arqus Arbeitskreis Quantitative Steuerlehre

Diskussionsbeitrag Nr. 134

Juni 2012

Annika Mehrmann / Georg Schneider / Caren Sureth

Asymmetric Taxation of Profits and Losses and its Influence on Investment Timing: Paradoxical Effects of Tax Increases

www.arqus.info

arqus Diskussionsbeiträge zur Quantitativen Steuerlehre

arqus Discussion Papers in Quantitative Tax Research

ISSN 1861-8944

Asymmetric Taxation of Profits and Losses and its Influence on Investment Timing: Paradoxical Effects of Tax Increases

Annika Mehrmann*, Georg Schneider†, Caren Sureth‡

Keywords: asymmetric taxation, loss offset restrictions, timing flexibility, investment decisions, uncertainty, tax effects

JEL-Classification: H21 · H25

Abstract: Applying a time-discrete investment model and a setting with an entry and an exit option and cash flow uncertainty we present a dynamic analysis of the impact of various loss offset regimes on risky investment timing decisions. We find that a tax system with loss offset restrictions will not distort timing decisions if the investor can exit the project. By contrast, in a setting without exit flexibility a tax discrimination against losses can cause paradoxical effects. In that respect, we analytically identify conditions for higher taxes to increase investors' propensity to choose early investment and hence accelerate entrepreneurial investment.

The authors gratefully acknowledge support by the German Research Foundation (DFG SCHN 1208/1-1 and DFG SU 501/4-1).

*University of Paderborn, Faculty of Business Administration and Economics, Department of Taxation, Accounting and Finance, Warburger Str. 100, 33098 Paderborn, Germany.
Tel.: +49-5251-60 3049, e-mail: annika.mehrmann@wiwi.upb.de.

†University of Paderborn, Faculty of Business Administration and Economics, Department of Taxation, Accounting and Finance, Warburger Str. 100, 33098 Paderborn, Germany.
Tel.: +49-5251-60 2914, e-mail: georg.schneider@wiwi.upb.de.

‡University of Paderborn, Faculty of Business Administration and Economics, Department of Taxation, Accounting and Finance, Warburger Str. 100, D-33098 Paderborn, Germany.
Tel.: +49-5251-60 5311, e-mail: csureth@notes.upb.de.

1 Introduction

The world-wide economic and financial crisis has exposed companies to an increased risk of loss.[4] At the same time tax authorities are in need of increasing tax revenues as they have accumulated tremendous amounts of public debt. The resulting politico-economic debate on whether to increase taxes raises the question how such reforms affect entrepreneurial investment behavior. Indeed, it is a well-known fact that the details of a tax system are highly relevant to optimal investment strategies.[5] It may hence be important to investors whether the government increases taxes by increasing profit taxation or by strengthening loss offset restrictions.

With regard to the impact of taxation on investment behavior the asymmetric design of worldwide tax systems deserves closer attention.[6] While profits are usually taxed once they are realized and hence trigger prompt tax payments, losses do not induce immediate tax rebates but at best can be offset against future profits.[7] Along with the delayed consideration of tax losses many jurisdictions provide further loss offset restrictions, such as timing restrictions and/or minimum taxation rules, which put losses at an additional tax disadvantage compared to profits.[8] At the latest since 1944, when Domar and Musgrave

[4]Not least, this trend is reflected by the high value of loss carryforwards in the financial statements of numerous business enterprises. See, e.g., Kager, Schanz and Niemann (2011), especially pp. 114-118, on German and Austrian corporations. The increasing relevance of loss-making companies in comparison to profitable corporations in the U.S. is addressed in the studies by, e.g., Altshuler et al. (2009) and Edgerton (2010), p. 936 f.

[5]On the impact of tax regulations on investment incentives see, e.g., already Lintner (1954), Brown (1962), and Sandmo (1974).

[6]Gutiérrez et al. (2011) provide an overview of loss compensation rules in industrialized nations. Endres et al. (2007) also give a detailed description of loss offset provisions across the EU.

[7]In their empirical study Cooper and Knittel (2006) investigate the loss offset behavior of U.S. corporations from 1993 to 2003 and show that around half of all losses is carried forward and mostly offset with considerable time delays. An additional third of all losses vanishes completely due to company closures, while around 10 to 20 percent are kept on the balance sheet but remain totally unused. See Cooper and Knittel (2006), p. 652.

[8]Only seven OECD countries allow for a loss carryback that is not subject to further preconditions regarding the size or (potential) closure of an enterprise. All of the OECD countries allow for loss carryforwards. Nevertheless, about one third of these countries restrict the time horizon of loss carryforwards from five to ten years. Moreover, minimum taxation rules and provisions regarding the purchase of corporate shells limit the firms' opportunities to make use of their losses.

published their seminal work, it has been a well-known fact that this inherent asymmetry can distort, i.e. typically discourage entrepreneurial investment decisions.

Apart from loss offset restrictions, in case of risky projects the degree of dynamic flexibility before and after initiating an investment project can also be a decisive factor for entrepreneurial investment policy. With regard to the discrimination of negative tax bases, waiting and abandonment options in particular can affect the value of an investment that is beset by losses. Against this background we investigate whether, under which conditions, and to what extent tax systems that treat profits and losses differently impact entrepreneurial investment timing decisions when the investor has the flexibility to delay the project and, under certain circumstances, to abandon it prematurely.

To analyze the impact of taxes on investment timing we apply an extended version of a time-discrete single-phase model similar to Schneider and Sureth (2010). Within this analytical framework, which incorporates an option to wait with uncertain future cash flows, we derive the optimal after-tax investment policy. We show that an asymmetric treatment of positive and negative tax bases can distort irreversible timing decisions and induce tax paradoxa that are non-existent within both a symmetric tax system and an asymmetric tax system in case of an abandonment option.

In our model a tax paradoxon occurs if the investor's willingness to invest, i.e., the propensity to invest early, increases due to a tax increase. Such a tax increase can have two shapes: first, the government may increase profit taxation or second, make the loss restriction rules more rigorous. When an investment is completely irreversible, we find that, under certain conditions derived in the following, both types of tax reform can accelerate investment.

From the tax authority's perspective, our findings provide helpful information to support discussions on how to shape profit and loss taxation so as to foster the designated fiscal incentives. Moreover, the results are helpful for investors facing timing decisions on risky projects.

The remainder of this study is organized as follows. The next section reviews relevant prior literature. Section 3 introduces our model, which reflects an investor's timing decision under uncertainty. As a benchmark scenario Section 4 first discusses the effects of a tax system that taxes profits and losses at an equal tax rate. In addition to an investment that is completely irreversible, it also includes a discussion of an investment alternative that is characterized by additional abandonment flexibility. In Section 5 we analyze the effects of an asymmetric taxation of profits and losses on investment timing. Finally, Section 6 summarizes our results and discusses their implications for future research.

2 Prior literature

Tax, accounting, and public finance researchers have studied the effects of (real-world) taxes on investment decisions for some decades.[9] The influence of asymmetric profit and loss taxation on investment behavior has also been discussed comprehensively. In their seminal work Domar and Musgrave (1944) show for the first time that loss offset restrictions can impede risky investments. Following this study, in the nineteen-sixties and nineteen-seventies many researchers, such as e.g., Mossin (1968), Näslund (1968), Feldstein (1969), Stiglitz (1969), Russel and Smith (1970), and Allingham (1972) used different modeling techniques and methods of optimization to verify and generalize these findings. Since then

[9] Neutral tax systems serve as a benchmark when evaluating real-world tax regimes and their influence on investment decisions. Important examples of such neutral tax systems under certainty are the cashflow tax and the taxation of the true economic profit. See Brown (1948), Samuelson (1964), Johansson (1969), Boadway and Bruce (1984), and Bond and Devereux (1995). Neutral tax systems under uncertainty are discussed by Niemann (1999), Panteghini (2001a, 2001b, 2005), Sureth (2002), and Niemann and Sureth (2004, 2005).

the body of literature dealing with the effects of asymmetric tax regulations on business decisions has steadily increased as researchers extended the aforementioned studies to include additional (tax) details and new research methods.[10] Yet most of these studies do not account for the value of flexibility, such as waiting or abandonment options. Here, the real option theory is one framework to capture these dynamic characteristics of business decisions under uncertainty and (partial) irreversibility.[11]

Against that background, both accounting and tax researchers started to incorporate real option theory into their studies. Recently, in (tax) accounting, e.g., Andrés-Alonso et al. (2006) provide empirical evidence that real options are an important component of the overall market value of high-tech companies. Furthermore, empirical studies on the abandonment option hypothesis (Hayn 1995, Berger et al. 1996, Joos and Plesko 2005), which implies that shareholders will abandon their investment if losses are expected to continue, indicate larger positive price responses to losses in case of a small likelihood of exercising the exit option. Darrough and Ye (2007) especially focus on the valuation of firms reporting losses. Extending previous research suggesting that the market value of such firms should highly depend on the abandonment and adaptation options for its assets, the authors explore additional value drivers and highlight the value relevance of hidden assets, which are not captured by the accounting system. Denison (2009) uses experimental methods to show that applying real options in capital budgeting can improve decisions on risky projects. Grasselli (2011) assesses the properties and the value of a finite-time option to invest in the absence of complete markets. The author shows that it is time

[10] See, e.g., Schneider (1980), Bamberg and Richter (1984), and Eeckhoudt, Gollier and Schlesinger (1997) integrate progressive tax systems. Auerbach (1986) uses dynamic programming while Majd and Myers (1987) apply numerical simulations to identify the effects that are due to loss offset restrictions. Moreover, Auerbach and Poterba (1987), Mintz (1988), and Altshuler and Auerbach (1990) discuss the empirical relevance of loss offset restrictions and provide evidence of their quantitative relevance in the U.S.

[11] On the fundamentals of real option theory see Myers (1977), Dixit and Pindyck (1994), and Trigeorgis (1996).

flexibility itself rather than the spanning property that is pivotal for the option value.

Although there are a multitude of papers dealing with real options in decision making and firm valuation, timing decisions themselves are rarely an issue. However, Hirth and Uhrig-Homburg (2010) apply a real option-based model to analyze the investment timing of companies that face external financing constraints. Depending on the liquidity level of a firm, the authors show that financing costs can accelerate or decelerate investment. Alpert (2010) investigates the early exercise of financial call options and includes taxes into the decision calculus, showing that taxes can be decisive in explaining a great deal of early exercise events.

Tax analyses that incorporate managerial flexibility into the analyses of real investment decisions often abstract from negative tax bases at all or assume a uniform tax treatment of current operating profits and losses.[12] Schneider and Sureth (2010) also assume a symmetric tax regime with an immediate and complete tax refund in case of a loss. Within a binomial model the authors investigate the interdependencies between a profit tax and a) an option to wait and b) an abandonment option. They find that an increased profit tax can foster the investors' willingness to invest. This paradoxical tax effect is due to the existence of the abandonment option as this effect is non-existent when the investor has no exit flexibility.

However, some studies on the effects of asymmetric taxation on investment decisions do indeed exist for scenarios with *entry flexibility*. In due consideration of an option to wait MacKie-Mason (1990) investigates the impact of nonlinear tax policies on asset values and investment when prices are uncertain. Although he focuses on the effects of a particular U.S. tax rule, namely the U.S. percentage depletion allowance, he also accounts for the

[12] See, e.g., Pennings (2000), Agliardi (2001), Alvarez and Koskela (2008), Niemann (2011), and Niemann and Sureth (2011).

effects of tax loss asymmetries by distinguishing between a tax system that grants a full loss offset and a tax rule without loss tax refunds. He finds a tax paradoxon, i.e., increasing the corporate tax can encourage investment as it leads to a decrease in the risky value of waiting. However, this effect, which is caused by changing the government's share of project risk, is derived explicitly only in the full-refunds case. It hence remains unclear whether and to what extent similar effects occur if tax losses are not fully refundable. Unlike most of the studies cited above, Panteghini (2001a) shows in a setting with and without policy uncertainty and an option to delay that asymmetric tax schemes are not necessarily distortive. He uses a tax regime without interest taxation where the tax base is equivalent to the difference between the firm's return net of an imputation rate. Tax refunds are not allowed if the company's return is less than the imputation value. Even though taxation is asymmetric, the author shows that there is a set of imputation factors that ensure tax neutrality. More precisely, for a tax regime to be neutral the imputation factor has to be sufficiently high to compensate for the distortions caused by the lack of full loss refundability. In conclusion, Panteghini (2001a) proves that under certain conditions, incomplete loss offset provisions do not affect entrepreneurial timing decisions. Panteghini (2001b) generalizes these results by relaxing some assumptions and showing that under the expanded model framework a neutral tax system still exists. Within a continous-time model Panteghini (2005) then extends his own analyses to include two-step investments and (partially) reversible decisions. In all of his studies Panteghini focuses on determining neutrality conditions, i.e. determining the characteristics of the tax system that are necessary to ensure this specific regime does not impact the firm's decision on whether to invest or wait.

By contrast, the approach we take highlights the impact of increasing taxes on investment timing for a tax system that turns out to be inherently distortive. Furthermore, we analytically identify conditions for so-called normal and paradoxical effects.

Apart from the above mentioned studies that account for waiting options there are some other analyses that capture *exit flexibility*. For instance, Agliardi and Agliardi (2008) do not focus on investment but rather on divestment decisions. They use a continuous-time real option model to analyze the impact of progressive taxation on entrepreneurial liquidation decisions. The authors show a progressive tax schedule to be non-neutral since it can accelerate or decelerate closure policy. Wong (2009), who extends the work of Agliardi and Agliardi (2008) to include equity-financed companies, in particular, confirms these findings. In an additional study Agliardi and Agliardi (2009) again analyze whether and in what direction taxes affect the optimal liquidation policy. Within a real option model they distinguish between progressive and linear tax scales on the one hand and between full and partial loss offset provisions on the other hand. They show that both kinds of tax scale distort divestment decisions if losses are not fully deductable.

All of the aforementioned studies provide first insights into the interactions of tax loss asymmetry and investment timing under uncertainty and flexibility. Yet none of them allow for general analytical statements on the influence of different degrees of loss offset restrictions on entrepreneurial investment decisions in the presence of timing and abandonment flexibility. To close this gap, we develop an analytical model that incorporates both an entry and an exit option and analyze the effects of complete and incomplete loss offset compensation rules on investment timing. Moreover, we derive conditions for different types of investment effects. Unlike the studies that are based on option pricing methods we stick to a time-discrete model with uncertainty captured by a binomial random variable. This model allows for analytical solvability while enabling us to identify and interpret the tax effects on timing decisions.

3 Model framework

3.1 Basic model with future cash flow uncertainty

In accordance with the work of Schneider and Sureth (2010) we consider a risk neutral entrepreneurial investor that, at the time of decision $t = 0$, uses their own financial resources to invest in a real investment project.[13] The investment can be realized at two different points of time. The investor can choose to either invest immediately, i.e., at the decisive point of time $t = 0$, or they can postpone the investment to a pre-specified future date $t = 1$ in the hope of better conditions and higher investment earnings. However, either way the decision has to be made at $t = 0$. If the investor decides to invest straight away at date $t = 0$, they have to pay an initial outlay $I > 0$ and simultaneously receive a deterministic cash flow CF_0 from the project. In contrast to a future investment, which is affected by uncertainty, we assume a deterministic early cash flow since it is realized time-invariantly.[14] Furthermore, we presume the $t = 0$ -investment is not unprofitable, i.e., $CF_0 \geq I$.

If, on the other hand, the investor decides to delay the investment, until $t = 1$ they will invest funds in the capital market to earn the risk-free market rate of return r. The initial outlay for a delayed investment, payable in $t = 1$, amounts to βI. Here, $\beta > 0$ captures the either positive or negative growth in investment costs between the investment dates $t = 0$ and $t = 1$. In contrast to the immediate investment opportunity, which earns a deterministic cash flow, future cash flows in $t = 1$ are subject to uncertainty. Here,

[13]The assumption of risk neutrality facilitates the analysis and allows us to identify the basic effects. Even though the analytical integration of risk averse investors is desirable, the attention to risk neutral investors is appropriate because investors can eliminate the risk inherent in a single investment project by diversifying their portfolios.

[14]Since this assumption may be crucial for our results derived below, we relax this restriction and test whether the results are valid in a setting with uncertain cash flows in $t = 0$ and $t = 1$ as well. See Section 3.2 and further discussion in Sections 4 and 5.

stochasticity is modeled as a binary random variable. With a probability of 50% the good state of nature leads the project to generate a surplus of $P_1 = \alpha(CF_0 + 1) - \beta I > 0$. Likewise, in case of the bad state of nature the investor suffers a loss of $L_1 = \alpha(CF_0 - 1) - \beta I < 0$ with equal probability. The parameter $\alpha > 0$ denotes the growth in (expected) cash flows between the investment dates $t = 0$ and $t = 1$. At the time of decision $t = 0$ the investor cannot anticipate the future state of nature.

Where the delayed investment is concerned, two different scenarios are possible, both of which are incorporated into our analyses.

Irreversible investment: The investor's decision at $t = 0$ is irreversible. If they decide at $t = 0$ to postpone the investment to $t = 1$, they are obliged to realize the project in the future. That is, once the project is initiated, the investor is committed to their decision and cannot withdraw from the arrangement even if the investment generates a loss. Figure 1 illustrates the timing decision in case of no abandonment flexibility.[15]

[Insert Figure 1 here]

Reversible investment: If the investor decides to delay the investment and realize the risky project at $t = 1$, they can observe the state of nature and then react to new information available at $t = 1$. Specifically, the investor now has the option to refrain from the originally planned delayed investment and can prematurely abandon it. If the investor abandons the project in case of a loss, they neither have to pay the initial outlay βI nor do they receive the investment cash flow L_1. As there are no investment payments, in the bad state the investor realizes neither profits nor losses. The decision tree in the extended scenario with an exit option is depicted in Figure 2.[16]

[15] See Schneider and Sureth (2010), p. 156 for a similar illustration.
[16] See Schneider and Sureth (2010), p. 159 for a similar illustration.

[Insert Figure 2 here]

Profits from the real investment are taxed at a proportional tax rate $\tau_p \in (0;1)$, while losses are subject to a linear tax rate $\tau_l \in (0;1)$[17]. By assumption, this stylized profit tax is the only tax that applies to income from the real investment.[18]

Unlike profits, which are taxed promptly on realization, in real-world tax systems losses do not normally trigger an immediate tax reimbursement. At best, negative tax bases can be offset against future profits causing a deferral of the tax refund. Beyond this time-induced discrimination of tax losses, they can even expire (partially) due to there being other loss offset restrictions, such as an upper limit on the number of periods to which losses can be carried forward. Altogether, the asymmetric treatment of positive and negative tax bases implies that losses are put at a tax disadvantage, i.e., the present value of the refund induced by a tax loss is less than the tax payment triggered by a corresponding profit.[19] Although loss offset restrictions can cause two different types of tax effects, namely time and base effects, both of them can be captured assuming a lower (effective) tax rate for losses. Therefore, the relation $\tau_p \geq \tau_l$ applies. The lower the tax rate τ_l, the more restrictive the loss compensation rules.

We assume the investment object to be completely depreciable in the period of acquisition.[20] The tax base is hence computed as the difference between the cash flow resulting from the investment and the depreciation allowance. Even though we call this a "profit tax", in this respect the underlying tax system is similar to a cash flow-oriented tax.

[17] If $\tau_l = 0$, a tax loss remains completely irrelevant for tax purposes. For mathematical convenience and to keep the intervals for profit and loss tax rates symmetric, we exclude this special case from our investigation since its integration does not yield new insights.

[18] By assumption, no capital gains accrue so that we can abstract from capital gains taxation.

[19] Based on data from U.S. corporations in the fiscal years 1993 to 2004 Cooper and Knittel (2010) estimate that loss offset restrictions erode the real value of a tax loss by more than 50%. See Cooper and Knittel (2010), pp. 34, 40 f.

[20] In this respect our investigation differs from the model chosen by Schneider and Sureth (2010) who restrict their analysis to capitalized investments.

Despite this similarity, which is primarily caused by the one-period lifetime and full depreciation of the asset in its acquisition period, the underlying tax system is not exactly a cash flow tax. Therefore, we keep on using the term "profit tax" for further discussion.

Again, as an alternative to the real investment, the investor can invest their funds in a capital market opportunity and earn the risk-free interest rate r. Interest accrued by the financial investment are subject to a final flat rate tax τ_f.[21] Therefore, the after-tax capital market rate of return is $r_f = r(1 - \tau_f)$.

3.2 Extended model with overall cash flow uncertainty

The design of the basic model with uncertainty of future cash flows only while immediate cash flows are deterministic might be crucial for the analytical outcome of our investigation. Therefore we additionally apply an extended version of the model to test whether the results of the basic model remain robust within a more complex setting with overall cash flow uncertainty. More precisely, we relax the assumption of the immediate cash flow being deterministic and profitable. All other assumptions being equal, we instead assume that early investment earns an uncertain cash flow as well. In correspondence with delayed investment, there are two different states of nature for immediate investment, both of which are equally probable. In the good state the immediate investment earns a surplus of $P_0 = CF_0 + 1 - I > 0$. By contrast, in the bad state of nature the investment generates a loss amounting to $L_0 = CF_0 - 1 - I < 0$. Figure 3 illustrates the timing decision within the extended model if the investor faces no abandonment flexibility.

[Insert Figure 3 here]

[21] Prominent examples of tax systems that tax income from real investment at a different tax rate than income from financial investment are the dual income tax regimes in Austria, Germany, and Scandinavian countries.

Accordingly, Figure 4 depicts the decision tree if the investor can abandon the investment project in case of an unfavorable development of investment cash flows.[22]

[Insert Figure 4 here]

The modeling of reversible immediate investment is analogous to the exit option in case of future investment. If the investor decides to realize the investment at $t = 0$, they can first observe the state of nature and react to new information. If the project generates a loss in $t = 0$, they can refrain from the originally planned investment and therefore realize neither profits nor losses.

3.3 Assessment of tax effects

To identify, measure, and assess the impact of taxes on the investor's willingness to invest, we first need an appropriate decision criterion. By assumption, the risk-neutral investor decides on an investment alternative based on the (expected) after-tax net present value of the investment cash flows. To optimize the timing decision they hence compare the (expected) after-tax net present value of an immediate investment (NPV_0 or $E[NPV_0]$) to the expected after-tax net present value of a delayed investment ($E[NPV_1]$). However, the investor will only opt for the real investment at $t = 0$ or $t = 1$ if it is at least as advantageous as the financial investment and hence earns a non-negative net present value. The investor's decision rule reads as

$$\max\{0, NPV_0, E[NPV_1]\}.$$

[22]To avoid distortions arising from different degrees of flexibility for early and delayed investment we consider a setting in which the investor can exit both early and late investment in case of a loss. If, alternatively, the investor could only exit delayed investment, he would suffer a loss from immediate investment while delayed investment is profitable in either case. Therefore, such setting would add further asymmetries to the decision structure leading to very complex joint tax and flexibility effects.

in the basic model and

$$\max\{0, E[NPV_0], E[NPV_1]\}$$

in the extended model. As, by assumption, the immediate real investment yields an (expected) cash flow that is at least as high as the investment outlay I, in present value terms this investment is at least as profitable as the financial investment.[23] Therefore, the investor's decision rule simplifies to

$$\max\{NPV_0, E[NPV_1]\} \tag{1}$$

and

$$\max\{E[NPV_0], E[NPV_1]\}, \tag{2}$$

respectively.

In addition to determining the investor's decision criterion we also need to interpret and evaluate the tax effects we found. For this purpose we apply the concept of investment neutrality, which states that a tax system is neutral if taxation does not distort investment decisions at all. More precisely, within our model we assume a tax system to be *neutral* if "the Brown condition with the option to delay"[24] is met. This condition is based on Brown (1948) who developed the characteristics of the neutral cash-flow tax. Many years later Panteghini (2001a) extended the condition to include waiting options, assuming a unique tax rate τ for all types of taxable income:

$$(NPV_0 - T_0) - (NPV_1 - T_1) = (1-\tau)(NPV_0 - NPV_1). \tag{3}$$

[23] Our model framework requires this premise due to the split tax rate on profits and losses. Since the real investment project is profitable if realized immediately, the tax profit is subject to the profit tax rate τ_p while a tax deficit would be subject to the tax rate τ_l.
[24] Panteghini (2001a), p. 276.

T_0 and T_1 denote the tax payments of the periods $t = 0$ and $t = 1$, respectively. If this equation is satisfied, the pre-tax ranking order of the investment alternatives does not change when taxes are levied so that taxation does not distort investment timing decisions.[25] In contrast to Panteghini (2001a), who abstracts from taxation of interest income, we levy a final tax on interest payments. Therefore, in the following the above condition cannot be satisfied in its pure form. Nevertheless, we can use the condition to verify whether taxation induces distortions or not by focusing on those tax parameters that relate to the real investment. Abstracting from distortions caused by interest taxation we assume that a tax system is neutral with regard to entrepreneurial investment timing decisions if equation (3) is met for the real investment parameters.

By contrast, we assume a tax system to be *distortive* if condition (3) is not satisfied with regard to the real investment tax parameters. In that case, the tax effects need to be further analyzed and we distinguish between expected (normal) and rather unexpected (paradoxical) effects. *Normal effects* occur if increased taxes, i.e., higher profit taxes or stricter loss compensation rules, decrease the investor's willingness to invest. Since a delayed investment can be interpreted as a decrease in the investor's willingness to invest, we have normal effects if higher taxes less frequently induce the decision-maker to choose an immediate investment. By contrast, we have *paradoxical effects* if increased taxes increase the investor's willingness to invest, i.e., if they lead more often to an earlier investment.[26]

4 Effects of symmetric profit and loss taxation

As a benchmark scenario we use a system, which symmetrically taxes profits and losses, i.e., we assume that positive and negative tax bases are taxed uniformly at a tax rate

[25] See Johansson (1969), and Panteghini (2001a), pp. 274-276.
[26] In this respect we adopt the approach of Schneider and Sureth (2010).

$\tau = \tau_p = \tau_l$.[27]

4.1 Optimal investment timing without abandonment option

First, we abstract from an abandonment option and assume that the investor takes an irreversible decision at $t = 0$, as depicted in Figures 1 and 3. Whatever investment alternative they choose, they are committed to this decision even if the investment generates a loss and hence have to realize the project at either $t = 0$ or $t = 1$.

The investor realizes the project at $t = 0$ if an immediate investment exceeds a delayed investment in (expected) net present value terms and vice versa:

$$\begin{aligned} &\max\left\{NPV_{0,sym}, E[NPV_{1,sym}]\right\} \\ =&\max\left\{E[NPV_{0,sym}], E[NPV_{1,sym}]\right\} \\ =&\max\left\{(1-\tau)(CF_0 - I), (1-\tau)\frac{\alpha CF_0 - \beta I}{1+r_f}\right\}. \end{aligned} \tag{4}$$

Using this maximum constraint in the basic and the extended model we find a cash flow cut-off level CF^* that makes the investor indifferent to either investing immediately or delaying the project. If the currently observed cash flow exceeds or falls below the cash flow threshold, the investor will choose either an immediate or a delayed investment. That is, the investment threshold CF^* exactly captures the cash flow level that induces a change in the optimal timing decision.[28] Taking into account that the investment cash

[27] Although worldwide tax codes do not provide immediate tax reimbursements in case of losses, profits and losses are de facto treated symmetrically whenever losses generated by a project can be offset without restrictions against profits earned by other projects in the same tax period. Schneider and Sureth (2010) also assume a perfect loss offset.

[28] The investment threshold indicates whether the investor should invest immediately or rather delay the investment. Whether immediate or delayed investment is optimal when the actual cash flow exceeds the threshold level particularly depends on the growth parameter α and its relation to the investor's

flow is higher than I, in the symmetric case the threshold reads as

$$CF^*_{0,sym} = \max\{I, \frac{I(1 - \frac{\beta}{1+r_f})}{(1 - \frac{\alpha}{1+r_f})}\}. \tag{5}$$

Obviously, the cut-off level solely depends on the investment outlay and the ratio of the growth parameters α and β to the after-tax cost of capital. Taxation of the real investment, captured by the unitary tax rate $\tau = \tau_p = \tau_l$, is irrelevant to the investor's timing decision. Regardless of whether the investment is profitable or loss-making, taxation of the real investment proceeds does not affect the investor's willingness to invest. Equation (3) is satisfied if we only focus on the real investment parameters:

$$(E[NPV_{0,sym}] - T_0) - (E[NPV_{1,sym}] - T_1) = (1 - \tau)(E[NPV_{0,sym}] - E[NPV_{1,sym}]). \tag{6}$$

Apart from those distortions that are induced by interest taxation the pre-tax and post-tax investment threshold are identical. As we focus on those tax effects that arise from real investment, we can conclude that a tax system that treats profits and losses symmetrically is neutral with respect to real investment timing decisions.[29]

4.2 Optimal investment timing with abandonment option

Again, the investor decides to invest at $t = 0$ if the (expected) after-tax net present value of the immediate investment is higher than the expected net present value of the delayed investment and vice versa. However, now the investor is not committed to the decision they

cost of capital.

[29] However, Schneider and Sureth (2010) provide evidence that a symmetric tax system can likewise induce distortions. This divergent result is the outcome of the authors' assumption of capitalized investments as opposed to our model, which assumes depreciable assets.

take at $t = 0$, i.e., they can abandon the project in case cash flows develop unfavorably. They exercise the abandonment option in the bad state of nature as they would otherwise suffer an investment loss. Therefore, in the basic model setting the probability of realizing the investment project at $t = 1$ is only 50%. Within the extended model the likelihood of realizing either of the investment projects is 50% each. The investor hence acts according to the decision rule

$$\max\left\{(1-\tau)(CF_0 - I), \frac{1}{2}(1-\tau)\frac{\alpha(CF_0+1)-\beta I}{1+r_f}\right\} \tag{7}$$

if the basic model applies and

$$\max\left\{\frac{1}{2}(1-\tau)(CF_0 + 1 - I), \frac{1}{2}(1-\tau)\frac{\alpha(CF_0+1)-\beta I}{1+r_f}\right\} \tag{8}$$

in case of the extended model.

The investment thresholds for a reversible investment derived from these conditions in the basic and extended model are

$$CF_{0,rev}^{*,bas} = \max\{I, \frac{I(1-\frac{1}{2}\frac{\beta}{1+r_f}) + \frac{1}{2}\frac{\alpha}{1+r_f}}{1-\frac{\alpha}{1+r_f}}\} \tag{9}$$

and

$$CF_{0,rev}^{*,ext} = \max\{I, \frac{I(1-\frac{\beta}{1+r_f})}{1-\frac{\alpha}{1+r_f}} - 1\}, \tag{10}$$

respectively. Again, taxation of the real investment does not affect optimal investment timing.[30] We have

$$(E[NPV_{0,rev}] - T_0) - (E[NPV_{1,rev}] - T_1) = (1-\tau)(E[NPV_{0,rev}] - E[NPV_{1,rev}]). \quad (11)$$

This result holds regardless of whether the tax system allows for an immediate tax loss offset or provides loss offset restrictions.[31]

5 Effects of asymmetric profit and loss taxation

Moving away from the assumptions of the previous section, we now assume that tax losses are discriminated against tax profits, i.e., we have $\tau_l < \tau_p$. The present value of the tax refund in case of a loss is, in fact, lower than the present value of the tax liability caused by a corresponding profit.[32]

5.1 Optimal investment timing without abandonment option

If the investor cannot exit the project, it is no longer possible to provide evidence that "the Brown condition with the option to delay" is satisfied. To gain insight into the effects of tax asymmetries on timing decisions we subsequently investigate the influence of the tax parameters on the critical cash flow level.

Again the decision-maker invests at $t = 0$ whenever the (expected) net present value of the immediate investment is greater than the expected net present value of the delayed

[30] Using our model framework with depreciable investments we hence cannot approve the paradoxical tax effect derived by Schneider and Sureth (2010) who find that an abandonment option can trigger tax paradoxa in a symmetric tax system.

[31] For further discussion see also the remarks in Section 5.2.

[32] This asymmetric tax treatment of profits and losses can be due to either delayed tax refunds, partial expiration of tax loss carryforwards, or minimum taxation rules.

investment and vice versa. Within the basic model this condition reads as

$$\max\left\{(1-\tau_p)(CF_0-I), \frac{1}{2}(1-\tau_p)\frac{\alpha(CF_0+1)-\beta I}{1+r_f}+\frac{1}{2}(1-\tau_l)\frac{\alpha(CF_0-1)-\beta I}{1+r_f}\right\} \tag{12}$$

while in the extended model we have

$$\begin{aligned}&\max\{\frac{1}{2}(1-\tau_p)(CF_0+1-I)+\frac{1}{2}(1-\tau_l)(CF_0-1-I),\\ &\frac{1}{2}(1-\tau_p)\frac{\alpha(CF_0+1)-\beta I}{1+r_f}+\frac{1}{2}(1-\tau_l)\frac{\alpha(CF_0-1)-\beta I}{1+r_f}\}.\end{aligned} \tag{13}$$

The critical cash flow thresholds, which result from the direct comparison of the (expected) net present values for an immediate and delayed investment in both the basic and the extended model, amount to

$$CF_{0,asym}^{*,bas}=\max\left\{I, \frac{I(1-\tau_p+\frac{\beta}{1+r_f}(\frac{\tau_p+\tau_l}{2}-1))+\frac{1}{2}\frac{\alpha}{1+r_f}(\tau_l-\tau_p)}{1-\tau_p+\frac{\alpha}{1+r_f}(\frac{\tau_p+\tau_l}{2}-1)}\right\} \tag{14}$$

and

$$CF_{0,asym}^{*,ext}=\max\{I, \frac{I(1-\frac{\beta}{1+r_f})}{1-\frac{\alpha}{1+r_f}}-\frac{\frac{1}{2}(\tau_l-\tau_p)}{1-\frac{\tau_p+\tau_l}{2}}\}, \tag{15}$$

respectively. The implementation of an asymmetric tax treatment of profits and losses means that now the timing decision is no longer independent of the taxation of the real investment. As opposed to the symmetric tax system, now not only is the relation between the growth parameters α and β and the investor's after-tax capital costs $(1+r_f)$ crucial to the timing decision, but also the value of the split income tax rate. Therefore, it is evident that “the Brown condition with the option to delay” cannot be satisfied. The asymmetric tax regime is distortive.

The resulting question whether asymmetric taxation induces normal or paradoxical effects can be answered by identifying the change in the optimal investment policy caused by a variation in the real investment tax parameters. Therefore, we subsequently investigate the impact of modifying τ_l and τ_p on the investment threshold in both the basic and the extended model setting.

5.1.1 Effects of loss taxation under future cash flow uncertainty

To begin with, we focus on the basic scenario and analyze whether tax increases induce rather normal or paradoxical tax effects when immediate cash flows are deterministic while future cash flows are subject to uncertainty. Within our model framework tax increases can take two different forms: The tax legislator can either strengthen loss compensation rules or increase profit taxes.

The effects that are driven by the degree of loss offset restrictions, captured by τ_l, can be derived directly from condition (12). As the immediate investment alternative, by assumption, does not suffer any losses, the parameter τ_l does not affect the net present value of early investment NPV_0. Only the expected net present value of the delayed investment alternative changes with a variation in the loss tax rate τ_l. This value, which reads as

$$E[NPV_{1,asym}] = \frac{1}{2}(1-\tau_p)\frac{\alpha(CF_0+1)-\beta I}{1+r_f} + \frac{1}{2}(1-\tau_l)\frac{\alpha(CF_0-1)-\beta I}{1+r_f},$$

is composed of two components. The first addend captures the 50% chance of realizing a tax surplus that is subject to profit taxation. The second addend captures the loss that the investor can suffer with the same probability. The loss is subject to loss offset restrictions but always induces a tax reimbursement when $\tau_l > 0$. As the tax refund increases in τ_l, the net present value of the delayed investment increases in τ_l as well, i.e.,

$$\frac{\partial E[NPV_{1,asym}]}{\partial \tau_l} = -\frac{1}{2}\frac{\alpha(CF_0 - 1) - \beta I}{1 + r_f} > 0. \tag{16}$$

Stricter loss compensation rules induce the decision-maker to prefer the immediate investment alternative. That is to say, a deterioration in the investor's tax position by stricter loss offset rules causes faster investment and hence paradoxical tax effects. Although the notion *paradoxical* suggests that these effects are unexpected, this result is quite intuitive. In our model setup only the delayed investment alternative is subject to the loss tax rate. It thus appears that stricter loss compensation rules inevitably raise the investor's willingness to invest immediately.

[Insert Figure 5 here]

The situation is illustrated in Figure 5 that exemplifies three possible alternative outcomes of $E[NPV_{1,asym}]$. Obviously, NPV_0 does not depend on τ_l. Conversely, $E[NPV_{1,asym}]$ increases in τ_l. Two extreme cases are depicted by $E[NPV^{I}_{1,asym}]$ and $E[NPV^{III}_{1,asym}]$. For $E[NPV^{I}_{1,asym}]$ an immediate investment is always optimal while in the case of $E[NPV^{III}_{1,asym}]$ delayed investment is favorable. The most interesting case is depicted by $E[NPV^{II}_{1,asym}]$. Here, early investment is optimal for all tax rates with $\tau_l < \tau_l^*$. By contrast, in the case of $\tau_l > \tau_l^*$, delayed investment is more attractive than immediate investment. If $\tau_l = \tau_l^*$, the investor is indifferent to the two options. In that case, a reduction of τ_l undoubtedly increases the relative attractiveness of the immediate investment. According to our definition we can hence identify paradoxical tax effects.

5.1.2 Effects of profit taxation under future cash flow uncertainty

To analyze the impact of profit taxes on investment behavior, let the net present values of immediate and delayed investment NPV_0 and $E[NPV_{1,asym}]$ be linear functions of $(1-\tau_p)$. We hence have

$$NPV_0(\tau_p) = a_1 + b_1(1 - \tau_p) \text{ and } E[NPV_{1,asym}(\tau_p)] = a_2 + b_2(1 - \tau_p).$$

The parameters a_t and b_t read as $a_1 = 0$, $b_1 = CF_0 - I$, and

$$a_2 = \frac{1}{2}(1 - \tau_l)\frac{\alpha(CF_0 - 1) - \beta I}{1 + r_f}\ ,\ b_2 = \frac{1}{2}\frac{\alpha(CF_0 + 1) - \beta I}{1 + r_f}.$$

On the basis of our assumptions, $a_2 < 0$ applies. Henceforth, independently of the remaining parameters we always have $\lim_{\tau_p \to 1} NPV_0(\tau_p) > \lim_{\tau_p \to 1} E[NPV_{1,asym}(\tau_p)]$. In the extreme case with a profit tax that converges towards 100% the investor always prefers early investment. This result can be explained as follows. Profit taxation reduces the entire after-tax value NPV_0 that converges towards zero for very high tax rates. At investment date $t = 1$ the investor loses their entire profit in the good state. However, if the investor suffers a loss in the bad state, the lower tax rate τ_l applies. Independently of all other parameters the expected net present value $E[NPV_{1,asym}]$ is negative.

Obviously, an investment at $t = 1$ can only be advantageous if $b_1 < b_2$. Therefore, it is a necessary condition for delayed investment to be favorable that

$$CF_0 - I < \frac{1}{2}\frac{\alpha(CF_0 + 1) - \beta I}{1 + r_f}.$$

This condition is more likely to be satisfied if α takes high and/or β takes small values. Moreover, a small after-tax interest rate r_f benefits the delayed investment alternative. The situation is depicted in Figure 6. The functions $E[NPV^{I}_{1,asym}]$ and $E[NPV^{II}_{1,asym}]$ capture both feasible cases ($b_2 \leq b_1$ and $b_2 > b_1$).

[Insert Figure 6 here]

If we have $b_2 \leq b_1$, immediate investment is optimal at all times, i.e., independently of the value of τ_p.

However, if we have $b_2 > b_1$, the net present value functions NPV_0 und $E[NPV^{II}_{1,asym}]$ can cross, as depicted in Figure 6. In this case there is a threshold level τ^*_p such that delayed investment is optimal for low tax rates $\tau_p < \tau^*_p$, while immediate investment is advantageous for high tax rates $\tau_p \geq \tau^*_p$. This setting occurs whenever the difference of the slopes of the net present value functions is sufficiently large. If $\tau_p < \tau^*_p$, a tax increase can stimulate early investment. If the difference of the function slopes is not big enough, there is no intersection and immediate investment is invariably more beneficial to the investor than delayed investment.

Based on the previous discussion, we subsequently show that tax effects are paradoxical rather than normal if the net present value functions have a point of intersection. For this purpose, the net present values are respectively presented as functions of the variables τ_p

and CF_0. For each value of CF_0 the difference

$$E[NPV_{1,asym}(CF_0, \tau_p)] - NPV_0(CF_0, \tau_p)$$

is negative, either unexceptionally or for those τ_p that are equal to or exceed the threshold level $\tau_p^*(CF_0)$. A negative difference implies that an early investment is more advantageous than a delayed investment. We now assume that $B(\tau_p)$ denotes the set of cash flow values CF_0, depending on τ_p, which trigger immediate investment. A paradoxical tax effect occurs if for any $\tau_{p1} < \tau_{p2}$ we have $B(\tau_{p1}) \subset B(\tau_{p2})$. For $CF_0 \in B(\tau_{p1})$ we obtain

$$E[NPV_{1,asym}(CF_0, \tau_{p1})] - NPV_0(CF_0, \tau_{p1}) < 0.$$

Since this inequation is satisfied for every tax rate $\tau_p > \tau_p^*(CF_0)$, it is fulfilled for τ_{p2} in particular. Therefore, we have

$$E[NPV_{1,asym}(CF_0, \tau_{p2})] - NPV_0(CF_0, \tau_{p2}) < 0$$

and thus $B(\tau_{p1}) \subset B(\tau_{p2})$. The inclusion is stringent if the inequations

$$\tau_{p1} < \tau_p^*(CF_0) < \tau_{p2}$$

are satisfied for at least one value of CF_0. The problem is illustrated in Figure 7.

[Insert Figure 7 here]

The indifference curve indicates that immediate investment is optimal for each value of CF_0 exceeding the threshold $\tau_p^*(CF_0)$. The plotted verticals illustrate the sets of cash flows in τ_{p1} and τ_{p2} that trigger early investment, i.e., they describe $B(\tau_{p1})$ and $B(\tau_{p2})$. As $B(\tau_{p1}) \subset B(\tau_{p2})$, obviously, increasing tax rates imply an increased set of cash flow values that foster immediate investment. Hence, increasing profit taxes can accelerate investment and figure 7 illustrates a scenario with a paradoxical tax effect.

5.1.3 Tax effects under overall cash flow uncertainty

The effects induced by a variation of profit and loss taxation within the extended model can best be discussed if we assume the growth parameters α and β to be equal. Although the results remain unchanged in case of relaxing this assumption, which hence is not pivotal for the discussion, it allows for a more intuitive and straightforward line of argument.[33]

If $\alpha = \beta$, the expected net present values of early and late investment read as

$$E[NPV_0] = \frac{1}{2}(1-\tau_p)P_0 + \frac{1}{2}(1-\tau_l)L_0 \tag{17}$$

and

$$E[NPV_1] = \frac{1}{2}(1-\tau_p)\frac{\alpha}{1+r_f}P_0 + \frac{1}{2}(1-\tau_l)\frac{\alpha}{1+r_f}L_0 \tag{18}$$

with $P_0 = CF_0 + 1 - I$ being the profit in the good state of nature and $L_0 = CF_0 - 1 - I$ being the loss in the bad state of nature at $t = 0$. Comparing equations (17) and (18) it becomes obvious that they are built of the same components, namely a 50%-chance that the investor realizes a profit subject to profit taxation and a probability of 50% that they

[33] If we relax this premise and assume that $\alpha \neq \beta$, we can also prove this outcome determining analytically the investment threshold and interpreting its partial derivatives.

suffer a loss subject to loss taxation. The only difference between the two equations is the additional multiplier $\frac{\alpha}{1+r_f}$ in equation (18) that captures the discounting effect due to the time lag between the alternative investment dates. Evidently, it is exactly this discounting factor that is crucial for the investment timing decision. If investment growth exceeds the after-tax cost of capital, i.e., if $\alpha > 1+r_f$, both the profit and loss from delayed investment are higher than the profit and loss from immediate investment. Therefore, an increase of profit taxation inevitably raises the relative attractiveness of immediate investment as the advantage of late investment, namely a higher potential profit, is reduced while the disadvantage, namely a higher potential loss, remains unchanged. Similarly, tighter loss compensation rules inevitably increase the relative attractiveness of early investment since they aggravate the potential disadvantage of suffering a higher loss from late investment. To sum up, whenever $\alpha > 1+r_f$, both higher profit taxes and stricter loss offset provisions induce paradoxical tax effects. On the other hand, if $\alpha < 1 + r_f$, only normal tax effects occur.

5.2 Optimal investment timing with abandonment option

Apparently, a tax system that provides loss offset restrictions induces no distortions given the investor can abandon the project at no additional cost. In that case an asymmetric tax regime is perfectly comparable to a symmetric tax system. Since the investor abandons the investment in the bad state, they avoid tax losses. In this respect, the asymmetric treatment of tax profits and losses is irrelevant to their timing decision. Also, a tax system that provides loss offset restrictions can hence induce neutral effects with respect to investment timing decisions.

In conclusion, a tax system that treats profits and losses asymmetrically can induce paradoxical tax effects. That is, under certain conditions both a profit tax increase and a loss tax decrease can foster the investor's willingness to invest early and thus to accelerate investment activities. In particular, an asymmetric tax system can cause a tax paradoxon, which is non-existent under both a symmetric tax regime and an asymmetric tax regime with exit flexibility.[34]

6 Conclusion

It is generally known that asymmetric taxation of profits and losses can distort risky entrepreneurial investment decisions. Nevertheless, little work has been done to investigate the effects of loss offset restrictions on investment decisions in the presence of entrepreneurial flexibility. Most of the studies that deal with the effects of taxes on entrepreneurial decisions and incorporate dynamic elements of business decisions into the analyses disregard the asymmetries that are omnipresent in the tax systems around the world.

Extending the existing body of literature, we analyze whether different loss offset systems affect an investor's decision to either realize an investment immediately or wait until a later point in time in the hope of better investment conditions. Applying an investment model that presents uncertain earnings prospects in terms of a binary discrete random variable, we derive optimal after-tax investment strategies.

On the one hand, we show that taxes can be neutral with respect to investment timing decisions. First, a tax system that provides an immediate full loss offset does not distort investment timing decisions. Second, independent of a country's fiscal treatment of tax

[34] The possibility to abandon an initiated investment project without exit costs can hence eliminate tax paradoxa caused by an asymmetric taxation of profits and losses. In contrast to the results obtained by Schneider and Sureth (2010), who show that the existence of an abandonment option can cause tax paradoxa in a symmetric tax system, within this modified setup we find opposed results.

losses a similar result can be obtained if the investor can abandon an ongoing investment project without exit costs because this helps them avoid tax losses.

On the other hand, we demonstrate that tax regimes with loss offset restrictions do affect timing decisions whenever a risky and (potentially) loss-making investment is irreversible, i.e., distortions of investment timing occur if investment losses are unavoidable. A closer look at these results reveals that tax increases – in the form of either a profit tax increase or a loss tax decrease – can accelerate entrepreneurial investment. A tax discrimination against losses can hence cause paradoxical effects that are non-existent under tax regimes that allow for an immediate and full tax refund in case of a loss. Whereas previous studies focus on other or more general types of tax asymmetries or do not analytically determine paradoxical settings caused by loss-offset restrictions in timing decisions, we identify conditions for paradoxical effects. We show that distortions and particularly paradoxical tax effects, that are known for mere profitability decisions, can occur in case of investment timing decisions as well, but vanish under exit flexibility.

Since profits and losses are usually taxed asymmetrically, these findings can assist the tax legislator in evaluating potential tax reform proposals that arise in the wake of the financial and economic crisis. Our findings are also helpful for investors facing investment timing decisions.

However, the model carries some caveats. In the first place, the analytical approach we use solely accounts for one specific asymmetric feature of a tax system. Recent studies that account for additional (asymmetric) determinants of entrepreneurial decisions, such as limited liability or loss aversion, opposingly show that, under certain conditions, an asymmetric tax treatment of profits and losses is essential to avoid distortions of investment decisions.[35] Against this background, our findings have to be interpreted with

[35]See, e.g., Jacob/Fochmann (2011) who account for loss aversion and Niemann/Ewert (2012) who analyze

due care. Moreover, the straightforwardness of our model suggests that the identified effects may not hold in a more complex environment. Relaxing some assumptions in future research and expanding the model with respect to additional (random) variables and extending the model to a multiple-period framework could yield new insight and help to shed more light on the timing puzzle. Furthermore, it is worth investigating whether the same effects occur under a tax system with a uniform tax rate on income from real and financial investment. Apart from that, some aspects of behavioral economic theory could help to disentangle the forces at work, especially if our investment model is subject to experimental studies in future research. Indeed, given the wide application range of models with flexibility, there are doubtless several possibilities for future research on the impact of taxes on timing decisions under uncertainty.

the combined effects of limited liability, loss offset restrictions and risk taking.

References

Agliardi, E. (2001), 'Taxation and Investment Decisions: A Real Options Approach', *Australian Economic Papers*, Vol. 40, No. 1 (March), pp. 44-55.

Agliardi, E. and R. Agliardi (2008), 'Progressive Taxation and Corporate Liquidation Policy', *Economic Modelling*, Vol. 25, No. 3 (May), pp. 532-541.

Agliardi, E. and R. Agliardi (2009), 'Progressive Taxation and Corporate Liquidation: Analysis and Policy Implications', *Journal of Policy Modeling*, Vol. 31, No. 1 (January/February), pp. 144-154.

Allingham, M.G. (1972), 'Risk-Taking and Taxation', *Journal of Economics*, Vol. 32, Nos. 2&3 (June), pp. 203-224.

Alpert, K. (2010), 'Taxation and the Early Exercise of Call Options', *Journal of Business Finance and Accounting*, Vol. 37, No. 5&6 (June/July), pp. 715-736.

Altshuler, R. and A.J. Auerbach (1990), 'The Significance of Tax Law Asymmetries: An Empirical Investigation', *The Quarterly Journal of Economics*, Vol. 105, No. 1 (February), pp. 61-86.

Altshuler, R., A.J. Auerbach, M. Cooper and M. Knittel (2009), 'Understanding U.S. Corporate Tax Losses', *NBER/Tax Policy and the Economy*, Vol. 23, No. 1 (July), pp. 73-122.

Alvarez, L.H.R. and E. Koskela (2008), 'Progressive Taxation, Tax Exemption, and Irreversible Investment under Uncertainty', *Journal of Public Economic Theory*, Vol. 10, No. 1 (February), pp. 149-169.

Andrés-Alonso, P. de, V. Azofra-Palenzuela and G. de la Fuente-Herrero (2006), 'The Real Options Component of Firm Market Value: The Case of the Technological Corporation', *Journal of Business Finance and Accounting*, Vol. 33, Nos. 1&2 (January/March), pp. 203-219.

Auerbach, A.J. (1986), 'The Dynamic Effects of Tax Law Asymmetries', *Review of Economic Studies*, Vol. 53, No. 173 (April), pp. 205-225.

Auerbach, A.J. and J.M. Poterba (1987), 'Tax-Loss Carryforwards and Corporate Tax Incentives', in M. Feldstein, *The Effects of Taxation on Capital Accumulation* (Chicago: Chicago University Press), pp. 305-338.

Bamberg, G. and W.F. Richter (1984), 'The Effects of Progressive Taxation on Risk-Taking', *Journal of Economics*, Vol. 44, No. 2 (June), pp. 93-102.

Berger, P.G., E. Ofek and I. Swary (1996), 'Investor valuation of the abandonment option.', *Journal of Financial Economics*, Vol. 42, No. 2 (October), pp. 257-287.

Boadway, R.W. and N. Bruce (1984), 'A General Proposition on the Design of a Neutral

Business Tax', *Journal of Public Economics*, Vol. 24, No. 2 (July), pp. 231-239.

Bond, S.R. and M.P. Devereux (1995), 'On the Design of a Neutral Business Tax under Uncertainty', *Journal of Public Economics*, Vol. 58, No. 1 (September), pp. 57-71.

Brown, E.C. (1948), 'Business-Income Taxation and Investment Incentives', in L.A. Metzler et al. (eds.), *Income, Employment and Public Policy*, Essays in Honor of A.H. Hansen (New York: Norton & Co), pp. 300-316.

Brown, E.C. (1962),'Tax Incentives for Investment', *American Economic Review*, Vol. 52, No. 2 (May), pp. 335-345.

Cooper, M.G. and M.J. Knittel (2006), 'Partial Loss Refundability: How Are Corporate Tax Losses Used?', *National Tax Journal*, Vol. 59, No. 3 (September), pp. 651-664.

Cooper, M.G. and M.J. Knittel (2010), 'The Implications of Tax Asymmetry for U.S. Corporations', *National Tax Journal*, Vol. 63, No. 1 (March), pp. 33-62.

Darrough, M. and J. Ye (2007), 'Valuation of loss firms in a knowledge-based economy', *Review of Accounting Studies*, Vol. 12, No. 1 (March), pp. 61-93.

Denison, C.A. (2009), 'Real Options and Escalation of Commitment: A Behavioral Analysis of Capital Investment Decisions', *The Accounting Review*, Vol. 84, No. 1 (January), pp. 133-155.

Dixit, A.K. and R.S. Pindyck (1994), *'Investment under Uncertainty'* (Princeton: Princeton University Press).

Domar, E.D. and R.A. Musgrave (1944), 'Proportional Income Taxation and Risk-Taking', *Quarterly Journal of Economics*, Vol. 58, No. 3 (May), pp. 388-422.

Edgerton, J. (2010), 'Investment Incentives and Corporate Tax Asymmetries', *Journal of Public Economics*, Vol. 94, Nos. 11&12 (December), pp. 936-952.

Eeckhoudt, L., C. Gollier and H. Schlesinger (1997), 'The No-loss Offset Provision and the Attitude Towards Risk of a Risk-Neutral Firm', *Journal of Public Economics*, Vol. 65, No. 2 (August), pp. 207-217.

Endres, D., A. Oestreicher, W. Scheffler and C. Spengel (2007), *'The Determination of Corporate Taxable Income in the EU Member States'* (Alphen aan den Rijn: Kluwer Law International).

Feldstein, M.S. (1969), 'The Effects of Taxation on Risk Taking', *Journal of Political Economy*, Vol. 77, No. 5 (September/October), pp. 755-764.

Fochmann, M. and M. Jacob (2011), 'Behavioral Explanation of Tax Asymmetries', FEMM Working Paper No. 21, October.

Grasselli, M.R. (2011), 'Getting Real with Real Options: A Utility-Based Approach for Finite-Time Investment in Incomplete Markets', *Journal of Business Finance and Ac-*

counting, Vol. 38, Nos. 5&6 (June/July), pp. 740-764.

Gutiérrez P.C., R. Hamzaoui, J.G. Rienstra, M. Soo and O. van Boeijen-Ostaszewska (2011), *'Global Corporate Tax Handbook 2011'* (Amsterdam: IBFD).

Hayn, C. (1995), 'The information content of losses', *Journal of Accounting and Economics*, Vol. 20, No. 2 (September), pp. 125-153.

Hirth, S. and M. Uhrig-Homburg (2010), 'Investment Timing when External Financing is Costly', *Journal of Business Finance and Accounting*, Vol. 37, Nos. 7&8 (July/August), pp. 929-949.

Johansson, S.-E. (1969), 'Income Taxes and Investment Decisions', *The Swedish Journal of Economics*, Vol. 71, No. 2 (June), pp. 104-110.

Joos, P. and G.A. Plesko (2005), 'Valuing Loss Firms', *The Accounting Review*, Vol. 80, No. 3 (July), pp. 847-870.

Kager, R., D. Schanz and R. Niemann (2011), 'Estimation of Tax Values Based on IFRS Information: An Analysis of German DAX30 and Austrian ATX Listed Companies', *Accounting in Europe*, Vol. 8, No. 1 (May), pp. 89-123.

Lintner, J. (1954): 'Effect of Corporate Taxation on Real Investment', *American Economic Review*, Vol. 44, No. 2 (May), pp. 520-534.

MacKie-Mason, J.K. (1990), 'Some Nonlinear Tax Effects on Asset Values and Investment Decisions under Uncertainty', *Journal of Public Economics*, Vol. 42, No. 3 (August), pp. 301-327.

Majd, S. and S.C. Myers (1987), 'Tax Asymmetries and Corporate Income Tax Reform', M. Feldstein (ed.), *The Effects of Taxation on Capital Accumulation* (Chicago: Chicago University Press), pp. 343-373.

Mintz, J.M. (1988), 'An Empirical Estimate of Corporate Tax Refundability and Effective Tax Rates', *Quarterly Journal of Economics*, Vol. 103, No. 1 (February), pp. 225-231.

Mossin, J. (1968), 'Taxation and Risk-Taking: An Expected Utility Approach', *Economica*, Vol. 35, No. 137 (February), pp. 74-82.

Myers, S.C. (1977), 'Determinants of Corporate Borrowing', *Journal of Financial Economics*, Vol. 5, No. 2 (November), pp. 147-175.

Näslund, B. (1968), 'Some Effects of Taxes on Risk-Taking', *Review of Economic Studies*, Vol. 35, No. 3 (July), pp. 289-306.

Niemann, R. (1999), 'Neutral Taxation under Uncertainty - a Real Options Approach', *FinanzArchiv*, Vol. 56, No. 1 (March), pp. 51-66.

Niemann, R. (2011), 'The impact of Tax Uncertainty on Irreversible Investment', *Review of Managerial Science*, Vol. 5, No. 1 (March), pp. 1-17.

Niemann, R. and R. Ewert (2012), 'Limited Liability, Asymmetric Taxation, and Risk Taking - Why Partial Tax Neutralities Can Be Harmful', *FinanzArchiv*, Vol. 68, No. 1 (March), pp. 83-120.

Niemann, R. and C. Sureth (2004), 'Tax Neutrality under Irreversibility and Risk Aversion', *Economics Letters*, Vol. 84, No. 1 (July), pp. 43-47.

Niemann, R. and C. Sureth (2005), 'Capital Budgeting with Taxes under Uncertainty and Irreversibility', *Journal of Economics and Statistics*, Vol. 225, No. 1 (January), pp. 77-95.

Niemann, R. and C. Sureth (2011), 'The Impact of Differential Capital Income Taxation on the Value of Risky Projects', *Economics Bulletin*, Vol. 31, No. 2 (April), pp. 1047-1054.

Panteghini, P.M. (2001a), 'On Corporate Tax Asymmetries and Neutrality', *German Economic Review*, Vol. 2, No. 3 (August), pp. 269-286.

Panteghini, P.M. (2001b), 'Corporate Tax Asymmetries under Investment Irreversibility', *FinanzArchiv*, Vol. 58, No. 3 (September), pp. 207-226.

Panteghini, P.M. (2005), 'Asymmetric Taxation under Incremental and Sequential Investment', *Journal of Public Economic Theory*, Vol. 7, No. 5 (December), pp. 761-779.

Pennings, E. (2000), 'Taxes and the Stimuli of Investment under Uncertainty', *European Economic Review*, Vol. 44, No. 2 (February), pp. 383-391.

Russel, W.R. and P.E. Smith (1970), 'Taxation, Risk-Taking, and Stochastic Dominance', *Southern Economic Journal*, Vol. 36, No. 4 (April), pp. 425-433.

Samuelson, P.A. (1964), 'Tax Deductibility of Economic Depreciation to Insure Invariant Valuations', *Journal of Political Economy*, Vol. 72, No. 6 (December), pp. 604-606.

Sandmo, A. (1974): 'Investment Incentives and the Corporate Income Tax, '*Journal of Political Economy*, Vol. 82, No. 2 (March), pp. 287-302.

Schneider, D. (1980), 'The Effects of Progressive and Proportional Income Taxation on Risk-Taking', *National Tax Journal*, Vol. 33, No. 1 (March), pp. 67-75.

Schneider, G. and C. Sureth (2010), 'Capitalized Investments with Entry and Exit options and Paradoxical Tax Effects', *Review of Managerial Science*, Vol. 4, No. 2 (July), pp. 149-169.

Stiglitz, J.E. (1969), 'The Effects of Income, Wealth and Capital Gains Taxation on Risk-Taking', *Quarterly Journal of Economics*, Vol. 83, No. 2 (May), p. 263-283.

Sureth, C. (2002), 'Partially Irreversible Investment Decisions and Taxation under Uncertainty: A Real Option Approach', *German Economic Review*, Vol. 3, No. 2 (May), pp. 185-221.

Trigeorgis, L. (1996), *'Real Options, Managerial Flexibility and Strategy in Resource Allocation'* (Cambridge/London: MIT Press).

Wong, K.P. (2009), 'Progressive Taxation, Tax Exemption, and Corporate Liquidation Policy', *Economic Modelling*, Vol. 26, No. 2 (March), pp. 295-299.

Figure 1: Decision tree in the basic model with future cash flow uncertainty without abandonment flexibility

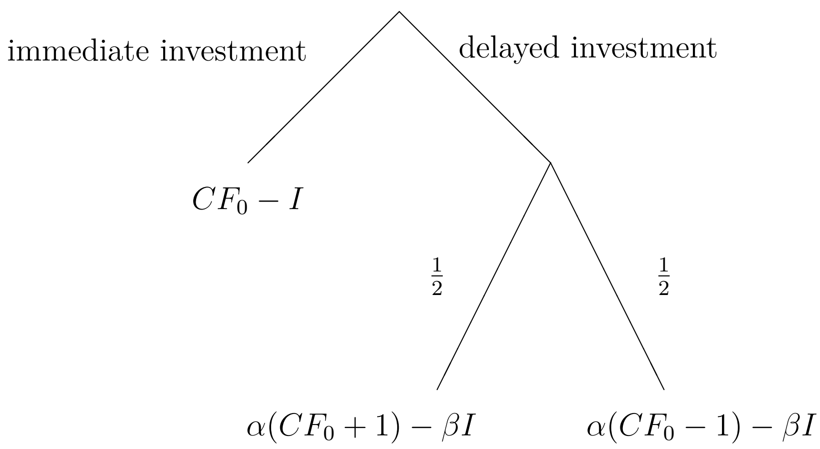


Figure 2: Decision tree in the basic model with future cash flow uncertainty and abandonment flexibility

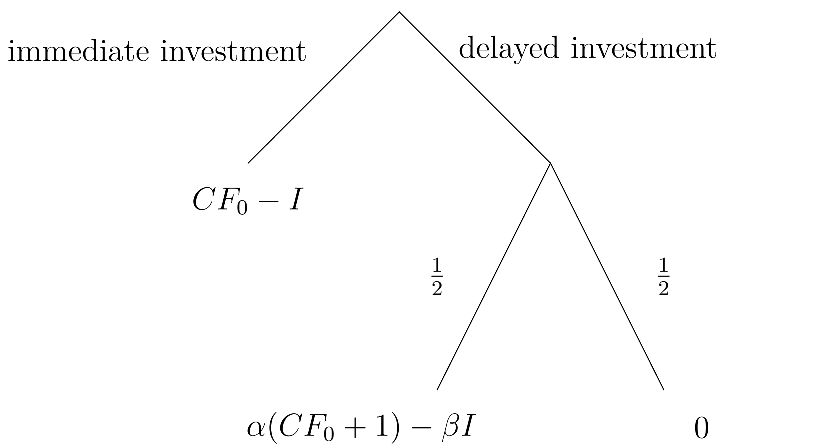


Figure 3: Decision tree in the extended model with overall cash flow uncertainty without abandonment flexibility

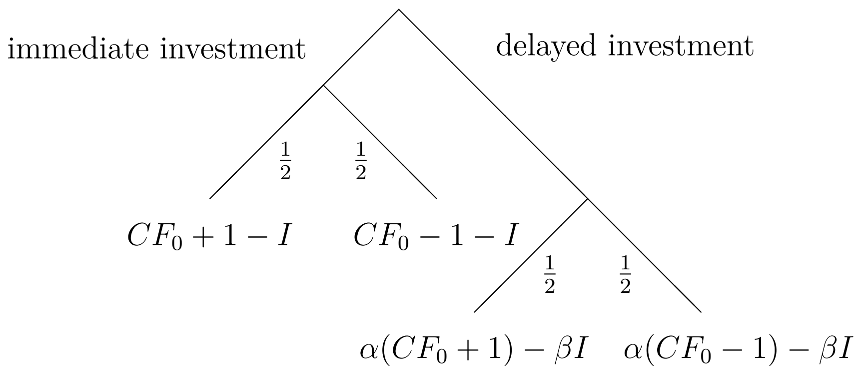


Figure 4: Decision tree in the extended model with overall cash flow uncertainty and abandonment flexibility

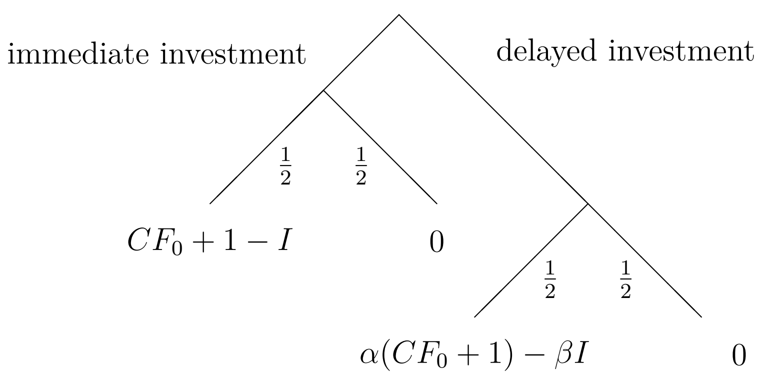


Figure 5: Effects of loss taxation on investment timing

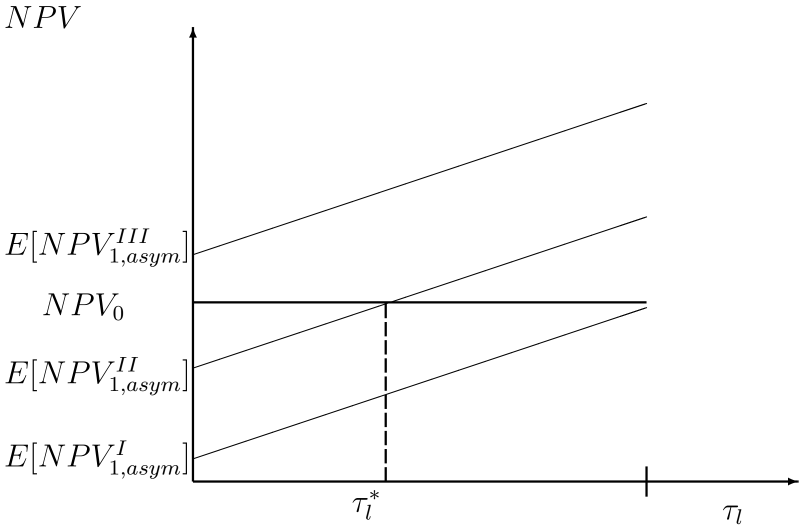


Figure 6: Effects of profit taxation on investment timing

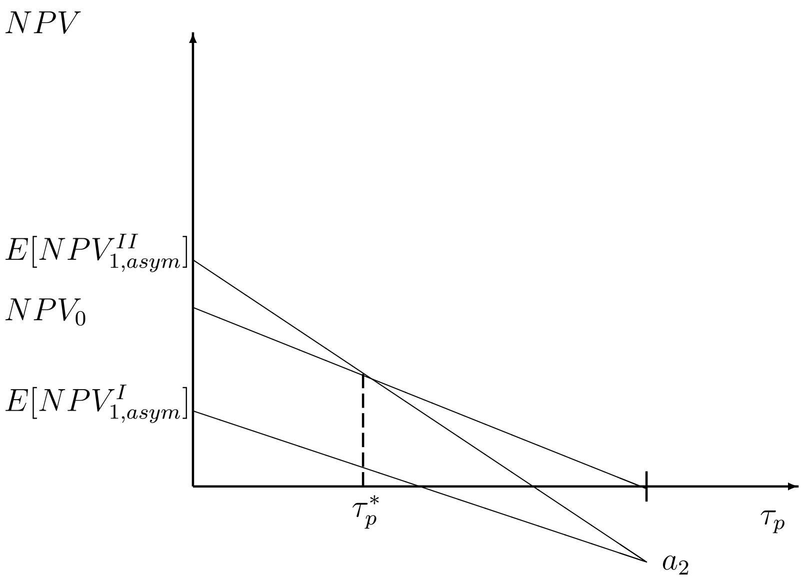
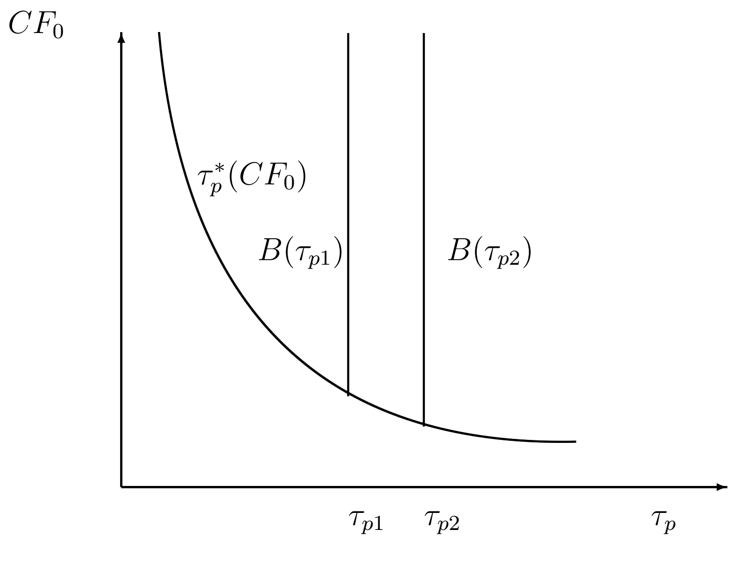


Figure 7: Indifference curve $\tau_p^*(CF_0)$



Impressum:
Arbeitskreis Quantitative Steuerlehre, arqus, e.V.
Vorstand: Prof. Dr. Jochen Hundsdoerfer,
Prof. Dr. Dirk Kiesewetter, Prof. Dr. Ralf Maiterth
Sitz des Vereins: Berlin

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

Kontaktadresse:
Prof. Dr. Caren Sureth, Universität Paderborn, Fakultät für Wirtschaftswissenschaften,
Warburger Str. 100, 33098 Paderborn,
www.arqus.info, Email: info@arqus.info

ISSN 1861-8944