

The prospect theoretical Findings 1 to 5 derived above are based on the premise that the decision maker has an undistorted perception of the 50% probability of a gain or a loss from the investment project when making their investment calculation. Even though there are those who would not adjust their subjective probabilities in the event of equally high (objective) probabilities, the empirical evidence suggests that even in this case, investor make subjective transformations (Wakker 2003, Baucells and Heukamp 2004, Levy and Benita 2009).

The subjective transformation of objective probabilities is a core element of prospect theory. Tversky and Kahneman (1992) propose the split function (equation (4)) as the transformation function with respect to the probability weights. Using this function, assuming $x_{ref} = 0$ and extending our baseline scenario with respect to probability weighting, we obtain from equation (10)

$$\Phi = \frac{0.5^{\gamma} x^{\alpha}}{0.5 \cdot 2^{\frac{1}{\gamma}}} - \frac{0.5^{\delta} \lambda x^{\beta}}{0.5 \cdot 2^{\frac{1}{\delta}}} \qquad \text{for} \quad x_{ref} = 0, p = 0.5\,, \tag{28}$$

$$\Phi_{\tau,sym} = \frac{0.5^{\gamma} \big(x(1-\tau)\big)^{\alpha}}{0.5 \cdot 2^{\frac{1}{\gamma}}} - \frac{0.5^{\delta} \lambda \big(x(1-\tau)\big)^{\beta}}{0.5 \cdot 2^{\frac{1}{\delta}}} \qquad \text{for} \quad x_{ref} = 0, p = 0.5, \theta = 1 \tag{29}$$

and

$$\Phi_{\tau,asym} = \frac{0.5^{\gamma}\big(x(1-\tau)\big)^{\alpha}}{0.5 \cdot 2^{\frac{1}{\gamma}}} - \frac{0.5^{\delta}\lambda\big(x(1-\theta\tau)\big)^{\beta}}{0.5 \cdot 2^{\frac{1}{\delta}}} \quad \text{for} \quad x_{ref} = 0, p = 0.5, 0 \leq \theta < 1. \tag{30}$$

Comparing the pre-tax preference value with the post-tax value clarifies that the effects caused by taxation now also depend on the relation between the probability weighting parameters γ and δ as well as the aforementioned value drivers. Empirical analysis shows that participants in experiments regularly underestimate mid-range probabilities but assign greater weight to probabilities of losses than gains ($\delta \geq \gamma$) (Tversky and Kahneman 1992). If we weigh the probability for the potential loss at least as high as the probability for the potential gain, and furthermore, if we assume that the value function in the domain of losses is less steep than in the domain of gains ($\alpha \leq \beta$), the higher probability weighting emphasizes the 'overweighting' of the loss due to loss aversion. For probabilities that are objectively equal in both states of nature, this therefore results in an additional imbalance from the probability transformation that increases the imbalance in preference value of tax payment and tax refund arising from loss aversion. As a result, according to the probability weighting, Finding 1a, derived for $\gamma = \delta$, applies all the more and can be adjusted as follows:

Finding 6*: If the value function for losses is at least as steep as it is for gains ($\alpha \leq \beta$), i.e., investors are at least as risk-averse in the domain of gains as they are risk-seeking in the domain of losses, and if $\gamma \leq \delta$, symmetrical taxation of gains and losses increases the attractiveness of a risky investment compared to an evaluation without taxation for loss averse investors ($\lambda > 1$).*

Non-surprisingly, in all other scenarios under symmetrical and asymmetrical taxation of gains and losses we find ambiguous tax effects.

To illustrate that our previous findings will be supported, we conduct a numerical analysis under a subjective distortion of the probabilities (Appendix D). We insert parameter values that apply to the median decision maker of $\gamma = 0.61$ in the domain of gains and $\delta = 0.69$ in the domain of losses, which lead to probability weightings of $\pi^{+}(0.5) = 0.42$ and $\pi^{-}(0.5) = 0.45$. We find the more weight an investor puts on losses the higher the likelihood of a behavioral tax paradox. For the median decision maker we find that the attractiveness of risky investments does not decrease in taxes, despite the application of loss offset restrictions, as long as at least 46% of a tax loss can still be offset.

In summary, we can conclude that accounting for probability transformation in the analysis does not change the fundamental findings, but rather strengthens them.

Variations of the objective probabilities p clarify that for investment projects with a rather high objective probability of a loss, in our numerical example for $(1-p) \geq 35\%$, the value-increasing tax effect is likely to prevail. Thus, the investor's assessment of a risky investment under probability weighting is very sensitive to the objective probabilities (Figure 13).

[Insert Figure 13 here]

Under specific conditions loss aversion and probability weighting, as the two major behavioral biases, may generate opposing effects on the preference value. We exemplify this finding in Figure 14. Here, we separate loss aversion and subjective probability weighting effects from each other. While for halved objective probabilities (p = 0.5) we observe opposing effects (value increasing and decreasing effects), both biases have equal signs if losses are rather unlikely (p = 0.9).

[Insert Figure 14 here]

Further sensitivity analyses of the combined biases clarify that a high subjective weight on low loss probabilities intensifies the value-increasing tax effect due to the subjective overestimation of small losses in contrast to underestimated (high probability) substantial gains.[30] Specifically, the sensitivity analysis for probability weights according to Kilka and Weber (2001), e.g., with $\gamma = 0.30$ and $\delta = 0.51$, highlights the prevailing value-increasing effect of tax loss offset restrictions for various probabilities p. These findings indicate that it is very important to account for both investors' probability weighting and objective probabilities when it comes to estimates on the assessment of risky investments. Neglecting behavioral features of risk assessment may lead to completely wrong estimates.

***Finding** 7: For the median decision maker, the attractiveness of a risky investment is very sensitive to probability weighting. If the objective loss probability is very high and the investor subjectively transforms these probabilities, the behavioral tax paradox is likely to occur for probability weighting functions that have been observed in prior experimental studies.*

4.3 Reference Dependence

Hitherto, we assumed that when evaluating the risky investment, the investor refers to a reference point with $x_{ref} = 0$. We relax this assumption in the following. Instead, we assume that the decision maker assesses the flow of payments from the potential investment referring to a reference point where $x_{ref} > 0$. This reference level may be, for example, an expected yield, an aspirational level or other comparable value. In addition, we assume $x(1-\tau) \geq x_{ref}$.[31] The value function shifts accordingly along the x-axis, as illustrated in Figure 15.

[Insert Figure 15 here]

The tax-induced difference in preference value is[32]

$$\Delta\Phi = 0.5\left(\left(x(1-\tau) - x_{ref}\right)^{\alpha} - \left(x - x_{ref}\right)^{\alpha}\right) - 0.5\lambda\left(\left(x(1-\theta\tau) + x_{ref}\right)^{\beta} - \left(x + x_{ref}\right)^{\beta}\right) \gtreqless 0. \tag{31}$$

The first summand in equation (31) represents the decrease in preference value caused by the gain taxation; the second summand is the increase in preference value caused by the tax refund in the event

[30] Cf. Appendix E for country-specific tax effects for various objective probabilities and probability weights previously found in laboratory experiments.

[31] This assumption ensures that, even after taxes, the gain from the investment in a good state of nature contributes positively to the preference value.

[32] For a corresponding derivation in case of a tax-sensitive reference level see Appendix F.

of a loss. Because of the varying distances between the reference point and the gain on one side and the reference point and the loss on the other, the previously completely symmetrical scenario has become 'oblique'. Loss offset restrictions cause an additional distortion in face of a positive reference point. The higher the reference level, the less weight the investor assigns to tax losses because the perceived "losses" exceed the tax loss significantly as illustrated in Figure 1.

The subsequent figure exemplifies for symmetrical taxation of gains and losses that an overall value-increasing tax effect from a tax refund on losses is less likely in case of a positive reference point than for $x_{ref} = 0$. This can be seen in the vertical distance between the pre- and post-tax function left of the ordinate (benefit from tax refund on loss) being smaller than the value-reduction due to the tax on gains in the domain of gains for positive reference values (Figure 16, center graph, $x_{ref} = 50$, $\lambda = 1.1$).

[Insert Figure 16 here]

Interestingly, the effect from a higher reference point is opposed to that from an increase in loss aversion. Compared to the baseline scenario, shifting the reference point leads to a relatively greater decrease in preference value because of gain taxation and a relatively smaller increase in preference value as a consequence of loss taxation. However, if we assume higher levels of loss aversion (right graph), we realize, that the investor assigns more weight to the loss and thus the perceived value-reduction from gain taxation can be overcompensated.

For both symmetrical and asymmetrical gain and loss taxation, the sign of the tax effect, i.e, the tax-induced difference in preference value $\Delta\Phi$ is ambiguous. For

$$\lambda^{\star} = -\frac{\left(x - x_{ref}\right)^{\alpha} - \left(x(1-\tau) - x_{ref}\right)^{\alpha}}{\left(x(1-\theta\tau) + x_{ref}\right)^{\beta} - \left(x + x_{ref}\right)^{\beta}} \tag{32}$$

we obtain $\Delta\Phi = 0$. If the investor is more loss averse than indicated by $\lambda^{\star}$ ($\lambda > \lambda^{\star}$), then taxation increases the relative attractiveness of the investment because the perception bias in favor of the tax refund increases in the level of loss aversion. For $\lambda < \lambda^{\star}$, however, the value-reducing effect of gain taxation is predominant. Table 8 summarizes these findings.

[Insert Table 8 here]

If gains and losses are taxed symmetrically ($\theta = 1$), then it is not just the relation between the risk attitude parameters α and β that determines the direction of the tax effect; it is also the interaction of all parameters affecting decisions that determines whether taxation has a value-increasing, value-reducing or value-neutral effect. Surprisingly, in this case and if the investor has a value function that meets the relation $\alpha \leq \beta$, symmetrical taxation of gains and losses can negatively affect the attractiveness of investments. Table 9 clarifies this finding using numerical examples.

[Insert Table 9 here]

The values in Table 9 can be interpreted as follows. When evaluating an investment that, in a good state of nature, generates a pre-tax gain of 100 and in a bad statue of nature, a loss of a similar level, and the investor refers to a reference point of $x_{ref} = 10$ and their attitude to risk can be characterized by $\alpha = \beta = 0.88$, then a symmetrical tax will always increase the value if the investor has a risk aversion co-efficient that exceeds a specific level of $\lambda > 1.03$. However, for a reference level of $x_{ref} = 50$ and an investor's value function with $\alpha = \beta = 0.5$, the decision maker only assesses the investment after taxes positively if they assign at least twice as much weight to losses as gains. This is because the high reference level reduces the tax benefit from a tax refund and increase the relative importance of the gain taxation (Figure 16). In turn, higher degrees of loss aversion (more weight on tax loss) are necessary to increase the tax benefit from the tax refund to a level that outweighs this opposing reference point effect.

While it is interesting, from a theoretical point of view, that the loss aversion level that ensures a behavioral tax paradox increases in the reference point, the identified critical loss aversion coefficients $\lambda^\star$ are significantly below the empirically estimated data for the median decision maker of $\lambda > 2.25$. Investors whose value functions are similar to the median decision maker, will continue to value a risky investment higher as a result of taxation even if they assign very high aspiration levels to the investment (Figure 16, right graph, $x_{ref} = 50, \lambda = 2.25$).

We conclude that the Finding 1a derived in the baseline scenario is no longer generally valid for positive reference levels. Even symmetrical taxation of gains and losses can have a negative effect on the attractiveness of a risky investment if the investor bases their valuation on positive minimum yields and if $\lambda < \lambda^\star$ applies. This effect is due to the shift in perceived relevance from tax losses towards perceived "losses" that do not match tax losses and perceived "gains" for increasing reference points.

Now, the effects of a symmetrical taxation of gains and losses have been shown to be ambivalent for positive reference points, this is even more so if the tax authorities have implemented tax loss offset restrictions. In this respect, Finding 2 holds. Because $\lambda^\star$ increases in the level of loss offset,[33] i.e.,

$$\frac{\partial \lambda^*}{\partial \theta} < 0, \tag{33}$$

there is a greater probability of taxation having an overall value-reducing effect, the more restrictive a tax system is regarding losses. If we assume, for example, that only 70% of losses are effectively deductible ($\theta = 0.7$), *ceteris paribus*, the findings in Table 9 illustrate the significance of the location of the reference point in determining the effect of taxation. This applies to symmetrical tax systems, but much more to asymmetrical ones.

We know from empirical research that more than half of the accumulated tax value of losses erodes and becomes effectively non-tax deductible because of loss offset restrictions (Cooper and Knittel

[33] Cf. Appendix C.

2010 for the U. S. and Kager and Niemann 2013 for Europe). These observations provide evidence for a loss offset factor of $\theta \leq 0.5$ and imply that even loss averse investors are likely to value risky investment opportunities lower as a result of significant loss offset restrictions.

The neutral loss offset factor under the given set of assumptions is

$$\theta^*_{x_{ref}>0} = -\frac{\left(-\frac{-\left(x(1-\tau)-x_{ref}\right)^{\alpha}+\left(x-x_{ref}\right)^{\alpha}-\lambda\left(x+x_{ref}\right)^{\beta}}{\lambda}\right)^{\frac{1}{\beta}}-x-x_{ref}}{\tau x} \tag{34}$$

The higher the reference point, the larger this critical threshold value and thus the need for generous loss offsetting regulations.[34] The higher the expectations that an investor uses as the benchmark when evaluating a project, the less restrictive loss offset regulations should be to prevent the investment from being devalued as a result of taxation.

We can determine the neutral loss offset factor for the median decision maker, depending on the reference level and tax rate, as illustrated in Table 10.

[Insert Table 10 here]

Obviously, these numerical results support Finding 4. By contrast, Finding 3 does not hold unconditionally. Under the assumption that $x_{ref} > 0$, the possibility of offsetting at least 50% of losses sometimes makes the median decision maker assign a lower value to the project because of taxation. If the reference point is sufficiently high, a median investor who assigns more than twice as much weight to losses than correspondingly high gains values the project lower as a result of taxation if only half of the losses can be effectively offset. Despite this deviation from the findings derived for the baseline scenario, it is notable that the neutral loss offset factors for the median decision maker are still significantly less than one, even for very high reference points. Both a symmetrical tax system and one with moderate loss offset restrictions increase the value for this type of investor, even if the reference level is rather high.

We conclude that by implementing or strengthening loss offset restrictions, tax authorities could cause a tax-induced devaluation of risky investments except for moderately loss averse investors with very high reference points.

5 Conclusions

This paper provides a theoretical analysis of the effects of tax loss offset restrictions on the evaluation of risky investments using a comprehensive prospect theoretical model. Extending Fochmann and Jacob (2015), we are the first to capture all three central elements of prospect theory, namely loss aversion, probability weighting and reference point dependence into our model. We show that taxes

[34] This finding can be numerically derived for empirically observable parameter constellations.

increase the attractiveness of a risky investment in absence of loss offset restrictions. This finding is consistent with the standard result under rationality originally derived in portfolio selection models (Domar and Musgrave 1944). However, in contrast to prior theoretical research, we reveal that even under a complete loss offset, taxation does not necessarily foster risk-taking but depends on the level of risk and loss aversion. This finding questions previous studies assuming rationality where such ambiguous tax effects only have been identified in face of loss offset restrictions. In our model, the uniform value-increasing effect (behavioral tax paradox) only occurs if loss aversion or, in case of a tax system with loss offset restrictions, if the extent of these restrictions exceeds a specific critical threshold. We show that such an overall value-increasing tax effect from a tax refund on losses is less likely in case of a positive reference point. However, both a symmetrical tax system and one with moderate loss offset restrictions increase the value for a median decision maker, even if the reference level is rather high. Thus, by implementing or strengthening loss offset restrictions, tax authorities could cause a tax-induced devaluation of risky investments except for moderately loss averse investors with very high reference points.

We find tax loss offset restrictions significantly bias investor's perceptions, even more heavily than the tax rate. If loss offset regulations are rather generous, investors are very loss averse or assign a huge weight to loss probabilities, taxation is likely to increase the preference value of the investment (behavioral tax paradox). Thereby our model explains why subjects in laboratory experiments mentally overestimate losses and the possibility to offset losses (Fochmann, Kiesewetter and Sadrieh 2012) and provides a descriptive theory for the experimental evidence for tax-induced biased perceptions of risky investments. Our model also reveals that investors' evaluation of a risky investment is very sensitive to loss aversion and probability weighting while it is less responsive to the risk attitude. These findings highlight the magnitude of behavioral biases in comparison to risk aversion as a feature being intensively scrutinized in prior risk-taking literature.

We analytically identify general behavioral neutral loss offset factors that serve as a new measure of the degree of perceived tax-deductible losses and as a yardstick for the distortive power of the interplay of tax rates and loss offset restrictions. We determine tax effects for different levels of loss offset restrictions, tax rate and prospect theoretical biases. Surprisingly, we find the identified significant perception biases of tax loss offset restrictions occur under both high and low tax rates and thus are relatively insensitive to tax rate changes. Accordingly, for the median decision maker, loss offset restrictions can be calibrated in a way to balance behavior biases.[35]

Finally, we determine country-specific tax effects and find huge differences across countries indicating that tax loss offset restriction crucially determine the perceived tax quality of a country for risky investments. Particularly, in many Eastern European countries, we find that the tax system negatively

[35] This is consistent with the numerically results by Fochmann and Jacob (2015), who employ a utility-based model with loss aversion.

affects the investors’ assessment of risky investments. By contrast, in most OECD countries, for the median decision maker the tax system enhances the preference value.

Obviously, loss offset restrictions are highly relevant for investors’ evaluations. Even if a tax system cannot account for investor-specific behavioral biases, future tax reform discussions should consider the enormous sensitivity that loss offset restrictions exert on risk-taking when deliberating about whether adjusting loss offset regulation or tax rates. Our analysis also supports investors to gauge, assess or even avoid these effects of taxation when making decisions. Our findings suggest that investors that neglect behavioral aspects in their decision calculus often are likely to be too cautious in their risk-taking decisions. Moreover, we show that neglecting behavioral aspects leads to a significant underestimation of the relevance of loss offset restrictions and often to severe underestimations of preference values, which might imply wrong investment or locational decisions. Our findings can serve as a theoretical base for further behavioral studies and should be tested in future laboratory experiments.

Our results are limited to the underlying set of assumptions. The findings are based on a partial analysis with binary random variables, whereby the same amount of gains and losses occurs with equal probability. In this respect, the findings of this study do not allow us to draw any direct conclusions about projects that display a different risk profile. Endogenizing the reference point in a behavioral economics assessment model (Schmidt and Zank 2012) that includes taxes also opens up a promising area for future research.

References

Abdeallaoui, Mohammed (2000): Parameter-Free Elicitation of Utilities and Probability Weighting Functions, *Management Science* 46 (11), 1497-1512.

Allais, Maurice (1953): Le Comportement de l'Homme Rationnel devant le Risque: Critique des Postulats et Axiomes de l'Ecole Americaine, *Econometrica* 21 (4), 503-546.

Allingham, Michael G. (1972): Risk-Taking and Taxation, *Journal of Economics* 32 (2), 203-224.

Amberger, Harald, Eberhartinger, Eva, Kasper, Matthias (2016): Tax Rate Biases in Tax Planning Decisions: Experimental Evidence. *WU International Taxation Research Paper Series No. 2016 – 01*. Available at SSRN: https://ssrn.com/abstract=2727680.

Baucells, Manel, Heukamp, Franz H. (2004): Reevaluation of the Results of Levy and Levy (2002a), *Organizational Behavior and Human Decision Processes* 94 (1), 15-21.

Bethmann, Inga, Jacob, Martin, Müller, Maximilian A. (2016): Asymmetric Treatment of Tax Losses and Corporate Investment, *FAccT Center Working Paper No. 20/2016*. Available at SSRN: https://ssrn.com/abstract=2711808.

Bleichrodt, Han, Pinto, Jose L. (2000): A Parameter-Free Elicitation of the Probability Weighting Function in Medical Decision Analysis, *Management Science* 46 (11), 1485-1496.

Bleichrodt, Han, Pinto, Jose L., Wakker, Peter P. (2001): Making Descriptive Use of Prospect Theory to Improve the Prescriptive Use of Expected Utility, *Management Science* 47 (11), 1498-1514.

Bond, Stephan R., Devereux, Michael P. (1995): On the design of a neutral business tax under uncertainty, *Journal of Public Economics* 58 (1), 57-71.

Brown, Edgar Cary (1948): Business-income taxation and investment incentives, in Income, Employment and Public Policy; Essays in Honor of A. H. Hansen, Lloyd A. Metzler et al. (eds.), New York: W. W. Norton, 300-316.

Chang, Otto H., Nichols, Donald R., Schultz, Joseph J. (1987): Taxpayer Attitudes Toward Tax Audit Risk, *Journal of Economic Psychology* 8 (3), 299-309.

Chen, Clara Xiaoling, Williamson, Michael G., Zhou, Flora H. (2012): Reward system design and group creativity: An experimental investigation, *The Accounting Review* 87 (6), 1885-1911.

Cooper, Michael G., Knittel, Matthew J. (2006): Partial Loss Refundability: How Are Corporate Tax Losses Used?, *National Tax Journal* 59 (3), 651-663.

Cooper, Michael G., Knittel, Matthew J. (2010): The Implications of Tax Asymmetry for U.S. Corporations, *National Tax Journal* 63 (1), 33-62.

Devereux, Michael P., Keen, Michael, Schiantarelli, Fabio (1994): Corporation tax asymmetries and investment. Evidence from U.K. panel data, *Journal of Public Economics* 53 (3), 395-418.

Domar, Evsey D., Musgrave, Richard A. (1944): Proportional Income Taxation and Risk-Taking, *Quarterly Journal of Economics* 58 (3), 388-422.

Dreßler, Daniel, Overesch. Michael (2013): Investment impact of tax loss treatment – empirical insights form a panel of multinationals, *International Tax and Public Finance* 20 (3), 513-543.

Edgerton, Jesse (2010): Investment incentives and corporate tax asymmetries, *Journal of Public Economics* 94 (11-12), 936–952.

Eeckhoudt, Louis, Gollier, Christian, Schlesinger, Harris (1997): The No-loss Offset Provision and the Attitude Towards Risk of a Risk-Neutral Firm, *Journal of Public Economics* 65 (2), 207-217.

Ellsberg, Daniel (1961): Risk, Ambiguity and the Savage Axioms, *Quarterly Journal of Economics* 75 (4), 643-669.

Fahr, René, Janssen, Elmar A., Sureth, Caren (2014): Can Tax Rate Increases Foster Investment under Entry and Exit Flexibility? – Insights from an Economic Experiment, *WU International Taxation Research Paper Series No. 2014 – 05* and *arqus, Quantitative Research in Taxation*, Discussion Paper No. 166. Available at SSRN: https://ssrn.com/abstract=2442721.

Falsetta, Diana, Rupert, Timothy J., Wright, Arnold M. (2013): The Effect of the Timing and Direction of Capital Gain Tax Changes on Investment in Risky Assets, *The Accounting Review* 88 (2), 499-520.

Falsetta, Diana, Tuttle, Brad (2011): Transferring Risk Preferences from Taxes to Investments, *Contemporary Accounting Research* 28 (2), 472-486.

Feldstein, Martin S. (1969): The Effects of Taxation on Risk Taking, *Journal of Political Economy* 77 (5), 755-764.

Fochmann, Martin, Jacob, Martin (2015): A Utility-Based Explanation of Tax Asymmetries, *World Tax Journal* 7 (3), 329-342.

Fochmann, Martin, Kiesewetter, Dirk, Sadrieh, Abdolkarim (2012): Investment Behavior and the Biased Perception of Limited Loss Deduction in Income Taxation, *Journal of Economic Behavior & Organization* 81 (1), 230-242.

Fochmann, Martin, Wolf, Nadja (2015): Mental Accounting in Tax Evasion Decisions ─ An Experiment on Underreporting and Overdeducting. Available at http://ssrn.com/abstract=2595070.

Gächter, Simon, Johnson, Eric J., Herrmann, Andreas (2007): Individual-Level Loss Aversion in Riskless and Risky Choices. Available at http://ftp.iza.org/dp2961.pdf.

Gries, Thomas, Prior, Ulrich, Sureth, Caren (2012): A Tax Paradox for Investment Decisions under Uncertainty, *Journal of Public Economic Theory*, 14 (3), 521-545.

Hlouskova, Jaroslava, Mikocziova, Jana, Sivak, Rudolf, Tsigaris, Peter (2014): Capital Income Taxation and Risk-Taking under Prospect Theory: The Continuous Distribution Case, *Czech Journal of Economics and Finance* 64 (5), 374-391.

Hlouskova, Jaroslava, Tsigaris, Panagiotis (2012): Capital Income Taxation and Risk Taking under Prospect Theory, *International Tax Public Finance* 19 (4), 554-573.

IBFD (2017): *Tax Research Database*. Amsterdam: IBFD.

Jacob, Martin, Michaely, Roni (2017): Taxation and Dividend Policy: The Muting Effect of Agency Issues and Shareholder Conflicts. *Review of Financial Studies*, 30 (9), 3176–3222.

Jacob, Martin, Pasedag, Andreas, Wagner, Franz W. (2011): Werden niedrige Steuersätze in Osteuropa durch Verzicht auf Verlustverrechnung erkauft?, *Perspektiven der Wirtschaftspolitik* 12 (1), 72-91.

Johansson, Sven-Erik (1969): Income taxes and investment decisions, *Swedish Journal of Economics* 71 (2), 104-110.

Kager, Rebekka, Niemann, Rainer (2013): Income determination for corporate tax purposes using IFRS as a starting point: evidence for listed companies within Austria, Germany, and The Netherlands, *Journal of Business Economics* 83 (5), 437-470.

Kahneman, Daniel, Tversky, Amos (1979): Prospect Theory: An Analysis of Decision under Risk, *Econometrica* 47 (2), 263-291.

Kanbur, Ravi, Pirttilä, Jukka, Tuomala, Matti (2008): Moral Hazard, Income Taxation and Prospect Theory, *The Scandinavian Journal of Economics* 110 (2), 321-337.

Kilka, Michael, Weber, Martin (2001): What Determines the Shape of the Probability Weighting Function Under Uncertainty?, *Management Science* 47 (12), 1712-1726.

Klapper, Daniel, Ebling, Christine, Temme, Jarg (2005): Another Look at Loss Aversion in Brand Choice Data, Can we Characterize the Loss Averse Consumer?, *International Journal of Research in Marketing* 22 (3), 239-254.

Köbberling, Veronika, Wakker, Peter P. (2005): An Index of Loss Aversion, *Journal of Economic Theory* 122 (1), 119-131.

Langenmayr, Dominika, Lester, Rebecca (2017): Taxation and Corporate Risk-Taking. *The Accounting Review*, in press, https://doi.org/10.2308/accr-51872.

Langer, Thomas, Weber, Martin (2005): Myopic Prospect Theory vs. Myopic Loss Aversion: How General is the Phenomenon?, *Journal of Economic Behavior & Organization* 56 (1), 25-38.

Lejarraga, Tomás, Müller-Trede, Johannes (2017): When Experience Meets Description: How Dyads Integrate Experiential and Descriptive Information in Risky Decisions, *Management Science* 63 (6), 1953-1971

Levy, Moshe, Benita, Golan (2009): Are Equally Likely Outcomes Perceived as Equally Likely?, *The Journal of Behavioral Finance* 10 (3), 128-137.

Ljungqvist, Alexander and Zhang, Liandong and Zuo, Luo (2017): Sharing Risk with the Government: How Taxes Affect Corporate Risk Taking. *Journal of Accounting Research* 55 (3), 669-707.

MacKie-Mason, Jeffrey K. (1990): Some nonlinear tax effects on asset values and investment decisions under uncertainty, *Journal of Public Economics* 42 (3), 301-327.

Mehrmann, Annika (2017): *Der Einfluss steuerlicher Verlustverrechnung auf Investitionsentscheidungen bei Risiko unter Berücksichtigung präskriptiver und deskriptiver Verhaltenselemente*, Hamburg: Dr. Kovac.

Mossin, Jan (1968): Taxation and Risk-Taking: An Expected Utility Approach, *Economica* 35 (137), 74-82.

Näslund, Bertil (1968): Some Effects of Taxes on Risk-Taking, *Review of Economic Studies* 35 (3), 289-306.

Niemann, Rainer (2004): Investitionswirkungen steuerlicher Verlustvorträge – Wie schädlich ist die Mindestbesteuerung, *Zeitschrift für Betriebswirtschaft/Journal of Business Economics* 74 (4), 359-384.

Niemann, Rainer, Sureth, Caren (2004): Tax Neutrality under Irreversibility and Risk Aversion, *Economics Letters* 84 (1), 43-47.

Niemann, Rainer, Sureth, Caren (2013): Sooner or Later? Paradoxical Investment Effects of Capital Gains Taxation under Simultaneous Investment and Abandonment Flexibility, *European Accounting Review* 22 (2), 367-390.

OECD (2011): *Corporate Loss Utilisation through Aggressive Tax Planning*, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264119222-en.

Robben, Henry S., Webley, Paul, Weigel, Russell H., Wärneryd, Karl-Erik, Kinsey, Karyl A., Hessing, Dick J., Martin, Francisco A., Elffers, Henk, Wahlund, Richard, van Langenhove, Luk, Long, Susan B., Scholz, John T. (1990): Decision Frame and Opportunity as Determinants of Tax Cheating, *Journal of Economic Psychology* 11 (3), 341-364.

Panteghini, Paolo (2001): On corporate tax asymmetries and neutrality, *German Economic Review* 2 (3), 269–286.

PwC (2015/2016): *Worldwide Tax Summaries*. www.pwc.com/taxsummaries: PwC.

Russell, William R., Smith, Paul E. (1970): Taxation, Risk-Taking, and Stochastic Dominance, *Southern Economic Journal* 36 (4), 425-433.

Sandmo, Agnar (1989): Differential Taxation and the Encouragement of Risk-Taking, *Economics Letters* 31 (1), 55-59.

Schmidt, Ulrich, Zank, Horst (2012): A Genuine Foundation for Prospect Theory, *Journal of Risk and Uncertainty* 45 (2), 97-113.

Schneider, Dieter (1992): *Investition, Finanzierung und Besteuerung*, 7th edition, Wiesbaden: Gabler.

Stiglitz, Joseph E. (1969): The Effects of Income, Wealth, and Capital Gains Taxation on Risk-Taking, *Quarterly Journal of Economics* 83 (2), 263-283.

Tversky, Amos, Fox, Craig R. (1995): Weighing Risk and Uncertainty, *Psychological Review* 102 (2), 269-283.

Tversky, Amos, Kahneman, Daniel (1992): Advances in Prospect Theory: Cumulative Representation of Uncertainty, *Journal of Risk and Uncertainty* 5 (4), 297-323.

Wakker, Peter P. (2003): The Data of Levy and Levy (2002) "Prospect Theory: Much Ado About Nothing?" Actually Support Prospect Theory, *Management Science* 49 (7), 979-981.

Wegener, Laura (2014): Verlusteinkunftsarten und Dynamik der Verlusterzielung im Taxpayer-Panel, *Wirtschaft und Statistik* 2, 119-133.

Appendix

Appendix A: Tax Loss Offset Restrictions Across Countries

Figure 17 exemplifies the time horizons that apply to tax loss offset restrictions in different jurisdictions:

[Insert Figure 17 here]

Besides restrictions in time, many countries have introduced additional tax loss offset restrictions in amount. As a consequence, huge amounts of loss carryforwards have been accumulated by individual taxpayers and in firms, in many countries more than 15% of GDP (OECD (2011), p. 21).

Studies on the real value of tax loss carry backwards and forwards suggest that approximately 50% of tax losses of U. S. firms remain unused (Cooper and Knittel 2006 and 2010 and Edgerton 2010). Kager and Niemann (2013) provide evidence that depreciations of deferred tax assets for tax losses have increased from 41% in 2004 to 76% in 2007 in a sample of Austrian, German and Dutch firms. Wegener (2014) reports more than 62 billion Euros of loss carryforwards in 2006. She uses German individual tax return panel data and finds that constantly more than 90% of losses reported are business losses for the years 2001 to 2006. More than 50% of the affected taxpayers report losses in two subsequent years and 25% in even four subsequent years. Losses from rental activities occur to be more sustainable and on average remain 1.5 times longer than business losses. These findings imply that tax loss carryforwards are a highly relevant topic for individual taxpayers and firms. Tax loss carryforwards are often even assumed to expire.

Appendix B: Selected Experimental Values

	α, β	γ, δ
Tversky and Kahneman (1992)	0.88	0.61, 0.69
Tversky and Fox (1995)	0.88	0.69
Abdellaoui (2000)	0.89, 0.92	0.60, 0.70
Bleichrodt and Pinto (2000)	0.77	0.67 / 0.55
Kilka and Weber (2001)	0.76 - 1.00	0.30 - 0.51

Appendix C: Mathematical Appendix

$$\frac{\partial \Delta \Phi_{sym}}{\partial \alpha} = \frac{\partial \Delta \Phi_{asym}}{\partial \alpha} = 0.5x^{\alpha}(1-\tau)^{\alpha}\ln(1-\tau) + 0.5x^{\alpha}\ln(x)\,(1-\tau)^{\alpha} - 0.5x^{\alpha}\ln(x) < 0 \quad \text{for} \quad x \geq 1$$

$$\frac{\partial \theta^*}{\partial \alpha} = \frac{-\left(\frac{(1-\tau)^{\alpha}x^{\alpha} - x^{\alpha} + \lambda x^{\beta}}{\lambda x^{\beta}}\right)^{\frac{1}{\beta}}\left(\ln(1-\tau)\,(1-\tau)^{\alpha}x^{\alpha} + (1-\tau)^{\alpha}x^{\alpha}\ln(x) - x^{\alpha}\ln(x)\right)}{\beta\lambda((1-\tau)^{\alpha}x^{\alpha} - x^{\alpha} + \lambda x^{\beta})} > 0$$

for $\alpha \leq \beta, x \geq 1$

$$\frac{\partial \Delta \Phi_{sym}}{\partial \beta} = 0.5(-\lambda)x^{\beta}\left(\ln(x)\left((1-\tau)^{\beta} - 1\right) + (1-\tau)^{\beta}\ln(1-\tau)\right) > 0 \quad \text{for} \quad x \geq 1$$

$$\frac{\partial \Delta \Phi_{asym}}{\partial \beta} = 0.5(-\lambda)x^{\beta}(\ln(x)((1-\theta\tau)^{\beta} - 1) + (1-\theta\tau)^{\beta}\ln(1-\theta\tau)) > 0 \quad \text{for} \quad x \geq 1$$

$$\frac{\partial \Delta \Phi_{sym}}{\partial \lambda} = -0.5x^{\beta}((1-\tau)^{\beta} - 1) > 0$$

$$\frac{\partial \Delta \Phi_{asym}}{\partial \lambda} = -0.5x^{\beta}((1-\theta\tau)^{\beta} - 1) > 0$$

$$\frac{\partial \theta^*}{\partial \lambda} = \frac{((1-\tau)^{\alpha} - 1)x^{\alpha}\left(\frac{x^{\beta}\lambda + ((1-\tau)^{\alpha} - 1)x^{\alpha}}{x^{\beta}\lambda}\right)^{\frac{1}{\beta}}}{\beta\tau\lambda(x^{\beta}\lambda + ((1-\tau)^{\alpha} - 1)x^{\alpha}} < 0$$

Appendix D: Numerical Analysis for Unequally Weighted Probabilities

The investor evaluates the pre-tax investment as

$$A = \left(-x, \frac{0.5^{\delta}}{0.5 \cdot 2^{\frac{1}{\delta}}}; x, \frac{0.5^{\gamma}}{0.5 \cdot 2^{\frac{1}{\gamma}}}\right) \tag{35}$$

and the post-tax investment as

$$A_{\tau} = \left(-x(1-\theta\tau), \frac{0.5^{\delta}}{0.5 \cdot 2^{\frac{1}{\delta}}}; x(1-\tau), \frac{0.5^{\gamma}}{0.5 \cdot 2^{\frac{1}{\gamma}}}\right). \tag{36}$$

We use the preference value functions (28), (29) and (30) and parameter values that apply to the median decision maker of $\gamma = 0.61$ in the domain of gains and $\delta = 0.69$ in the domain of losses, leading to probability weightings of $\pi^{+}(0.5) = 0.42$ and $\pi^{-}(0.5) = 0.45$. We obtain preference values before and after taxes,

$$\Phi = 0.42x^{\alpha} - 0.45\lambda x^{\beta} \tag{37}$$

and

$$\Phi_{\tau,asym} = 0.42\big(x(1-\tau)\big)^{\alpha} - 0.45\lambda\big(x(1-\theta\tau)\big)^{\beta}. \tag{38}$$

Taking into consideration the probability weighting by the median decision maker, we obtain for the critical loss offset factor θ^*

$$\theta^* = \frac{15^{-\frac{1}{\beta}}\left(15^{\frac{1}{\beta}} - \left(\frac{x^{-\beta}\big(14(1-\tau)^{\alpha}x^{\alpha} - 14x^{\alpha} + 15\lambda x^{\beta}\big)}{\lambda}\right)^{\frac{1}{\beta}}\right)}{\tau}. \tag{39}$$

We use the median values of the value function in equation (39) and determine the neutral loss offset factors listed in Table 11 for different levels of taxation.

[Insert Table 11 here]

When making calculations and acting according to prospect theory, the investor's distorted perception of probabilities leads to a decrease in the critical loss offset factors θ^* in comparison to a calculation with undistorted probabilities. This implies a comparatively more restrictive neutral loss offset policy caused by the imbalance of the probability transformation in the domains of gains and losses. The underweighting of the loss probability is less than the underweighting of the gain probability. The loss is thus weighted more than the correspondingly high gain, not just because of loss aversion, but also because of its higher perceived probability. This additional imbalance can only be neutralized by greater loss offset restrictions.

Finding 3 therefore holds, and the conclusion that allows for the probability transformation undertaken by the median decision maker can even be intensified: *For the median decision maker, the attractiveness of risky investments does not decrease as a result of taxation despite the application of loss offset restrictions, as long as at least 46% of a tax loss can still be offset.*

Finding 4, derived previously, does not need to be modified. Table 11 shows that the level of neutral loss offset factors varies only slightly with the level of taxation, even if we account for the probability transformation.

Appendix E: Sensitivity Analysis for Unequally Weighted Probabilities

[Insert Figure 18 here]

Appendix F: Tax-Sensitive Reference Point

If taxation changes not only the gain and loss from the investment but also the position of the reference point, then the tax-induced difference in preference value is given by

$$\Delta\Phi^{var} = 0.5\left(x - x_{ref}\right)^{\alpha}((1-\tau)^{\alpha} - 1) - 0.5\lambda\left(\left(x(1-\theta\tau) + x_{ref}(1-\tau)\right)^{\beta} - \left(x + x_{ref}\right)^{\beta}\right) \gtreqless 0. \tag{40}$$

For symmetrical taxation of gains and losses, this expression can be simplified to

$$\Delta\Phi_{sym}^{var} = 0.5\left(x - x_{ref}\right)^{\alpha}((1-\tau)^{\alpha} - 1) - 0.5\lambda\left(\left(x + x_{ref}\right)^{\beta}\left((1-\tau)^{\beta} - 1\right)\right) > 0. \tag{41}$$

Assuming that $\alpha \leq \beta$, the tax-induced difference in preference value as a result of symmetrical taxation is positive. Findings 1a and 1b in the baseline scenario regarding symmetrical taxation of gains and losses hold even if the investor uses a reference point of $x_{ref} > 0$ when evaluating the risky investment.

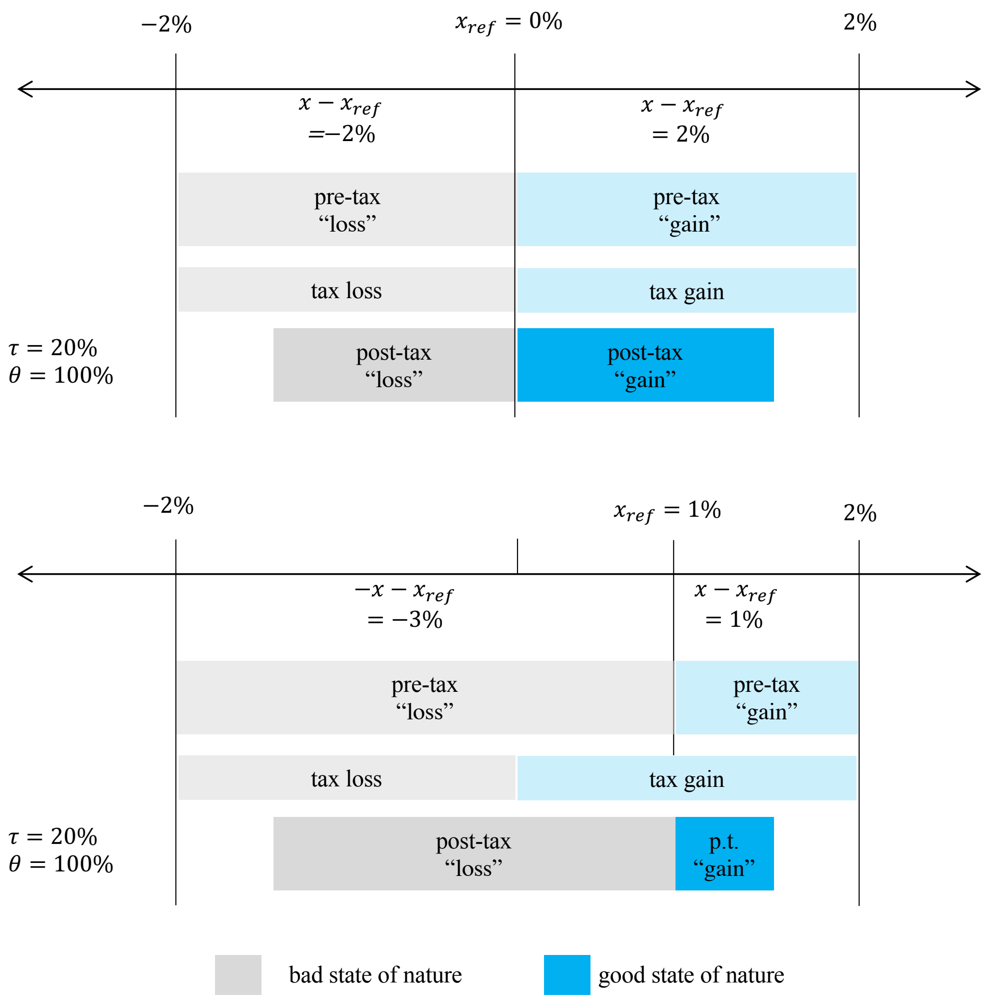
As in the baseline scenario, the effects of asymmetrical taxation are ambiguous (Finding 2). The value of the risky investment remains unaffected by this kind of tax system only if the loss offset precisely equates to the following condition:

$$\theta_{x_{ref}>0}^{*,var} = -\frac{\left(\frac{\left(x - x_{ref}\right)^{\alpha}((1-\tau)^{\alpha} - 1) + \lambda\left(x + x_{ref}\right)^{\beta}}{\lambda}\right)^{\frac{1}{\beta}} + x_{ref}(1-\tau) - x}{\tau x}. \tag{42}$$

When $\theta > \theta_{x_{ref}>0}^{*,var}$, taxation is value-increasing; when $\theta < \theta_{x_{ref}>0}^{*}(var)$, it is value-reducing. A high reference point thus implies a lower threshold value. Under tax-sensitive conditions, shifting the reference point consequently has the opposite effect compared to tax-insensitive and thus fixed conditions. Our numerical analyses support Finding 4. Finding 3 also holds.

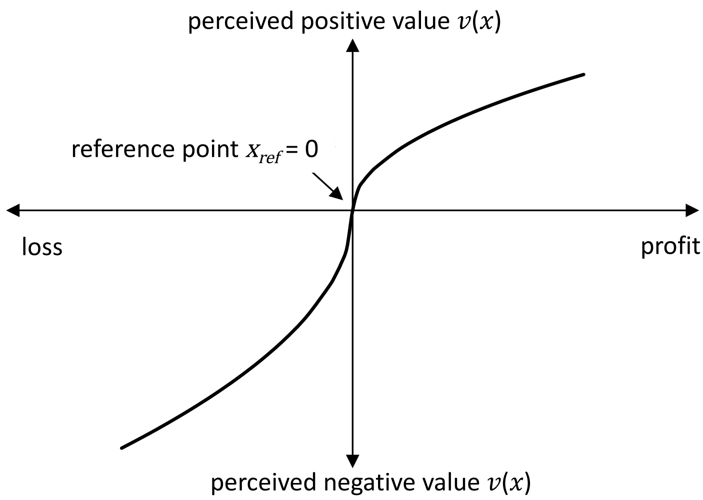
Figures

Figure 1: Good and bad states of nature for $x = 2\%$ and $x_{ref} = 0$ or $x_{ref} = 1 > 0$



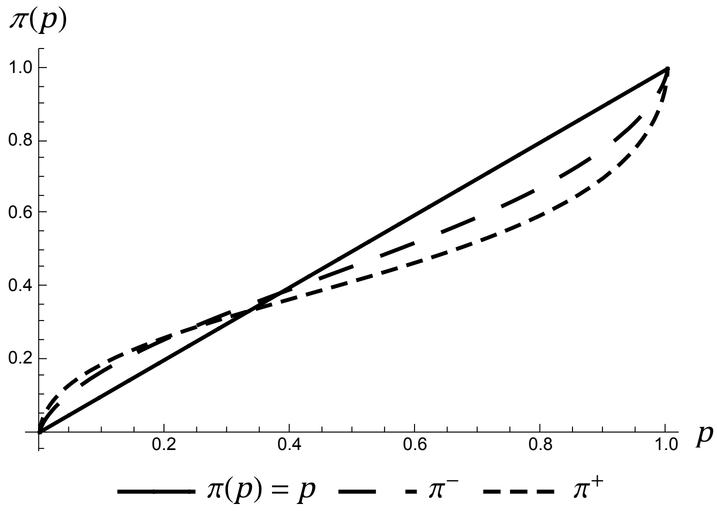
Notes: p.t. = post-tax.

Figure 2: Value function



Source: Own calculation, in line with Tversky and Kahneman (1992).

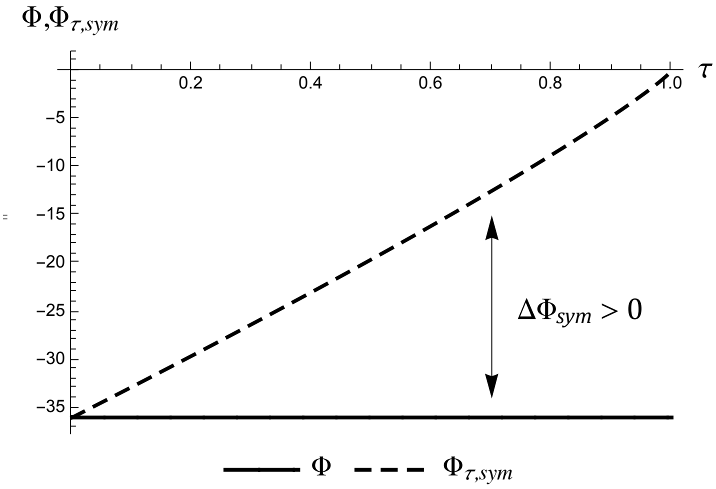
Figure 3: Probability weighting function
$\gamma = 0.6, \delta = 0.7$



Source: Own calculation, in line with Tversky and Kahneman (1992), p. 310.

Figure 4: Preference values of the median decision maker depending on the tax rate for symmetrical taxation of gains and losses

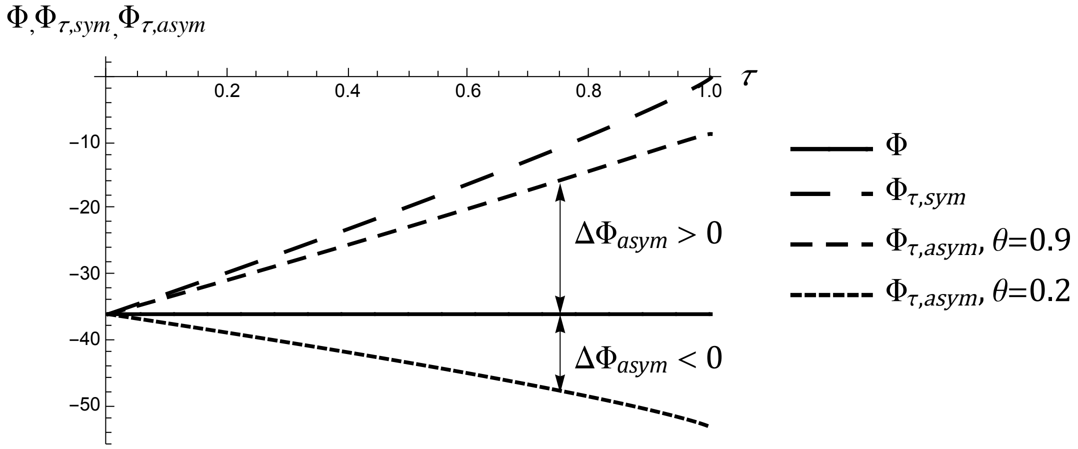
$x = 100, x_{ref} = 0, \gamma = \delta = 1, \alpha = \beta = 0.88, \lambda = 2.25, \theta = 1$



Source: Own calculations.

Figure 5: Preference values of the median decision maker depending on the level of taxation when gains and losses are taxed asymmetrically

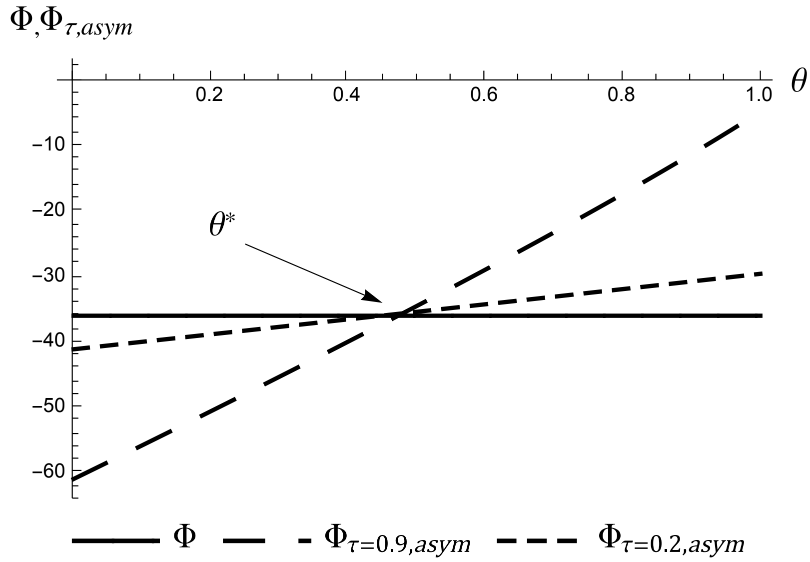
$x = 100$, $x_{ref} = 0$, $\gamma = \delta = 1$, $\alpha = \beta = 0.88$, $\lambda = 2.25$, sym: $\theta = 1$, asym: $\theta = 0.9$ or $\theta = 0.2$



Source: Own calculations.

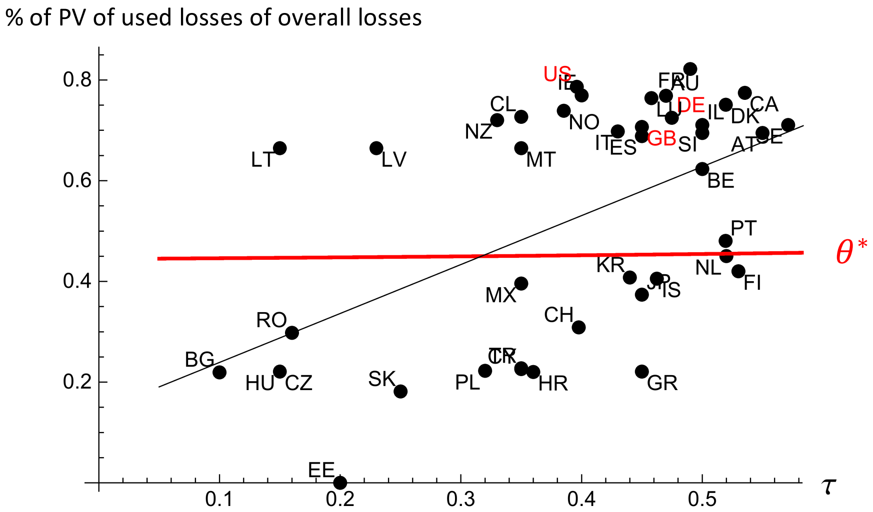
Figure 6: Preference values of the median decision maker depending on the level of loss offset restrictions

$x = 100$, $x_{ref} = 0$, $\gamma = \delta = 1$, $\alpha = \beta = 0.88$, $\lambda = 2.25$, $\tau = 0.2$ or. $\tau = 0.9$



Source: Own calculations.

Figure 7: Country-specific present value of used tax losses as share of overall losses for a time horizon of 20 years and neutral loss offset factors θ^* for country-specific statutory tax rates τ

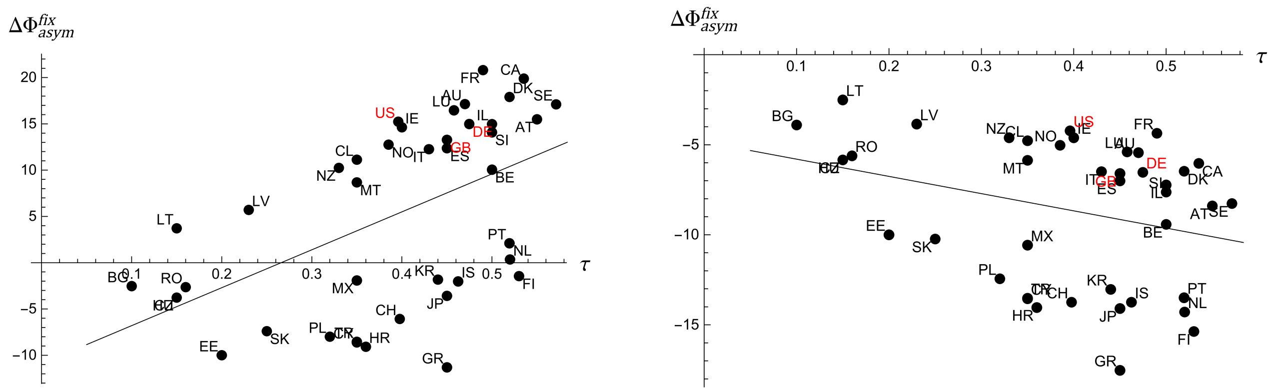


Notes: We assume a constant profit stream for periods $t = 1$ to $t = 20$ such that a specific loss that occurs in period $t = 0$ can be completely offset over 20 years under an unrestricted loss carryforward. Then, we introduce country-specific institutional loss offset regulations, i.e., loss carrybacks and loss carryforward with country-specific restrictions in time and amount) and determine the share of used losses of overall losses in present value terms.

Source: Own calculations, consistent with the determination of present values for used corporate losses by Jacob, Pasedag and Wagner (2011), p. 82. Data from IBFD (2017).

Figure 8: Country-specific tax effect on the assessment of the risky investment for different evaluation approaches

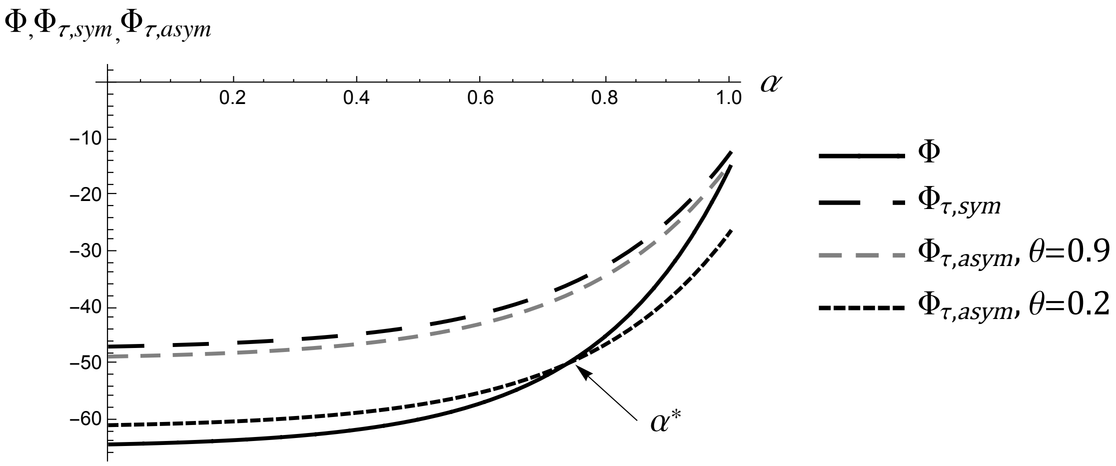
prospect theoretical preference value of risk-neutral median decision maker	expected utility of risk-neutral decision maker
$x = 100, x_{ref} = 0, \gamma = \delta = 1, \alpha = \beta = 1, \lambda = 2.25$	$x = 100, \alpha = \beta = 1$



Notes: To focus on the behavioral effects we assume risk neutrality under both prospect theory and rational choice under expected utility. We assume a constant profit stream for periods $t = 1$ to $t = 20$ such that a specific loss that occurs in period $t = 0$ can be completely offset over 20 years under an unrestricted loss carryforward. Then, we introduce country-specific institutional loss offset regulations, i.e., loss carrybacks and loss carryforward with country-specific restrictions in time and amount) and determine the share of used losses of overall losses in present value terms.

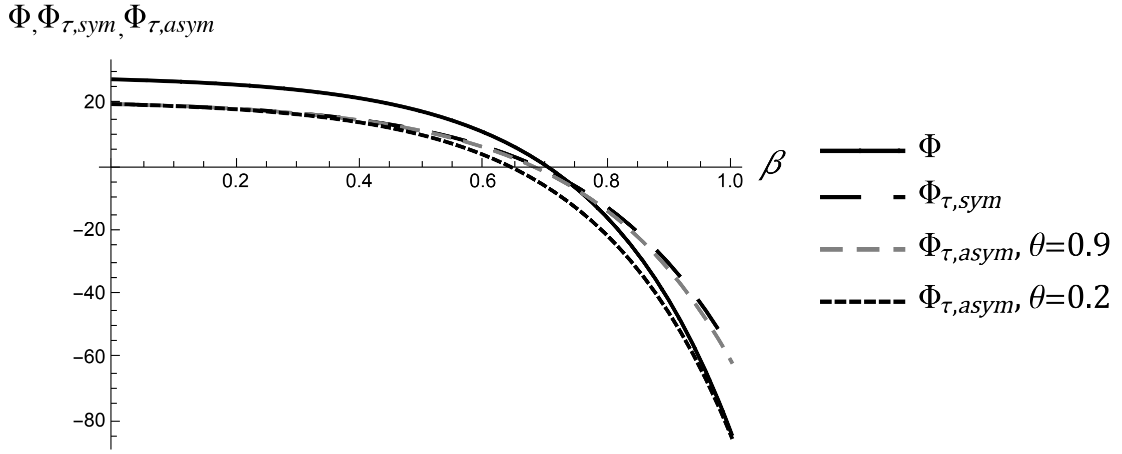
Source: Own calculations

Figure 9: Preference values depending on risk aversion in the domain of gains
$x = 100$, $x_{ref} = 0$, $\gamma = \delta = 1$, $\beta = 0.88$, $\lambda = 2.25$, $\tau = 0.3$, $\theta = 0.9$ or $\theta = 0.2$



Source: Own calculations.

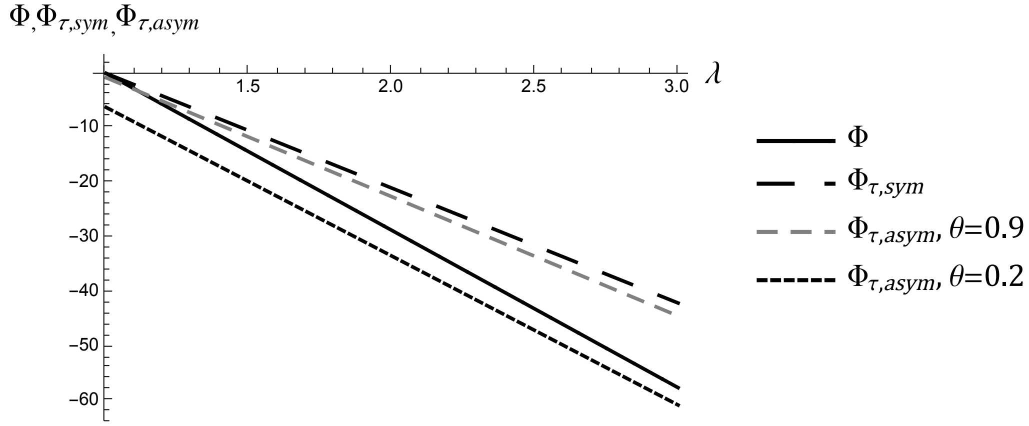
Figure 10: Preference values depending on risk seeking in the domain of losses
$x = 100$, $x_{ref} = 0$, $\gamma = \delta = 1$, $\alpha = 0.88$, $\lambda = 2.25$, $\tau = 0.3$, $\theta = 0.9$ or $\theta = 0.2$



Source: Own calculations.

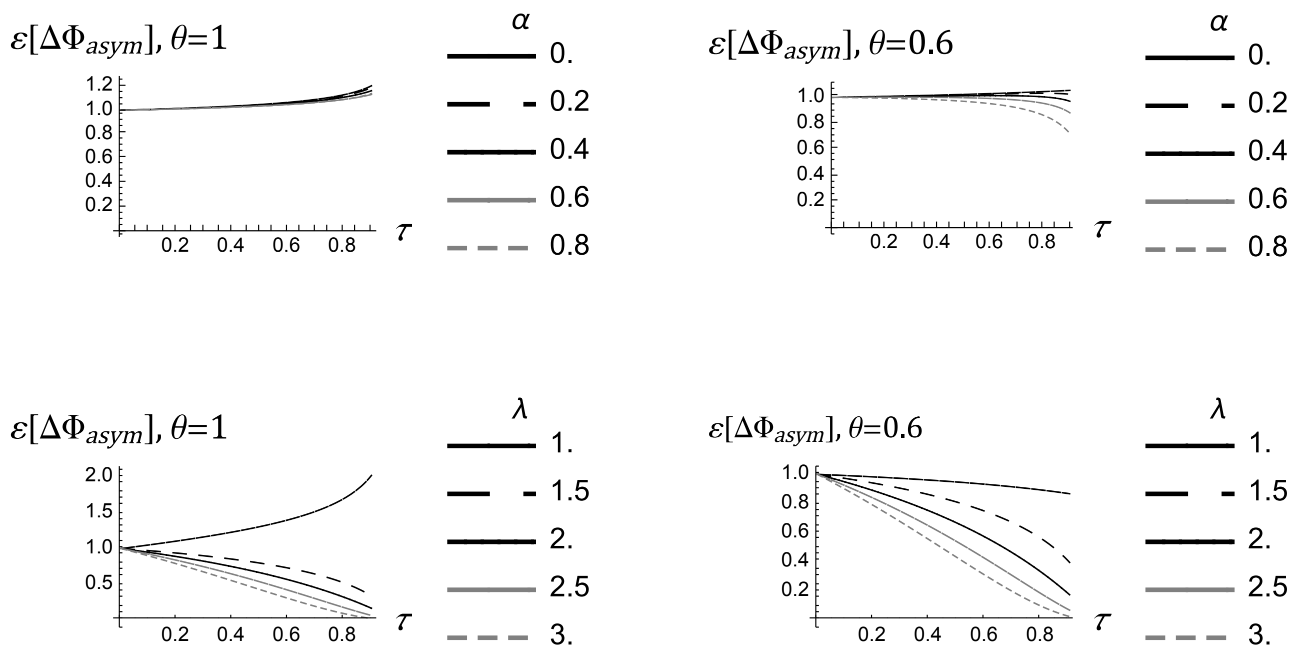
Figure 11: Preference values depending on loss aversion

$x = 100$, $x_{ref} = 0$, $\gamma = \delta = 1$, $\alpha = \beta = 0.88$, $\tau = 0.3$, $\theta = 0.9$ or $\theta = 0.2$



Source: Own calculations.

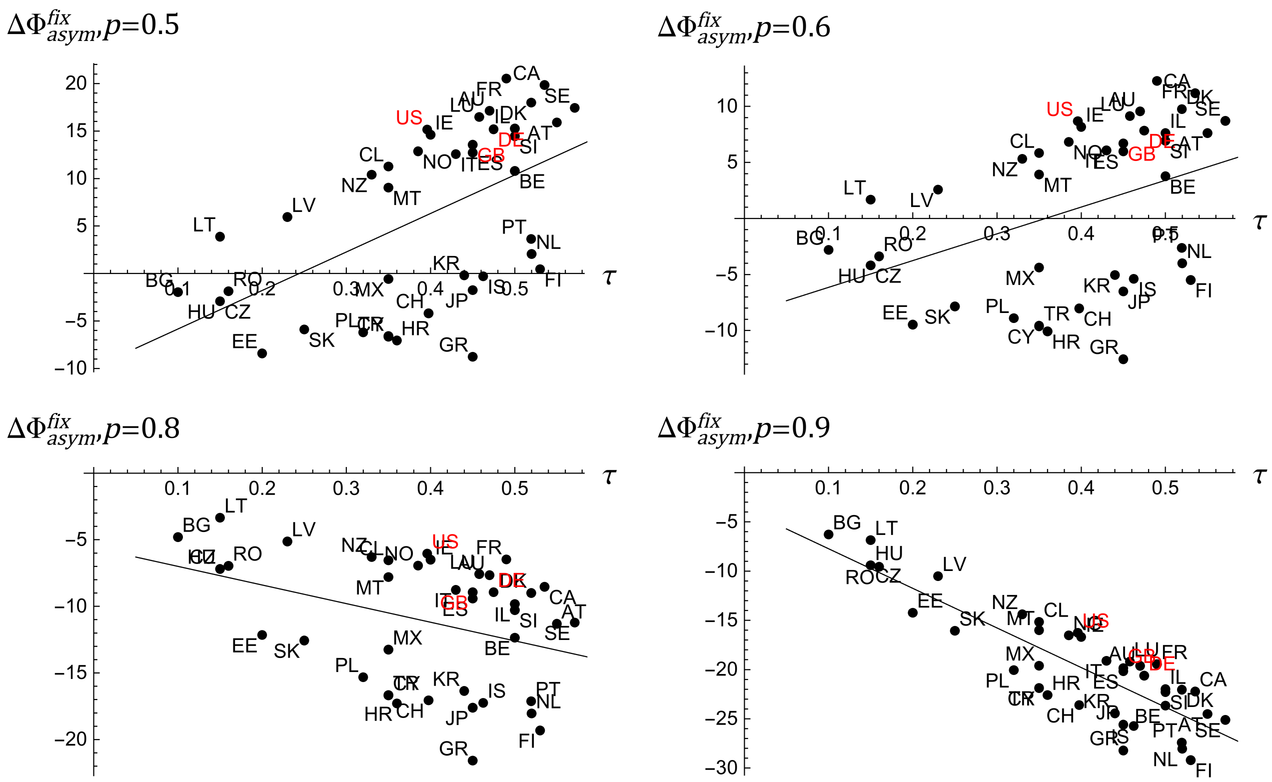
Figure 12: Tax elasticity of the tax effect on the preference value
for various levels of θ, α and λ



Source: Own calculations.

Figure 13: Country-specific tax effect on the assessment of the risky investment for different probabilities p

$x = 100, x_{ref} = 0, \alpha = \beta = 1, \gamma = 0.61, \delta = 0.69, \lambda = 2.25$



Notes: To focus on the behavioral effects from loss aversion and probability weighting we assume risk neutrality. We assume a constant profit stream for periods $t = 1$ to $t = 20$ such that a specific loss that occurs in period $t = 0$ can be completely offset over 20 years under an unrestricted loss carryforward. Then, we introduce country-specific institutional loss offset regulations, i.e., loss carrybacks and loss carryforward with country-specific restrictions in time and amount) and determine the share of used losses of overall losses in present value terms.

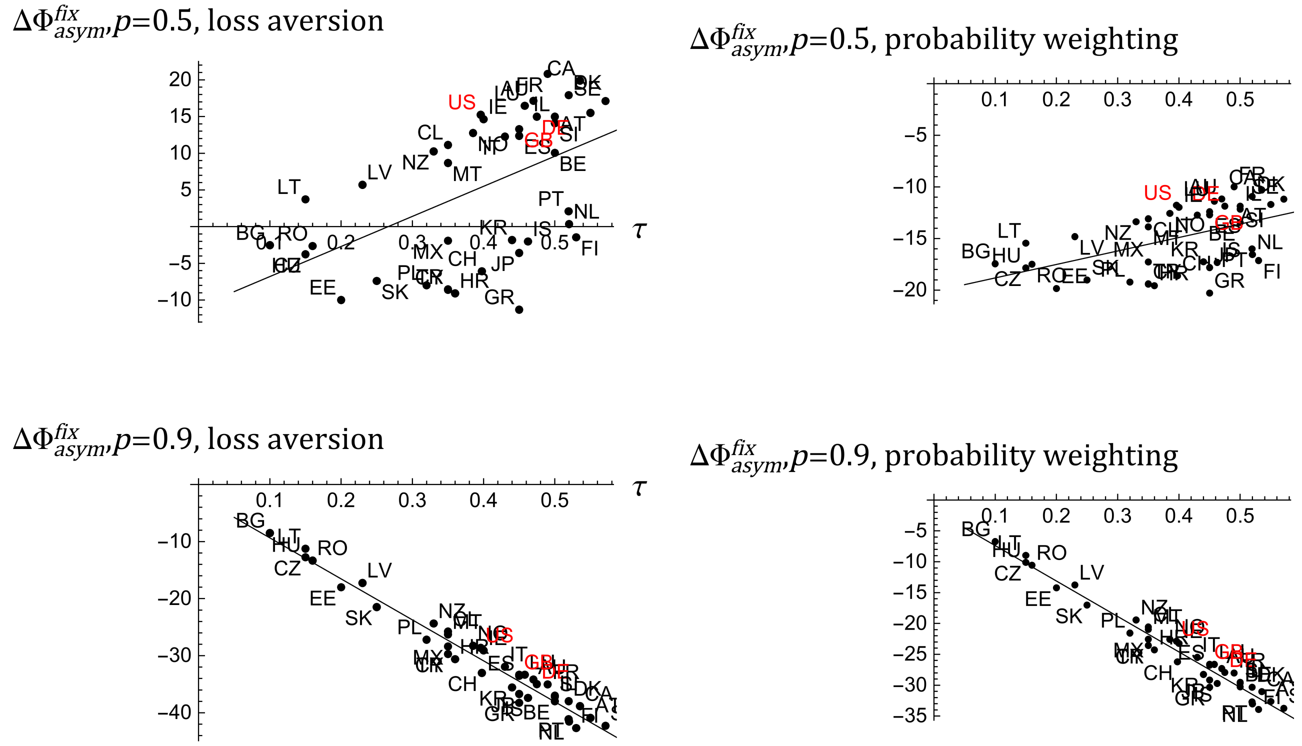
Source: Own calculations

Figure 14: Country-specific tax effect on the assessment of the risky investment for loss aversion or probability weighting for different probabilities p

$x = 100, x_{ref} = 0, \alpha = \beta = 1,$

$\gamma = \delta = 1, \lambda = 2.25$

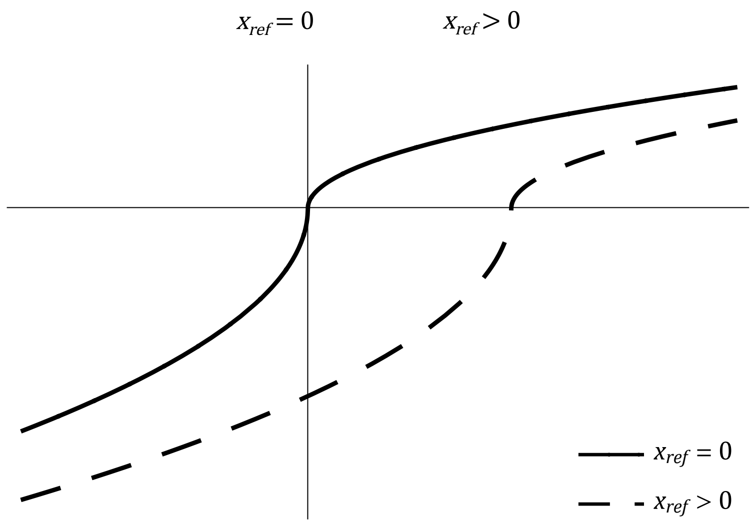
or $\gamma = 0.61, \delta = 0.69, \lambda = 1$



Notes: To focus on the behavioral effects from loss aversion and probability weighting we assume risk neutrality. We assume a constant profit stream for periods $t = 1$ to $t = 20$ such that a specific loss that occurs in period $t = 0$ can be completely offset over 20 years under an unrestricted loss carryforward. Then, we introduce country-specific institutional loss offset regulations, i.e., loss carrybacks and loss carryforward with country-specific restrictions in time and amount) and determine the share of used losses of overall losses in present value terms.

Source: Own calculations

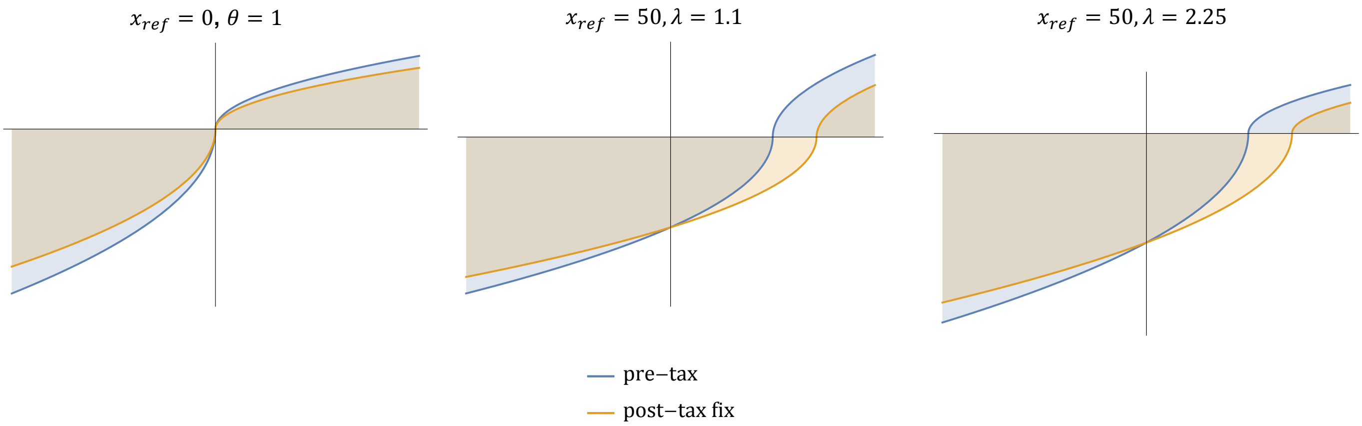
Figure 15: Prospect theory value function for different reference points
$x_{ref} = 0$ or $> 0, \gamma = \delta = 1, \alpha = \beta = 0.5, \lambda = 2.25, \tau = 0.3, \theta = 1$



Source: Own calculations.

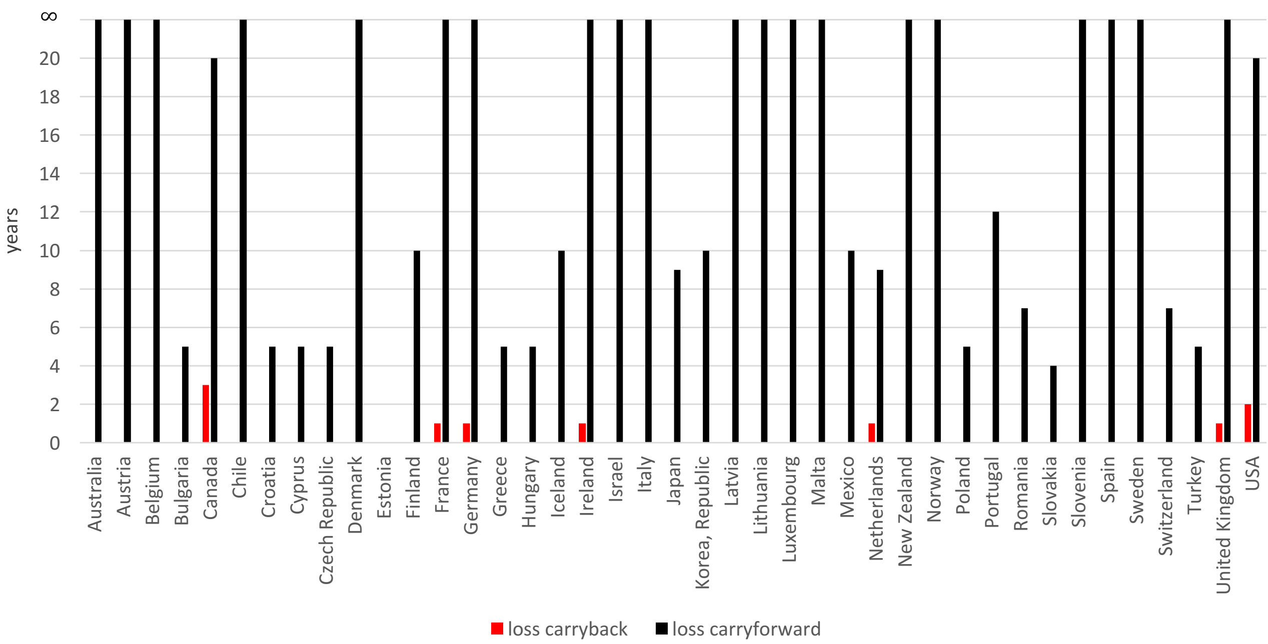
Figure 16: Prospect theory value function for various reference points and levels of loss aversion

$x = [-100{,}100]$, $x_{ref} = 0$ or $x_{ref} = 50$, $\gamma = \delta = 1$, $\alpha = \beta = 0.5$, $\lambda = 1.1$ or $\lambda = 2.25$, $\tau = 0.3$, $\theta = 1$



Source: Own calculations.

Figure 17: Loss carryforwards and carrybacks in years across selected countries



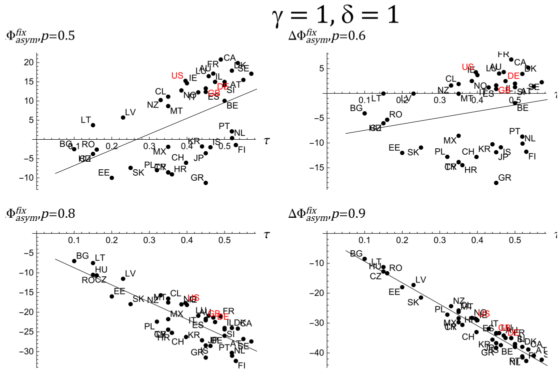
Source: PwC (2015/2016), IBFD (2017).

Figure 18: Country-specific tax effect on the assessment of the risky investment for different probabilities p

$x = 100, x_{ref} = 0, \alpha = \beta = 1, \lambda = 2.25$

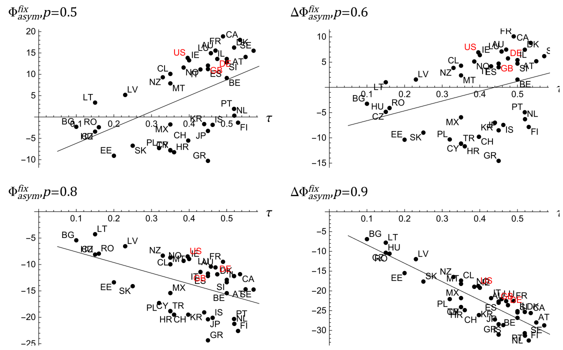
no probability weighting

$\gamma = 1, \delta = 1$



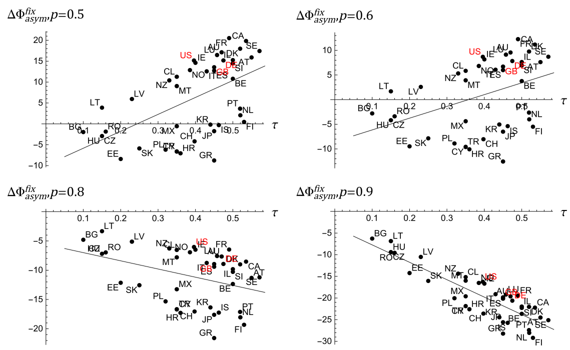
probability weighting Tversky and Fox (1995)

$\gamma = 0.69, \delta = 0.69$



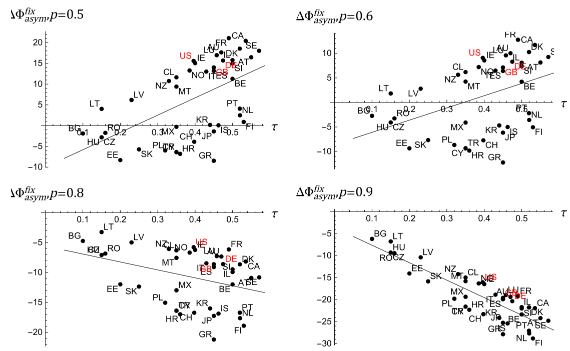
probability weighting Kahneman and Tversky (1992)

$\gamma = 0.61, \delta = 0.69$



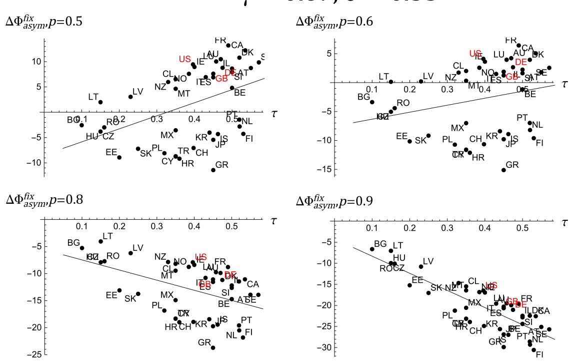
probability weighting Abdellaoui (2000)

$\gamma = 0.60, \delta = 0.70$



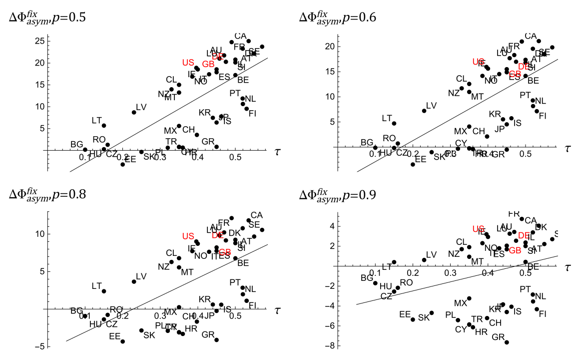
probability weighting Bleichrodt and Pinto (2000)

$\gamma = 0.67, \delta = 0.55$



probability weighting Kilka and Weber (2001)

$\gamma = 0.30, \delta = 0.51$



Notes: To focus on the behavioral effects from loss aversion and probability weighting we assume risk neutrality. We assume a constant profit stream for periods $t = 1$ to $t = 20$ such that a specific loss that occurs in period $t = 0$ can be completely offset over 20 years under an unrestricted loss carryforward. Then, we introduce country-specific institutional loss offset regulations, i.e., loss carrybacks and loss carryforward with country-specific restrictions in time and amount) and determine the share of used losses of overall losses in present value terms.

Source: Own calculations

Tables

Table 1: Assessment of tax-induced effects

$\Delta\Phi < 0$	Taxation reduces the attractiveness of a risky investment as it reduces its preference value.
$\Delta\Phi > 0$	Taxation increases the attractiveness of a risky investment as it increases its preference value.
$\Delta\Phi = 0$	Taxation has no effect on the attractiveness of a risky investment as it does not alter its preference value.

Table 2: Parameters in baseline scenario

Investment-specific parameters (fixed)	
Reference point	$x_{ref} = 0$
Probability of gain	$p = 0.5$
Probability of loss	$1 - p = 0.5$
Tax parameters (variable)	
Symmetrical taxation of gains and losses	$\theta = 1$
Asymmetrical taxation of gains and losses	$0 \leq \theta < 1$

Table 3: Tax effects on preference value for a symmetrical taxation of gains and losses

Risk and loss aversion	Tax effect on preference value	
$\alpha \leq \beta$ and $\lambda > 1$	$\Delta\Phi_{sym} > 0$	value-increasing
$\alpha > \beta$ and $\lambda > \lambda^* = \frac{x^\alpha - (x-\tau x)^\alpha}{x^\beta - (x-\tau x)^\beta}$	$\Delta\Phi_{sym} > 0$	value-increasing
$\alpha > \beta$ and $\lambda < \lambda^* = \frac{x^\alpha - (x-\tau x)^\alpha}{x^\beta - (x-\tau x)^\beta}$	$\Delta\Phi_{sym} < 0$	value-decreasing

Table 4: Initial numerical values for the preference function

Investor-specific parameters (median investor)	
Undistorted probabilities	$\gamma, \delta = 1$
Distorted probabilities	$\gamma = 0.61; \delta = 0.69$
Value function curvature	$\alpha = \beta = 0.88$
Scale of loss aversion	$\lambda = 2.25$

Table 5: Neutral loss offset factors for the median decision maker depending on the level of taxation without probability distortion

$x = 100, x_{ref} = 0, \gamma = \delta = 1, \alpha = \beta = 0.88, \lambda = 2.25$

τ	θ^*	$\tau_l^* = \tau\theta^*$
10%	44.6%	4.5%
20%	44.8%	9.0%
30%	45.0%	13.5%
40%	45.2%	18.1%
50%	45.4%	22.7%
60%	45.7%	27.4%
70%	46.1%	32.3%
80%	46.6%	37.3%
90%	47.3%	42.5%
99%	48.4%	47.9%

Source: Own calculations.

Table 6: Neutral loss offset parameters depending on risk aversion in the domain of gains

$x = 100, x_{ref} = 0, \gamma = \delta = 1, \beta = 0.88, \lambda = 2.25$

θ^*		τ		
		0.20	0.30	0.90
α	0.99	0.82	0.82	0.79
	0.90	0.50	0.50	0.52
	0.70	0.16	0.16	0.19
	0.50	0.05	0.05	0.07
	0.30	0.01	0.01	0.02
	0.10	0.00	0.00	0.00

Source: Own calculations.

Table 7: Neutral loss offset rates depending on loss aversion

$x = 100, x_{ref} = 0, \gamma = \delta = 1, \alpha = \beta = 0.88$

θ^*		τ 0.20	0.30	0.90
	1.25	0.80	0.80	0.82
	1.5	0.67	0.67	0.70
λ	2.0	0.50	0.51	0.53
	2.5	0.40	0.41	0.43.
	3.0	0.34	0.34	0.36

Source: Own calculations.

Table 8: Tax effects on preference value for a positive reference yield

Relation of decision-making determinants	Tax effect on preference value	
$\lambda > \lambda^* = -\dfrac{\left(x - x_{ref}\right)^{\alpha} - \left(x(1-\tau) - x_{ref}\right)^{\alpha}}{\left(x(1-\theta\tau) + x_{ref}\right)^{\beta} - \left(x + x_{ref}\right)^{\beta}}$	$\Delta\Phi > 0$	value-increasing
$\lambda < \lambda^* = -\dfrac{\left(x - x_{ref}\right)^{\alpha} - \left(x(1-\tau) - x_{ref}\right)^{\alpha}}{\left(x(1-\theta\tau) + x_{ref}\right)^{\beta} - \left(x + x_{ref}\right)^{\beta}}$	$\Delta\Phi < 0$	value-decreasing

Table 9: Numerical examples of the effects of asymmetrical taxation on the neutral loss aversion level for positive reference yields

$x = 100, \gamma = \delta = 1, \tau = 0.3, \theta = 1$ bzw. $\theta = 0.7$

x_{ref}	$\alpha = \beta$	λ^*_{sym}	λ^*_{asym}
10	0.88	1.03	1.48
50		1.18	1.69
10	0.7	1.07	1.56
50		1.52	2.19
10	0.6	1.10	1.60
50		1.75	2.53
10	0.5	1.13	1.65
50		2.01	2.92

Source: Own calculations.

Table 10: Neutral loss offset factors depending on the reference level and tax rate

$x = 100, \gamma = \delta = 1, \alpha = \beta = 0.88, \lambda = 2.25$

τ	x_{ref}	θ^*
10%	10	45.7%
	30	48.2%
	50	51.3%
30%	10	46.2%
	30	49.0%
	50	52.8%
50%	10	46.9%
	30	50.2%
	50	56.9%

Source: Own calculations.

Table 11: Neutral loss offset factors for the median decision maker depending on the tax rate for distorted probabilities

$x = 100, x_{ref} = 0, \gamma = 0.61, \delta = 0.69, \alpha = \beta = 0.88, \lambda = 2.25$

τ	θ^*	$\tau_l^* = \tau\theta^*$
10%	41.6%	4.2%
20%	41.8%	8.4%
30%	42.0%	12.6%
40%	42.2%	16.9%
50%	42.5%	21.2%
60%	42.8%	25.7%
70%	43.1%	30.2%
80%	43.6%	34.9%
90%	44.2%	39.8%
99%	45.3%	44.8%

Source: Own calculations.

Impressum:
Arbeitskreis Quantitative Steuerlehre, arqus, e.V.
Vorstand: Prof. Dr. Ralf Maiterth (Vorsitzender),
Prof. Dr. Kay Blaufus, Prof. Dr. Dr. Andreas Löffler
Sitz des Vereins: Berlin

Herausgeber: Kay Blaufus, Jochen Hundsdoerfer, Martin Jacob, Dirk Kiesewetter, Rolf J. König, Lutz Kruschwitz, Andreas Löffler, Ralf Maiterth, Heiko Müller, Jens Müller, Rainer Niemann, Deborah Schanz, Sebastian Schanz, Caren Sureth-Sloane, Corinna Treisch

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ISSN 1861-8944