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SOCIAL AND ECONOMIC DIMENSIONS OF AN AGING POPULATION

**Tax Incentives and Household Portfolios:
A Panel Data Analysis**

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Søren Leth-Petersen**

SEDAP Research Paper No. 163

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Tax Incentives and Household Portfolios: A Panel Data Analysis

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Abstract:

This paper investigates the responsiveness of household portfolios to tax incentives by exploiting a substantial tax reform that altered after-tax returns and cost of debt for a large number of households. An extraordinary panel data set that covers two years before and after the reform is used for the analysis. Our empirical findings suggest that households reshuffle their balance sheets in the case of a partial deductibility phase-out. In particular, heavily taxed, interest-bearing assets are used to pay off mortgage debt. Furthermore, we find that taxes have a significant impact on the structure of household portfolios even after controlling for unobserved heterogeneity.

Résumé :

Cet article examine la sensibilité du choix de portefeuille des ménages aux incitations fiscales en s'appuyant sur une importante réforme fiscale qui affecta les rendements après impôt et le coût de l'endettement d'un grand nombre de ménages. Notre analyse repose sur une base de donnée longitudinale exceptionnelle couvrant les deux années antérieures et postérieures à la réforme. Nos résultats empiriques suggèrent que les ménages remanient leurs portefeuilles dans le cas de l'élimination progressive de la déductibilité partielle. En particulier, les actifs rémunérés lourdement imposés sont utilisés au remboursement des crédits hypothécaires. En outre, nous constatons que les impôts ont un impact significatif sur la diversification du portefeuille des ménages même après la prise en compte des effets de l'hétérogénéité non observée.

JEL codes: G11, H31

Keywords: Household portfolios; Taxation; Panel data; Natural experiment

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1. Introduction

This paper analyzes the impact of tax incentives on household portfolios by exploiting a substantial tax reform that altered after-tax returns and the cost of debt for a large number of households. For this, we employ an extraordinary panel data set that covers two years before and after the reform. The unique features of this quasi-experiment allow us to link previous empirical work on taxes and financial portfolios with that on taxes and the cost of debt. Our empirical analysis consists of two parts. First, we document the response of household financial portfolios to a substantial change in the cost of debt. Second, following the literature on taxation and portfolio structure, we assess the effect of taxes on household portfolio composition by estimating portfolio share equations.

In 1986, high-income individuals faced a marginal tax rate of 73 percent on both earned and capital income in Denmark. A tax reform announced in 1985 and implemented in 1987 broke the link between the marginal tax rates on the two sources of income and lowered the top marginal rate on positive capital income to 56, and negative capital income to 50. Thus the tax reform decreased the tax rate on positive capital income for high-income households, from 73 percent to 56 percent; for the same households the tax value of interest deductions fell from 73 to 50 percent. As a result, the reform changed incentives in two dimensions. First, the cost of debt (primarily mortgages) increased substantially for (leveraged) high-income households, giving them a very strong incentive to lower their debt burden. Because the pre-payment of mortgage debt is not restricted in Denmark, this reform offers a unique opportunity to examine responses to such a change. Second, the reform increased the after-tax return on interest-bearing assets and therefore encouraged households to shift their portfolios toward such assets.

The objective of the paper is to exploit the Danish tax reform to investigate whether households decrease debt by liquidating their financial assets when the after-tax cost of debt increases, and to map how portfolios are reshuffled when the costs of debt increase. Moreover, we

investigate if households adjust the composition of their portfolio when the relative after-tax return on the elements of the portfolio changes.

The features of the Danish tax reform allow us to tie our work to two distinct strands of the empirical portfolio allocation literature. The first investigates household responses to changes in the cost of debt, usually by exploiting a tax reform. Empirical investigation in this area has been limited to estimating the effects of the cost of debt on household liabilities, for example, Maki (2001), Martins and Villanueva (2006) and Jappelli and Pistaferri (2006). The evidence is inconclusive³. Furthermore, it is silent about how portfolios are adjusted when the cost of debt changes. However, *how* households finance a reduction in liabilities is a key issue from the perspective of tax policy. Gervais and Pandey (2006) argue that the potential tax revenue gain due to the elimination of mortgage interest deductibility is overstated if one does not take into account the fact that mortgage debt (implicitly or explicitly) finances non-residential assets. As these assets would be used to reduce the debt burden imposed by a deductibility phase-out, tax revenues obtained from these assets would be reduced, offsetting the gain from the elimination of mortgage interest deductibility.

The second strand of the literature to which we contribute is the literature on portfolio allocation under differential taxation. Empirical results in this area are also inconclusive. Cross-section studies find strong effect of taxes on the structure of household portfolios. See, for example, Feldstein (1976), Hubbard (1985), King and Leape (1998), Samwick (2000), Poterba and Samwick (2002) and the excellent survey by Poterba (2002). However, all these cross-section studies suffer from the fact that unobserved taste parameters are likely to be correlated with portfolio shares and with marginal tax rates (through wealth and income). Bakija (2000) uses the limited panel module

³ Maki (2001) examines the effect of the deductibility phase-out introduced by the American Tax Reform Act of 1986 for the non-mortgage debt. He finds that households substitute non-mortgage debt with mortgage debt. Martins and Villanueva (2006) analyze the impact of a reform of a Spanish program that subsidized interest rates on mortgages and find that the size of the subsidy affects the propensity to get loan for lower income households. Jappelli and Pistaferri (2006) investigate whether the demand for mortgage debt is affected by a series of tax reforms that limited the deductibility of interest payments in Italy. They find no effect.

of the American Survey of Consumer Finances (SCF) to study portfolio changes around the 1988 tax reform. He finds that no tax effect remains once unobserved heterogeneity is controlled for. However, his data set is very small (984 households) and unrepresentative due to the well-known attrition problem in the SCF panel module⁴. Furthermore, the estimators applied do not exploit the full potential of the panel data in handling unobserved heterogeneity.

The analysis presented here uses a representative household level panel data set on portfolio composition and a tax reform providing a large exogenous change in the cost of debt and after-tax returns to financial assets. The panel data set is constructed from administrative records. It is large and representative since it is not subject to any attrition problem (other than death and emigration). The panel aspect of the data allows us to control for fixed idiosyncratic effects in preferences that, without doubt, should be taken into account when studying household portfolio allocation. We follow the literature referenced above and estimate reduced forms, but we choose to use estimation techniques that impose minimal structure on the analysis while controlling appropriately for unobserved heterogeneity. We believe that this setup provides a powerful framework for assessing households' responsiveness to tax incentives, and it does not suffer from many of the weaknesses in the previous literature.

In the first part of our analysis, we investigate if household financial portfolios respond to the very strong incentive to reduce debt by analyzing whether variation in mortgage interest payments across the reform is correlated with variations in financial asset holdings. We find strong evidence that households reduce their mortgage interest payments and that they liquidate heavily taxed financial assets (bond holdings) rather than their stock holdings in order to do so.

⁴ See Kennickell and Woodburn (1997). Two other studies based on the SCF panel module are Ioannides (1992) and Guell (1991). Both studies use the 1983-1986 panel and have a serious identification problem because no major tax reform took place within the sample period. The former makes no allowance for unobserved heterogeneity while the latter does. Both studies are inconclusive.

Next, we study the effect of marginal tax rates on financial portfolio shares after controlling for the initial reshuffling associated with debt reduction after the reform and for individual fixed effects. Here, we exploit the residual variation in marginal tax rates coming from differences in the municipal income tax rates, and the interaction of those differences with the reform. Our results indicate that households do re-allocate their portfolios in response to changes in after-tax returns. Controlling for fixed effects and holding wealth constant, households substitute toward interest bearing, heavily taxed assets when they face decreasing marginal tax rates.

The next section outlines the details of the Danish Tax Reform. Section 3 presents the data and some descriptive evidence. Section 4 presents our results and the final section concludes.

2. The Tax Reform

The Danish income tax system is built around a proportional local government tax and a progressive tax collected by the central government. While the progressive schedule is the same for everybody in Denmark, the local government tax rates vary across municipalities. In 1986, for example, the highest local government tax rate was 31% and the lowest was 21.4%. The pre-reform tax schedule implied that a high-income person living in the municipality with a tax rate of 31% would face a marginal tax rate of 75.95 percent. A tax ceiling, however, insured that the marginal tax rate could be at the maximum 73%. After the reform the tax ceiling was reduced to 68% in the highest bracket and 56% in the middle bracket. The marginal tax rates across tax brackets before and after the reform are summarized in Table 1.

Table 1. Marginal tax rates before and after implementation of the 1987 tax reform

Before Reform		After Reform			
Tax bracket	Earnings + cap. inc.	Tax bracket	Earnings	Net cap. inc <0	Net cap inc.>0 ⁽¹⁾
0 – 113	M+19.75	0 – 130	M+22.00	M+22.00	M+22.00
113 – 186	M+34.15	130 – 200	M+28.00	M+22.00	M+28.00
186 –	M+44.95	200 –	M+40.00	M+22.00	M+28.00
Tax ceiling	73.00	68.00/56.00 ⁽²⁾			56.00 ⁽²⁾

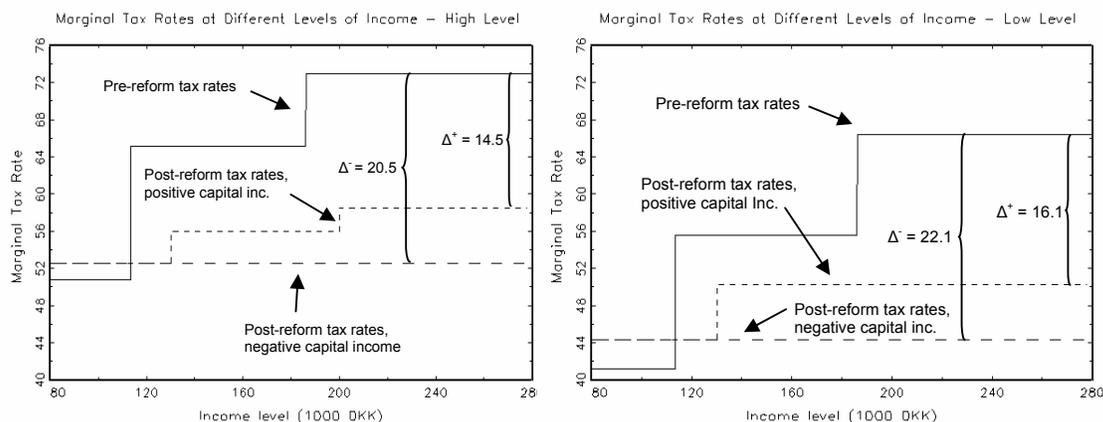
Note: M is the local government tax rate. Threshold values for the tax brackets are given in 1000 DKK. Thresholds are adjusted yearly. Threshold values used in the table are for 1986 (before the reform) and 1987 (after the reform). The marginal tax rates refer to personal income (as opposed to household income).

(1) The tax brackets for positive net capital income refer to the sum of earnings and positive net capital income. After the reform positive capital income is taxed progressively up to the first threshold, 130,000 DKK. For a married couple the progression threshold is 260,000 based on the sum of their joint positive net capital income and earnings.

(2) The 56% tax ceiling applies only to the middle bracket.

The application of a tax ceiling together with the heterogeneous local government tax rates implies that the reform had differential effects on people living in different municipalities. Figure 1 illustrates the changes in marginal tax rates due to the reform for a high-tax and a low-tax municipality.

Figure 1. Marginal tax rates on capital income before and after the reform for two different municipalities



For a high-income person living in the municipality with the high local government tax the marginal tax rate on positive net capital income falls by 14.5 percentage points and the marginal tax rate on negative net capital income falls by 20.5 percentage points. For a similar person living in the municipality with the low local government tax rate, the marginal tax rate on positive net capital income falls by 16.1 percentage points and negative net capital income falls by 22.1 percentage points. It is these differences in changes of marginal tax rates that we exploit for identifying the effect of changes in marginal tax rates on the portfolio allocation.

The marginal tax rates on capital income refer to income received in the form of dividends on stocks and interest payments from interest bearing accounts and bonds. Both before and after the reform realized capital gains/losses associated with trading assets and establishing mortgages are generally not taxed. The exemption from this rule is capital gains from corporate stocks held for less than three years. Such capital gains are taxed as earnings. Dividend payments were low relative to interests received from bonds⁵. This indicates that the lowering of marginal tax rate on positive capital income affected bonds and stocks differentially, favouring mainly income from bonds.

The tax reform gave house owners with a large mortgage a big negative shock and households with large capital income a big positive shock. For this reason, interim arrangements were implemented. In the first year of the reform, 1987, only the first 60,000 DKK was subject to the new proportional taxation, and positive capital income above this amount was taxed as earnings. In the subsequent years the threshold level was increased by 25,000 DKK. For negative capital income a similar scheme was put in place. In 1987 the first 35,000 DKK of negative capital income was deductible at 50%. Negative capital income above this amount was deductible at the same rates as earnings. In the subsequent years the threshold was increased by 25,000 DKK. By the end of 1988 less than 1% of the sample that we are considering had negative net capital income (defined as

⁵ The median household in the sample holding stocks received dividends corresponding to 2% of the value of the stocks. The median households in the sample holding bonds received interest payments from these corresponding to 10% of the value of the bonds.

gross income less earnings and transfers) larger than 60,000 DKK, and 5% had positive net capital income larger than 85,000 DKK. Thus, by 1988, 94% of the sample was no longer affected directly by the interim arrangements.

In summary, the tax reform altered the relative tax treatment of the components of the household balance sheets. First, by lowering the value of interest deductions, the reform unequivocally made it less attractive to hold debt for high-income households. Second, the reform increased the after-tax return on bonds. All these incentives were more likely to have affected the households in the highest tax bracket.

3. Data and descriptive evidence

3.1 Data set

The data set is drawn from a random sample of 10% of the Danish population observed in the years from 1984 to 1988. The information on portfolio allocations, income, wealth and demographics is collected and merged from different public administrative registers for all the adult members of the household that the sampled person belongs to. Portfolio and income information are obtained from the income tax register. The information on the portfolios exists because Denmark had a wealth tax that required all wealth holdings to be reported to the tax authorities. This information allows us to break the wealth of each household into holdings of corporate stocks, bonds, cash in banks, housing assets and mortgage debt. ‘Stocks’ includes all holdings of publicly and privately traded stocks, and ‘bonds’ includes government and corporate bonds. ‘Cash’ includes all cash holdings in banks. Housing assets contain the value of housing assets as they are assessed by the tax authorities. We have adjusted the value of housing assets by the aggregate ratio of sales price relative to tax assessed value for all traded houses in Denmark for the years considered. Mortgage includes the

market value of mortgages established in mortgage banks. We use the house value less the market value of the mortgage to define housing equity.

For some of the wealth components the amounts that we observe are reported directly by banks or financial intermediaries or calculated directly by the tax authority. Items that are reported automatically are cash holdings and value of the house. The reporting mode for the mortgage debt and mortgage interest payments has changed from selfreporting to automatic reporting by mortgage banks in 1987. This is going to be important for our analysis, and we shall return to the implications of it later. Because both value of the house and size of the mortgage debt are observed we can calculate the housing equity (and consequently, a measure of total non-pension wealth). Finally, we should note that we do not have information on pension wealth held in formal pension arrangements because it was not liable to the wealth tax.

3.2 Sample selection

For our analysis we exclude observations if one of the household members are self-employed since register data are not likely to contain a good measure of own business wealth and because taxable income is quite volatile for those individuals. Sampled individuals aged less than 18 or more than 60 are dropped as are students and individuals living together with his/her parents or living in common household, i.e. a household with more than one family. To keep focus on the importance of tax incentives we include only stable couples, i.e. couples where the partner is the same in 1984 throughout to 1988. On the same grounds we also exclude couples moving in the sample period. The reform introduced a strong incentive to reduce mortgage debt. To keep focus on this issue we include only home-owners. As mentioned, housing values are tax-assessed and this implies that a few observations have negative calculated value of their housing equity. These observations are dropped. Finally, conditional on these selection criteria we require that households be observed in

all years in the period 1984-1988. This leaves us with a sample of 26,868 households observed in all years 1984 through 1988, so that we have a balanced panel. An important feature of our data is that they are constructed from administrative registers. As there is no issue of attrition due to non-response, our sample is representative conditional on the selection criteria that we have applied.

Our objective is to investigate whether households reshuffle their portfolios in response to a change in tax incentives. However, as in most industrialised countries many Danish households have fairly undiversified portfolios, usually a mortgage and a limited amount of cash. Since the reform generated a large negative wealth shock, clearly, these households are not likely to engage in portfolio reshuffling, and hence cannot give us a clean answer regarding portfolio readjustments⁶. We therefore construct a sub-sample of households holding positive amounts of stocks or bonds of at least 5,000 DKK in 1984⁷. This sub-sample includes 11,372 households. In the next section we give summary statistics for both samples.

3.3 Assets before and after the reform

Table 2 presents the ownership probabilities across the three asset categories that we consider before (1984) and after (1988) the reform. Because most people have cash in their bank account for transaction purposes we do not see any important variation in this category over time. There is a considerable variation in ownership probabilities of stocks and bonds. The ownership rate for stocks goes up by about 10 percentage points whereas the bond market participation rate decreases by the same magnitude. The figures are similar for the sub-sample except that the decline in participation in the bond market from 1984 to 1988 is much higher for this group (approximately 32 percentage

⁶ There are obviously other margins these households can readjust to cope with this shock. Consumption (downsizing housing, delaying durable purchases etc.) and labor supply are among the most important. Investigating the impact on these real magnitudes is beyond the scope of this paper.

⁷ For assessing portfolio reshuffling renters could have been included. We have chosen to leave them out of this analysis because there are only a few renters (898) with positive financial wealth of at least 5000 DKK in 1984. Moreover, renters generally do not provide a good comparison group for house owners, since different preference parameters may govern their behavior.

points). As evidenced by Guiso et al. (2002) there has been a clear upward trend in the stock market participation in all industrialized countries. There is widespread agreement that this rise cannot be justified simply by returns. A more plausible explanation seems to be the apparent decline in the cost of stock market related activities (see, for example, Alan, 2006). There is no reason to believe such costs were not declining in this period in Denmark as well.

Table 2. Probability of ownership of liquid wealth before (1984) and after (1988)

	Whole sample (26,868 households)		Sub-sample (11,372 households)	
	1984	1988	1984	1988
Stocks	21.56	32.47	43.73	51.29
Bonds	41.51	29.97	89.05	56.71
Cash	99.64	99.64	99.26	99.37

Table 3 presents average unconditional and conditional portfolio shares across the three financial asset categories for 1984 and 1988. Shares are calculated based on two different wealth definitions. One labelled as ‘total wealth’ is based on the sum of housing equity, stocks, bonds and cash. The other wealth measure is based on the sum of stocks, bonds and cash and is denoted as ‘financial wealth’.

The first four columns of Table 3 present the average conditional and unconditional portfolio shares based on total wealth. As can be seen, average conditional and unconditional portfolio share of bonds declined significantly from 1984 to 1988. Even though we observe some decline in cash and stocks as well, these are not as sizeable. In fact, for the sub-sample average unconditional share of stocks remained roughly the same. The last four columns of Table 3 present the unconditional and conditional averages for both samples based on financial wealth. We now see a slightly different picture. The decline in the share of bonds seems quite robust across different wealth

definitions. While the share of stocks and cash in liquid wealth increased quite significantly, the share of bonds declined from 1984 to 1988 conditionally (from 50 percent to 45 percent) and unconditionally (from 20 percent to 13 percent).

Table 3. Average Unconditional and Conditional Portfolio Shares before (1984) and after (1988)

Unconditional								
	Total Wealth				Financial Wealth			
	Whole Sample		Sub-Sample (bonds+stocks>5000)		Whole Sample		Sub-Sample (bonds+stocks>5000)	
	1984	1988	1984	1988	1984	1988	1984	1988
Stocks	0.0144	0.0174	0.0330	0.0331	0.0483	0.0832	0.1136	0.1445
Bonds	0.0717	0.0363	0.1686	0.0690	0.2004	0.1301	0.4821	0.2505
Cash	0.1245	0.0990	0.1166	0.1053	0.7513	0.7867	0.4043	0.6050
Conditional on positive holdings of the related asset								
Stocks	0.0666	0.0536	0.0755	0.0644	0.2434	0.2732	0.2599	0.2817
Bonds	0.1726	0.1211	0.1893	0.1217	0.5087	0.4527	0.5414	0.4417
Cash	0.1250	0.0994	0.1175	0.1059	0.7546	0.7903	0.4073	0.6089
# obs.	26,868		11,372		26,868		11,372	

Note: "Total wealth" includes housing equity+stocks+bonds+cash. "Financial wealth" includes stocks+bonds+cash. Conditional shares are calculated conditional on ownership of the asset considered.

Table 4 presents the logarithm of mortgage interest payments over the sample period. Mortgage interest payments appear to have dropped 29 percent from 1986 to 1987. This massive drop is most likely related to the change in reporting mode for mortgage interest payments. It is noticeable, though, that mortgage interest payments continue to decline from 1987 to 1988 indicating strongly that households did reduce their debt burden over the sample period.

Table 4. Mortgage interest payments

	1984	1985	1986	1987	1988
Logarithm of mortgage interest payments for households with financial assets in 1984	10.18	10.22	10.26	9.97	9.94

Overall, the descriptive evidence suggests that homeowners reduced the share of bonds in overall portfolios. As there was a clear reduction in mortgage interest payments over the sample period it appears that bonds were the preferred assets to reduce size of the mortgage. In the next section we will be able to establish precisely the association between mortgage payments and bond liquidation.

4. Results

In the econometric analysis we estimate reduced form relationships documenting how households reshape their portfolios in response to the policy reform. Throughout we emphasize using estimation techniques imposing minimal structure on the data while controlling appropriately for unobserved heterogeneity. This is to ensure that the results we find are not driven by arbitrary statistical and economic assumptions. We first present a bivariate nonparametric analysis displaying correlations between changes in mortgage interest payments and changes in the holdings of financial assets. This analysis exploits the panel nature of the data and uncovers much of the heterogeneity present in the data. Moreover, it gives a very clean indication that households adjust their financial portfolios in order to decrease mortgage interest payments. Second, we follow the empirical portfolio allocation literature and estimate portfolio shares as a function of the marginal tax rates. This is to investigate the extent to which households re-shuffle their portfolios to take advantage of the changes in the relative returns that follow from the tax reform. This analysis is

based on a semiparametric estimation technique that exploits the potential of the panel data set in handling correlated unobserved heterogeneity.

4.1. Are bonds and/or stocks used for reducing mortgage debt?

The clearest incentive given by the reform was for households to reduce debt, since it increased the cost of holding debt increased dramatically. The only debt component in our data is the mortgage. The tax return also contains information on other debt, but this information is not reported consistently over the period we are considering and it is therefore not included in our analysis⁸. In Denmark mortgage debt is established through mortgage banks, and the Danish mortgage system has some particular features that we are going to exploit in this section in order to see if the households in our sample run down other assets in order to decrease the size of their mortgage.

In Denmark, mortgage banks offer loans where the borrower's real property is used as collateral for the loan. In the data period the mortgage can only be used to finance the housing unit that also serves as collateral for the loan⁹. The loans are funded by the issuing of callable mortgage credit bonds with a fixed coupon rate. The principal of the loan depends on the price of the bond at the point when the loan is established, and because the mortgage bonds have a fixed coupon rate, all future interest payments are determined at the point when the loan is established. Remortgaging to lock in lower market rates is not possible, but prepaying the loan is not restricted in any way.

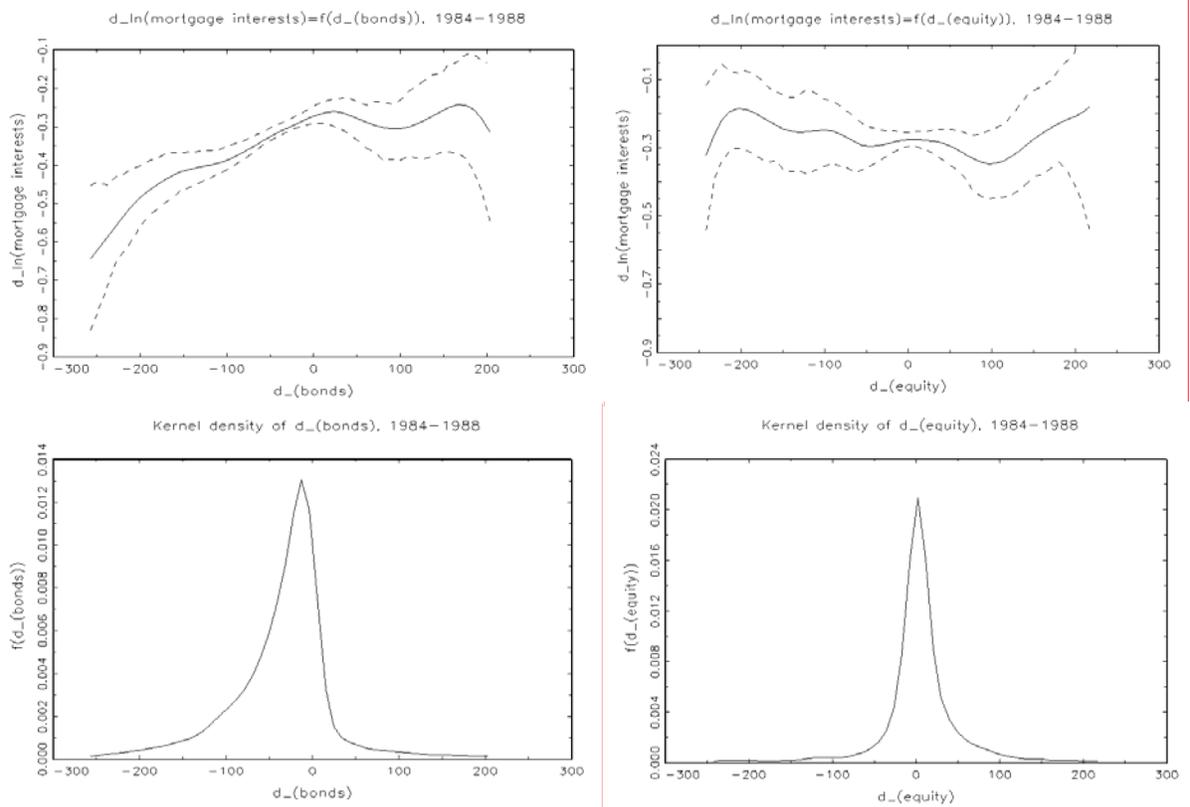
Our portfolio information comes from the tax return files due to the presence of a wealth tax. Therefore, it is the market value of the underlying bonds that we observe in the tax register and this is subject to capital gains that have no influence on the instalments and interest payments on the

⁸ Other debt components are reported from 1987 onwards. In 1987 the median value of these other debt components relative to total assets was 10% in the sample that we use in the empirical analysis. We have found no evidence that changes in these debt components from 1987 to 1988 are correlated with changes in any of the assets over the same period.

⁹ Of course, other financial assets can be implicitly financed by the mortgage debt.

loan. The market value of bonds held as assets will therefore be negatively correlated with the size of the market value of mortgages simply because the market value of the mortgage bonds co-varies very closely with the market value of other types of bonds. We are interested in checking whether the mortgage debt is reduced by liquidating bonds and/or stocks held as assets. To avoid the problem of observing correlations that are solely due to capital gains we consider how changes in mortgage interest payments correlate with changes in holdings of bonds and/or stocks. This also has intuitive appeal since it is interest payments that are affected by the reform.

Figure 2. Change in log mortgage interest payments against changes in bonds (left) and stocks (right) holding over the period 1984-1988. Top graphs show weighted local linear regressions, and the bottom graphs show kernel densities of changes in bonds and equity holdings



Note: Changes in bond and equity holdings are measured in 1000 DKK. Weighted Local linear regressions are estimated using Fan's (1992) estimator. Confidence intervals are 2.5 and 97.5 percentiles of the bootstrap distribution based on 500 re-samples.

Figure 2 shows weighted local linear regressions of changes in the log of mortgage interest payments against changes in the market value of bond holdings and stocks holdings, respectively, across the period 1984-1988 together with the corresponding kernel densities of changes in market values of bond holdings and stock holdings¹⁰. The Figure shows that reductions in mortgage interest payments are clearly associated with reductions in bond holdings, whereas changes in mortgage interest payments are not correlated with changes in stock holdings. This is an indication that households liquidate bonds rather than stocks to reduce mortgage debt.

Nonparametric estimates are generally inefficient. We therefore try to replicate the shape in a parametric fashion. There is a clear indication of a break at zero decumulation of bonds with linear responses above and below. Therefore, we regress changes in log mortgage interest payments on the change in bonds interacted with dummy variables for positive and negative adjustments. The results are presented in Table 5. They confirm that decumulation of bonds is associated with a decline in log mortgage interest payments, and that there is no connection between changes in stock holding and the change in mortgage interest payments.

Table 5. Parametric estimates corresponding to figure 2

	Bonds	Stocks
Change in asset holding, negative	0.1104**	-0.0112
Standard error	0.0130	0.0275
Change in asset holding, positive	-0.0100	-0.0070
Standard error	0.0209	0.0280
Constant	-26.5160**	-27.9269**
Standard error	0.8961	1.1654
Number of households	9,425	4,587

Note: ** indicates significance at 5% level. Parameter estimates are multiplied by 100

¹⁰ See Fan (1992) for details of the estimation technique.

The level of the changes of log mortgage interest payments in Figure 2 is about -0.3 at the horizontal parts of the regression curves, indicating that mortgage interest payments are reduced by approximately 30% even without any change in the holdings of the financial assets. This is likely to be due to the change in reporting mode of the mortgage information from 1986 to 1987. In 1986 and earlier the mortgage information was inserted in the tax return by the household, whereas it was reported directly to the tax authorities by the mortgage banks and pre-printed on the tax return from 1987 and onwards. To get an idea of the magnitude of this reporting error we have calculated the size of mortgage interest payments over the sample period for the group of households who held no financial assets in 1984 and therefore had limited potential to reshuffle their portfolios. The change in mortgage interest payments for these households is not influenced by reshuffling and should only include regular instalments (holding income and consumption fixed). This is reported in Table 6.

Table 6. Mortgage interest payments

	1984	1985	1986	1987	1988
Logarithm of mortgage interest payments for households without financial assets in 1984	10.13	10.17	10.21	9.91	9.89

Table 6 indicates that log mortgage interest payments decreased by -0.3 for this group from 1986 to 1987. This corresponds to the level of the horizontal parts of the regressions in Figure 1. If the two groups adjust consumption and income similarly as a response to the reform then this is consistent with the statement that the level of the horizontal part of figure 2 is related to the change in reporting mode.

In summary, there is evidence that households with financial wealth decreased bond holdings to reduce the impact of the (partial) phase-out of the mortgage interest deduction. This confirms the

hypothesis of Gervais and Pandey (2006) that mortgage debt implicitly financed holdings of financial assets, bonds in particular, before the reform.

4.2 Are household portfolios responsive to changes in relative after-tax returns?

In this section we investigate whether portfolios respond to the changes in relative after-tax returns on assets brought by the reform. The way similar analyses are conducted by the literature (Poterba and Samwick (2002) and Bakija (2000)) is to regress portfolio shares on marginal tax rates and some control variables¹¹. We follow the same route. The main features of the reform were to increase the cost of holding debt and to reduce the taxation of positive capital income, thereby favouring bonds relative to stocks. If the reform had only changed relative returns on assets (without changing interest rate deductibility) then economic theory suggests that in a portfolio share regression we should find a negative coefficient on the marginal tax rate variable for rather heavily taxed assets like bonds when asset prices are held fixed.

The most pronounced feature of the reform is, however, the partial interest deductibility phase-out. As we demonstrated in the previous section, this forced households to liquidate their bond holdings to cope with the debt burden imposed by the reform. We argue that controlling for this initial response along with wealth, we are able to identify the effect of capital income taxes on portfolio shares. We do this using the residual variation in marginal tax rates that comes from differences in the municipal income tax rates, and the interaction of those differences with the reform.

The distinguishing feature of our data set is the panel dimension. This facilitates estimating portfolio share equations allowing for correlated unobserved time invariant heterogeneity. This is

¹¹ Poterba and Samwick (2002) first look at the tax effect on participation by estimating a probit and then they estimate a tobit of portfolio shares using repeated cross-section provided by the American Survey of Consumer Finances (SCF). Bakija (2000) employs the SCF panel module and estimates similar equations using random effects panel data estimators.

important because we believe that unobserved time constant factors such as risk aversion¹² and time preference are correlated with wealth. High risk aversion may lead to a high wealth accumulation and consequently place the household in a higher tax bracket. High risk aversion may also lead to a higher portfolio share of safe assets such as bonds for a given level of wealth. Therefore, the response to changes in the marginal tax rate is likely to depend on such unobserved factors.

In this section we present estimates of portfolio share equations allowing for correlated heterogeneity. Portfolio shares by definition take values between 0 and 1. Consequently, an important feature of portfolio share data is that they are censored at one or both of these points. To address this issue we employ a new estimator for censored panel data suggested by Honoré and Leth-Petersen (2005) that allows the dependent variable to be censored at two sides. The estimator is a generalization of the panel data estimators with one-sided censoring developed by Honoré (1992). The estimator is the least restrictive estimator for censored panel data models known. Unlike any other estimator handling two-sided censoring it controls for fixed unobserved effects. Moreover, it does not impose specific distributional assumptions on the error term as do conventional tobit models applied in the portfolio allocation studies mentioned in the introduction.

When estimating the portfolio share equations we are facing the model

$$y_{it}^* = x_{it}\beta + \alpha_i + \varepsilon_{it} \quad t = 1984, \dots, 1988$$

where x_{it} is a vector of exogenous explanatory variables, ε_{it} is an independent error term that is identically distributed across observations conditional on (x_{it}, α_i) , and we observe $y_{it} = \max \min \{0, y_{it}^*, 1\}$ because some household hold all wealth exclusively in one asset category,

¹² Self reported subjective measures of risk aversion have been used in the cross section literature (see Poterba and Samwick, 2002, for example) to control for unobserved heterogeneity but these measures are known to be problematic.

and others hold more assets, but do not do have fully diversified portfolios. The model allows for x to be correlated with α . The parameter vector β is estimated by

$$\hat{\beta} = \arg \min_b \sum_{i=1}^n \frac{1}{T-1} \sum_{s < t} (r_s(y_s, d) - r_t(y_t, d))$$

where $d = (x_{is} - x_{it})' b$ and

$$r_s = \begin{cases} d + \frac{1}{2}d^2 + \frac{1}{2}(y_s - 1)^2 & \text{for } d \leq y_{is} - 1 \\ dy_s & \text{for } y_{is} - 1 \leq d \leq 0 \\ dy_s - \frac{1}{2}d^2 & \text{for } 0 \leq d \leq y_{is} \\ \frac{1}{2}y_s^2 & \text{for } y_{is} \leq d \end{cases} \quad \text{and} \quad r_t = \begin{cases} -\frac{1}{2}y_t^2 & \text{for } d \leq -y_{it} \\ \frac{1}{2}d^2 + dy_t & \text{for } -y_{it} \leq d \leq 0 \\ dy_t & \text{for } 0 \leq d \leq 1 - y_{it} \\ d - \frac{1}{2}d^2 - \frac{1}{2}(y_t - 1)^2 & \text{for } 1 - y_{it} \leq d \end{cases}$$

The estimator makes use only of the time variation in the x 's. This means that only variables that are not constant over the data period play a role in estimations. All x 's are assumed exogenous to ε . While allowing for correlated heterogeneity, the estimator has one drawback in common with all nonlinear estimators allowing for fixed effects that it is not possible to make statements about partial effects since these are generally a function of the parameters and the unknown fixed effects. For the same reason we will not be able to check standard integrability conditions such as adding up of the portfolio shares.

Our primary objective in this part of the analysis is to understand if changes in marginal tax rates on capital income influence portfolio share decisions. Before the reform, capital income and earnings were lumped together and taxed according to a progressive tax scheme. This implies that

households choose tax bracket when choosing their portfolio, and that the marginal tax rate on capital income is likely to be an endogenous regressor. We address this by calculating the marginal tax rate on capital income based on the household's income in 1984, the year before the reform was announced, but using current year rules. In this way the individual level tax bracket is allocated based on information that was predetermined relative to the portfolio response to the reform.

We estimate three sets of portfolio share equations including different covariate sets. In the first specification portfolio shares are regressed only on marginal tax rates. This gives the gross effect of the reform. The estimate will also include effects of changes in asset prices and does therefore not represent a clean estimate of the net effect of the reform. In the second specification we include time dummies to control for the change in asset prices and the effect of the reform that is common to all households. Tax rate changes vary across municipalities, but most of the change in tax rates is common across municipalities. Time dummies control for the effect of this common part thereby also removing the major part of the wealth effect brought by the reform. Effectively, by introducing time dummies, the coefficients on marginal tax rates are identified by differences in *changes* of marginal tax rates. Time dummies may also pick up common effects relating to fluctuations in asset prices and the change in the reporting mode for mortgage debt when we consider portfolio shares out of total wealth. Finally, in the third specification we further control for wealth by introducing total wealth as a regressor. In this specification we interpret the statistical significance of the coefficient on the marginal tax rate as an indication of tax effect. In all regressions fixed effects are controlled for as explained above.

An alternative identification strategy could be based on comparing the behaviour of households in different tax brackets. Households in the lowest tax bracket faced only very small changes in marginal tax rates on capital income, and households in the middle tax bracket faced different changes in marginal tax rates than households in the highest tax bracket. In our case this is

not a natural approach to follow, because people in lower tax brackets do not represent natural control groups for high income people. High and low income people are different in terms of wealth levels and portfolio composition and possibly different with respect to preference parameters such as the discount rate and the level of risk aversion. In our case we exploit differences in changes in tax rates across municipalities instead, and we do not face these problems.

Table 7 presents the parameter estimates from estimating fixed effects censored regression models for the three specifications for the case where portfolio shares are defined relative to total wealth. ‘Model 1’ refers to the specification with only marginal tax rate as a regressor. ‘Model 2’ adds time dummies. ‘Model 3’ further adds log wealth. All marginal tax rate coefficients are estimated precisely.

In Model 1 the parameter estimate on the marginal tax rate in the bond share equation is positive. Parameter estimates in the stock and cash equations are also positive and significant. These findings are consistent with households having decumulated bonds following a lowering of the marginal tax rate with the purpose of reducing their mortgage interest payments. The results from Model 1 simply reflect the pattern revealed by the nonparametric analysis: the bond share decreases as a result of the decrease in marginal tax rates on capital income (picking up the partial deductibility phase-out) and the shares of the other financial assets increase.

In Model 2 and 3, the estimated parameter on the marginal tax rate is negative in the equations for stocks, bonds and cash. If time dummies and wealth pick up the wealth-effect related to the reform, in particular the effect of the reduction in the value of interest deduction that leads households to liquidate financial assets, then this is exactly what the economic theory predicts. Households should substitute towards the assets whose after-tax return increased and this is what the results indicate.

Table 7. Fixed Effects Censored Regression Estimates of the Portfolio Share Equations for Total Wealth. Based on Sample with Positive Financial Wealth in 1984

	Stocks			Bonds			Cash		
	Model1	Model2	Model3	Model1	Model2	Model3	Model1	Model1	Model2
MTR capital income	0.0695**	-0.1074**	-0.1095**	0.4508**	-0.2653**	-0.2232**	0.0303**	-0.0817**	-0.0558**
Standard error	0.0055	0.0227	0.0232	0.0085	0.0265	0.0259	0.0032	0.0109	0.0110
D85	-	0.0304**	0.0298**	-	-0.0515**	-0.0408**	-	-0.0058**	0.0017**
Standard error		0.0024	0.0025		0.0027	0.0028		0.0013	0.0014
D86	-	0.0158**	0.0143**	-	-0.1394**	-0.1073**	-	-0.0298**	-0.0075**
Standard error		0.0022	0.0029		0.0031	0.0037		0.0014	0.0017
D87	-	-0.0210**	-0.0230**	-	-0.1887**	-0.1482**	-	-0.0417**	-0.0143**
Standard error		0.0037	0.0048		0.0043	0.0049		0.0018	0.0021
D88	-	-0.0107**	-0.0121**	-	-0.1873**	-0.1596**	-	-0.0193**	-0.0008**
Standard error		0.0035	0.0042		0.0045	0.0046		0.0018	0.0020
Ln(Total Wealth)	-	-	0.0046	-	-	-0.0959**	-	-	-0.0722**
Standard error			0.0062			0.0079			0.0040

Note: ** indicates significance at 5% level.

The after-tax income from bonds has increased relative to the after-tax income from stocks. This suggests that the effect should be bigger for bonds than for stocks. The parameter estimate for the marginal tax rate in the bond equation is numerically larger than the corresponding parameter estimate from the stock equation. Unfortunately, we cannot interpret this quantitatively, since the quantitative effect depends nonlinearly on the unknown fixed effects.

The parameter estimate on the MTR in the bond share equation based on total wealth may be inflated because mortgages are based on bonds implying that the market value of the mortgage and the market value of the stock of bonds held as assets co-varies closely and this influences the portfolio share. Because of this and the fact that portfolio shares based on total wealth are influenced by the mechanical increase in housing equity due to pre-arranged mortgage instalments we also performed the censored regressions for bonds, stocks and cash based on only financial wealth. Table 8 presents these results. The marginal tax rate coefficient has changed sign for cash, but the theoretically predicted sign for bonds is preserved.

Overall, the results indicate that households re-allocate their portfolios when the relative after-tax returns change. In particular, we find that households tilt their portfolios toward the assets whose after-tax return increase. These findings are in parallel with previous research based on cross section data. Poterba and Samwick (2002) also find statistically significant coefficient on marginal tax rates in the predicted direction for the interest bearing assets. Replication of their study by Bakija (2000) using the SCF panel module results in much smaller, often statistically insignificant coefficients. Bakija (2000) then concludes that controlling for unobserved heterogeneity wipes out most of the tax effect found in the cross-section literature. Our results disagree with his conclusion, but lend support to Poterba and Samwick (2002).

Table 8. Fixed Effects Censored Regression Estimates of the Portfolio Share Equations for Financial Wealth. Based on Sample with Positive Financial Wealth in 1984

	Stocks			Bonds			Cash		
	Model1	Model2	Model3	Model1	Model2	Model3	Model1	Model1	Model2
MTR capital income	-0.0711**	-0.1084**	-0.0731**	0.9611**	-0.3456**	-0.1624**	-0.7318**	0.2500**	0.1216**
Standard error	0.0122	0.0456	0.0450	0.0158	0.0473	0.0247	0.0124	0.0387	0.0167
D85	–	0.0913**	0.0853**	–	-0.0961**	-0.0883**	–	0.0407**	0.0361**
Standard error		0.0058	0.0057		0.0048	0.0025		0.0040	0.0018
D86	–	0.1269**	0.1247**	–	-0.1937**	-0.1602**	–	0.0970**	0.0731**
Standard error		0.0061	0.0060		0.0051	0.0027		0.0042	0.0019
D87	–	0.0759**	0.0834**	–	-0.2692**	-0.1967**	–	0.1708**	0.1152**
Standard error		0.0078	0.0076		0.0073	0.0037		0.0060	0.0026
D88	–	0.0651**	0.0722**	–	-0.3583**	-0.2758**	–	0.2377**	0.1705**
Standard error		0.0079	0.0077		0.0078	0.0039		0.0063	0.0027
Ln(Financial Wealth)	–	–	0.0407**	–	–	0.1906**	–	–	-0.1129**
Standard error			0.0077			0.0038			0.0020

Note: ** indicates significance at 5% level.

5. Conclusion

The way in which household portfolios respond to tax incentives is an interesting research pursuit for a number of reasons. First, as risk and return characteristics of household portfolios may be altered through tax systems, assessing the resulting distortionary effect of taxes on life time wealth accumulation of households is of great importance to government agencies and academics alike. Second, if households reshuffle their balance sheets in response to changing tax incentives this should be incorporated into the calculation of government tax revenues as households generally pay taxes on their capital income. Third, if households re-arrange the composition of assets in their portfolios in response to a tax system, this surely has impact on asset prices and financial markets which supply these assets.

In this paper we analyze the effects on the portfolio composition of a tax reform taking effect at the beginning of 1987 that sliced the marginal tax rate at which negative capital income was deductible by up to 23 percentage points, and lowered the marginal tax rate on positive capital income by up to 17 percentage points. The tax reform made it less attractive to hold debt, and more attractive to hold bonds and stocks relative to housing equity. We use a remarkable panel data set with household level information about wealth in housing equity, bonds, stocks and cash and about mortgage interest payments. The data cover the period 1984 to 1988 making it possible to follow households from a point before the reform was announced and up to two years after the implementation of the reform. We take care in exploiting the panel dimension of the data, and this facilitates overcoming some of the major data problems in the previous empirical literature on portfolio allocation, primarily controlling for the impact of unobserved heterogeneity.

Our empirical evidence can be summarized as follows: First, we find that households respond to an increase in the cost of debt by liquidating their more heavily taxed financial assets. Second,

consistent with the portfolio theory of differentially taxed assets, we find that households do reshuffle their portfolios when the after-tax returns change. In particular, we observe that households tilt their portfolios toward the assets whose after-tax return increases.

The objective of the Danish tax reform was to promote saving. In order to conclude that it accomplished this, one should keep in mind that the effect of tax incentives on overall saving depends on a number of parameters of the underlying structure (elasticity of intertemporal substitution in particular) and quite possibly the distribution of wealth. Even though we offer strong evidence on the effect of tax incentives on household portfolio composition, without modelling such structure it is very hard to make concrete policy-relevant statements regarding the overall effect on national saving. For example, even if one establishes that the private saving increases as a result of a reform like this, public saving is likely to decrease due to the lowering of tax revenues. The most obvious avenue for the future research would involve developing a realistically calibrated structural model to estimate the equilibrium effects of such a reform on the level of national saving.

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