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Abstract

We investigate how personal income taxes affect the portfolio share of personal wealth that entrepreneurs invest in their own business. In a portfolio choice model that allows for tax sheltering, we show that lower tax rates may increase investment in entrepreneurial equity at the intensive margin, but decrease it at the extensive margin. Using German panel data, we identify tax effects on the portfolio shares of six asset classes by exploiting tax and entry regulation reforms. Our results indicate that lower taxes drive out businesses that are viable only due to tax sheltering, but increase investment in productive entrepreneurial businesses.

Keywords Taxation · entrepreneurship · portfolio choice · tax sheltering · investment

JEL Classification H24 · H25 · H26 · L26 · G11

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1. Introduction

Taxes influence the decisions of households on which assets to hold and how much to invest in each asset type. A growing empirical literature has analyzed the effects of personal income taxes on household portfolio allocation (Feldstein 1976; Hubbard 1985; King and Leape 1998; Poterba 2002a,b; Poterba and Samwick 2002; Alan et al. 2010; Ochmann 2014). The literature considers tax effects on investment in assets such as owner-occupied housing, rental property, and various forms of financial assets. However, the literature is mostly silent about the impact of taxes on private business equity, i.e., the share of wealth that entrepreneurial households invest in their own businesses. Closing this knowledge gap is an important task from the perspectives of academics and policymakers. In Germany (the United States), 8% (9%) of the population own private business equity, and these entrepreneurs on average allocate as much as 40% (42%) of their wealth to their own businesses. Although entrepreneurial households form a minority among households, they hold a large share of aggregate wealth because they are much wealthier on average than other households: The average net worth of entrepreneurs is more than five times as much as that of non-entrepreneurs in Germany and even seven times as much in the United States.[1] Thus, tax effects on entrepreneurial portfolio allocation may dominate tax effects on aggregate capital allocation in the economy. In modern knowledge-based economies, innovation, economic growth and job creation depend on the willingness of entrepreneurs to take risky investments (Carree and Thurik 2003; Acs and Audretsch 2005; van Praag and Versloot 2007). This underscores the importance of understanding the effects of tax policy on entrepreneurial choice and investment.

Although the empirical results from the existing literature on household portfolio allocation are far from conclusive, they can generally be rationalized by the standard portfolio choice model. However, when we add entrepreneurial equity to the empirical analysis, the standard theory fails to explain the data. We extend the model by allowing for tax sheltering of private business income. Our extended model, which nests the standard model in case of no sheltering, yields results that are consistent with our empirical findings and provides a rationalization of them.

More specifically, we model a potential entrepreneur's choice of the asset composition of her portfolio. We first present a simple model in which a portfolio consists of a risky and a riskless asset, the returns from which are subject to the same tax rate. We distinguish between the decisions on whether to hold anything of an asset or not—the extensive margin—and, conditional on that, how much of the asset to hold—the intensive margin. We show that in the standard model, a change in the income tax rate, while it induces a change at the intensive margin, does not change the decision at the extensive margin, as long as the tax rate remains below 100%. Thus empirical evidence showing that when there is a fall in the tax rate, there is a reduction in the probability of holding the risky asset *together with* an increase in investment conditional on holding the asset cannot be rationalized in the standard model. At best it represents a puzzle, at worst a rejection of the model.

It seems reasonable to assume that tax avoidance or evasion in the form of shifting, concealing or underreporting income—what we refer to as "sheltering" income from taxation—is relatively less costly for business income than for most other forms of asset returns. For the United States, the Internal Revenue Service (2016) estimates that business income, in particular non-farm proprietor income, is the income category that gets by far most underreported for

[1] The U.S. figures are from Gentry and Hubbard (2004).

tax purposes. Alstadsæter et al. (2017) report that random audits reveal high evasion rates among the self-employed in Scandinavia, and Kleven et al. (2011) find that almost half of the entrepreneurs in Denmark evade taxes. The literature consistently estimates that true income of entrepreneurs is on average about 1.3-2 times their reported income (Pissarides and Weber 1989; Feldman and Slemrod 2007; Hurst et al. 2014; Artavanis et al. 2016).[2]

Therefore, we extend the model to show that a fall in the tax rate reduces the attractiveness of investments that are only profitable when part of their return is sheltered. The reason is that lower taxes reduce the net return to sheltering relative to its cost. This can account for the reduction in investment at the extensive margin. In contrast, investments that are profitable in the absence of taxation become more profitable when the tax rate falls and this would tend to increase investment. Therefore, we hypothesize that the effect of a fall in the tax rate on the portfolio share of private business equity is negative at the extensive margin, but positive at the intensive margin.

In our empirical model there are six classes of assets, including own business equity. We provide empirical evidence on how marginal tax rates affect the shares of personal wealth held in business equity as well as the other asset forms. We find that lower marginal personal income tax rates significantly decrease the probability of holding private business equity, but increase the conditional wealth share that entrepreneurs invest in their own business. This is contrary to the standard portfolio model but is rationalized by the tax sheltering model just discussed.

For our estimations, we use the German Socio-Economic Panel (SOEP), an annual household survey that collected detailed data on the personal wealth composition in 2002, 2007, and 2012, including private business equity, and a comprehensive tax-benefit microsimulation model for Germany to calculate marginal personal income tax rates. We estimate a system of simultaneous asset demand equations in first differences eliminating unobserved individual fixed effects. The effects of the endogenous individual tax rate are identified by an instrumental variables approach exploiting exogenous variation introduced by tax reforms and bracket creep during our observation period. We also integrate a panel data method to account for selection into entrepreneurship; for identification we use legislation changes on entry regulation into skilled trades in 2004 (see Rostam-Afschar 2014).

Our results indicate that a decrease in the marginal tax rate by 10 percentage points increases the portfolio share of private business equity conditional on owning a private business by 2.3% of the average conditional portfolio share (39%), but decreases the unconditional portfolio share by 5.5% of the unconditional average (3%). An important policy insight is that lower taxes drive out businesses that are viable only due to tax sheltering, but increase investment in private businesses that are also worthwhile in the absence of taxes.

One reason why the existing empirical literature analyzing tax effects on household portfolio choice listed above has mostly excluded own business equity is that most data bases do not provide this information. An exception is Samwick (2000), who includes private business equity in his empirical portfolio choice analysis using the 1998 cross-section of the U.S. Survey of Consumer Finances, but he does not focus on this asset type. Another reason why most of the literature has not included private business equity may be that entrepreneurial business assets do not fit into the standard portfolio choice model and require specific considerations not only because of their risky nature, but also because of the potentially important role played by tax sheltering opportunities.

[2] Consistent with this, Cullen et al. (2018) estimate a higher responsiveness of reported taxable income to a taxpayer's approval of the current government for income categories that are subject to little third party reporting such as income from small businesses.

A second related stream of empirical literature investigates effects of income taxes on entrepreneurship as an occupational choice (Bruce 2000; Gentry and Hubbard 2000; Bruce and Mohsin 2006; Cullen and Gordon 2007; Fossen 2009; Fossen and Steiner 2009; Hansson 2012; Wen and Gordon 2014). The literature is far from conclusive, with papers reporting both positive effects of personal income tax rates on entrepreneurial choice (Cullen and Gordon 2007) and negative effects (Hansson 2012). One of the reasons for the inconclusiveness of this literature may be its limitation to the binary occupational choice. The operationalization of entrepreneurship as an occupational choice is closely related to the extensive margin of entrepreneurial investment that we are explicitly considering in this paper. In our data, more than three quarters of business owners (who report positive private business equity) also indicate that self-employment is their main occupation. However, we go beyond the binary choice model by extending the analysis to the intensive margin of entrepreneurial portfolio investment. Our finding of opposite tax effects at the extensive and intensive margins, which we can explain with our extended theoretical model, contributes to reconciling the results from the binary choice literature. Even if we assume that entrepreneurs have a strong preference for self-employment because of the independence and autonomy it brings, our sheltering model still yields a negative effect of a tax cut at the extensive margin. The cost of that independence and autonomy increases for business investment that is unprofitable in the absence of sheltering, when the return to sheltering, the tax rate, falls.

The paper proceeds as follows. Section 2 presents our theoretical model explaining how tax changes may affect holdings of a risky asset, with different signs at the extensive and intensive margins, and Section 3 goes on to set out our econometric strategy. In Section 4, we provide relevant information on the personal income tax reforms and the reform of entry regulation in Germany that we exploit to identify tax and selection effects. Section 5 describes the panel data we use, and Section 6 presents our empirical results. Section 7 concludes the analysis.

2. Theoretical Model of Entrepreneurial Portfolio Choice

Portfolio choice under taxation in the presence of a risky asset such as own business equity has long been discussed in the theoretical literature (Domar and Musgrave 1944; Sandmo 1977; Feldstein and Slemrod 1980; Auerbach and King 1983; Konrad 1991). While this literature has focused on the intensive margin of portfolio investment, another literature stream has evolved that more specifically discusses tax effects on entrepreneurial choice as a decision at the extensive margin (Kanbur 1981; Gentry and Hubbard 2000; Cullen and Gordon 2007). In the following, we develop a portfolio choice model that allows for tax sheltering of private business income and that consistently rationalizes our empirical results for both the extensive and intensive margins of portfolio choice.

In the standard portfolio choice model, a risk averse investor with given initial wealth maximizes end of period utility by choosing a portfolio consisting of a safe and a risky asset,[3] and will hold a strictly positive amount of the latter if and only if its expected return net of the safe rate of return is positive. Imposing the same proportional rate of income tax on the returns to both assets cannot change this sign, and, *a fortiori*, reducing this tax rate cannot induce the investor to move to a corner solution in which she would hold none of the risky asset. Therefore, an empirical

[3] This could of course consist of a portfolio of risky assets.

observation that shows a fall in the tax rate having this effect cannot be rationalized in this model and so presents a "puzzle", or, more accurately, a rejection of the model.

When the model is applied to a class of decisions for which the risky asset is the business income of an individual entrepreneur however, a straightforward rationalization of the observation that the tax rate has opposite effects at the extensive and intensive margins suggests itself. If part of the business income can be tax-sheltered in such a way that its net of tax return increases relative to that of the safe asset, the return to which cannot be sheltered, it can happen that a business investment that would not be undertaken in the absence of taxation because its expected net return is negative could actually become profitable in the presence of a suitably high tax rate, since this is the rate of return to sheltering.[4] In a population of such investments with a given distribution, a reduction in the tax rate could then eliminate the least profitable of them. Businesses that are marginal and survive only because of the possibility of tax-sheltering income may no longer be viable in light of the alternative return on riskless assets and so shut down. At the same time, investment in businesses whose net expected return in the absence of taxation is positive could increase,[5] so that the signs of the effects of the tax reduction at the extensive and intensive margins are the opposite of each other. The analysis of this section explores this intuition more rigorously.

2.1. Why the Standard Portfolio Choice Model Fails to Predict the Extensive Margin

We take a single entrepreneur who supplies capital $k \geq 0$ to her own business, and this has a risky rate of return of $\tilde{e} \gtreqless 0$,[6] with gross business income of $(1+\tilde{e})k$, and b is the holding of the safe asset, with a riskless rate of return of r (all before tax). In each state of the world, defined by a realization of $\tilde{e}$, she shelters $\tilde{c} \geq 0$. The income tax rate is t and initial wealth is W_0. Note that k is chosen before and $\tilde{c}$ after the state of the world is known.

Ignoring sheltering for the moment, end of period wealth is

$$\widetilde{W} = (1+\tilde{e})k + (1+r)(W_0 - k) \tag{1}$$

$$= (1+r)W_0 + (\tilde{e} - r)k \tag{2}$$

and so taxable (Schanz 1896; Haig 1921; Simons 1938) income is

$$\tilde{y} = \widetilde{W} - W_0 = rW_0 + (\tilde{e} - r)k. \tag{3}$$

Thus after tax wealth, with a tax rate $t \in (0,1)$, is

$$\widetilde{W}_T = W_0 + \tilde{y}_T = W_0 + (1-t)(rW_0 + (\tilde{e} - r)k). \tag{4}$$

[4] We are not specifying as yet whether sheltering of business income is due to legal tax avoidance activities such as profit shifting or illegal tax evasion. In practice, it is likely that a mixture of both occurs, although it is of course very hard to find direct evidence due to the very nature of income concealment. However, it is very plausible that income from private businesses, which must be declared by the entrepreneur, can be sheltered more easily than other income types such as wage and salary income or income from interest or dividends, all of which are subject to withholding taxes. This is further discussed below.

[5] In general, as is well-known, the effect of a tax reduction on investment in a risky asset with expected return greater than the riskless rate is ambiguous, as it depends on how the risk aversion of the entrepreneur varies with income or wealth. But an increase in that investment is certainly plausible.

[6] A tilde denotes a random variable.

Notice that this is implicitly assuming that negative business income can be set against positive income from the safe asset, and that there is full loss offset if total income is negative. We discuss this assumption below and show that the main conclusions of the model are not affected by restrictions on the nature of tax offsets such as are usually found, for example, in the German economy.[7]

Given a cumulative distribution function $F(\tilde{e})$ the entrepreneur solves:

$$\max_k \bar{U} = E[u(\widetilde{W}_T)] \tag{5}$$

subject to $k \geq 0$.[8] The FOC is[9]:

$$\frac{\partial \bar{U}}{\partial k} = Eu'(\widetilde{W}_T)[(1-t)(\tilde{e}-r)] \leq 0; \;\; k^* \geq 0; \; k^* \frac{\partial \bar{U}}{\partial k} = 0. \tag{6}$$

Suppose that $k^* = 0$. Then, since $k^* = 0 \Rightarrow \widetilde{W}_T = [1+(1-t)r]W_0$ for certain, the condition becomes

$$(1-t)E(\tilde{e}-r) \leq 0. \tag{7}$$

This local maximum is also global since at all values of k, risk aversion implies

$$\frac{\partial^2 \bar{U}}{\partial k^2} = Eu''(\widetilde{W}_T)[(1-t)(\tilde{e}-r)]^2 < 0. \tag{8}$$

For the purpose of this analysis it is important to note that the existence of this equilibrium is independent of the tax rate, and depends only on the distribution of $(\tilde{e}-r)$. Therefore it is not possible for a fall in the tax rate to induce an entrepreneur with $k^* > 0$ before this fall, implying $E(\tilde{e}-r) > 0$, to move to a corner solution with $k^* = 0$. Intuitively, if the marginal expected utility with respect to k is strictly positive at $k = 0$ there must be an optimum at some $k^* > 0$, the value of which depends on the rate at which the marginal expected utility falls with k. For such an entrepreneur, the tax change may cause k^* to rise or fall, depending on the interplay of wealth and substitution effects,[10] but the necessary condition for $k^* = 0$ cannot be satisfied.

There is of course a large literature on tax evasion and avoidance in public economics, and there is an embarrassment of riches in terms of structural tax sheltering models, along the lines for example of Allingham and Sandmo (1972), Yitzhaki (1974), Mayshar (1991), Lin and Yang (2001), Slemrod (2001), and many others. These models, with very few exceptions, deal with tax sheltering of certain labor income. Tax evasion is generally modeled as a trade off for a risk averse decision taker between the gain from underreporting income against the risk of being audited, which leads to detection and punishment, while tax avoidance introduces tax planning and advising costs which are taken into account in determining the legal minimization of tax liabilities.

[7] It is possible to formulate a more complicated model without tax offsets for negative values of portfolio income, but our main conclusion, that tax changes can have opposite effects at the extensive and intensive margins, continues to hold.

[8] The zero lower bound on k seems reasonable because short-selling capital in one's own business would create obvious moral hazard problems. We do not exclude the possibility of borrowing at the riskless rate as long as that does not create a bankruptcy risk, which would then have to be explicitly taken into account in the model.

[9] Asterisks denote optimal values.

[10] If $r = 0$ or we have constant absolute risk aversion the well-known Domar/Musgrave effect (Domar and Musgrave 1944) will imply that k increases with the tax rate.

Here we take the model of Slemrod (2001), as representative of tax avoidance models, and extend it to address the portfolio choice problem.[11] We then give necessary and sufficient conditions under which we predict opposite signs of the effect of a tax change at the extensive and intensive margins respectively.

2.2. *Extensive and Intensive Portfolio Choice with Tax Avoidance*

We focus on Slemrod (2001)'s model of tax avoidance,[12] which we have adapted to relate to portfolio rather than labor income. The important difference is that business income is risky, with an exogenously given component, the rate of return $\tilde{e}$, and an endogenously chosen component k. For every $\tilde{e}$, with $k \in (0, W_0]$ given, the entrepreneur solves the optimal sheltering problem:

$$\max_{\tilde{c} \geq 0} u = u(W_0 + (1-t)\tilde{y} + t\tilde{c} - a(\tilde{c}, k\tilde{e})), \tag{9}$$

where the avoidance cost function satisfies $a(0, k\tilde{e}) = 0$ because no avoidance costs arise if sheltered income $\tilde{c} = 0$. If $\tilde{c} > 0$, avoidance costs $a(.)$ are strictly increasing and strictly convex in the amount sheltered, $\partial a/\partial \tilde{c}$, $\partial^2 a/\partial \tilde{c}^2 > 0$, and both average and marginal avoidance costs are strictly decreasing in the gross *business income* of the entrepreneur, $\partial a/\partial k\tilde{e} < 0, \partial^2 a/\partial \tilde{c} \partial k\tilde{e} < 0$ (recall that income from the riskless asset cannot be sheltered). This captures the idea that wealthier entrepreneurs have access to lower cost technologies of tax sheltering, although cost is still increasing in the amount sheltered for any given technology. Moreover, it seems reasonable to assume that $\tilde{e} \leq 0 \Rightarrow \tilde{c} = 0$, so that one cannot overstate actual losses.[13]

The FOC is:

$$\frac{\partial u}{\partial \tilde{c}} = u'(W_0 + (1-t)\tilde{y} + t\tilde{c} - a(\tilde{c}^*, k\tilde{e}))\left[t - \frac{\partial a}{\partial \tilde{c}}\right] \leq 0,\ \tilde{c}^* \geq 0,\ \tilde{c}^* \frac{\partial \bar{u}(\tilde{c})}{\partial \tilde{c}} = 0,\ \forall \tilde{c} \tag{10}$$

and since $u'(.) > 0$, we have a corner solution if and only if $t \leq \partial a/\partial \tilde{c}$ at $\tilde{c} = 0$. Otherwise $\tilde{c}^* > 0$, which we assume to be the case for at least one $\tilde{e}$. With $u'(.) > 0$, the FOC in that case reduces to $t = \partial a/\partial \tilde{c}$. However, this condition is not independent of $k\tilde{e}$, since a fall in this increases the marginal cost of avoidance and so could lead to a corner solution with $\tilde{c} = 0$ in a relatively low income state. This is less likely, other things equal, the higher the initial wealth of the entrepreneur, W_0, since then, in a diversified portfolio, the higher is the income from the risky asset, given that risk aversion does not increase with wealth.

On standard assumptions we obtain from the FOC a differentiable function which we write as $\tilde{c}^* = \gamma(k\tilde{e}, t)$, with $\gamma(0, t) = 0\ \forall \tilde{e}$ and we are interested in its partial derivatives $\partial \tilde{c}^*/\partial k\tilde{e}$ and $\partial \tilde{c}^*/\partial t$. Since strict convexity of $a(.)$ in $\tilde{c}$ implies $\partial^2 u/\partial \tilde{c}^2 < 0$, these signs are given by those of $\partial^2 u/\partial k\tilde{e} \partial \tilde{c}$ and $\partial^2 u/\partial t \partial \tilde{c}$ respectively. We then have:

$$\frac{\partial \tilde{c}^*}{\partial k\tilde{e}} > 0 \text{ since } -\frac{\partial^2 a}{\partial k\tilde{e} \partial \tilde{c}} > 0,\ \ \forall \tilde{e} > 0. \tag{11}$$

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[11] A similar, though far lengthier, analysis can be carried out for the tax evasion models of Allingham and Sandmo (1972) and Yitzhaki (1974) but for reasons of space limitations is not presented here. It is available from the authors on request.

[12] This is actually a specialized version of the model of Mayshar (1991), which has a more general specification of the sheltering technology and tax system. But Slemrod's model is sufficient for our purposes here.

[13] The standard models of tax avoidance typically consider labor income which is always positive so this case does not arise. Of course allowing losses to be exaggerated would increase the attraction of tax avoidance when there is any kind of loss offset, so this assumption here goes some way toward adjusting for the assumption of full loss offset.

Simply put: shifts downward (upward) in the marginal cost of avoidance resulting from having larger (smaller) business income increase (reduce) the amount avoided in a state in which it is positive, and can cause it to increase from (fall to) zero, depending on the relationship between t and $\partial a/\partial \tilde{c}$.

On the other hand we have

$$\frac{\partial \tilde{c}^*}{\partial t} = \frac{1}{\partial^2 a/\partial \tilde{c}^2} > 0 \tag{12}$$

which follows from the strict convexity of the cost function, so a discrete increase in the tax rate causes an increase in avoidance in all states in which it is positive and possibly in some in which it is zero, while a discrete reduction in the tax rate reduces avoidance in all states where it is positive, in some possibly to zero.

We established above that in the standard portfolio model, given the condition $E(\tilde{e}-r) \leq 0$ we always have $k^* = 0$ as a local optimum, but at least *a priori*, introducing the possibility of raising the net return from the business relative to that from the safe asset by tax avoidance, which requires $k^* > 0$, may allow a local optimum with an expected utility greater than that at the corner. Necessary and sufficient conditions under which this will hold are, for the Slemrod (2001) model:

There exists a critical value $k_C > 0$ such that at the given tax rate:

$$\bar{U}(k_C) \equiv E[u(W_0 + (1-t)(rW_0 + (\tilde{e}-r)k_C) + t\gamma(k_C\tilde{e},t) - a(\tilde{c},k_C\tilde{e}))]$$

$$= u((1+(1-t)r)W_0), \tag{13}$$

$$\left.\frac{\partial \bar{U}}{\partial k}\right|_{k=k_C} > 0. \tag{14}$$

where $\tilde{c}^* = \gamma(k_C\tilde{e},t)$, and the expectation is taken with respect to the distribution of $\tilde{e}$.

In words, there exists a positive k-value (k_C) at which expected utility is equal to that at $k=0$ and is strictly increasing at that point. Intuitively, the tax gain from tax sheltering for all positive realizations of $\tilde{e}$ must be sufficient to compensate for the negative net returns in some states.

Figure 1 illustrates this. Curve AA corresponds to a level of the tax rate t_A such that $k^* > 0$ is a global maximum, while curve BB corresponds to a tax rate t_B at which the entrepreneur is just indifferent between the interior and corner solutions. We assume that $t_A > t_B$ and argue below that a further tax reduction (to t_C) would cause the corner solution to be strictly preferred, thus having a negative effect at the extensive margin.

If condition (13) is satisfied, using the certainty equivalent of the left hand side, the entrepreneur will have a risk premium $\rho_C > 0$ such that

$$E[(1-t)(rW_0 + (\tilde{e}-r)k_C) + t\gamma(k_C\tilde{e},t) - a(\tilde{c},k_C\tilde{e})] = (1-t)rW_0 + \rho_C \tag{15}$$

implying

$$(1-t)E(\tilde{e}-r) + \frac{tE[\tilde{c} - a(\tilde{c},k_C\tilde{e})]}{k_C} = \frac{\rho_C}{k_C} \tag{16}$$

with $E[\tilde{c} - a(\tilde{c},k_C\tilde{e})] > 0$. This tells us that this case is more likely to arise the higher the tax rate, the greater the expected value of sheltered income net of transactions costs, the less risk averse the entrepreneur and the smaller the absolute value of the (negative) expected net return.

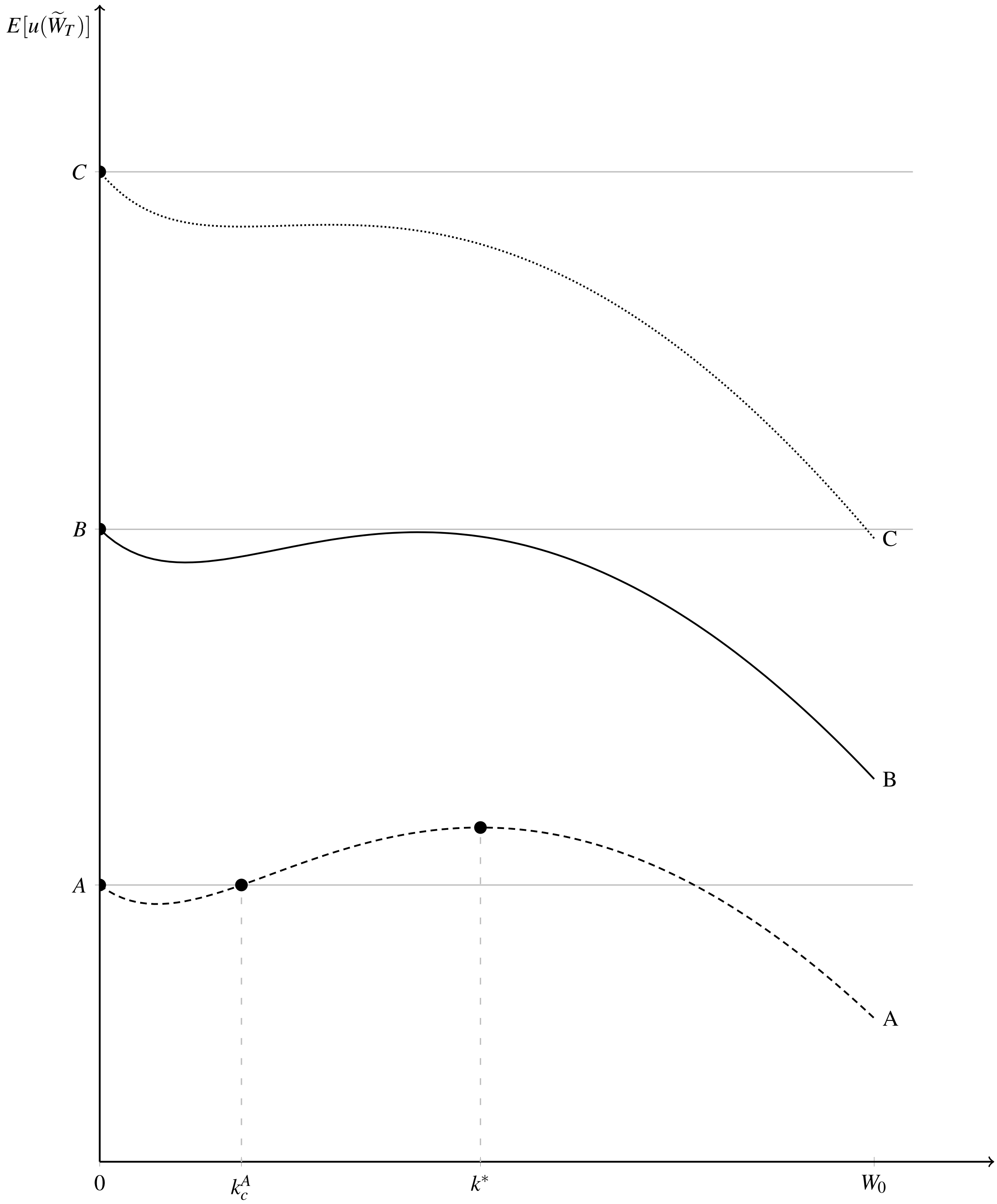

Figure 1: Optimal Investment in Entrepreneurship with Tax Sheltering.

Note: The figure shows an individual's optimal investment in entrepreneurship for a high tax rate (line *AA*), a medium tax rate (line *BB*), and a low tax rate (line *CC*), illustrating an example of an individual for whom entrepreneurship would not be worthwhile without taxation. With the high tax rate, this individual's optimal investment in entrepreneurship is positive ($k^* > 0$). When the tax rate is decreased, the individual reaches a situation where she is just indifferent between no investment or a positive investment in entrepreneurship. A further decrease in the tax rate makes the individual strictly better off when choosing not to be an entrepreneur (line *CC*). This numerical example was generated using equally probable good and bad states of the world with returns to the risky asset of $\tilde{e}_{\text{Good State}} = 0.1$ and $\tilde{e}_{\text{Bad State}} = 0.01$, $r = 0.06$, tax rates $t_A = 39.37\%$, $t_B = 38.37\%$, and $t_C = 37.37\%$, $W_0 = 100$, preferences implying constant relative risk aversion $u(\widetilde{W}_T) = \log(\widetilde{W}_T)$, and the avoidance cost function $a(\tilde{c}, k\tilde{e}) = 0.3 \times (\exp(\tilde{c}) - 1)/(0.2 \times k\tilde{e} + 1)^2$. Optimal sheltering is then $\tilde{c}^* = \log(4/30 \times (5 + k\tilde{e})^2 \times t)$.

To put this more formally, define

$$\varphi(k) = (1-t)E(\tilde{e}-r)k + tE[\tilde{c} - a(\tilde{c}, k\tilde{e})] - \rho \tag{17}$$

and we require

$$\varphi'(k_C) = (1-t)E(\tilde{e}-r) + tE\left[\frac{\partial \tilde{c}}{\partial k\tilde{e}} - \frac{\partial a}{\partial k\tilde{e}}\right] - \frac{\partial \rho}{\partial k} > 0. \tag{18}$$

Thus if the risk aversion of the entrepreneur is falling sufficiently with the scale of investment and/or the rate of increase of the expected value of the amount sheltered, net of costs, is sufficiently large in the neighborhood of k_C then the condition for $k^* > 0$ is satisfied. Thus we expect that an entrepreneur with constant or diminishing absolute risk aversion and whose income sheltering at the margin rises strongly with the amount she invests, at least over some range, is more likely to satisfy these conditions, which is quite intuitive.

Note that if $t = 1$, in this model, as long as the net return from sheltering *any* business income is positive, we must have $k > 0$, since then

$$E[u(W_0 + \tilde{c} - a(\tilde{c}, k\tilde{e}))] > u(W_0). \tag{19}$$

Therefore, by continuity of $\tilde{y}_T$ in t, there must exist an interval of t-values sufficiently close to 1 for which condition (13) is satisfied. On the other hand, at $t = 0$ these conditions cannot be satisfied, and again by continuity there will be an interval of t-values at which the corner solution is optimal. How large these respective intervals are will be determined by the parameters of the model.

We can then conclude that the population of entrepreneurs could be distributed such that at any tax rate a marginal reduction in the rate will cause some to switch from the interior to the corner solution. These can however only be entrepreneurs for whom $E(\tilde{e}-r) \leq 0$, since those for whom $E(\tilde{e}-r) > 0$ will never choose the corner solution regardless of the tax rate. Thus the reduction in tax rate drives out at least some of the entrepreneurs who only invest because of the possibilities of tax sheltering.[14] The effects on k of tax changes for those entrepreneurs who would be in business in the absence of taxation, with $E(\tilde{e}-r) > 0$, are ambiguous, depending as they do on the interplay of wealth and substitution effects, but it is certainly not a puzzle if these are found to expand their investment when the tax rate falls.

2.3. Loss Offset and Progressive Taxes

Throughout this analysis we have assumed full loss offset and a simple proportional income tax. On the other hand in the German tax system tax offset possibilities are restricted and the tax system is more complex than the simple proportional system assumed here. Nevertheless we argue that our simple models are sufficient to resolve the puzzle of why the effects of tax changes can have opposite effects at the extensive and intensive margins. What matters is the return to the optimal amounts of income sheltering. However, it is also true that the greater the generosity of tax offsets, the more likely it is that an optimum with $k^* > 0$ will exist. At the same time, given that the marginal tax rate is determined by total income from all sources, effectively the full loss on one form of income is in fact set against positive income from the other sources.

[14] This is not to imply that reducing the tax rate is the best way of dealing with tax evasion or avoidance.

Moreover, in a piecewise linear tax system, any individual can be modeled as being faced by a linear tax with a virtual lump sum and a constant marginal tax rate. Decisions about allocations of capital between different income-earning assets are taken in the light of the net income each yields at the margin, and so the corner solution with the amount of income from a particular source set at zero represents the correct extensive margin for income from that source. This is in contrast to the case of, say, a multinational company deciding on the location of a new factory, or a second earner in a household deciding on whether to go out to work or not, where the average tax rate may be more relevant.

3. Empirical Asset Demand Model with Endogenous Tax Rate

We now go on to present the empirical work, the results of which are rationalized by the theoretical model of entrepreneurial portfolio choice just discussed. We estimate tax rate effects at the extensive and intensive margins based on a system of asset demand equations using panel data covering the period 2002 to 2012. Tax rate effects are identified by exogenous changes in the income tax code that took place during the period under analysis.

We formulate a system of equations to model individual demand for asset classes. We distinguish between six asset classes: Private business equity, owner-occupied housing, rental property, financial assets (stocks, bonds and savings accounts balances), life and private pension insurance, and tangible assets. In the six linear equations

$$y_{mit} = X_{it}\beta_m + (\mu_{mi} + u_{mit}) \tag{20}$$

the dependent variable y_{mit} is the share of asset class m in the private gross wealth portfolio of individual i at time t. Gross wealth is the sum of assets before subtracting liabilities, so the shares are between zero and one. Among the explanatory variables X_{it}, the individual- and time-specific marginal tax rate is of most interest. The model further includes an error term that is composed of two components: an unobserved fixed effect μ_{mi} with $E(\mu|X) = 0$ that captures individual tastes for asset m, and a mean-zero residual error term u_{mit}.

In our setting, the unobserved fixed effect μ_{mi} includes preferences for entrepreneurship such as desire for independence and autonomy. Such unobserved tastes are likely to be correlated with income and individual marginal tax rates. Therefore, we expect cross-sectional estimations to be biased, and it is crucial to econometrically eliminate the unobserved fixed effect. We achieve this using panel data on private wealth portfolios. This improves on most of the literature on household portfolio choice, which does not use panel data methods.

To identify tax effects at the extensive and intensive margins of asset demands, we estimate both the probability that an individual invests in a specific asset class at all and the demand for that asset, conditional on investing in this asset. From an econometric perspective, since most individuals hold incomplete portfolios (King and Leape 1998), for consistent estimation of the coefficient vector β_m in equation (20) we need to account for the choice of investing in a specific asset class in the first place. This is particularly important in our setup because we extend the set of asset classes considered in King and Leape (1998) by including business equity, which most households do not hold.

To predict selection into ownership we assume that

$$y_{mit} > 0 \text{ iff } \nu_{mit} < Z_{it}\gamma_m + \alpha_{mi}, \tag{21}$$

$$y_{mit} = 0 \text{ iff } v_{mit} \geq Z_{it}\gamma_m + \alpha_{mi}, \tag{22}$$

where v_{mit} is a residual error term and α_{mi} is an individual-specific fixed effect with $E(\alpha|Z) = 0$ that again contains unobserved tastes for certain assets. Z_{it} is a vector of selection variables that comprises X_{it} (including the marginal tax rate) and additional variables we discuss further below.

The standard way of accounting for selection would be to assume a normal distribution of v_{mit}, estimate a probit model, and then include the Inverse Mill's Ratio in the asset demand regressions as a selection correction term (Heckman 1979). However, this approach does not allow elimination of the unobserved fixed effect α_{mi} in the selection equation and would lead to biased estimates of the coefficients and the selection correction term. Therefore, we follow Olsen (1980) and assume that v_{mit} is uniformly distributed over $[0,1]$. Then the vector γ_m in the selection model can be consistently estimated using the linear probability model in first differences based on our panel data (see Appendix A.1).

Next, we estimate the asset demand system based on the full sample, building upon methods developed by Shonkwiler and Yen (1999). In our setting the estimation equations, derived in Appendix A.2, are

$$E(y_{mit}|X_{it}) = (Z_{it}\hat{\gamma}_m)X_{it}\beta_m + \delta_m[(Z_{it}\hat{\gamma}_m)^2 - Z_{it}\hat{\gamma}_m], \tag{23}$$

where $\delta_m = \rho_m\sigma_{mu}\sqrt{3}$ is the coefficient for the selection term, and ρ_m measures the correlation of v_{mit} and u_{mit}. In order to estimate these equations, we transform the vector of variables X_{it} to $(Z_{it}\hat{\gamma}_m)X_{it}$ and include the predicted selection terms $(Z_{it}\hat{\gamma}_m)^2 - Z_{it}\hat{\gamma}_m$ as additional regressors. We jointly estimate six asset demand equations using 3SLS in first differences to eliminate the unobserved fixed effects.

The marginal tax rate is endogenous to both the choice to hold a specific asset class and the share of the overall portfolio invested in a given class. The endogeneity occurs because certain investments may change income, which may influence the marginal tax rate due to the progressivity of the tax schedule. First differencing alone does not remove this endogeneity because changes in tax rates may be endogenous to changes in the portfolio for the same reasons.

To deal with this endogeneity, we estimate the selection equations and the wealth share equations based on the instrumental variable method in first differences. We use the tax-benefit microsimulation model STSM (Steiner et al. 2012) to simulate individual marginal personal income tax rates.[15] To construct an exogenous instrument for the marginal tax rate, we first update individual incomes from 2002, the first year in our data, to forecast hypothetical incomes in 2007 and 2012, using the consumer price index.[16] These are the incomes that taxpayers would have received had incomes changed solely due to inflation without any behavioral adjustments. Then we simulate predicted marginal tax rates based on the forecasted incomes using the tax codes of the respective years. We use the changes in these predicted marginal tax rates from one time period to the next as instrument for the endogenous actual changes in

[15]This tax calculator takes into account the details of the German tax and benefit system and its changes over time, including, for example, the rules for income splitting by married couples and basic and child allowances. We compute individual marginal tax rates by simulating the additional tax liability due to an additional 1000 Euro of income in a given year and dividing by 1000. By using an increment of 1000 Euro we avoid rounding issues.

[16]In a robustness check reported in Section 6.4, we use updated incomes from 2001 instead.

the marginal tax rates that are calculated based on observed incomes. Variation in the changes of the predicted marginal tax rates over time exclusively stem from changes in tax laws and bracket creep during our observation period that affect different taxpayers to different degrees due to the nonlinearities and discontinuities of the tax schedule. These effects of tax reforms and inflation are exogenous to the individual.[17] Note that regression of changes on changes, i.e. estimation in first differences, is crucial for this instrumental variable strategy, which we use to estimate both the selection equations and the asset demand equations. Section 4.1 describes the relevant tax reforms during our period of analysis that provide exogenous variation for the identification of tax effects. Almost all marginal tax rates change due to the tax reforms and bracket creep, so the local average treatment effect we identify informs about a reasonably general population. The IV method also accounts for potential measurement error in the marginal tax rates, which could occur due to possible measurement error in income, for example.

In the portfolio share equation (23), besides the marginal tax rate, the transformed variables $(Z_{it}\hat{\gamma}_m)X_{it}$ are also endogenous because Z_{it} includes the marginal tax rate. As instruments for $(Z_{it}\hat{\gamma}_m)X_{it}$ we therefore use modified versions of the transformed variables $(Z_{it}^{IV}\hat{\gamma}_m)X_{it}$ where we replace the marginal tax rate with the simulated marginal tax rate based on exogenously updated income. Analogously, we treat the selection term as endogenous as well and use $(Z_{it}^{IV}\hat{\gamma}_m)^2 - Z_{it}^{IV}\hat{\gamma}_m$ based on the simulated marginal tax rate as its instrument. Since the model is exactly identified, 3SLS is efficient and equivalent to GMM.

The vector of variables X_{it} includes controls for time-varying heterogeneity both in the ownership and the portfolio share equations. It is important to control for possibly nonlinear effects of income because income is correlated with the marginal tax rate and is likely to influence portfolio choice. We use monthly income before tax and its square and assess robustness when we model splines of base year income instead (Section 6.4). Further control variables include net worth and its square,[18] age squared, the number of children in the household, marital status, the willingness to take risks reported on an 11-point Likert scale, and local GDP per capita at the level of Germany's 96 Spatial Planning Regions. By eliminating individual fixed effects, we also control for any time-invariant characteristics such as gender and ethnicity.

Including the selection term $(Z_{it}\hat{\gamma}_m)^2 - Z_{it}\hat{\gamma}_m$ in equation (23) controls for selection into holding a particular asset class (most importantly, business ownership) based on unobservables. In principle, the selection terms' coefficients δ_m are identified by the nonlinear functional form of the selection term, but identification is stronger when exclusion restrictions exist. Reforms in entry regulation into entrepreneurship in 2004 (see Section 4.2) are likely to have an effect on the probability of being an entrepreneur in certain occupations, but not on the portfolio share invested in one's own business conditional on being an entrepreneur. Similarly, changes in the local unemployment rate over time affect individual entrepreneurial choice because individuals are pushed into self-employment when it is difficult to

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[17] Our usage of a simulated tax rate change as the instrument is similar to the approach taken by parts of the literature on the elasticity of taxable income (Gruber and Saez 2002; Saez et al. 2012; Weber 2014). However, our dependent variables are ownership indicators or portfolio shares of asset classes, not taxable income, so the issues of regression to the mean and income dispersion do not arise in our context. In Section 6.4, we run robustness checks with respect to different specifications used in this literature.

[18] Net worth is gross wealth minus liabilities. We do not include gross wealth as a control variable because the leverage decision is potentially endogenous.

find paid employment (Evans and Leighton 1989), but we do not expect an effect on the conditional portfolio share (especially considering that we are also controlling for changes in local GDP). Therefore, we include interaction terms that capture the effect of the 2004 entry regulation reform and the local unemployment rate (at the Spatial Planning Region level) in Z_{it} but exclude these variables from X_{it}.

Our approach of estimating portfolio choice in two steps is flexible and does not restrict the signs of tax effects to be the same at the extensive margin (asset ownership) and the intensive margin (conditional portfolio share of the same asset). In this respect, our empirical model is similar to that used in King and Leape (1998), although these authors use cross-sectional data only and cannot eliminate unobserved individual fixed effects. In contrast, the Tobit model frequently used in the literature (Poterba and Samwick 2002; Alan et al. 2010; Fossen and Rostam-Afschar 2013) implicitly imposes the restriction that the sign be the same at both margins. Since our theoretical model allows for opposing signs of tax effects at the extensive and intensive margins, it is important to use a general empirical specification that does not impose such a restriction.

4. Identification of Tax and Selection Effects Through Legislation Changes

4.1. Personal Income Tax Reforms

To identify the effects of marginal personal income tax (PIT) rates on portfolio choice, we rely on changes in the tax code over time. The legislative changes in marginal tax rates are of different magnitudes for different persons at different points in time and can be considered exogenous for the individual. In this section, we briefly describe the relevant German tax reforms that provide quasi-experimental variation in our time period of analysis (2002-2012). We simulate all the details in the German tax laws and their changes over time to calculate individual marginal PIT rates.

Unincorporated businesses are much more important in Germany than in other countries. In 2012, only 13% of the businesses in Germany that were large enough to pay turnover tax (generally when the turnover exceeds 17,500 Euro per year) were incorporated (German Federal Statistical Office 2016). Accounting for entrepreneurs with lower turnover, who are almost exclusively unincorporated, would reduce the share of incorporated firms even further, although no exact statistics are available. Therefore, in our analysis we focus on unincorporated businesses. Profits of unincorporated businesses are passed through to their owners and are subject to the owners' PIT, which makes the PIT the relevant tax for entrepreneurial decisions. There is also a local business tax, but it is largely credited against the PIT liability of unincorporated business owners and thus of minor importance for unincorporated entrepreneurs.

Germany's PIT follows the principle of comprehensive income taxation to a large extent. The same PIT schedule is applied for most income sources such as wage and salary income or profits from self-employment and unincorporated businesses. In contrast, corporations are legal entities and subject to a flat corporate income tax and the local business tax, which is very relevant for corporations.

The PIT schedule is directly progressive. Above a basic allowance, there are two progressive zones with linearly increasing marginal tax rates, followed by a tax bracket with a constant marginal tax rate. In 2007, an additional bracket was introduced ("rich tax", see below). On top of income tax, the so-called "solidarity surcharge" is levied at a rate of 5.5% of the PIT liability for higher incomes, initially introduced to finance the reunification of Germany.

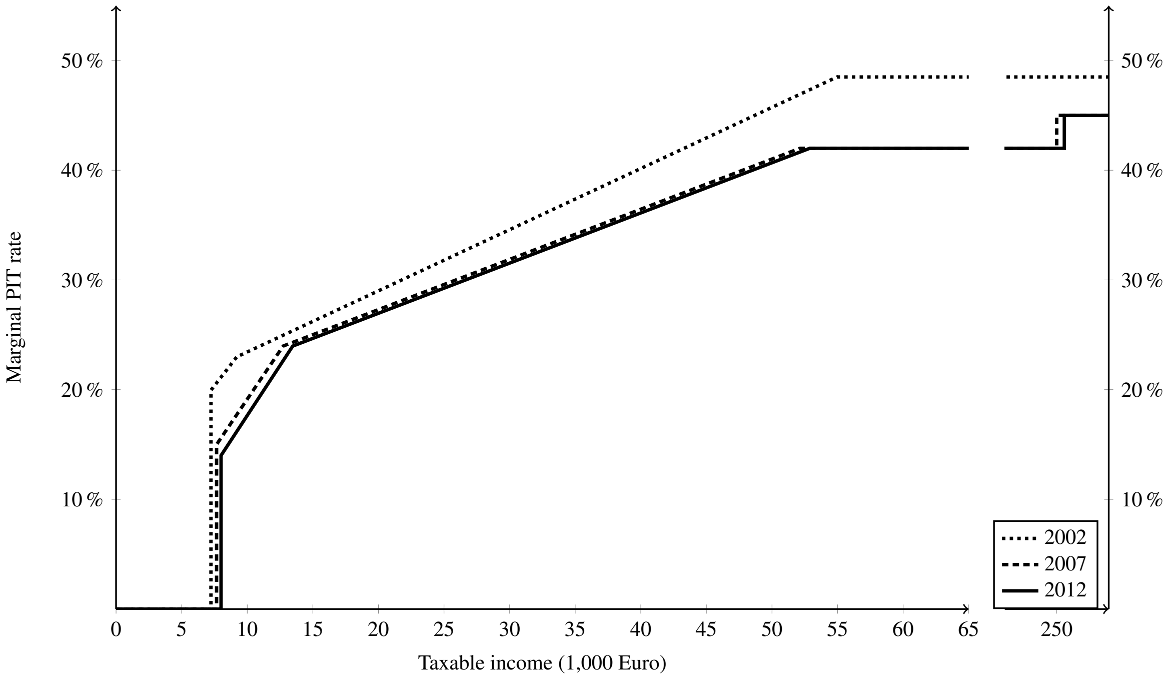

Figure 2: Personal Income Tax Reforms in Germany.

Note: Statutory marginal PIT rates for unmarried persons in 2002, 2007 and 2012.

The personal income tax underwent several reforms between 2002 and 2012. Figure 2 displays the statutory marginal PIT rates for unmarried persons in 2002, 2007 and 2012, the three years we use in our empirical analysis. The top marginal income tax rate was reduced from 48.5% in 2003 to 42% in 2005. The "rich tax" reform in 2007 introduced an additional tax bracket with a new top marginal income tax rate of 45% for incomes in excess of 250,000 Euro. The lowest marginal tax rate was decreased from 19.9% in 2003 to 15% in 2005 and further to 14% in 2009. The basic allowance was raised several times and amounted to 7235 Euro in 2002, 7664 Euro in 2007 and 8004 Euro in 2012 for a single taxpayer and double these amounts for a married couple filing jointly.

Another tax reform was implemented in 2009. Before this date, interest and dividend income were taxed jointly with income from other sources using the PIT schedule. For dividend income, a shareholder tax relief of 50% was applied to account for taxes already paid by the corporation. From 2009 on, a separate final withholding tax for interest and dividend income was introduced instead at a flat rate of 25% plus solidarity surcharge. In turn, the shareholder relief for dividends was abolished, so dividends were effectively taxed at a similar rate as before, taking into account taxes paid at the corporation level.[19]

Since 2008, unincorporated partnerships have the option to tax retained earnings at a rate of 28.25% instead of the personal tax rate of the PIT schedule. Once the profit is withdrawn, a follow-up tax of 25% is due. This option is therefore only attractive for a small number of entrepreneurs who face high marginal tax rates and who intend to retain

[19] We cannot exploit the lower tax rate on interest income available since 2009 to identify effects of taxes on the choice of specific financial assets because our data do not distinguish between holdings of bonds and stocks.

their profits for a long time.[20]

In the German PIT, apart from setting losses against positive income from other sources, losses can also be carried back to the previous year or carried forward for an unlimited number of years. While losses below 1 million Euro (2 million in case of married couples) can by carried forward in full, since 2004 only 60% of the part of a loss that exceeds these thresholds can be carried forward. Since the thresholds are fairly large, these loss offset restrictions are hardly relevant for the entrepreneurs in our sample, who have a mean monthly income of 4,527 Euro (see Table 3).

The changes in the PIT schedule generated quite substantial variation in the shifts of marginal PIT rates for different taxpayers over time. For instance, because for married couples joint filing is the rule, the tax bracket applicable for a person depends on the earnings of the spouse. Jessen et al. (2017) show marginal tax rates and budget constraints for singles and married couples and provide a comprehensive overview of the German tax and transfer system. Since the PIT schedule is not adjusted for inflation in Germany, bracket creep generates additional cross-sectional variation in changes of marginal PIT rates over time, because the effects of bracket creep are largest in the progressive zones of the tax schedule.

4.2. Reform of Entry Regulation Into Entrepreneurship

To control for selection into entrepreneurship (extensive margin), we exploit exogenous variation in entry regulation for certain occupations in crafts and trades. This group of entrepreneurs amounts to about 19% of all entrepreneurs in our sample.

Market entry for prospective entrepreneurs in craft trades has been strictly regulated in Germany. Before 2004, and dating back to 1935, setting up an own crafts business was conditional on having obtained an educational qualification called "Meister" (master craftsman) in 94 occupations listed as A-occupations in the German Trades and Crafts Code. Obtaining this qualification is associated with significant costs. Full-time courses to prepare for the Meister exam take 1-3 years, and the overall costs range from 4000 to 10,000 Euro depending on the occupation. In January 2004, this entry regulation underwent a major change. In many occupations that had required a Meister qualification for market entry, the educational requirement was completely abolished (B1 occupations) or relaxed by allowing "senior journeymen" with six years of relevant work experience to start up without a Meister degree (A1 and A2 occupations). Furthermore, a new rule allowed the exemption of "easy jobs" from the entry requirement. A2 occupations are defined as a group that we conjecture to often make use of this rule, so the entry requirement could be further loosened for this group in practice. Table 1 summarizes the changes in the entry regulation for the occupation groups and lists examples of occupations. Rostam-Afschar (2014) analyzes the effects of this reform on entry rates into entrepreneurship and estimates significant effects for B1 and A1 occupations. We account for this reform by including interaction terms of the four occupation group dummies (AC, A1, A2, B1; omitted base category: no craft or trade occupation) with a post reform dummy (years 2004 and later) in the selection equations.

[20] See Fossen and Simmler (2016) for details on the final withholding tax and the tax option for retained earnings.

Table 1: Reform of Entrepreneurial Entry Regulation For Craft and Trade Occupations

Group	Change in Entry Regulation in 2004	% of all Entrep.	Example Occupations
AC	Craft and trade occupation with no change	0.3	Chimney sweeps, optometrists, hearing aid audiologists, orthopedic technicians, dental technicians
A1	Relaxation through "senior journeyman rule"	10.1	Roofers, surgical instrument makers, gunsmiths, plumbers, gas and water fitters, joiners, pastry cooks
A2	In addition, frequent exemptions for "easy jobs"	3.8	Masons and concreters, painters and varnishers, metalworkers, motor vehicle body and vehicle construction mechanics, bike mechanics, information electronics technicians, vehicle technicians, butchers
B1	Abolishment of entry requirement	4.9	Tile and mosaic layers, coppersmiths, turners, tailors, millers, photographers

Note: There is some classification ambiguity in our data because some of the occupational classification codes used may include some occupations that are legally not defined as crafts occupations.

5. Panel Data with Private Business Equity

For our analysis of portfolio choice we require individual panel data reporting private asset holdings. In particular, we need information on private business equity, which is unavailable in most datasets and rules out the use of administrative tax return data. Furthermore, the data must provide sufficient information on various income sources and the household situation for detailed tax-benefit simulation. It must also report occupations at a detailed level and include control variables relevant for entrepreneurship. Equation (16) shows that it is important to control for individual risk attitudes (see also Caliendo et al. 2009), which are again unavailable in administrative data.

Our data requirements are fulfilled by the SOEP, a representative annual household panel survey for Germany. Wagner et al. (2007) provide a detailed description of the data. The waves of 2002, 2007 and 2012 included a special module collecting detailed information on private wealth. The interviewers asked for the current market values of the most important asset and liability types of private households. The items include personally owned real estate (owner-occupied housing, property rented out, mortgage debt), financial assets, private life and pension insurance, tangible assets, consumer credits, and, most importantly for this analysis, private business equity (net market value, own share in case of a business partnership). As there is no wealth tax in Germany, there is no reason to expect underreporting of particular assets classes.

All information on assets is elicited at the level of the individual respondent. When an asset is owned by more than one person, e.g., a house owned by a couple, the respondents are asked to indicate which share they own. Therefore, our analysis is on the individual, not the household level.[21] We define an entrepreneur as a person with strictly positive holdings of own business equity. We restrict our sample to persons between 25 and 65 years of age and exclude those not in the labor force, the unemployed, students, and pensioners.

[21] We use directly observed information on asset holdings only. Using imputations provided by the SOEP increases the size of our final estimation sample only slightly and our estimation results do not change much.

Table 2: Entrepreneurial and Non-entrepreneurial Balance Sheets

		Entrepreneurs			*Non-Entrepreneurs*		
Personal Assets and Liabilities		Mean assets (Euro)	Percentage of gross wealth	Percentage of owners	Mean assets (Euro)	Percentage of gross wealth	Percentage of owners
I	Financial assets	51,061	10.5	59.2	16,291	23.0	57.9
II	**Ownership equity**	206,263	40.0	100.0	0	0.0	0.0
III	Contractual savings	35,943	13.4	74.7	12,637	30.8	70.3
IV	Tangible assets	3,588	0.8	13.4	815	1.7	7.4
V	Real estate						
	Primary house or apartment	155,648	26.0	52.6	101,886	38.6	47.9
	Other (rental) property	152,835	9.2	29.3	25,031	6.0	12.8
Gross wealth		519,565	100.0	100.0	109,726	100.0	100.0
VI	Mortgages						
	On primary house or apart.	38,125	8.9	33.3	29,506	13.0	32.6
	On other (rental) property	47,479	3.9	15.9	8,509	3.7	7.1
VII	Other liabilities	13,904	20.8	30.4	3,158	69.4	23.1
Total Liabilities		99,507	33.6	62.7	41,173	86.1	50.9
Net worth		441,494	67.1	95.3	82,229	15.4	91.4

Note: Pooled averages of 1,135 entrepreneur-years and 13,409 non-entrepreneur-years based on the SOEP waves 2002, 2007, and 2012, using population weights provided by the SOEP. The percentages of total gross wealth are means over individual percentage shares in gross wealth portfolios. The large average share of other liabilities in gross wealth for non-entrepreneurs is driven by individuals who have very small gross wealth, but large liabilities. *Financial assets* include savings balance, savings bonds, bonds, shares or investments, *ownership equity* commercial enterprise, i.e. a company, a shop, an office, a practice or an agricultural enterprise, *contractual savings* life insurance or private retirement insurance policies, and *tangible assets* gold, jewelry, coins or valuable collections. *Other liabilities* are liabilities other than mortgages or building loans.

Table 2 shows private wealth balance sheets of entrepreneurs and non-entrepreneurs, respectively.[22] On average, entrepreneurs' net worth is more than five times as large as that of non-entrepreneurs. Entrepreneurs hold very undiversified portfolios: On average, they invest 40% of their gross wealth in their own business. This is very similar to observations made for the United States (Gentry and Hubbard 2004).[23] By definition, non-entrepreneurs do not own any private business equity. They invest the largest share of their gross wealth in owner-occupied housing.

Table 3 summarizes means of other individual characteristics used in our analysis by entrepreneurial status. Entrepreneurs have higher monthly income on average than non-entrepreneurs, which is in line with their larger net worth. However, their marginal PIT rate is only slightly larger, which may partly be due to the fact that they are more likely to be married and have a larger number of children on average. The large standard deviations show the substantial cross-sectional variation in marginal tax rates. Entrepreneurs also self-report a higher willingness to take risks on an 11-point scale from 0 (completely unwilling) to 10 (fully willing).

[22] For the descriptive statistics we use the same sample restrictions as in the econometric estimations (concerning the age and labor market status of the respondents as described above and no missing values in the relevant variables), but we do not limit the sample to individuals observed in two consecutive periods yet, which is required in the first differenced regressions.

[23] Fossen (2011, 2012) and Fossen and Rostam-Afschar (2013) discuss possible reasons why entrepreneurs hold these undiversified portfolios. In particular, Fossen (2011) finds that lower average risk aversion of entrepreneurs may explain their risky portfolio choices.

Table 3: Descriptive Statistics

Variable	Unit	Entrepreneurs Mean	Entrepreneurs Std. dev.	Non-Entrepreneurs Mean	Non-Entrepreneurs Std. dev.
Marginal tax rate	%	38.2	12.9	38.1	22.5
Marginal tax rate using updated income (IV)	%	37.8	19.8	36.8	23.0
Real gross income per month	Euro (2005 prices)	4,527	5,121	2,618	1,989
Age	Years	45.2	9.3	43.1	10.0
Married	%	66.7		65.0	
Number of children in household	Integer	0.64	0.92	0.55	0.86
Willingness to take risks	Scale 0-10	5.90	2.12	4.86	2.11
Higher technical college or similar	%	28.7		26.2	
University degree	%	39.6		23.4	
Local GDP per capita	1,000 Euro	30.3	9.0	29.9	8.5
Local unemployment rate	%	8.5	3.9	8.5	4.0

Note: Pooled averages of 1,135 entrepreneur-years and 13,409 non-entrepreneur-years based on the SOEP waves 2002, 2007, and 2012, using population weights provided by the SOEP. Standard deviations are not shown for binary variables.

6. Empirical Portfolio Choice Results

6.1. Extensive Margin

We begin the discussion of the results by presenting the first estimation step, the regressions of selection into ownership of the six different asset classes. Table 4 shows the estimation results (with standard errors robust to clustering at the individual level). Each column represents a linear probability model, where the dependent variable is a dummy that is one if a person has strictly positive holdings of the asset class indicated at the column head and zero otherwise. The equations are separately estimated using the IV method in first differences. The marginal tax rate is treated as endogenous. The instrument is the simulated marginal tax rate based on each year's tax code, but exogenously updated individual income from 2002 (see Section 3). The instrument is relevant, as indicated by the first stage F-statistic of the excluded IV of 25.9.[24]

The marginal personal income tax rate has significant effects on the probabilities of holding two asset classes, business equity and rental property. Increasing the marginal tax rate by 10 percentage points *increases* the probability of holding assets in a private business by 1.2 percentage points. This corresponds to 14% of the average ownership probability of 8.4% indicated at the bottom of the table, so the effect is economically very significant. The positive effect of the marginal tax rate on business ownership is consistent with a tax avoidance or evasion motivation. Higher tax rates raise incentives to create a private business as a vehicle to shelter income. The empirical result is in line with the findings of Cullen and Gordon (2007) using U.S. tax return data.

The second significant effect of the marginal tax rate is on property rented out, with the opposite sign. A hike in the marginal tax rate by 10 percentage points decreases the probability of holding rental property by 2.1 percentage points, i.e. 12.6% of the average ownership probability of 16.5%. The effects on the ownership probabilities of the

[24]The first stage of the IV regressions has the marginal tax rate as the dependent variable and is identical for all asset classes.

other asset classes are small and insignificant. Together, the results indicate that tax-induced investment in an own business and in rental property are substitutes at the extensive margin.

Table 4: Ownership Probabilities of Asset Classes

	Business equity	Owner Housing	Rental Property	Financials	Life Insurance	Tangible Assets
Marginal tax rate	0.1189*	-0.0576	-0.2069**	-0.0312	-0.0786	0.0650
	(0.0617)	(0.0769)	(0.0868)	(0.1442)	(0.1254)	(0.0921)
Local unempl. rate	-0.0027	0.0042	-0.0038	0.0078	0.0028	-0.0018
	(0.0021)	(0.0035)	(0.0032)	(0.0048)	(0.0045)	(0.0030)
Occupations A1 $\times \geq 2004$	0.0351*	0.0340	-0.0413	-0.0266	-0.0032	0.0068
	(0.0213)	(0.0278)	(0.0301)	(0.0418)	(0.0345)	(0.0183)
Occupations A2 $\times \geq 2004$	0.0450	0.0806*	-0.0365	0.0934	0.0129	0.0427*
	(0.0308)	(0.0417)	(0.0328)	(0.0603)	(0.0651)	(0.0248)
Occupations AC $\times \geq 2004$	-0.0815	-0.1074*	0.0741	-0.0143	0.0234	0.0011
	(0.0607)	(0.0644)	(0.1140)	(0.0940)	(0.1140)	(0.1356)
Occupations B1 $\times \geq 2004$	-0.0151	0.0104	-0.0418	0.0033	-0.0013	-0.0058
	(0.0176)	(0.0272)	(0.0309)	(0.0497)	(0.0449)	(0.0321)
Gross income	0.1586**	-0.0266	0.1245**	0.2345***	0.1857***	0.0326
	(0.0646)	(0.0501)	(0.0606)	(0.0851)	(0.0686)	(0.0577)
Gross inc. sq.	-0.0136	0.0072	-0.0107*	-0.0163*	-0.0216***	-0.0027
	(0.0096)	(0.0060)	(0.0055)	(0.0088)	(0.0070)	(0.0052)
Net worth	0.6152***	1.3759***	1.1622***	0.2274	0.5284**	0.1018
	(0.2296)	(0.3053)	(0.3036)	(0.2303)	(0.2279)	(0.1701)
Net worth sq.	-0.0686*	-0.1700***	-0.1285***	-0.0374	-0.0432	0.0194
	(0.0379)	(0.0370)	(0.0347)	(0.0300)	(0.0267)	(0.0192)
Further controls	✓	✓	✓	✓	✓	✓
N (first-differenced observations)	3,979	3,979	3,979	3,979	3,979	3,979
F-test income terms (*p*-val.)	0.0446	0.3295	0.0972	0.0085	0.0078	0.6814
F-test wealth terms (*p*-val.)	0.0256	0.0000	0.0005	0.4469	0.0261	0.0000
F-test selection var.: (*p*-val.)	0.0519	0.1772	0.4887	0.2326	0.9635	0.5710
First stage *F* statistic	25.8651	25.8651	25.8651	25.8651	25.8651	25.8651
Mean ownership prob.	0.0840	0.5412	0.1646	0.5933	0.7081	0.0854

Note: Linear probability models of ownership of asset classes (separate IV regressions in first differences). The left-hand-side variable in the model equation is one if a person owns a strictly positive amount of the asset class indicated at the column head and zero otherwise. The marginal tax rate is treated as endogenous. Instrumental variable: the simulated marginal tax rate using exogenously updated individual income from 2002 and the contemporaneous tax code. Estimated in first differences to eliminate individual fixed effects. The occupation groups are defined in Table 1. Gross income is in 10,000 Euro and net worth in 10 mill. Euro, both in prices of 2005. Further control variables included: Age squared, number of children, married, willingness to take risks, local GDP per capita, educational degree dummies, time dummy for 2012. The *F*-tests are for joint significance of the variables indicated; the selection variables are the local unemployment rate and the interaction terms involving the trade occupation dummies. Standard errors clustered at the person level in parentheses. $^{*}/^{**}/^{***}$: Significance at the 10%/5%/1% levels. *Source:* Own estimations based on the German Socio-Economic Panel 2002, 2007, and 2012.

Next, we consider the variables testing the effects of the change in the regulation of entry into entrepreneurship for trade and craft occupations in 2004. The interaction term of the dummy variable indicating A1 occupations with the post-reform time period dummy is positive and significant in the ownership equation of private business equity. This indicates that the probability of owning a business increased after the entry regulation reform for workers in A1 occupations. This is very plausible because the reform lowered the educational entry requirements for these occupations (see Section 4.2). This result confirms the finding of Rostam-Afschar (2014), though the interaction on B1 is not significantly positive as expected. The variables included in these first step selection equations, but excluded from the second step estimations of portfolio shares (i.e., the entry regulation reform dummies and the local unemployment rate) are jointly significant in the business equity ownership equation (*p*-value: 0.0519). This facilitates identification of the equation of the conditional portfolio share of business equity, which is of primary interest in this analysis.[25]

Income and wealth have significant effects on the probability of owning most asset classes (see the *p*-values of the *F*-tests of joint significance of the linear and square terms at the bottom of the table). The probability of owning private business equity increases with gross (before-tax) income and personal net worth at decreasing marginal rates. (The turning points are beyond the ranges relevant in our data.) Similar income and wealth effects can be observed for rental property and life and private pension insurance. For owner occupied housing, only the wealth effect is significant, whereas for financial assets, only the income effect is significant. The finding that the wealth and income effects are initially positive or insignificant for all asset classes at the extensive margin is plausible. When individuals have higher income and larger amounts of wealth, they hold more diversified portfolios with a larger number of different asset classes (e.g., Carroll 2002).

6.2. *Intensive Margin*

Table 5 presents the results of the second step estimations of the portfolio shares of the six asset classes in the private wealth portfolio. The system of demand equations is estimated jointly using 3SLS in first differences, with an endogenous marginal tax rate and with selection correction. As outlined in Section 3, all transformed explanatory variables are treated as endogenous and appropriately instrumented.[26]

The strength of the instruments in the system of demand equations is tested using Shea's Partial R^2. The instruments are particularly strong in the equation of the portfolio share of private business equity (in the first column), which is of primary interest, with Shea's Partial $R^2 = 23.9\%$. The statistic is smaller, but still satisfactory in the other equations, although quite small for tangible assets.[27] The estimated coefficient of the selection term is significant in four out of the six equations including the equation of the portfolio share of private business equity. This indicates that it is important to account for selection into ownership of these assets.[28]

[25] The exclusion restrictions are jointly insignificant in the ownership equations of the other assets, although some of these variables are individually significant. It is plausible that regulation of entry into entrepreneurship and the local unemployment rate affect the probability of owning a business, but not necessarily ownership of other assets.

[26] In Table B.1 in Appendix B, we report standard errors robust to clustering at the person level. The clustered standard errors turn out to be mostly smaller than the regular standard errors in our 3SLS estimations. Therefore, to be conservative, we report regular standard errors in Table 5. We also estimate bootstrapped standard errors with 200 replications taking into account clustering at the person level and sampling error in the predicted selection correction term. While again some standard errors shrink, this increases the *p*-value of the coefficient of the marginal tax rate in the business equity equation to 0.057, and the marginal tax rate becomes insignificant in the owner-occupied housing equation.

[27] A limitation of Shea's Partial R^2 is that it does not allow to formally test for weak instruments. Therefore, for each endogenous regressor, we also conduct Sanderson-Windmeijer's χ^2 and *F*-test for underidentification and for weak identification. In both versions of the test as well as in a joint *F*-test (not reported in the table), no *p*-value exceeds the 5% significance level, and we can infer that the hypotheses that the endogenous regressors are underidentified or weakly identified are rejected. The method by Sanderson and Windmeijer (2016) is a modification of the tests described by Angrist and Pischke (2009), which we report in the table.

[28] Note that our linear selection correction model allows interpreting the effect of an increase in the probability of being an entrepreneur ($Z_{it}\gamma_m$) more directly than other selection correction models (see equation A.1 in Appendix A.2). If a 10 percentage points larger share of the population engaged in entrepreneurship, the share invested in own business equity conditional on business ownership would be 1.5 percentage points lower.

Table 5: Portfolio Shares of Asset Classes

	Business equity	Owner Housing	Rental Prop.	Financials	Life Insurance	Tangible Assets
Marginal tax rate	-0.0708**	0.0348***	-0.0753**	0.0084	-0.0896**	-0.0533
	(0.0296)	(0.0130)	(0.0313)	(0.0750)	(0.0350)	(0.0449)
Gross income	0.1838***	0.0151	0.0081	-0.1314***	0.0214	0.0586
	(0.0459)	(0.0160)	(0.0666)	(0.0455)	(0.0473)	(0.0645)
Gross income sq.	-0.0111**	-0.0017	-0.0025	0.0128***	0.0008	0.0003
	(0.0055)	(0.0031)	(0.0095)	(0.0047)	(0.0054)	(0.0185)
Net worth	0.0790	0.0428	0.1067	-0.6237***	0.1251	0.3120
	(0.0857)	(0.0805)	(0.1108)	(0.1784)	(0.1578)	(0.2250)
Net worth sq.	-0.0294*	0.0041	-0.0018	0.0585**	-0.0302	-0.0663
	(0.0165)	(0.0212)	(0.0291)	(0.0243)	(0.0242)	(0.0689)
Selection term $(Z\hat{\gamma})^2 - Z\hat{\gamma}$	-0.1540*	0.0076	-0.1107*	-0.0358	-0.1554**	0.1494*
	(0.0793)	(0.0208)	(0.0583)	(0.0773)	(0.0651)	(0.0846)
Further controls	✓	✓	✓	✓	✓	✓
N (first-differenced observations)	3,979	3,979	3,979	3,979	3,979	3,979
F-test income terms (p-val.)	0.0000	0.6183	0.9510	0.0145	0.2900	0.5194
F-test wealth terms (p-val.)	0.1427	0.6233	0.2611	0.0017	0.4445	0.3681
Angrist/Pischke Partial R^2	0.1924	0.0576	0.0327	0.0516	0.0727	0.0233
Shea's Partial R^2	0.2387	0.0572	0.0401	0.0522	0.0703	0.0250
Uncond. mean portfolio share	0.0325	0.4132	0.0697	0.2039	0.2673	0.0135
Conditional mean portf. share	0.3865	0.7636	0.4231	0.3437	0.3775	0.1577

Note: System 3SLS estimation of asset class shares in first differences with endogenous tax rate and selection correction. The left-hand-side variable in the model equation is the share in the private wealth portfolio of the asset class indicated at the column head. The instrument for the actual marginal tax rate is the simulated marginal tax rate using exogenously updated individual income from 2002 and the contemporaneous tax code. Estimated in first differences to eliminate individual fixed effects. Gross income is in 10,000 Euro and net worth in 10 mill. Euro, both in prices of 2005. Further control variables included: Age squared, number of children, married, willingness to take risks, local GDP per capita, time dummy for 2012. All variables are transformed and instrumented as described in Section 3. Standard errors in parentheses. $^{*}/^{**}/^{***}$: Significance at the 10%/5%/1% levels. *Source:* Own estimations based on the German Socio-Economic Panel 2002, 2007, and 2012.

The estimated coefficient of the marginal personal income tax rate is significant for the portfolio share of private business equity, as in the ownership probability equation, but has the opposite sign. An increase in the marginal tax rate *decreases* the share of own business equity in the private wealth portfolio conditional on being a business owner.[29] This is consistent with a disincentive effect of taxation on marginal investment in productive businesses. The negative effect of taxes on entrepreneurial activity is in line with Hansson (2012).

Our finding of opposite signs of tax effects at the extensive and intensive margins are inconsistent with the standard theoretical model of portfolio choice, but can be rationalized using our extended model that allows for tax sheltering. The opposing effects of taxes on the probability of ownership and on the conditional portfolio share of the same asset type also indicates that a Tobit model is inappropriate for estimation of tax effects on household portfolio choice when business equity is included, because the Tobit model restricts the signs of the effects to be the same.

Significant tax effects are also detected for owner-occupied housing, rental property, and life and private pension insurance policies. For owner-occupied housing, the coefficient of the marginal tax rate is positive and significant, which may indicate that business equity and owner-occupied housing are used as substitutes when tax rates change. The estimated tax effect on business equity is the most robust among the six asset classes. When instead of 3SLS we estimate inefficient 2SLS models equation by equation without taking into account correlation of the error terms across equations (Table B.2 in Appendix B), the coefficient of the marginal tax rate in the business equity equation

[29] We discuss the effect size in Section 6.3.

becomes even more negative and remains statistically significant, but the coefficients of the marginal tax rate become statistically insignificant for the other asset classes. Therefore, our conclusions focus on the robust evidence we find on the tax effects on private business equity.

Income effects are significant for the portfolio shares of business equity and financial assets (joint significance of the linear and square terms as indicated at the bottom of Table 5). When their income grows, individuals invest a larger share of their wealth in their own business, but a lower share in financial assets at the intensive margins. These effects attenuate when income increases further. The income effects occur holding net worth constant. Wealth effects are significant (joint tests of the linear and square terms) for financial assets, with an initially negative effect on the portfolio share of financial assets.

6.3. Unconditional and Conditional Marginal Effects

The average unconditional portfolio shares as well as the portfolio shares conditional on owning a positive amount of an asset class appear at the bottom of Table 5 (unweighted). Based on the estimated coefficients of the selection and portfolio share equations, we calculate the average unconditional and conditional marginal effects of the marginal personal income tax rate using the formulas derived in Appendix A.3. When the legislator increases the marginal tax rate by 10 percentage points, the portfolio share of private business equity conditional on owning a private business *decreases* by 0.891 percentage points. This is 2.3% of the unweighted average conditional portfolio share of private business equity in the sample of 38.7%. The finding is consistent with a disincentive effect of the marginal tax rate on marginal investment conditional on being a business owner.

The signs of the unconditional effects depend on both the estimated selection and the portfolio share equations. Increasing the marginal tax rate by 10 percentage points *increases* the unconditional portfolio share of private business equity by 0.093 percentage points. This is 5.5% of the average unconditional portfolio share of private business equity in the sample of 3.25%. Thus, the sign of the unconditional tax effect is the same as in the ownership selection equation, but opposite to the effect on the conditional portfolio share. This indicates that the tax effect at the extensive margin overcompensates the effect at the intensive margin.

6.4. Further Robustness Checks

In our preferred specification, we include income and income squared (before tax) in the model equation (20) and then take first differences. As a robustness check, we control for splines of base year income in the otherwise first-differenced estimation equation instead. More precisely, we construct six splines of monthly gross income in 2002. The first five splines have a width of 1000 Euro each and cover 0 to 5000 Euro and the sixth spline covers incomes above 5000 Euro. Table B.3 in Appendix B shows the results for the asset ownership probabilities and Table B.4 for the portfolio shares of the asset classes. The estimates of the coefficients of the marginal tax rate remain similar to the baseline estimates in Tables 4 and 5, which indicates that the results are robust to the choice of income controls.

In another robustness check, we use income from 2001 instead of income from 2002 to construct the instrument for the marginal tax rate. As this requires additionally observing respondents in 2001, the number of first-differenced observations used in the estimations decreases from 3979 to 3302. This alternative instrument turns out to be weak in our context: In the asset ownership probability models, the first stage F-statistic of the excluded instrument drops from 25.9 to 5.6, and in the estimation of the portfolio share of private business equity, Shea's Partial R^2 falls from 0.24 to 0.06. The estimated standard errors increase, and most coefficients become insignificant, including those of the marginal tax rate for all asset ownership probabilities. In the GMM estimation, the point estimate of the coefficient of the marginal tax rate for the portfolio share of private business equity is -0.0586 using this IV, similar to our baseline estimate in Table 5, but it is insignificant due to a large standard error as well. When we estimate the portfolio share of private business equity separately by 2SLS (as in Table B.2) using this IV, we obtain a significantly negative point estimate of -1.17 with a large standard error of 0.36. This confirms our qualitative result of a significantly negative effect of the marginal tax rate on entrepreneurial investment at the intensive margin, but we prefer the more conservative point estimate from our baseline estimation because of the difference in the strength of the instruments.

7. Conclusion

We have investigated the effects of the marginal personal income tax rate on household portfolios focusing on entrepreneurial business equity, which has been almost completely neglected in the extant empirical literature on tax effects on household portfolio choice. At the theoretical level, we extend the standard theoretical portfolio choice model by allowing for partial sheltering of income from an own business. This could be legal tax avoidance and/or illegal tax evasion. In contrast to the standard model, our model implies that tax effects could have different signs at the extensive margin (probability of being an entrepreneur, i.e., of holding own business equity) and intensive margin (portfolio share of private business equity conditional on being a business owner). This rationalizes our empirical results.

For our empirical analysis, we use representative panel data including private business equity and the other most important asset types of private persons in Germany. We estimate simultaneous demand equations for six asset classes, including private business equity, eliminate unobserved individual fixed effects, and identify tax effects through changes in the tax code over time. We also control for selection into entrepreneurship by exploiting a reform in entry regulation during our observation period.

Our empirical results indicate that lower marginal personal income tax rates decrease the probability of owning a business, but increase the conditional portfolio share that entrepreneurs invest in their own business. This is consistent with both a tax avoidance and evasion motive for owning a marginal business and a disincentive effect of higher marginal tax rates on marginal investment in productive businesses. Quantitatively, a decrease in the marginal tax rate by 10 percentage points increases the conditional portfolio share of private business equity by 2.3% of the average conditional portfolio share of 39%, but decreases the unconditional portfolio share by 5.5% of the unconditional average of 3%. The latter occurs due to a negative effect of a tax cut on the probability of being an entrepreneur. The opposing signs of the tax effects at the intensive and extensive margins are inconsistent with the standard portfolio choice model, but can be rationalized using our reformulated model allowing for tax sheltering of business income.

Our results contribute to reconciling the inconclusive results from the literature about tax effects on entrepreneurship. Our finding that lower marginal tax rates have a negative effect on the probability of being an entrepreneur is consistent with Cullen and Gordon (2007), who find that a uniform cut in personal income tax rates would lead to a fall in the entrepreneurship rate in the United States. However, our finding that the conditional amount of own wealth that entrepreneurs put at risk in their business increases when tax rates are lower may explain why other studies find positive effects of tax cuts on entrepreneurship in other countries and situations, such as that by Hansson (2012) for Sweden.

In light of the mixed empirical results from the literature, our theoretical model, together with our empirical results, offers some guidance for policymakers. By highlighting that lower taxes may drive out businesses that are viable only due to tax sheltering, but increase equity investment in private businesses that are also worthwhile in the absence of taxes, our analysis strengthens the case for lower tax rates to stimulate productive entrepreneurial risk taking. Future research should more specifically investigate the mechanisms identified in the model to scrutinize this point. An important challenge for the future is to collect and analyze data on tax avoidance and evasion which could be used to provide tests of the model, though we realize of course that this is notoriously difficult due to the very nature of income concealment.

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Appendix A. Derivation of the Estimation Equations

Appendix A.1. Selection Correction

Equation (20) describes portfolio shares at the intensive margin, where equations (21) and (22) are the equations of selection into ownership of a particular asset. To avoid clutter, we suppress the asset class indices in this subsection and assume that the individual fixed effects have already been eliminated by partialling out from the linear selection and share equations. X_{it} and Z_{it} are row vectors which conform to the column vectors of unknown coefficients β and γ, respectively. The X's and Z's are assumed to be exogenous in this Appendix to focus on selection.

Assume that the expected value of the error of the intensive regression is zero, $E(u_{it}) = 0$, and its variance is $E(u_{it}u_{jt}) = \sigma_u^2$ for $i = j$, and zero otherwise. The expected value of the selection threshold is equal to $E(\nu_{it}) = \mu_\nu$, its variance is $E[(\nu_{it} - \mu_\nu)(\nu_{jt} - \mu_\nu)] = \sigma_\nu^2$ for $i = j$, and zero otherwise. The covariance between the error of the intensive regression and the selection threshold is $Cov(u_{it}, \nu_{jt}) = E(u_{it}\nu_{it}) - E(u_{it})E(\nu_{it}) = \rho\sigma_\nu\sigma_u$ for $i = j$, and zero otherwise. Assume the expected value of the error of the intensive regression conditional on the value of the selection threshold is $E(u_{it}|\nu_{it}) = \rho(\nu_{it} - \mu_\nu)\sigma_u/\sigma_\nu$. By assuming the conditional expectation of u_{it} given ν_{it} is linear in ν_{it} we can use the decomposition

$$u_{it} = \rho(\nu_{it} - \mu_\nu)\sigma_u/\sigma_\nu + \varepsilon_{it},$$

where ε_{it} and ν_{it} are uncorrelated. Substituting this into $y_{it} = X_{it}\beta + u_{it}$ gives

$$y_{it} = X_{it}\beta + \rho(\nu_{it} - \mu_\nu)\sigma_u/\sigma_\nu + \mu_i + \varepsilon_{it}.$$

Then the conditional mean is

$$E(y_{it}|X_{it}, \nu_{it} < Z_{it}\gamma) = X_{it}\beta + \rho\sigma_u E(\nu_{it}|\nu_{it} < Z_{it}\gamma)/\sigma_\nu - \rho\sigma_u\mu_\nu/\sigma_\nu.$$

If ν_{it} is a standard normally distributed random variable with mean $\mu_\nu = 0$ and variance $\sigma_\nu^2 = 1$ (Heckman 1979), then it follows that

$$E(\nu_{it}|\nu_{it} < Z_{it}\gamma) = -\frac{\phi(Z_{it}\gamma)}{\Phi(Z_{it}\gamma)} \text{ (Inverse Mill's Ratio)}$$

and the estimation equation is:

$$E(y_{it}|X_{it}, v_{it} < Z_{it}\gamma) = X_{it}\beta - \underbrace{\rho\sigma_u}_{\delta}\frac{\phi(Z_{it}\gamma)}{\Phi(Z_{it}\gamma)},$$

where δ and β are the parameters to be estimated.

Following Olsen (1980) instead, if v_{it} is uniformly distributed over the interval $[0,1]$, then $E(v_{it}) = \mu_v = \frac{1}{2}$ and $V(v_{it}) = \frac{1}{12}$, so $\sigma_v = \frac{1}{2\sqrt{3}}$. Using the equation for the conditional mean as above with these values gives

$$E(y_{it}|X_{it}, v_{it} < Z_{it}\gamma) = X_{it}\beta + \rho\sigma_u E(v_{it}|v_{it} < Z_{it}\gamma)/\sigma_v - \rho\sigma_u\mu_v/\sigma_v$$

$$= X_{it}\beta + 2\sqrt{3}\rho\sigma_u E(v_{it}|v_{it} < Z_{it}\gamma) - \sqrt{3}\rho\sigma_u.$$

Using $E(v_{it}|v_{it} < Z_{it}\gamma) = Z_{it}\gamma E(v_{it}) = Z_{it}\gamma/2$ we can write

$$E(y_{it}|X_{it}, v_{it} < Z_{it}\gamma) = X_{it}\beta + \sqrt{3}\rho\sigma_u(Z_{it}\gamma) - \sqrt{3}\rho\sigma_u$$

$$= X_{it}\beta + \sqrt{3}\rho\sigma_u(Z_{it}\gamma - 1).$$

From this follows

$$E(y_{it}|X_{it}, v_{it} < Z_{it}\gamma) = X_{it}\beta + \underbrace{\sqrt{3}\rho\sigma_u}_{\delta}(Z_{it}\gamma - 1).$$

Appendix A.2. System Estimation

Based on the assumption of a normally distributed error term in the selection equation, Shonkwiler and Yen (1999) show that the conditional mean of y_{mit} for individual i in equation $m = 1, \ldots, M$ is

$$E(y_{mit}|X_{it}, v_{mit} < Z_{it}\gamma_m) = X_{it}\beta_m + \delta_m\frac{\phi(Z_{it}\gamma_m)}{\Phi(Z_{it}\gamma_m)}.$$

Because $E(y_{mit}|X_{it}, v_{mit} \geq Z_{it}\gamma_m) = 0$, the unconditional mean of y_{mit} for the mth equation, which can be estimated based on the full sample, is

$$E(y_{mit}|X_{it}) = \Phi(Z_{it}\gamma_m)X_{it}\beta_m + \delta_m\phi(Z_{it}\gamma_m).$$

In our case, we have analogously for the uniform distribution

$$E(y_{mit}|X_{it}, v_{mit} < Z_{it}\gamma_m) = X_{it}\beta_m + \delta_m(Z_{it}\gamma_m - 1) \tag{A.1}$$

and

$$E(y_{mit}|X_{it}) = (Z_{it}\gamma_m)X_{it}\beta_m + \delta_m((Z_{it}\gamma_m)^2 - Z_{it}\gamma_m). \tag{A.2}$$

Appendix A.3. Marginal Effects

Under the assumptions listed above, the marginal effects for a variable x_{itk} that is an element of both Z_{it} and X_{it} conditional on selection are

$$\frac{\partial E(y_{mit}|X_{it}, v_{mit} < Z_{it}\gamma_m)}{\partial x_{itk}} = \beta_{mk} + \delta_m\gamma_{mk},$$

and the unconditional marginal effects are

$$\frac{\partial E(y_{mit}|X_{it})}{\partial x_{itk}} = \gamma_{mk}(X_{it}\beta_m) + (Z_{it}\gamma_m)\beta_{mk} + 2\delta_m\gamma_{mk}(Z_{it}\gamma_m) - \delta_m\gamma_{mk}.$$

Appendix B. Supplementary Tables

Table B.1: Portfolio Shares of Asset Classes (with Cluster Robust Standard Errors)

	Business equity	Owner Housing	Rental Prop.	Financials	Life Insurance	Tangible Assets
Marginal tax rate	-0.0708**	0.0348***	-0.0753***	0.0084	-0.0896***	-0.0533*
	(0.0288)	(0.0126)	(0.0257)	(0.0667)	(0.0320)	(0.0316)
Gross income	0.1838***	0.0151	0.0081	-0.1314***	0.0214	0.0586
	(0.0625)	(0.0130)	(0.0659)	(0.0383)	(0.0297)	(0.0423)
Gross income sq.	-0.0111	-0.0017	-0.0025	0.0128***	0.0008	0.0003
	(0.0069)	(0.0024)	(0.0111)	(0.0036)	(0.0031)	(0.0086)
Net worth	0.0790	0.0428	0.1067	-0.6237**	0.1251*	0.3120*
	(0.2122)	(0.0586)	(0.1310)	(0.2465)	(0.0721)	(0.1759)
Net worth sq.	-0.0294	0.0041	-0.0018	0.0585**	-0.0302***	-0.0663*
	(0.0281)	(0.0126)	(0.0351)	(0.0247)	(0.0090)	(0.0352)
Selection term	-0.1540*	0.0076	-0.1107***	-0.0358	-0.1554***	0.1494**
	(0.0809)	(0.0185)	(0.0374)	(0.0555)	(0.0488)	(0.0719)
Further controls	✓	✓	✓	✓	✓	✓
N (first-differenced observations)	3,979	3,979	3,979	3,979	3,979	3,979
F-test income terms (*p*-val.)	0.0012	0.4508	0.9686	0.0017	0.0002	0.2194
F-test wealth terms (*p*-val.)	0.2097	0.3723	0.431	0.0353	0.0001	0.156
Angrist/Pischke Partial R^2	0.1924	0.0576	0.0327	0.0516	0.0727	0.0233
Shea's Partial R^2	0.2387	0.0572	0.0401	0.0522	0.0703	0.0250
Uncond. mean portfolio share	0.0325	0.4132	0.0697	0.2039	0.2673	0.0135
Conditional mean portf. share	0.3865	0.7636	0.4231	0.3437	0.3775	0.1577

Note: System 3SLS estimation of asset class shares in first differences with endogenous tax rate and selection correction. The left-hand-side variable in the model equation is the share in the private wealth portfolio of the asset class indicated at the column head. The instrument for the actual marginal tax rate is the simulated marginal tax rate using exogenously updated individual income from 2002 and the contemporaneous tax code. Estimated in first differences to eliminate individual fixed effects. Gross income is in 10,000 Euro and net worth in 10 mill. Euro, both in prices of 2005. Further control variables included: Age squared, number of children, married, willingness to take risks, local GDP per capita, time dummy for 2012. All variables are transformed and instrumented as described in Section 3. Standard errors clustered at the person level in parentheses. */**/***: Significance at the 10%/5%/1% levels. *Source:* Own estimations based on the German Socio-Economic Panel 2002, 2007, and 2012.

Table B.2: Portfolio Shares of Asset Classes (Equation-by-Equation 2SLS Estimation)

	Business equity	Owner Housing	Rental Prop.	Financials	Life Insurance	Tangible Assets
Marginal tax rate	-0.1840**	-0.0406	0.3542	0.3499	0.1390	0.0152
	(0.0787)	(0.0760)	(0.2537)	(0.6948)	(0.2031)	(0.3043)
Gross income	0.2163***	0.0260	0.0717	-0.1281	-0.3646*	-0.0292
	(0.0634)	(0.0327)	(0.1069)	(0.1917)	(0.2204)	(0.2523)
Gross income sq.	-0.0132*	-0.0001	-0.0025	0.0138	0.0395	0.1032
	(0.0070)	(0.0048)	(0.0132)	(0.0156)	(0.0241)	(0.1592)
Net worth	0.3402***	0.1226	-0.4594	-0.2701	0.0608	0.9556
	(0.1179)	(0.2280)	(0.4882)	(0.3185)	(0.3679)	(1.1630)
Net worth sq.	-0.0624***	-0.0183	0.0468	0.0181	-0.0412	-0.4357
	(0.0203)	(0.0410)	(0.0697)	(0.0406)	(0.0380)	(0.5709)
Selection term	-0.7080***	-0.1244	0.6366	-0.0653	0.3119	-0.0661
	(0.1574)	(0.1213)	(0.4976)	(0.4266)	(0.5991)	(0.3023)
Further controls	✓	✓	✓	✓	✓	✓
N (first-differenced observations)	3,979	3,979	3,979	3,979	3,979	3,979
F-test income terms (*p*-val.)	0.0004	0.8624	0.2400	0.8460	0.3629	0.6429
F-test net worth terms (*p*-val.)	0.0001	0.4544	0.6142	0.3470	0.2546	0.3012
Angrist/Pischke Partial R^2	0.1924	0.0576	0.0327	0.0516	0.0727	0.0233
Shea's Partial R^2	0.2387	0.0572	0.0401	0.0522	0.0703	0.0250
Uncond. mean portfolio share	0.0325	0.4132	0.0697	0.2039	0.2673	0.0135
Conditional mean portf. share	0.3865	0.7636	0.4231	0.3437	0.3775	0.1577

Note: Equation-by-equation 2SLS estimation of asset class shares in first differences with endogenous tax rate and selection correction. The left-hand-side variable in the model equation is the share in the private wealth portfolio of the asset class indicated at the column head. The instrument for the actual marginal tax rate is the simulated marginal tax rate using exogenously updated individual income from 2002 and the contemporaneous tax code. Estimated in first differences to eliminate individual fixed effects. Gross income is in 10,000 Euro and net worth in 10 mill. Euro, both in prices of 2005. Further control variables included: Age squared, number of children, married, willingness to take risks, local GDP per capita, time dummy for 2012. All variables are transformed and instrumented as described in Section 3. Standard errors in parentheses. */**/***: Significance at the 10%/5%/1% levels. *Source:* Own estimations based on the German Socio-Economic Panel 2002, 2007, and 2012.

Table B.3: Ownership Probabilities of Asset Classes with Base Year Income Splines

	Business equity	Owner Housing	Rental Property	Financials	Life Insurance	Tangible Assets
Marginal tax rate	0.1359*	-0.0473	-0.1839*	-0.0130	-0.0723	0.1006
	(0.0765)	(0.0869)	(0.0963)	(0.1606)	(0.1403)	(0.1018)
Base year gross income spline 1	0.0185	-0.4591	0.1808	-0.4429	0.2461	0.3285
	(0.3773)	(0.4719)	(0.4880)	(0.7091)	(0.7162)	(0.3765)
Base year gross income spline 2	0.1330	0.5274**	0.0520	0.5772	-0.2119	0.3169
	(0.1362)	(0.2464)	(0.2386)	(0.3666)	(0.3647)	(0.2077)
Base year gross income spline 3	-0.0282	-0.0080	-0.0851	-0.0844	-0.3357	-0.4224**
	(0.1299)	(0.2255)	(0.2160)	(0.3250)	(0.3239)	(0.2036)
Base year gross income spline 4	-0.1069	-0.3745	0.2149	-0.5212	0.7520**	0.4113
	(0.1932)	(0.2948)	(0.3065)	(0.3869)	(0.3796)	(0.2587)
Base year gross income spline 5	0.0981	0.3651	0.3118	-0.1927	0.3359	-0.3770
	(0.2256)	(0.2699)	(0.2779)	(0.3499)	(0.3379)	(0.2657)
Base year gross income spline 6	-0.0144	-0.0281	-0.0203	-0.0460	-0.0032	-0.0089
	(0.0547)	(0.0315)	(0.0145)	(0.0310)	(0.0437)	(0.0136)
Further controls	✓	✓	✓	✓	✓	✓
N (first-differenced observations)	3,979	3,979	3,979	3,979	3,979	3,979

Note: Linear probability models of ownership of asset classes (separate IV regressions in first differences). The left-hand-side variable in the model equation is one if a person owns a strictly positive amount of the asset class indicated at the column head and zero otherwise. In this table, we include splines of the level of gross income in the first year of a two-year pair in the otherwise first differenced equation. Gross income is in 10,000 Euro in prices of 2005. Apart from the income terms, the regressions include the same variables as used in Table 4. The marginal tax rate is treated as endogenous. Instrumental variable: the simulated marginal tax rate using exogenously updated individual income from 2002 and the contemporaneous tax code. Standard errors clustered at the person level in parentheses. $^{*}/^{**}/^{***}$: Significance at the 10%/5%/1% levels. *Source:* Own estimations based on the German Socio-Economic Panel 2002, 2007, and 2012.

Table B.4: Portfolio Shares of Asset Classes with Base Year Income Splines

	Business equity	Owner Housing	Rental Prop.	Financials	Life Insurance	Tangible Assets
Marginal tax rate	-0.0546*	0.0409***	-0.0535**	0.0232	-0.0545**	-0.0088
	(0.0331)	(0.0136)	(0.0236)	(0.0674)	(0.0255)	(0.0484)
Base year gross income spline 1	-0.0783	0.1620	0.2989	-0.1597	-0.3526	-0.5151**
	(0.3501)	(0.1452)	(0.2856)	(0.3107)	(0.2540)	(0.2625)
Base year gross income spline 2	-0.0895	-0.0952	-0.2994	0.1759	0.3674	0.2154
	(0.4147)	(0.1225)	(0.2664)	(0.3180)	(0.2275)	(0.2523)
Base year gross income spline 3	0.4821	-0.0481	0.0286	-0.1360	0.0136	-0.0304
	(0.4122)	(0.1104)	(0.2505)	(0.2968)	(0.2019)	(0.2328)
Base year gross income spline 4	-0.6864	0.1839	0.1998	0.1037	-0.3217	-0.3299
	(0.5366)	(0.1387)	(0.3250)	(0.3827)	(0.2462)	(0.2984)
Base year gross income spline 5	0.6877	-0.0505	-0.2983	-0.2382	0.1403	0.2278
	(0.5105)	(0.1274)	(0.2989)	(0.3702)	(0.2278)	(0.2913)
Base year gross income spline 6	-0.0649	0.0035	0.0076	0.0656	0.0093	-0.0225
	(0.0402)	(0.0113)	(0.0219)	(0.0405)	(0.0183)	(0.0396)
Further controls	✓	✓	✓	✓	✓	✓
N (first-differenced observations)	3,979	3,979	3,979	3,979	3,979	3,979

Note: System 3SLS estimation of asset class shares in first differences with endogenous tax rate and selection correction. The left-hand-side variable in the model equation is the share in the private wealth portfolio of the asset class indicated at the column head. In this table, we include splines of the level of gross income in the first year of a two-year pair in the otherwise first differenced equation. Gross income is in 10,000 Euro in prices of 2005. Apart from the income terms, the regressions include the same variables as used in Table 5. The instrument for the actual marginal tax rate is the simulated marginal tax rate using exogenously updated individual income from 2002 and the contemporaneous tax code. All variables are transformed and instrumented as described in Section 3. Standard errors in parentheses. $^{*}/^{**}/^{***}$: Significance at the 10%/5%/1% levels. *Source:* Own estimations based on the German Socio-Economic Panel 2002, 2007, and 2012.

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