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366

# TAXATION AND DEBT FINANCING OF HOME ACQUISITION: EVIDENCE FROM THE FINNISH 1993 TAX REFORM

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**Abstract:** The 1993 Finnish tax reform reduced the incentives to use debt financing in home acquisition for high-income households. Before the reform mortgage interest was deductible according to a progressive schedule creating a so-called upside-down effect, which means that the benefit from the deduction was the greater the higher was taxpayer's income. After the reform, the deduction is made according to a flat schedule, and thus, the size of the benefit no longer depends on taxpayer's income. We use household level data from the Income Distribution Survey of Statistics Finland to study whether high-income households have responded to the reform. Using tobit, Heckman and two-part model on repeated cross-sectional data from 1990–2000 we find that the probability of having a mortgage debt is clearly less dependent on the income of household's head after the tax reform. This income variable measures the tax deduction effect and we conclude that the 1993 tax reform was behind the observed behavioural change. The results for the amount of mortgage debt conditional on a positive amount are more ambiguous. It seems that the tax reform had no or very little effect on the demand for the amount of mortgage debt.

**Key words: mortgage interest deduction, tax reform, mortgage demand**

**Tiivistelmä:** Suomessa 1993 toteutettu tuloverouudistus vähensi merkittävästi suurituloisten kotitalouksien kannustimia asuntolainanottoon. Ennen verouudistusta asuntolainan korot vähennettiin progressiivisen verokannan mukaan verotettavista tuloista, mikä johti ns. upside-down ilmiöön, jossa verovähennyksestä saatava hyöty oli sitä suurempi, mitä suuremmat olivat verovelvollisen veronalaiset tulot. Uudistuksen myötä asuntolainan korot vähennetään suhteellisen verokannan mukaan verotettavasta pääomatulosta, joten korkovähennyksestä saatava hyöty ei enää riipu verovelvollisen tulotasosta. Tutkimuksessa tarkastellaan Tilastokeskuksen Tulonjakotilastoa käyttäen, miten suomalaiset kotitaloudet ovat reagoineet verouudistukseen. Tutkimuksessa käytetään tobit-, Heckman ja ns. kaksiosaista mallia vuosien 1990–2000 poikkileikkausaineistoihin. Tulosten mukaan asuntolainan ottamisen todennäköisyys on uudistuksen jälkeen selkeästi vähemmän riippuvainen kotitalouden viitehenkilön tuloista kuin ennen uudistusta. Tulos voidaan tulkita verouudistuksen aiheuttamaksi. Sen sijaan uudistus ei näyttäisi vaikuttaneen asuntolainan suuruuteen tai ainakin vaikutus on hyvin pieni.

**Asiasanat: asuntolainojen korkovähennys, verouudistus, asuntolainan kysyntä**

# Summary

Previous studies from different countries show that the extent of tax deductibility of interest expenses has major implications for households' borrowing behaviour. This study utilises a major tax reform implemented by the Finnish Government in 1993 to analyse the demand for mortgage debt (housing loans) by Finnish households. The tax reform significantly reduced the incentives to use debt financing in home acquisition for high-income households. Before the reform mortgage interest was deductible according to a progressive tax schedule creating a so-called upside-down effect, which means that the benefit from the deduction was the greater the higher was the taxpayer's income. After the reform the deduction is made according to a flat schedule, and thus, the benefit no longer depends on taxpayer's income.

We used household level data from the 1990–2000 Income Distribution Surveys of Statistics Finland to study whether Finnish high-income households have responded to these changes in incentives. Using tobit, Heckman and separate estimation of a two-part model (independent probit and truncated regression) to estimate a demand model for mortgage debt we find that the probability of having a mortgage debt is clearly less dependent on the income of household's head after the tax reform. As we argue that this income variable can be used to measure the tax deduction effect, we conclude that the 1993 tax reform is behind the observed behavioural change. The results for the amount of mortgage debt conditional on a positive amount are more ambiguous. It seems that the tax reform had no or very little effect on the demand for the amount of mortgage debt.

There may be several reasons behind the latter result. First and foremost, mortgage loan stock adjusts to changes slowly. In the Finnish case the incentive to reduce current mortgage was reduced by a transitional deduction subsidy aimed at high-income households who suffered most from the tax reform, and thus, the reform mainly influenced the households who took their mortgage after the reform. Since the annual amount of new mortgage debt is small compared to the whole stock the effects of the reform may emerge gradually over time.

Second, the lack of house value data may be the reason behind the results. Namely, it seems plausible that house value truly drives the demand for the amount of mortgage debt and the proxy variables used in the estimation of the mortgage demand model were insufficient to capture house price variation.

Third, because households' mortgage amounts were estimated using information on interest expenses, a measurement error is apparent in the dependent variable of our model for the cases above the zero-limit. Thus, the probit model does not suffer from measurement error and the probit results are most reliable.

Fourth, it may be that taxes truly only affect the choice of whether or not to have a mortgage debt and not so much the amount. This result is in line with current empirical evidence on taxation and household portfolio behaviour. Majority of studies indicate that taxes have substantial effects on the set of assets held by different households, but they have a relatively small effect on the portfolio shares conditional on ownership.

Finally, we have to consider whether the tax reform is the only plausible explanation for the results. Other possible explanations are the increased availability of mortgage debt and lower interest rates in the latter part of the 1990's compared to the situation before the reform. On other hand, the research period coincided with an extremely turbulent time in the Finnish economy. If these factors have affected low- and high-income households differently, the results presented might result from this. Thus, the results should be interpreted with some caution at this point. Further work on different sub-populations, for example credit-constrained households, is needed to investigate these points.

# Contents

# 1. Introduction

Mortgage interest deduction has always been a controversial housing policy tool. The opponents of the deduction argue first of all that the government can raise a significant amount of tax revenue by eliminating the deduction.[1] Secondly, mortgage interest deduction is criticised for being skewed toward high-income households, i.e. to those who are in least need of the subsidy.[2] Thirdly, it is argued that the subsidy does not increase housing consumption or reduce the budget share of households' housing expenses as intended, but instead only inflates house prices.

Although the above arguments may be valid, the nature of mortgage interest deduction is often misunderstood. The fundamental tax advantage that homeowners receive in Finland is not the deductibility of mortgage interest but the non-taxation of imputed rental income and capital gains. The removal of mortgage interest deduction would not eliminate the fundamental tax advantage but would tilt the advantage in favour of those wealthy and high-income households who are less dependent on debt financing in home acquisition.[3] The deductibility of mortgage interest can be seen as a way to extend the tax advantage to those who must rely on mortgage financing in order to purchase a home. As Hendershott et al. (2003) argue the non-deductibility of mortgage interest can be seen as tax a penalty against debt financing and in favour of equity financing. Under a neutral tax system from investment point of view a household should be indifferent between debt and equity financing.[4]

In 1993 the Finnish government introduced a dual income tax system, in which capital and labour income are divided as different types of income and are taxed with different tax rates. The new system replaced a progressive tax rate on capital income with a flat rate of 25 percent, but labour income is still taxed with a progressive schedule.[5] Before the reform mortgage interest was deductible according to a progressive schedule creating a so-called upside-down effect, which means that the value of the deduction subsidy was the greater the higher was the taxable income of the taxpayer. After the reform mortgage interests are deductible according to a flat rate equal to the capital income tax rate. Thus, as a result of the reform, the link between taxpayer's income and the value of the subsidy resulting from mortgage interest deduction was broken. Furthermore, the reform broadened the capital income tax base. The interesting result of the

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[1] According to the tax expenditure report by the Government Institute for Economic Research in Finland the amount of tax revenue forgone was about 440 million euros in 2002.

[2] See e.g. Viitamäki (1999) for evidence from Finland.

[3] See e.g. Woodward and Weicher (1989).

[4] This is true also in the corporate sector.

[5] The current tax rate on capital income in Finland is 28 percent.

reform for the purposes of this study is that it brought the mortgage interest deduction and capital income tax rates closer together, especially for high-income households. The purpose of this paper is to study, how Finnish households have responded to the 1993 tax reform in terms of mortgage demand.

In understanding the effects of mortgage interest deduction or tax incentives in general it is crucial to know, whether households really respond to these incentives. Studying the effects of taxation on household behaviour is difficult for a number of reasons.[6] First, a fundamental problem of identification arises in a cross-sectional study when the marginal tax rate is a function of taxable income, which results in high collinearity between the two explanatory variables. Second, when the (marginal) tax rate is the same for all households the tax incentive effects cannot be identified from a single cross-section. Third, in a case where mortgage interest is deductible from taxable income of the taxpayer marginal tax rate becomes an endogenous variable, i.e. the amount of mortgage debt a taxpayer chooses affects her marginal tax rate, and correspondingly, the marginal tax rate lowers the price of mortgage debt. Finally, especially in household investment considerations it may be that it is the future marginal tax rates that are of importance in the household's decision.[7] However, in the case of mortgage debt interest payments are highest at the start of repayment, and thus, future tax considerations should not play such an important role here as opposed to long-term investment decisions where the gains are realised and taxed in the future.

To account for these econometric problems this study utilises the 1993 tax reform in order to study the impact of the after-tax price of mortgage debt on the leverage used by Finnish households in home acquisition. The method we use is based on the notion that under a progressive tax schedule taxable income affects mortgage demand in two ways.[8] First, because housing is a normal good an increase in income should lead to an increase in housing demand and consequently in mortgage demand. Second, under a progressive tax schedule increase in income leads to a higher marginal tax rate and lowers the after-tax price of mortgage debt, and thus, higher income leads to higher mortgage demand due to this price effect as well. From a cross-section analysis it is very difficult to identify these effects. However, after the tax reform the after-tax price of mortgage debt is the same for all households regardless of their income. Therefore, with cross-section data from both before (cross-sections from 1990 and 1992) and after (cross-sections from 1994, 1996, 1998 and 2000) the reform we can identify the impact of the tax-price effect. The difficulty in this situation is how to disentangle the tax reform effect from other economic changes that

[6] Triest (1998) offers a non-technical introduction to econometric issues in taxation and households' behaviour.

[7] See e.g. Poterba (2001).

[8] See also Fjærli (2004).

occurred at the same time. In the econometric specification we account for the fact that mortgage debt can have only non-negative values and many households have no outstanding mortgage debt by using tobit and Heckman's (1979) sample selection models.

The results may shed light on some broader issues as well. First, by studying the behavioural responses we can assess more precisely the amount of tax revenue lost due to mortgage interest deduction. The tax expenditure lists and estimated revenue losses presented in the government budget are based on the assumption that households would not adjust their behaviour if the provision in question is removed. This is not a very realistic assumption in the light of current research results, however, which clearly indicate that households do respond to changes in tax rules. So it is likely that government's tax revenue would not increase by the amount of revenue forgone reported in the budget, if mortgage interest deduction is removed.

Second, besides housing markets mortgage interest deduction affects other sectors of the economy as well. For example, if the mortgage interest deduction is removed, the price of mortgage debt that a consumer faces rises which in turn should reduce the demand for mortgage debt. This might result in a significant reduction in the house loan stock, which of course is of great concern to the banking sector.[9]

Third, incentives to borrow created trough taxation also affect the overall rate of saving in the economy.[10] A change in the interest rate changes the price of current consumption relative to future consumption. This may have important implications to the saving rate and thereby to economic growth. Finally, the results would give an indication, whether incentives created indirectly trough taxation are effective in promoting particular activities. If households have not responded to clear incentive changes, the applicability of tax incentives may be questioned. Thus, the results can be used as an input to tax policy debate. Some of these questions are, however, related to general equilibrium effects of tax reforms and are beyond the direct scope of this paper.

The paper is organized as follows. In section 2 the central features of Finnish housing markets and the 1993 tax reform are outlined. This section also illustrates the effect of the 1993 tax reform on households' incentives to borrow. Section 3 presents empirical evidence from earlier studies on taxation and mortgage demand from different countries. In section 4 the research methodology and econometric specification are presented in more detail. Section

[9] See e.g. Follain and Melamed (1998) who estimate an average drop of 40 percent in the mortgage demand of U.S. households if mortgage interest deduction is removed.

[10] See Jappelli and Pistaferri (2002a) for further discussion.

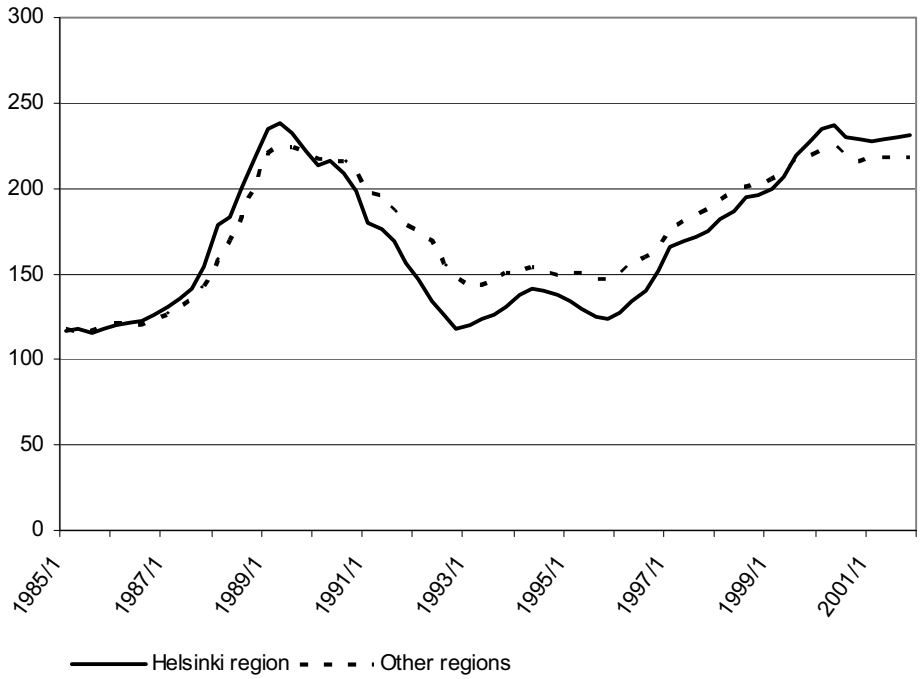
4 also contains the description of the data used. In section 5 estimation results are presented and section 6 concludes.

# 2. Finnish Housing Markets and the 1993 Tax Reform

## 2.1 Background: Finnish housing markets and institutional changes

When studying the consequences of a particular reform we must account for other reforms and economic changes coinciding with it. Next we will shortly review the development of Finnish housing markets and institutions during the research period. In the latter part of the 1980's Finnish financial markets were liberalized. Before the liberalization interest rates were regulated which led to negative real interest rates and credit rationing. Mortgage borrowing required heavy up-front saving from the households and annuities were relatively short.[11] The improved availability of mortgage loans and longer repayment periods triggered a boom in house prices, which can be seen in Figure 1. The house prices busted as the economy went into a deep recession in the early 1990's and have been increasing again rapidly since the late 1990's as result of economic recovery, low interest rates and migration.[12]

*Figure 1. Development of house prices in 1985–2001 (1983=100)*



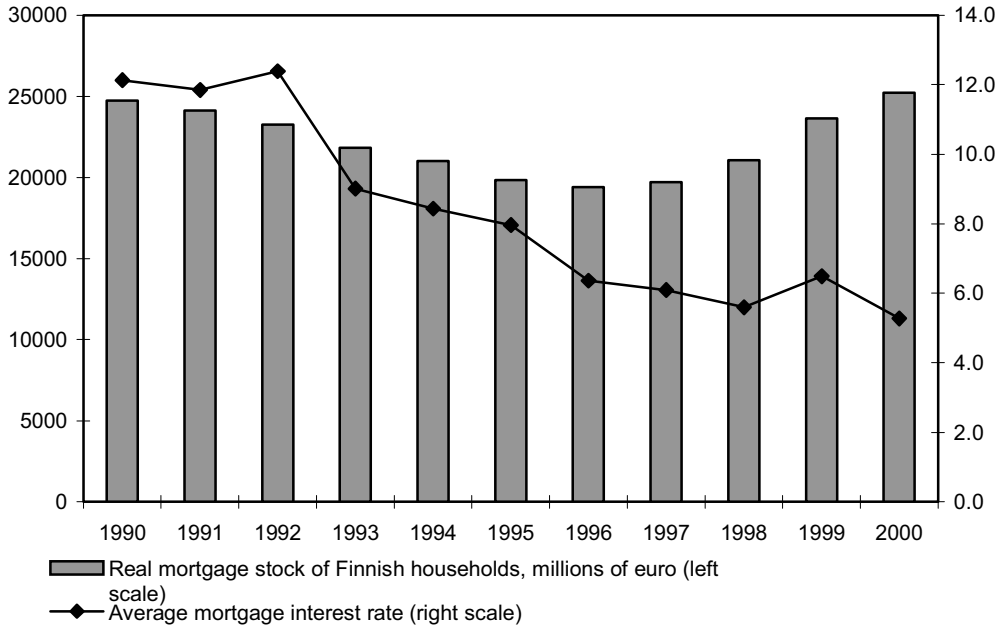

Source: Statistics Finland.

[11] See Bengs and Loikkanen (1991) for an overview of earlier development of Finnish housing markets and institutions.

[12] The Finnish GDP collapsed about 12 percent in 1991–1993. At the same time unemployment rate rose from 3.5 percent in 1990 to 18.4 percent in 1994. See Kalela et al. (2001) for more details on the Finnish recession and recovery.

The recession made its mark also on the mortgage market. The banking sector was hit especially hard as collateral values collapsed and more and more businesses went bankrupt.[13] Figure 2 illustrates the development of the real mortgage stock of Finnish households and the average mortgage interest rate during the 1990's. The high interest rates in the early 1990's were due to an unsuccessful defence of a fixed exchange rate after which the Finnish Markka was devaluated by 12 percent in November 1991 and floated in September 1992. The decline in the mortgage stock was a result of both a declined demand for mortgage debt during the recession and a tightened lending policy by the banking sector as a reaction to credit-losses.

*Figure 2. Finnish mortgage stock and average mortgage interest rate in 1990–2000*




Source: Statistics Finland.

Although the liberalization of financial markets increased mortgage availability in the long run, the ratio of mortgage stock to GDP in Finland is still relatively low in international comparisons. According to European Central Bank (2003) the ratio of mortgage stock to GDP in Finland was 21 percent in 2001.[14]

[13] In Finland there are only few financial firms concentrated on private housing finance. The biggest mortgage suppliers are general commercial, savings and co-operative banks.

[14] Mortgage stock to GDB ratio in 2001 was on average 33 percent in the Euro area and 39 percent in the EU. Highest ratios can be found in the Netherlands (74 percent), Denmark (67 percent) and the U.K. (60 percent).

Another major institutional change took place in 1991–1995 when rent control was phased out. The removal has probably increased the availability of rental dwellings and affected the tenure choice of households. Homeownership rate declined from 69 percent in 1990 to 65 percent in 2000.[15] However, due to data limitations we are unable to model the tenure choice and we limit our study to the debt usage of homeowners.

## 2.2 Tax reform and the incentive to borrow

Before the 1993 tax reform in Finland capital and labour income were taxed essentially the same way according to a progressive schedule. In principle, taxation was based on all nominal income regardless of the source. However, the effective tax rate on capital income from different assets varied considerably because of many different concessions and exemptions. In particular, imputed rental income from owner-occupied housing was taxed only on the part of the house value that exceeded a certain limit. In practice, most owner-occupiers did not pay any taxes on imputed rental income, mainly because houses were valued well below market rates. All this together with the possibility to deduct mortgage interest expenses according to a progressive schedule made mortgage debt a good way to pursue tax arbitrage goals especially for high-income taxpayers with high marginal tax rates. One of the main goals of the 1993 reform was to harmonize the taxation of capital income from different assets by broadening the tax base and to eliminate these arbitrage possibilities.[16]

In 1993 the Finnish government introduced a dual-tax system, in which capital and labour income are divided as different types of income and are taxed with different tax rates. The new system replaced a progressive tax rate on capital income with a flat rate of 25 percent (currently 29 percent), whereas labour income remained under a progressive schedule. In addition, the tax code was simplified by harmonizing the deduction rules for different capital assets. Also in 1993 a new municipal-level property tax was introduced, which replaced the taxation of imputed rental income. At the same time some municipal-level payments on property such as the street maintenance fee, land tax and presumptive taxation of property were eliminated. So in effect the taxation of the return from owner-occupied housing did not change due to these reforms. Furthermore, a stamp tax on interest income was phased in between 1991 and

[15] Rest of the households are renters. The rates are calculated from the Income Distribution Statistics. Right of occupancy apartments are excluded because they only account for about one percent of the housing stock.

[16] See Government bill 200/1992 for the Income Tax Act.

1994, from where on the stamp tax rate has been equal to capital income tax rate.[17]

In the Finnish tax system the deductibility of interest expenses is determined according to the purpose of use of the debt. The interest expenses that are deductible in Finland include interest on mortgage loans[18], interest on government secured student loans and interest expenses accrued from producing taxable income. Mortgage debt refers here only to acquisition debt, including construction and home improvement. Before the reform a limited amount of consumer credit interest was deductible. In the new system interest expenses are deductible from capital income. Thus, the deduction rate is the same as the tax rate on capital income. If interest expenses exceed capital income, the taxpayer is allowed to deduct the resulting tax deficit from her labour income tax liability in form of a tax credit. In this situation the deduction rate is equal to the capital income tax rate.[19] Table 1 summarizes the interest deduction rules from 1990 to 2000.

*Table 1. Interest deduction rules in 1990–2000*

| Year | Deduction rate | Percentage deductible | Limit (€) single[c] | Limit (€) married | Limit (€) one child[d] | Limit (€) two or more children |
|---|---|---|---|---|---|---|
| 1990 | Progressive (49.7)[a] | 85 | 3 360 | 3 700 | 590 | 1 180 |
| 1991 | Progressive (48.9)[a] | 80 | 3 360 | 4 040 | 590 | 1 180 |
| 1992 | Progressive (51.7)[a] | 75 | 3 360 | 4 370 | 670 | 1 350 |
| 1993 | Flat (25 %)[b] | No limit | 1 350 | 2 700 | 335 | 670 |
| 1994 | Flat (25 %) | No limit | 1 350 | 2 700 | 335 | 670 |
| 1995 | Flat (25 %) | No limit | 1 350 | 2 700 | 335 | 670 |
| 1996 | Flat (28 %) | No limit | 1 350 | 2 700 | 335 | 670 |
| 1997 | Flat (28 %) | No limit | 1 350 | 2 700 | 335 | 670 |
| 1998 | Flat (28 %) | No limit | 1 350 | 2 700 | 335 | 670 |
| 1999 | Flat (28 %) | No limit | 1 350 | 2 700 | 335 | 670 |
| 2000 | Flat (29 %) | No limit | 1 350 | 2 700 | 335 | 670 |

[a]Average deduction rate.

[b]For first-time buyers the deduction rate is 30 % from 1993 onwards.

[c]After 1992 the limits apply only to the tax credit from labour income tax liability. Interest deduction from capital income is unlimited.

[d]The limits for singles and married couples are inceared by the amounts in the last two colums.

From Table 1 we see that the average deduction rate was almost halved because of the tax reform. Therefore, also the tax subsidy resulting from the deduction

[17] The stamp tax on interest income was first introduced in 1991 when the rate was 10 percent. The rate was increased to 15 in 1992, to 20 in 1993 and finally to 25 percent in 1994.

[18] To be precise, Finnish house loans are not assumable mortgages but personal loans. However, most Finnish house loans are secured by a home.

[19] First time homebuyers are allowed to deduct the tax deficit resulting from mortgage interest at 30 per-cent rate.

was halved. Before the reform there was a limit on the percentage of interest expenses eligible for deduction. This limit was removed in 1993. Furthermore, the amount of deductible interest expenses was limited before the reform. After the reform, the amount is limited only in a case where interest expenses exceed capital income, i.e. the size of the tax credit is limited not the amount of interest eligible for deduction. If the tax credit limit becomes binding a taxpayer can offset the resulting loss from her capital income accrued in the next ten years. However, the loss does not make the taxpayer eligible for another tax credit in future years.

Because the significant reduction in the deduction rate Finnish authorities legislated a transition period for high-income households, who had taken a mortgage before the reform, so that they could deduct more mortgage interests than others. Thus, for high-income households with a mortgage taken before the reform the incentives to shuffle current portfolios were reduced somewhat. The transition period ended in 1999 and the amount of the transitional subsidy was significantly reduced during the latter part of the 1990's. Fortunately, we are able to identify the households receiving the transitional subsidy and we can control for it in the estimation. The enactment of the transitional subsidy highlights the fact that the tax reform substantially reduced the subsidy for high-income households. Also the fact that first time buyers can deduct interests at a higher rate may cause some problems, but the rate difference has been reduced considerably in the late 1990's.

We formalise the decision-making process of homebuyer with a stylised model for mortgage demand presented by Brueckner (1994). The basic model has two periods and includes no uncertainty.[20] Current period utility depends on consumption of housing services, $h$, and non-housing consumption, $x$. The price of a unit of housing services is $p$ and the price of the composite consumption good is normalised to unity. Current period preferences are depicted by a strictly concave utility function $U(x,h)$, with $U' > 0$ and $U'' < 0$. Future period utility is determined by subsequent wealth, denoted by $z$, which is determined in the first period. The discounted utility from the second period is denoted by $\delta V(z)$, where $\delta < 1$ is the discount factor and $V$ is again a strictly concave function.

The consumer has an initial wealth of $w$ at the beginning of the first period, which includes current income and assets. This wealth can be used for house purchase, non-housing consumption or saving. The consumer is not allowed to borrow, except trough a mortgage for house purchase. Let $m$ denote the size of the mortgage and $s$ the amount of saving. Now the current period budget constraint can be written as $x = w - s - (ph - m)$. The constraints governing $s$ and $m$ are

$$s \geq 0 \qquad (1)$$

[20] Follain and Dunsky (1997) consider a similar model.

$$\alpha ph \geq m \tag{2}$$

$$m \geq 0. \tag{3}$$

The constraint in (2) depicts the maximum amount of mortgage debt, where $\alpha < 1$ is the maximum loan-to-value ratio, i.e. the maximum percentage of house value that can be debt-financed. The consumer cannot be a mortgage lender, which is implied by (3).

Denoting the mortgage interest rate with $r_m$, the interest rate for saving with $r_s$, and future income with $y$, future wealth can be written as

$$z = y + (1 + r_s)s + ph - (1 + r_m)m. \tag{4}$$

Substituting the current period budget constraint to $U$ and (4) into $V$ yields the consumer's objective function

$$U\left[w - s - \left(ph - m\right), h\right] + \delta V\left[y + (1 + r_s)s + ph - (1 + r_m)m\right]. \tag{5}$$

Consumer optimisation problem is to choose $h$, $s$ and $m$ in order to maximise (5) subject to the constraints in (1)–(3). The corresponding Lagrangian is

$$\begin{aligned} L\left(h, s, m, \lambda_1, \lambda_2, \lambda_3\right) &= U\left[w - s - \left(ph - m\right), h\right] \\ &+ \delta V\left[y + (1 + r_s)s + ph - (1 + r_m)m\right] + \lambda_1 s + \lambda_2\left(\alpha ph - m\right) + \lambda_3 m, \end{aligned} \tag{6}$$

where the $\lambda_i$:s are the multipliers for the constraints in (1)–(3) respectively. The optimality conditions are

$$\frac{\partial L}{\partial s} = -U_x + (1 + r_s)\delta V' + \lambda_1 = 0 \tag{7}$$

$$\frac{\partial L}{\partial m} = U_x - (1 + r_m)\delta V' - \lambda_2 + \lambda_3 = 0 \tag{8}$$

$$\frac{\partial L}{\partial h} = -pU_x + U_h + p\delta V_2' + \alpha p\lambda_2 = 0, \tag{9}$$

along with (1)–(3), and the complementary slackness conditions associated with inequality constraints:

$$\lambda_1 \geq 0, \quad \lambda_1 s = 0 \tag{10}$$

$$\lambda_2 \geq 0, \quad \lambda_2(\alpha ph - m) = 0 \tag{11}$$

$$\lambda_3 \geq 0, \quad \lambda_3 m = 0. \tag{12}$$

The main point from the model for our purposes is the choices of *m* and *s* conditional on *h*. In other words, what is the optimal amount of mortgage and saving plan given the housing demand of the consumer? As Brueckner argues, combining equations (7) and (8) is central to the discussion. This yields

$$(1 + r_s)\delta V' + \lambda_1 = (1 + r_m)\delta V' + \lambda_2 - \lambda_3. \tag{13}$$

We use the expression in (13) to illustrate the effects of the tax reform on the optimal amount of mortgage debt. To consider the Finnish tax reform we rewrite the pre-reform mortgage and savings interest rates as

$$r_m = (1 - t)r \tag{14}$$

$$r_s = (1 - \theta t)r, \tag{15}$$

where *t* is the marginal tax rate of the consumer. Thus, we assume that the pre-tax interest rates are equal and the difference between the two after-tax interest rates is solely due to tax treatment. We argued above that only a part of an investor's capital income was taxed in the pre-reform period. This means that in (15) the percentage of capital income that was taxable was below unity, i.e. $\theta < 1$. From (14) and (15) we easily see that in the pre-reform period $r_m > r_s$. What implications does this have for the choice of optimal mortgage amount? In this case, for (13) to be satisfied requires that

$$\lambda_1 < \lambda_2 - \lambda_3. \qquad (16)$$

From the complementary slackness conditions in (10)–(12) we know that none of the multipliers can be negative. This means that some of the cases can be ruled out. First, $\lambda_2 = \lambda_3 = 0$ cannot hold because this would imply $\lambda_1 < 0$. Thus, from the constraints either (2) or (3) must bind, i.e. either $m = 0$ or $m = \alpha ph$. But if $m = 0$, then $\lambda_3 > 0$ and $\lambda_2 = 0$, which again implies $\lambda_1 < 0$. So we are left with the solution that $m = \alpha ph$ and $s \geq 0$, which means that the consumer chooses the largest possible mortgage. The result is intuitively clear. If a consumer chooses a mortgage that is lower than $\alpha ph$, she could acquire an extra euro of mortgage debt and invest it at a higher rate $r_s$. This choice would have no effect on current consumption but would raise future wealth.

The 1993 tax reform implied a change from $r_m > r_s$ to $r_m = r_s$. Given the constraint $s \geq 0$ with equal interest rates, the demand for mortgage debt is driven solely by consumer time-preferences and housing demand, and the optimal amount is anywhere between zero and the maximum amount limited by the loan-to-value ratio constraint.

# 3. Previous Studies

In this section we review shortly previous empirical studies on tax incentives on borrowing and mortgage debt in particular. The majority of studies concerning tax incentives focuses on tax reforms, mainly because a tax reform is an exogenous event, and thus, often creates a situation resembling a natural experiment. Usually this is the case when different groups of taxpayers are affected differently by the reform. For example, the U.S. Tax Reform Act of 1986 (TRA 86) has produced a voluminous literature on how different groups of U.S. taxpayers have responded to changes in tax incentives to saving and borrowing.[21]

Jones (1993, 1994 and 1995) is one of the first to study empirically the demand for the amount of mortgage debt.[22] Jones argues that the demand for owner-occupied housing is not a sufficient explanation for households' demand for mortgage debt. Households with mortgage debt have two options for investing their savings. Either they can invest in non-housing assets, which yield an after-tax return of $r_s$ or they can reduce their holdings of mortgage debt, which yields an after-tax return of $r_m$ in form of saved interest expenses. The optimal saving plan is the one that offers higher return. Crucial to the decision is whether mortgage interest is tax deductible. Using U.S. and Canadian data Jones finds that non-housing portfolio considerations play a major role in households' mortgage decisions.

Follain and Dunsky (1997) study explicitly the effect of taxation on mortgage demand. The centrepiece of their paper is an econometric model in which the demand for mortgage debt depends on the after-tax costs of equity and debt financing. The empirical specification is a reduced version of a general theoretical model, in which households' derive utility from non-housing consumption, consumption of housing services and expected future wealth. The results indicate that the demand for mortgage debt is sensitive to the difference in the after-tax costs of equity and debt financing, which suggests that the elimination of mortgage interest deduction would decrease mortgage demand substantially. Ling and McGill (1998) use a similar approach and estimate a two-equation model of housing consumption and mortgage demand. Also Ling and McGill (1998) find evidence that taxation is an important factor in mortgage demand.

In relating studies Maki (1996 and 2001) analyses the effects of the TRA 86 on the debt composition of U.S. households. The TRA 86 limited the possibility to deduct interest on consumer debt. Starting in 1986 consumer interest deduction was totally phased out over a five-year period. The aim of the U.S. Congress was

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[21] See Auerbach and Slemrod (1997) for a review of the reform, its goals and consequences.

[22] See Follain (1990) for a review of earlier literature on factors influencing the mortgage choice of households.

to increase saving and raise significant amounts of tax revenue. However, because mortgage interest deduction was left almost untouched, a possible loophole was created for owner-occupiers to use mortgage debt to finance the purchase of consumer goods, and thus enjoy full deductibility.[23]

Using sample selection regression methods with instrumental variables and difference-in-difference techniques Maki (2001) investigates, whether owner-occupiers have responded to the reform by substituting consumer debt with mortgage debt. The results indicate that high-income owner-occupiers have responded to the TRA 86 by substituting consumer debt with mortgage debt.[24] High-income renters who did not have access to mortgage debt did not reduce their consumer debt relative to other renters. This can be seen as evidence that households do respond to tax incentives. Because the decline in consumer debt was almost totally offset by an increase in mortgage debt, the phase out had little impact on total borrowing and saving of U.S. households'. The response of high-income owner-occupiers had also a major impact on the revenue collected by the government. Maki (2001) reports that the tax revenue generated by the reform was cut to half relative to a case with no portfolio shuffling. So it seems that both government goals failed to be realized because of ill-planned reform.

Jappelli and Pistaferri (2002b) investigate the effects of tax reforms implemented in Italy in 1992–1998 to incentives to borrow and to the demand for mortgage debt. The tax reform in Italy had a similar impact to borrowing incentives as in the Finnish case. In Italy before the reform (from 1982 to 1992) mortgage interests were fully deductible up to 3,500 euros (7 million lire), so that the tax incentive was proportional to the borrower's marginal tax rate. In 1992 the system was changed so that the deductions can be made according to a flat rate of 27 percent. The rate was then lowered to 22 percent in 1994 and to 19 percent in 1998. This reform meant that the incentive to borrow was substantially reduced for high-income households, slightly increased for low-income households and (almost) unchanged for middle-income households. So *a priori* all other things equal high-income (low-income) households should reduce (increase) their borrowing, i.e. the amount of outstanding mortgage debt. Surprisingly, Jappelli and Pistaferri (2002b) find no evidence of the supposed responses. They argue that the most likely explanation for the absence of response to changes in the incentives to borrow is the lack of financial information in general and awareness of the specific changes in tax incentives in the mortgage market in particular of Italian households.[25]

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[23] The U.S. tax law was changed so that interest was fully deductible up to $1 million in acquisition debt and $100,000 in home equity debt. Debt is qualified as acquisition debt if it is used for the purchase or improvement of a home and home equity debt includes all other debt secured by a home.

[24] Earlier Scholz (1994) found similar changes but was unable to identify the reasons behind them.

[25] Maki (1996) considers similar questions.

Hendershott et al. (2003) analyse the phasing out of the mortgage interest deduction or MIRAS-system[26] in the U.K. in the 1990's. Already in 1983 a ceiling of £30,000 was set to limit the amount of mortgage debt eligible for interest deduction. In 1991 the deduction rate was dropped to 25 percent for all taxpayers and was then totally phased out by 2000. Prior to 1991 the deduction was made according to household's marginal income tax rate. Hendershott et al. (2003) present the phase out in terms of a tax penalty. If initially the costs of debt and equity financing both equal the after-tax interest rate, $(1-t)r$, then the weighted average cost of capital $WACC = (1-t)r$. If the deductibility of mortgage interest is restricted it in effect means implementing a tax penalty on debt usage and $WACC = (1-t)r + \alpha(p)r$, where $p$ is the tax penalty. If the penalty is non-deductibility ($p = t$), WACC is increased by the product $\alpha tr$. Other things equal this means that $WACC$ increases. However, households with sufficient funds or other investments can respond to the reduction in $t$ by adjusting their loan-to-value ratio $\alpha$. By lowering $\alpha$, households can mitigate or totally prevent the increase in $WACC$. Hendershott et al. (2003) estimate the reduction in loan-to-value ratio to be about 30 percent on aggregate when house values are assumed to stay constant.

The latest addition to this branch of literature is the paper by Fjærli (2004). He studies the demand for debt before and after a major tax reform in Norway in 1992. Like Finland a year after, Norway replaced the progressive taxation of capital income and interest expenses with a dual income tax, which imposed a flat tax rate of 28 percent on capital income and a progressive tax rate on labour income.[27] Consequently, the tax subsidy resulting from interest deductions was reduced for high-income households. As opposed to Jappelli and Pistaferri (2002b), Fjærli (2004) finds strong evidence that after the reform household debt is not as much dependent on income as before the reform. This again can be seen as an indication that households' have responded to tax incentives as predicted by theory.

[26] Mortgage Interest Relief at Source.

[27] The Norwegian system differs from the Finnish so that in Norway all forms of interest are tax deductible not only mortgage interest.

# 4. Econometric Specification and Data Description

## 4.1 Modelling the demand for mortgage debt and the tax reform

As Follain and Dunsky (1997) note the demand for mortgage debt would ideally be specified as one of a system of equations that include demand for housing consumption, demand for non-housing consumption and demands for various assets. Unfortunately, our data does not include house price information or holdings of different assets by households so we estimate a reduced version for mortgage demand only. However, since house value is a major driving force behind mortgage demand we use proxy variables to account for the omitted variable problem.

We include only homeowners in our final sample. Thus, we model the mortgage demand of those who are eligible for a mortgage interest deduction. Of course, the tax reform may have had an effect on the tenure choice of households', which means that the underlying population of homeowners may be different before and after the reform. However, our data does not permit us to estimate a tenure choice model because there is no data available on the relative prices of owner and rental housing. This is an unfortunate drawback, because one of the interesting questions would be how the tax reform affected the probability of becoming a homeowner, which in many cases is analogous to the probability of obtaining a mortgage debt, at least for young and low-income households.

In the econometric specification we must account for the fact that mortgage debt can have only non-negative values and many homeowner households have no outstanding mortgage debt. In this situation ordinary least squares estimation would lead to inconsistent estimates. However, it should also be noted that mortgage debt is not a censored variable, i.e. it cannot, in principle, have negative values, which is the idea behind censoring.[28] Instead, zero values are actual choices made by households' given the constraints they face. This distinction is important when interpreting the results. There is a further censoring limit apparent in mortgage demand modelling, also discussed in Brueckner's (1994) model, which is the loan-to-value constraint. In a usual mortgage contract in Finland the size of the mortgage cannot exceed 80 percent of house value. Sometimes banks also impose an upper-limit to loan servicing expenses (interest expenses and repayment) to income ratio. However, this upper-limit varies across households and is not observed so we ignore it in the estimation. We start with a fairly general formulation of the Heckman's (1979) sample selection model[29]

[28] See Greene (2003), pp. 758–801 for an overview of censored regression models.

[29] See Vella (1998), p. 129. Sometimes this model is called a type 2 tobit model according to Amemiya's (1985) taxonomy or generalised tobit.

$$y_i^* = \mathbf{x}_i'\boldsymbol{\beta} + \varepsilon_i, \quad i = 1,...,n \tag{17}$$

$$d_i^* = \mathbf{z}_i'\boldsymbol{\gamma} + \nu_i, \quad i = 1,...,n \tag{18}$$

$$d_i = 1 \text{ if } d_i^* > 0; \quad d_i = 0 \text{ otherwise} \tag{19}$$

$$y_i = y_i^* * d_i, \tag{20}$$

where $y_i^*$ is an unobserved latent variable with an observed counterpart $y_i$. Also $d_i^*$ is a latent variable with indicator function $d_i$ that is observed. In our case $y_i^*$ is the unobserved mortgage demand, $y_i$ is the observed positive amount of mortgage debt associated with household $i$, and $d_i$ indicates the choice of having a mortgage debt. In other words, a positive $y_i$ is observed only if $d_i$ equals 1. $\mathbf{x}_i$ and $\mathbf{z}_i$ are vectors of exogenous variables, and $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are vectors of unknown parameters. The error terms are assumed bivariate normal: $(\varepsilon_i, \nu_i) \sim N(0, 0, \sigma_\varepsilon, 1, \rho)$, where $\rho$ denotes the correlation between $\varepsilon_i$ and $\nu_i$, and the variance of $\nu_i$ is scaled to unity.

In the above model the choice of having a mortgage debt and the decision of how much mortgage debt to have conditional on a positive amount can be seen as distinct decisions, although correlated. The independent variables in $\mathbf{x}_i$ and $\mathbf{z}_i$ may be totally distinct, may include some common variables or may be identical. In the last case the model (or more precisely the vector $\boldsymbol{\beta}$) is identified trough functional form only.

Because in this case the dependent variable of interest is not censored our interest lies in the conditional expectation of $y_i$ instead of $y_i^*$ and in the probability of a positive outcome. There are many interesting results that can be obtained from the above model. First, by simply estimating the probit model or the so-called selection equation we obtain the marginal effect of a covariate on the probability of having a mortgage debt

$$\frac{\partial P(d = 1 \mid \mathbf{z})}{\partial z_j} = \gamma_j \phi(\mathbf{z}'\boldsymbol{\gamma}), \tag{21}$$

where $\phi(.)$ is the density of the standard normal distribution. For the whole population of homeowners the marginal effect of a covariate is simply

$$\frac{\partial E(y_i \mid \mathbf{x}, \mathbf{z})}{\partial x_{ij}} = \beta_j. \tag{22}$$

With the distributional assumptions made above the conditional expectation of $y_i$ for the sub-population of homeowners with a mortgage debt is[30]

$$E(y_i \mid \mathbf{x}, \mathbf{z}, d = 1) = \mathbf{x}_i'\boldsymbol{\beta} + E(\varepsilon_i \mid \mathbf{x}, \mathbf{z}, d = 1) \tag{23}$$

where

$$E(\varepsilon_i \mid \mathbf{x}, \mathbf{z}, d = 1) = \rho\sigma_\varepsilon \lambda(\mathbf{z}_i'\boldsymbol{\gamma}) \quad \text{and} \quad \lambda(\mathbf{z}_i'\boldsymbol{\gamma}) = \frac{\phi(\mathbf{z}_i'\boldsymbol{\gamma})}{\Phi(\mathbf{z}_i'\boldsymbol{\gamma})}. \tag{24}$$

$\lambda(.)$ is the so-called the inverse Mill's ratio (IMR), where $\phi(.)$ and $\Phi(.)$ are the density and cumulative distribution functions of the standard normal distribution. If $E(\varepsilon_i \mid \mathbf{x}, \mathbf{z}, d = 1) \neq 0,$ estimating the level equation without controlling for sample selection leads to inconsistent estimates. The full effect of a marginal change in covariate *j* for the sub-population with a positive amount of mortgage debt is

$$\frac{\partial E(y_i \mid \mathbf{x}, \mathbf{z}, d = 1)}{\partial x_{ij}} = \beta_j - \gamma_j \rho\sigma_\varepsilon \left[ \mathbf{z}_i'\boldsymbol{\gamma}\lambda(\mathbf{z}_i'\boldsymbol{\gamma}) + \lambda(\mathbf{z}_i'\boldsymbol{\gamma})^2 \right]. \tag{25}$$

The full effect of a covariate consist of two parts: a direct effect trough $\beta_j$ and an indirect effect trough $\lambda$. Of course, if the covariate in question does not enter the selection equation then $\gamma_j = 0$ and the marginal effect is simply $\beta_j$. An important feature in (25) is that it is quite possible that in addition to magnitude, also the sign and statistical significance of the total effects may be different from those of the estimated $\boldsymbol{\beta}$.

The model is estimated with the two-step procedure suggested by Heckman (1979). First, we estimate a probit model for the choice and calculate the IMRs for each household. In the second step, we estimate an OLS regression for the non-limit values including the IMRs as additional explanatory variables. In this case OLS produces invalid standard errors and they must be corrected. The *t*-test

[30] See e.g. Greene (2003), pp. 782–783.

for the coefficient of the IMR tells whether the sample selection bias is statistically significant.

If the correlation of $\varepsilon_i$ and $\nu_i$ is zero the model can be estimated in two parts: a probit model for the indicator function *d* and a log-linear model for the observed (non-limit) *y*. Henceforth this model is referred to as the two-part model. If, on the other hand, we assume that the decision of having a mortgage debt and the decision of how much mortgage debt to have conditional on a positive amount are generated through the same mechanism we have $\mathbf{x}_i = \mathbf{z}_i$, $\boldsymbol{\beta} = \boldsymbol{\gamma}$ and $\rho = 1$. For example, if income is assumed to increase the probability of having a mortgage debt, then by construction of the model, income also has a positive impact on the amount of mortgage conditional on a positive amount. Now the model in (17)–(20) reduces to the conventional tobit model[31] and can be defined as

$$\begin{aligned} y_i &= \mathbf{x}_i'\boldsymbol{\beta} + \varepsilon_i, \quad \text{if } \mathbf{x}_i'\boldsymbol{\beta} + \varepsilon_i > 0 \\ y_i &= 0 \quad \text{otherwise,} \end{aligned} \tag{26}$$

where $y_i$ is the observed dependent variable, $\boldsymbol{\beta}$ a vector of parameters, $\mathbf{x}_i$ the vector of independent variables and the error terms are assumed normally and independently distributed: $\varepsilon_i \sim N(0, \sigma^2)$.

The appropriateness of the above assumption can be tested. If $\mathbf{x}_i = \mathbf{z}_i$, then the restriction $\boldsymbol{\beta} = \boldsymbol{\gamma}$ can be tested by using a likelihood ratio test based on the log-likelihoods of tobit, probit and truncated regression models. In fact, in this case the the tobit specification is tested against the two-part model.[32] In the probit model the dependent variable is the indicator whether a household has a mortgage debt, and truncated regression is simply a linear regression for the non-limit households only. If the tobit specification is correct the tobit log-likelihood should equal the probit log-likelihood plus the log-likelihood from the truncated regression model. A likelihood ratio test statistic can be computed as $LR = -2[\ln L_T - (\ln L_P + \ln L_{TR})]$, where $\ln L_T$ is the log-likelihood from the tobit model, and $\ln L_P$ and $\ln L_{TR}$ are the log-likelihoods from the probit and truncated regression models respectively.

[31] The name refers to Tobin (1958) where the model was first proposed.

[32] See Greene (2003, pp. 770).

An attractive feature of the tobit model, first proposed by McDonald and Moffitt (1980), is that the marginal effect of an explanatory variable $x_j$ on $y$ can be decomposed as follows

$$\frac{\partial E(y_i \mid \mathbf{x})}{\partial x_{ij}} = P(y_i > 0 \mid \mathbf{x}) \frac{\partial E(y_i \mid \mathbf{x}, y_i > 0)}{\partial x_{ij}} + E(y_i \mid y_i > 0) \frac{\partial P(y > 0 \mid \mathbf{x})}{\partial x_{ij}}, \tag{27}$$

where $\partial E(y_i \mid \mathbf{x}, y_i > 0) / \partial x_{ij}$ is the change in the expected value of $y$ for those cases above the limit (with mortgage debt) and $\partial P(y > 0 \mid \mathbf{x}) / \partial x_{ij}$ is the change in the probability of being above the limit (having a mortgage debt). McDonald and Moffitt (1980) showed that both of these partial derivates are quite easily calculable:

$$\frac{\partial E(y_i \mid \mathbf{x}_i, y_i > 0)}{\partial x_{ij}} = \beta_j \left[ 1 - \frac{\frac{\mathbf{x}_i'\boldsymbol{\beta}}{\sigma} \phi\left(\frac{\mathbf{x}_i'\boldsymbol{\beta}}{\sigma}\right)}{\Phi\left(\frac{\mathbf{x}_i'\boldsymbol{\beta}}{\sigma}\right)} - \frac{\phi\left(\frac{\mathbf{x}_i'\boldsymbol{\beta}}{\sigma}\right)^2}{\Phi\left(\frac{\mathbf{x}_i'\boldsymbol{\beta}}{\sigma}\right)^2} \right] \tag{28}$$

and

$$\frac{\partial P(y_i > 0 \mid \mathbf{x})}{\partial x_{ij}} = \beta_j \frac{\phi\left(\frac{\mathbf{x}_i'\boldsymbol{\beta}}{\sigma}\right)}{\sigma}, \tag{29}$$

where $\beta_j$ is the coefficient of $x_j$ from the tobit model and $\sigma$ is obtained from the estimation. Both of these partial derivates are interesting for policy considerations. Furthermore, the term in the brackets in (28) is interesting by itself as it tells the fraction of the total mean response due to the response above the limit.[33]

The underlying question in choosing the correct model is whether we should consider zero amounts of mortgage debt in terms of marginal adjustments, i.e. as corner solutions, or as a separate discrete choice. If we assume that zero amount of mortgage is a separate choice, there are no corner solution outcomes in the

[33] See McDonald and Moffitt (1980), p. 319.

data, and once the decision to have a mortgage debt is made a tobit-type censoring is no longer relevant. This is because the zeros are generated by a different mechanism than the one governing the demand for the amount. Thus, the individuals with zero amounts do not pose any restrictions on the parameters in the regression for the positive amount.[34] This is the reasoning behind the Heckman and two-part models.

In *a priori* considerations the most plausible decision-making process is the one implied by the tobit framework, which means that the decision of having a mortgage debt and the amount desired are generated trough the same mechanism and that the zeros are actual corner solutions. However, the assumption that all the variables affect the probability of having a mortgage debt and the conditional on positive amount may be too restrictive. For this reason we estimate different models and compare the results.

The tax reform is modelled in the above framework using dummy and interaction variables. For example, in the level equation of the Heckman model the natural logarithm of outstanding mortgage debt is regressed on different household characteristics and income.[35] The model is of the form

$$\ln M_i = \alpha_0 + \alpha_1 \ln INC_i + \sum_{t=1}^{k} \phi_{0t} D_{it} + \sum_{t=1}^{k} \phi_{1t} \ln INC_i * D_{it} + \mathbf{x}_{1i}'\boldsymbol{\delta} + \varepsilon_i, \qquad (30)$$

where $M_i$ is the outstanding mortgage debt of household $i$, $\alpha_0$ the intercept term, $INC_i$ the income of household $i$. $D_{it}$ are dummy variables, indicating the sample year of household $i$. Reference year is 1990. The interaction terms $INC_i * D_{it}$ capture the income effects of different years. $\boldsymbol{\delta}$ is a vector of parameters and $\mathbf{x}_{1i}$ is a vector of control variables. A similar dummy and interaction term structure is embedded to the probit and tobit models.

The income variable refers to the taxable income of household's head. Household's head is the individual with the highest income in the household. This income concept was chosen because it is the best proxy for the benefit received from the interest deduction. In the pre-reform period it was optimal for the households to deduct mortgage interest from the income of the person with the highest income in order to maximise the deduction rate. Before the reform, in-

[34] Jones (1989) discusses these issues at some length in the context of cigarette consumption. See also Cragg (1971) for seminal work on the subject.

[35] Because many households have no outstanding mortgage debt we add one euro to each household's outstanding mortgage debt in order to make the logarithmic transformation.

come affected mortgage demand in two ways.[36] First, because housing is a normal good an increase in income should lead to an increase in housing demand and consequently in mortgage demand. Second, under a progressive tax schedule an increase in income lowers the after-tax price of mortgage debt, and thus, higher income leads to higher mortgage demand also due to this price effect. Before the reform, the income variable captures both the income and price effects. After the reform, the price of mortgage debt is the same for all households and the income variable captures only the pure income effect. By comparing the marginal effect of income before and after the reform the tax price effect can be identified.

It's important to note that in a non-linear model the statistical significance of the interaction effect cannot be tested with a simple *t*-test on the coefficient of the interaction term.[37] The correct way is to compare the marginal effect of income before the reform to the one after the reform. For example, if we compare the income effect of 1990 to 1994 the interaction effect is calculated as

$$\text{interaction effect} = \frac{\partial E\left(\ln M_i \mid \mathbf{x}_{1i}, D_{i94} = 1\right)}{\partial \ln INC_i} - \frac{\partial E\left(\ln M_i \mid \mathbf{x}_{1i}, D_{i94} = 0\right)}{\partial \ln INC_i}. \quad (31)$$

The interaction effects and their standard errors are calculated with the WALD command in LIMDEP Version 8.0.[38]

When using the above technique to identify the effects of the tax reform we have to assume that all other economic changes that occurred during the time period have affected all households the same way. For example, it may be argued that increased availability of credit in the 1990's and decreasing interest rates have substantially increased mortgage demand. However, if we assume that these factors have affected all households the same way, these factors should not affect inferences drawn from the models. If this assumption is not valid, the possible behavioural responses found in the analysis might be resulting from some other economic change than the tax reform.

[36] See also Fjærli (2004).

[37] See Ai and Norton (2003).

[38] See Greene (2002) for details.

## 4.2 Data and variable description

The datasets used in this study are the 1990–2000 household surveys from the Income Distribution Survey (IDS) by Statistics Finland. The IDS includes information on various household characteristics such as socio-economic status, demographics, incomes, taxes, housing and taxable wealth. Most of the information is collected from administrative registers and some of the information is collected through interviews. The IDS is a stratified sample drawn from all private households in Finland. Each household is included in the sample for two consecutive years so that every year half of the total sample is based on a new panel. Thus, the whole sample is renewed every other year. Because the techniques used in this paper demand for independent random samples we omit every other year from the analysis. After this we are left with two cross-sections before (1990 and 1992) and four years after the reform (1994, 1996, 1998 and 2000).

The biggest drawback of the data is that it does not include information on the households' outstanding mortgage debt before 1993. It does, however, include information on the tax-deductible mortgage interest payments for the entire period. Using this information we construct a debt variable by dividing the interest payments with the average rate of mortgage interest of each year.[39] This, of course, does not provide accurate mortgage positions for the households but it is the best we can do with the data at hand. Because an overwhelming majority of Finnish households' mortgages are adjustable rate mortgages the constructed variable should perform reasonable well.[40] A problem arises in those cases where a household has taken the mortgage during the survey year. In these cases interest payments underestimate the amount of outstanding mortgage debt. Unfortunately we are unable to identify these households from the data. This measurement error in the dependent variable is absorbed by the error term in the model and should not seriously affect the parameter estimates as long as the measurement error is not correlated with the independent variables. Some summary statistics for homeowners from the IDS are presented in Table A1 in Appendix 1.

From Table A1 it is apparent that the households included in the sample have on average higher incomes and wealth, are more likely to be married, have more children and live in bigger dwellings than homeowners as a whole. This is because Statistics Finland assigns higher inclusion probabilities for high-income households in order to minimize data collection costs and non-response.

The control variables in the model include the age of household head, a dummy indicating whether the household is a married couple and the number of children in the household. These variables should control for life-cycle effects. Education

[39] See Figure 2 on how the average mortgage interest rate has varied during the period.

[40] For example, in 2001 94 percent of new mortgages in Finland were adjustable rate mortgages (Stephens, 2002).

variables are used to approximate human capital. As proxies for the missing dwelling value we use dummy variables indicating the degree of urbanisation of the municipality the household resides in and floor area of the dwelling. We also include household's gross wealth as an explanatory variable. Wealth status can be seen as a proxy for risk aversion, i.e. wealthier households are assumed to use more leverage in their portfolio design. The gross wealth variable is taken from tax registers and includes a tax price estimate of the dwelling value. Year-dummies should capture the changes that have affected all the households the same way, mainly the changes in aggregate economic activity. We also include as a control variable the income of other persons in the household (named spouse's income). All the money amounts are deflated using the cost-of-living index produced by Statistics Finland.

# 5. Estimation Results

We include only homeowners in our final sample. We also omit those households where the head of the household had no taxable income in the survey year. The final sample size is 45 570 households (16 624 before and 28 946 after the reform) of whom 48 percent had outstanding mortgage debt during the year they were surveyed.

The results from the tobit model are presented in Table 2. The first column presents the tobit coefficients for the latent variable and the second column reports the asymptotic *p*-values. Third and fourth columns present the marginal and interaction effects and their *p*-values. Columns five and six are the partial derivates from (28) and (29) respectively. The *p*-values in the fourth column apply also to the last two columns. The marginal effect for a dummy variable is calculated as a discrete change from 0 to 1. We also report the *LR*-test statistics for the tobit specification described above and a test statistic for normality of the error terms. The normality test is a conditional moments test for the hypothesis that the error terms in the tobit model are normally distributed.[41]

The results for the Heckman model are presented in Tables 3 and 4. Table 3 presents the selection equation results and Table 4 contains the results for the level equation. The results in Table 4 include the regression coefficients along with the indirect and full effects of the variables in both equations. The full effect refers to the effect of a covariate on the above the limit cases. The effect is comparable to the above the limit effect obtained from the tobit model presented in Table 2.

[41] See Pagan and Vella (1989) and Drucker (2002).

*Table 2. Results for the tobit model, dependent variable is natural log of mortgage debt*

| | **Tobit coefficient** | **P-value** | **Marginal and interaction effects** | **P-value** | **Above the limit** | **Probability not censored** |
|---|---|---|---|---|---|---|
| *constant* | -36.97 | 0.000 | -20.03 | 0.000 | | |
| *age* | 0.772 | 0.000 | 0.418 | 0.000 | 0.299 | 0.043 |
| *(age)* [2] | -0.019 | 0.000 | -0.010 | 0.000 | -0.007 | -0.001 |
| *(age)* [3] | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| *married* | 0.656 | 0.000 | 0.355 | 0.000 | 0.251 | 0.037 |
| *number children* | 0.618 | 0.000 | 0.335 | 0.000 | 0.239 | 0.034 |
| *education = 1* [a] | 0.131 | 0.186 | 0.071 | 0.186 | 0.051 | 0.007 |
| *education = 2* | 0.506 | 0.000 | 0.274 | 0.000 | 0.198 | 0.028 |
| *Helsinki region* [b] | 0.993 | 0.000 | 0.538 | 0.000 | 0.396 | 0.055 |
| *other urban regions* | 1.414 | 0.000 | 0.766 | 0.000 | 0.556 | 0.078 |
| *other densely pop.* | 0.828 | 0.000 | 0.449 | 0.000 | 0.328 | 0.046 |
| *transitional deduction* [c] | 7.587 | 0.000 | 4.111 | 0.000 | 3.480 | 0.379 |
| *log of floor area* | -0.407 | 0.000 | -0.220 | 0.000 | -0.157 | -0.023 |
| *log of wealth* | 0.081 | 0.002 | 0.044 | 0.002 | 0.031 | 0.004 |
| *log of spouse's income* | -0.112 | 0.015 | -0.071 | 0.015 | -0.050 | -0.006 |
| ***log of income*** | **3.339** | **0.000** | **2.120** | **0.000** | **1.487** | **0.176** |
| *year = 1992* [d] | -3.651 | 0.093 | -1.736 | 0.093 | -1.283 | -0.201 |
| *year = 1994* | 21.57 | 0.000 | 17.37 | 0.000 | 14.34 | 0.628 |
| *year = 1996* | 25.78 | 0.000 | 21.04 | 0.000 | 17.91 | 0.673 |
| *year = 1998* | 29.00 | 0.000 | 23.88 | 0.000 | 20.71 | 0.701 |
| *year = 2000* | 22.18 | 0.000 | 17.44 | 0.000 | 14.37 | 0.671 |
| ***income*year = 1992*** [e] | **0.503** | **0.019** | **0.288** | **0.034** | **-0.144** | **0.038** |
| ***income*year = 1994*** | **-2.576** | **0.000** | **-1.359** | **0.000** | **-0.740** | **-0.175** |
| ***income*year = 1996*** | **-2.919** | **0.000** | **-1.701** | **0.000** | **-1.070** | **-0.176** |
| ***income*year = 1998*** | **-3.090** | **0.000** | **-1.872** | **0.000** | **-1.239** | **-0.176** |
| ***income*year = 2000*** | **-2.195** | **0.000** | **-0.979** | **0.000** | **-0.363** | **-0.175** |
| *s-income*year = 1992* [f] | -0.087 | 0.178 | 0.007 | 0.831 | -0.020 | -0.005 |
| *s-income*year = 1994* | -0.086 | 0.207 | -0.127 | 0.032 | -0.144 | 0.006 |
| *s-income*year = 1996* | -0.099 | 0.101 | -0.140 | 0.005 | -0.160 | 0.006 |
| *s-income*year = 1998* | -0.154 | 0.010 | -0.195 | 0.000 | -0.216 | 0.006 |
| *s-income*year = 2000* | 0.071 | 0.212 | 0.030 | 0.507 | 0.010 | 0.006 |
| *sigma* | 7.138 | 0.000 | | | | |
| *log L* | | -87 117 | *Number of observations* | | | 45 570 |
| *Scale factor for marginal effects* | | 0.542 | *Percentage of non-limit observations* | | | 0.48 |
| *Fraction of the total mean response due to response above the limit* | | | | | | 0.39 |
| *LR-test for tobit specification (P-value)* | | | | | | 59 170 (0.000) |
| *Conditional moments tests for normality (P-value)* | | | | | | 6 321 (0.000) |

*Notes: Results are from un-weighted regressions. Only owner-occupiers are included. Marginal and interaction effects are evaluated at the means of the covariates.*

[a] *Dummy variables where education refers to years of education after comprehensive school, 1 = 2–3 years, 2 = 4 years or more. Reference group is comprehensive school only.*

[b] *Regional dummy variables, reference group is rural areas.*

[c] *Dummy variable indicating that the household received the transitional deduction subsidy.*

[d] *Dummy variables, reference year is 1990.*

[e] *Interaction variables where log of income is multiplied by the year dummy.*

[f] *Interaction variables where log of spouse's income is multiplied by the year dummy.*

*Table 3. Results for the Heckman selection equation (probit model)*

| | Coefficient | Standard error | Marginal and interaction effects | P-value |
|---|---|---|---|---|
| *constant* | -5.908 | 0.342 | -2.343 | 0.000 |
| *age* | 0.170 | 0.015 | 0.068 | 0.000 |
| *(age)* $^2$ | -0.004 | 0.000 | -0.002 | 0.000 |
| *(age)* $^3$ | 0.000 | 0.000 | 0.000 | 0.000 |
| *married* | 0.162 | 0.019 | 0.064 | 0.000 |
| *number children* | 0.130 | 0.007 | 0.052 | 0.000 |
| *education = 1* [a] | 0.023 | 0.016 | 0.009 | 0.164 |
| *education = 2* | 0.148 | 0.020 | 0.059 | 0.000 |
| *Helsinki region* [b] | 0.156 | 0.023 | 0.062 | 0.000 |
| *other urban regions* | 0.250 | 0.017 | 0.099 | 0.000 |
| *other densely pop.* | 0.148 | 0.020 | 0.059 | 0.000 |
| *log of floor area* | -0.118 | 0.019 | -0.047 | 0.000 |
| *log of wealth* | 0.012 | 0.004 | 0.005 | 0.003 |
| *log of spouse's income* | -0.032 | 0.008 | -0.014 | 0.000 |
| ***log of income*** | **0.466** | **0.026** | **0.185** | **0.000** |
| *year = 1992* [c] | -0.600 | 0.374 | -0.226 | 0.108 |
| *year = 1994* | 2.343 | 0.378 | 0.645 | 0.000 |
| *year = 1996* | 2.584 | 0.375 | 0.675 | 0.000 |
| *year = 1998* | 2.961 | 0.362 | 0.708 | 0.000 |
| *year = 2000* | 3.427 | 0.343 | 0.762 | 0.000 |
| ***income*year = 1992*** [d] | **0.079** | **0.037** | **-0.007** | **0.584** |
| ***income*year = 1994*** | **-0.248** | **0.038** | **-0.167** | **0.000** |
| ***income*year = 1996*** | **-0.266** | **0.037** | **-0.173** | **0.000** |
| ***income*year = 1998*** | **-0.282** | **0.036** | **-0.179** | **0.000** |
| ***income*year = 2000*** | **-0.346** | **0.034** | **-0.182** | **0.000** |
| *s-income*year = 1992* [e] | -0.011 | 0.011 | -0.001 | 0.733 |
| *s-income*year = 1994* | 0.011 | 0.011 | 0.011 | 0.000 |
| *s-income*year = 1996* | 0.013 | 0.010 | 0.012 | 0.000 |
| *s-income*year = 1998* | 0.006 | 0.010 | 0.012 | 0.000 |
| *s-income*year = 2000* | 0.017 | 0.010 | 0.013 | 0.000 |
| *log L for probit model* | | -24 643 | *Restricted log L* | -31 539 |
| *Number of observations* | | 45 570 | *Pseudo* $R^2$ | 0.22 |

*Notes: Results are from un-weighted regressions. Only owner-occupiers are included. Marginal and interaction effects are evaluated at the means of the covariates.*

[a] *Dummy variables where education refers to years of education after comprehensive school, 1 = 2–3 years, 2 = 4 years or more. Reference group is comprehensive school only.*

[b] *Regional dummy variables, reference group is rural areas.*

[c] *Dummy variables, reference year is 1990.*

[d] *Interaction variables where log of income is multiplied by the year dummy.*

[e] *Interaction variables where log of spouse's income is multiplied by the year dummy.*

*Table 4. Results for the Heckman level equation*

| | Coefficient | P-value | Indirect effect | P-value | Full effect | P-value |
|---|---|---|---|---|---|---|
| *constant* | 0.442 | 0.665 | | | | |
| *age* | 0.216 | 0.000 | -0.125 | 0.000 | 0.091 | 0.026 |
| *(age)* [2] | -0.006 | 0.000 | 0.003 | 0.071 | -0.003 | 0.115 |
| *(age)* [3] | 0.000 | 0.000 | 0.000 | 0.991 | 0.000 | 0.990 |
| *married* | 0.073 | 0.022 | -0.119 | 0.000 | -0.045 | 0.268 |
| *number children* | 0.129 | 0.000 | -0.096 | 0.000 | 0.033 | 0.160 |
| *education = 1* [a] | -0.018 | 0.436 | -0.017 | 0.181 | -0.035 | 0.190 |
| *education = 2* | 0.128 | 0.000 | -0.109 | 0.000 | 0.019 | 0.629 |
| *Helsinki region* [b] | 0.467 | 0.000 | -0.115 | 0.000 | 0.352 | 0.000 |
| *other urban regions* | 0.407 | 0.000 | -0.184 | 0.000 | 0.223 | 0.000 |
| *other densely pop.* | 0.271 | 0.000 | -0.109 | 0.000 | 0.163 | 0.000 |
| *transitional deduction* [c] | 0.107 | 0.001 | | | | |
| *log of floor area* | 0.159 | 0.000 | 0.087 | 0.000 | 0.246 | 0.000 |
| *log of wealth* | -0.009 | 0.200 | -0.009 | 0.017 | -0.018 | 0.025 |
| *log of spouse's income* | -0.015 | 0.201 | 0.024 | 0.001 | 0.009 | 0.460 |
| ***log of income*** | **0.602** | **0.000** | **-0.348** | **0.000** | **0.254** | **0.000** |
| *year = 1992* [d] | -0.962 | 0.075 | 0.441 | 0.123 | -0.520 | 0.395 |
| *year = 1994* | 1.355 | 0.024 | -1.722 | 0.000 | -0.367 | 0.616 |
| *year = 1996* | 2.480 | 0.000 | -1.899 | 0.000 | 0.581 | 0.445 |
| *year = 1998* | 2.039 | 0.001 | -2.176 | 0.000 | -0.137 | 0.862 |
| *year = 2000* | 3.075 | 0.000 | -2.518 | 0.000 | 0.556 | 0.498 |
| ***income*year = 1992*** [e] | **0.082** | **0.125** | **-0.110** | **0.049** | **-0.028** | **0.597** |
| ***income*year = 1994*** | **-0.160** | **0.007** | **0.313** | **0.000** | **0.152** | **0.010** |
| ***income*year = 1996*** | **-0.253** | **0.000** | **0.324** | **0.000** | **0.071** | **0.248** |
| ***income*year = 1998*** | **-0.227** | **0.000** | **0.307** | **0.000** | **0.079** | **0.196** |
| ***income*year = 2000*** | **-0.323** | **0.000** | **0.413** | **0.000** | **0.090** | **0.142** |
| *s-income*year = 1992* [f] | -0.006 | 0.697 | 0.012 | 0.322 | 0.006 | 0.707 |
| *s-income*year = 1994* | 0.006 | 0.719 | -0.020 | 0.321 | -0.015 | 0.372 |
| *s-income*year = 1996* | -0.001 | 0.959 | -0.022 | 0.232 | -0.022 | 0.127 |
| *s-income*year = 1998* | 0.008 | 0.587 | -0.022 | 0.569 | -0.014 | 0.308 |
| *s-income*year = 2000* | 0.001 | 0.956 | -0.023 | 0.100 | -0.023 | 0.108 |
| λ | 1.114 | 0.000 | | | | |
| *Number of observations overall* | | 45 570 | *Observations after selection* | | | 21 737 |
| *ρ* | | 0.78 | $R^2$ | | | 0.15 |

*Notes: Results are from un-weighted regressions. Only owner-occupiers are included. Marginal and interaction effects are evaluated at the means of the covariates.*

[a] *Dummy variables where education refers to years of education after comprehensive school, 1 = 2–3 years, 2 = 4 years or more. Reference group is comprehensive school only.*

[b] *Regional dummy variables, reference group is rural areas.*

[c] *Dummy variable indicating that the household received the transitional deduction subsidy.*

[d] *Dummy variables, reference year is 1990.*

[e] *Interaction variables where log of income is multiplied by the year dummy.*

[f] *Interaction variables where log of spouse's income is multiplied by the year dummy.*

We discuss first the results for the tobit model presented in Table 2. The variable of most interest for our purposes is the log of income and interaction effects with time. The situation before the reform is as expected: income has a clear positive effect on mortgage demand. In 1990 the marginal effect for the income variable is 2.120. This figure captures both the change in the probability of having a mortgage debt and the change in the amount of mortgage debt conditional on a positive amount. For the non-limit cases the marginal effect in 1990 is 1.487. Furthermore, a marginal change in income clearly increases the probability of having a mortgage debt.

The interaction effect for 1992 is positive and statistically significant. From 1994 onwards the interaction effects are significantly negative and also quantitatively meaningful. In 1994 the marginal effect is only 0.761 [2.12–1.359 = 0.761] and in 1996 and 1998 the figure is even lower. For some reason, the effect is again a bit higher in 2000. While the effect of income on the probability of having a mortgage debt (column 6 in Table 2) is positive before the reform it declines significantly and is close to zero after the reform. Other family income has a small negative effect on mortgage demand and the effect is somewhat larger after the reform. However, there is no sign reversal after the reform.

The fraction of the total mean response due to response above the limit is only 39 percent in the tobit model. Thus, 61 percent of the total response is due to changes in the probability of having a mortgage debt. This indicates that the independent variables in the model are more important for the choice of whether to have a mortgage debt or not than for the amount of mortgage debt demanded.

Although in *a priori* considerations the tobit framework seemed to be the appropriate model for the decision-making process, the diagnostic tests indicate that there is something wrong with the specification. The *LR*-test clearly rejects the tobit model as the correct specification. Furthermore, the normality test for the tobit disturbances rejects normality. This might be a serious problem because in the case of non-normality the tobit estimates are inconsistent.[42]

The picture changes somewhat with the results form the Heckman model presented in Tables 3 and 4. First of all, the marginal effect for the income variable in 1990 is much lower than in the tobit model, 0.602 compared to 2.210. There is a clear reduction in the income effect after the reform for the overall mean (first column) and the effects are much closer to the tobit estimates. Because most of the variables are in both equations we are also interested in the full effects of the variables on the conditional mean for the cases above the limit, which are reported in the second to last column of Table 4. These results correspond to the tobit results reported in the second to last column in Table 2. The income elastic-

[42] Possible remedies for this problem, not pursued at this point, include using an alternative distribution for the disturbances or using an estimator, which is robust to changes in the distribution.

ity estimate for the non-limit cases in 1990 is only 0.254, again a very low number compared to the comparable estimate of 1.487 obtained from the tobit model. Only one of the full effect interactions is statistically significant in Table 4 and it has a positive sign. According to the results from the Heckman model the tax reform did not have the predicted effect on the mortgage demand of those households with a positive amount. Although the two-step procedure finds a statistically significant estimate for the IMR, the results in the last column of Table 4 are quite close to the results from the truncated regression where sample selection correction is ignored (Table A2 in Appendix 2).[43]

On the other hand, the results from the selection equation are very close to the ones obtained from the tobit model reported in the last column of Table 2. The marginal effect for income in 1990 in the probit model is 0.185 while the corresponding partial derivate of income on the probability in the tobit model was 0.176. In both models the income effect is close to zero in the post-reform period.

When interpreting the results in the light of income and price effects, it seems that the pure income effect on the probability of having a mortgage debt is zero, and the positive pre-reform income effect can be interpreted as a pure price effect due to tax deductibility. In 1990 the income effect for the homeowner population as a whole (probability + amount) obtained from different models ranges from 0.602 to 2.120. After the reform, the effect is clearly smaller ranging from 0.280 to 1.141. For the non-limit cases, i.e. the subpopulation of homeowners with a mortgage, the income effect ranges from 1.487 to 0.254 in the pre-reform period. In the tobit model there is a clear reduction in the income effect also in this case but in the Heckman model the reform seems to have had no effect. Thus, it seems that income has a positive effect on the amount of mortgage demanded that is not associated with tax deductibility. However, the interpretation of the results for the subpopulation of homeowners with a mortgage is difficult because the composition of the subpopulation may have been influenced by the reform.[44]

Other notable differences emerge when comparing the results from the tobit and Heckman models. The regional pattern seems more plausible in the Heckman model, as the Helsinki region, which is the region with highest house prices, has also the highest total effect on mortgage demand. Interestingly, in the Heckman model floor area has a negative effect on the probability of having a mortgage debt but a positive effect on the conditional amount. Perhaps as households move up the housing ladder into more spacious dwellings the need for a mortgage declines as households overall wealth increases at the same time, whereas among

[43] Obvious point of critique aimed at the Heckman model is that there are no exclusion restrictions in the level equation, i.e. the model is identified trough functional form only. However, plausible and valid exclusion restrictions are difficult to find in this context. A covariate affecting the probability of having a mortgage debt will most likely affect the amount as well.

[44] See Angrist (2000) for a discussion on treatment effects in limited dependent variable models.

the sub-population of households who rely on mortgage financing, floor area increases mortgage demand.

The overall results indicate that the 1993 tax reform had a considerable effect on the probability of having a mortgage debt and on the overall mean. However, the effect on the amount of mortgage debt conditional on a positive amount is more ambiguous. The Heckman model and the separate estimation of the two-part model support the view that the tax reform had no or very little effect on the sub-population of households with mortgage debt, whereas the results from the tobit specification are quite the opposite. The tobit specification was clearly rejected on statistical grounds. Furthermore, the tobit results suggest that the total effect of the covariates on the conditional mean is dominated by the changes in the probability of having a mortgage debt in the first place. It seems that the probability part (probit) of the tobit model dominates the overall results and the results for the sub-sample of households with a mortgage may be unreliable. Also, the less restrictive Heckman and the two-part model are preferable because there are different signs and statistically significant variables in the selection and level equations, a possibility which is ruled out in the tobit specification by construction.

The results differ somewhat from the previous studies presented in section 3. For example, Follain and Dunsky (1997) and Fjærli (2004) use tobit regression in their demand models but do not test the appropriateness of the tobit specification, although Fjærli (2004) does use panel data techniques to confirm his results. Their results resemble the ones obtained with the tobit specification in this study and raises the question whether their results would be different if a more general model was used.

# 6. Conclusions

The 1993 Finnish tax reform significantly reduced the incentives to use debt financing in home acquisition for high-income households. Before the reform mortgage interest was deductible according to a progressive schedule creating a so-called upside-down effect, which means that the benefit from the deduction was the greater the higher was the taxpayer's income. After the reform, the deduction is made according to a flat schedule, and thus, the benefit no longer depends on taxpayer's income.

We used household level data from the 1990–2000 Income Distribution Surveys by Statistics Finland to study whether high-income households have responded to these changes in incentives. Using tobit, Heckman and separate estimation of the two-part model (independent probit and truncated regression) we find that the probability of having a mortgage debt is clearly less dependent on the income of household's head after the tax reform. We argue that this income variable can be used to measure the tax deduction effect and conclude that the 1993 tax reform is behind the observed behavioural change. The results for the amount of mortgage debt conditional on a positive amount are more ambiguous. It seems that the tax reform had no or very little effect on the demand for the amount of mortgage debt.

There may be several reasons behind the results. First and foremost, the mortgage loan stock adjusts to changes slowly. In the Finnish case the incentive to reduce current mortgage was reduced by a transitional deduction subsidy aimed at high-income households who suffered most from the tax reform, and thus, the reform mainly influenced the households who took their mortgage after the reform. Since the annual amount of new mortgage debt is small compared to the whole stock the effects of the reform may emerge only later. Second, the lack of house value data may be the reason behind the results. Namely, it seems plausible that house value truly drives the demand for the amount of mortgage debt and the proxy variables used in the estimation were insufficient to capture all house price variation. Third, measurement error in the dependent variable is apparent only for the cases above the zero-limit. The probit model does not suffer from measurement error. Fourth, it may be that taxes truly only affect the choice of whether or not to have a mortgage debt and not so much the amount. This result is in line with current empirical evidence on taxation and household portfolio behaviour. Majority of studies indicate that taxes have substantial effects on the set of assets held by different households, but they have a relatively small effect on the portfolio shares conditional on ownership.[45]

[45] See Poterba (2001) for a review of the literature.

Finally, we have to consider whether the tax reform is the only plausible explanation for the results. Other possible explanations are the increased availability of mortgage debt and lower interest rates in the latter part of the 1990's compared to the situation before the reform. If these factors have affected low- and high-income households differently, the results presented might result from this. Thus, the results should be interpreted with some caution at this point. Further work on different sub-populations, for example credit-constrained households, is needed to investigate these points.

If our interpretation of the results is correct we can infer that the elimination of mortgage interest deduction would probably result in a reduction in the use of leverage in home acquisition by Finnish households. This would have implications for both financial and housing markets. The elimination of mortgage interest deduction would not, however, eliminate the fundamental tax advantage to owner-occupied housing, which is the non-taxation of imputed rental income and capital gains. Thus, the effect on the demand for owner-occupied housing remains ambiguous because households can mitigate the rise in the user-cost of housing resulting from the elimination by adjusting their leverage as pointed out by Hendershott et al. (2003). The elimination might result in riskier household portfolios if households substitute debt with equity financing. Future research in this area should be extended to portfolio effects, including tenure choice, of changes in the taxation of owner-occupied housing and the impact on house and asset prices.

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*Appendix 1. Descriptive statistics from the Income Distribution Survey*

*Table A1. Descriptive statistics from the Income Distribution Survey, homeowners only*

| Variable | 1990 | | 1992 | | 1994 | | 1996 | | 1998 | | 2000 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample size** | 8 745 | | 7 907 | | 6 666 | | 7 019 | | 7 101 | | 8 187 | |
| **Sum of weights[a]** | 1 504 022 | | 1 490 108 | | 1 511 034 | | 1 492 340 | | 1 519 498 | | 1 548 521 | |
| | **Weighted** | **Unweighted** | **Weighted** | **Unweighted** | **Weighted** | **Unweighted** | **Weighted** | **Unweighted** | **Weighted** | **Unweighted** | **Weighted** | **Unweighted** |
| **Average age of household head** | 50.0 | 48.3 | 50.6 | 48.4 | 51.7 | 48.8 | 52.4 | 49.0 | 52.9 | 49.6 | 53.1 | 50.2 |
| **Average household size** | 2.49 | 2.93 | 2.48 | 2.94 | 2.41 | 2.96 | 2.42 | 2.91 | 2.38 | 2.86 | 2.35 | 2.83 |
| **Percentage married** | 0.59 | 0.72 | 0.60 | 0.73 | 0.56 | 0.73 | 0.58 | 0.73 | 0.57 | 0.73 | 0.57 | 0.73 |
| **Average number of children per household** | 0.63 | 0.77 | 0.63 | 0.79 | 0.58 | 0.84 | 0.58 | 0.84 | 0.56 | 0.81 | 0.54 | 0.76 |
| **Highest marginal tax rate, state taxes (%)** | 43 | 43 | 39 | 39 | 39 | 39 | 39 | 39 | 38 | 38 | 37.5 | 37.5 |
| **Capital income tax rate (%)** | . | . | . | . | 25 | 25 | 28 | 28 | 28 | 28 | 29 | 29 |
| **Average household's disposable income (€/y)** | 44 748 | 33 348 | 27 547 | 37 009 | 27 215 | 32 218 | 27 658 | 32 935 | 29 952 | 36 474 | 33 613 | 41 147 |
| **Average net wealth of household (tax value, €)** | 30 908 | 23 088 | 20 114 | 27 680 | 26 989 | 29 082 | 28 745 | 34 800 | 31 997 | 41 820 | 38 560 | 53 651 |
| **Average size of houshold's dwelling (square meters)** | 88.7 | 99.6 | 90.1 | 102.8 | 92.0 | 105.6 | 94.7 | 109.0 | 96.3 | 111.4 | 97.3 | 115.4 |
| **Average size of outstanding mortgage debt (€)** | 36 093 | 36 824 | 24 819 | 25 721 | 26 550 | 27 405 | 27 257 | 27 995 | 25 256 | 26 681 | 25 571 | 26 291 |
| **Interest expences (€/y)** | 4 378 | 4 448 | 3 075 | 3 173 | 2 238 | 2 294 | 1 734 | 1 780 | 1 414 | 1 494 | 1 660 | 1 706 |
| **Loan-to-income ratio[a]** | 0.85 | 0.78 | 1.06 | 0.97 | 1.03 | 0.96 | 0.98 | 0.92 | 0.85 | 0.79 | 0.78 | 0.72 |

**[a] Weights are the inverses of inclusion probabilities**

**[a] Household's outstanding mortgage debt divided by household's disposable income.**

## *Appendix 2. Additional estimation results*

### *Table A2. Results for the probit, truncated regression and whole sample OLS*

| | **Probit m-effect** | **P-value** | **Truncated regression** | **P-value** | **Whole sample OLS** | **P-value** |
|---|---|---|---|---|---|---|
| *constant* | -2.343 | 0.000 | 5.235 | 0.000 | -14.05 | 0.000 |
| *age* | 0.068 | 0.000 | 0.107 | 0.000 | 0.405 | 0.000 |
| *(age)* $^2$ | -0.002 | 0.000 | -0.003 | 0.000 | -0.012 | 0.000 |
| *(age)* $^3$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| *married* | 0.064 | 0.000 | -0.027 | 0.270 | 0.411 | 0.000 |
| *number children* | 0.052 | 0.000 | 0.059 | 0.000 | 0.434 | 0.000 |
| *education = 1* [a] | 0.009 | 0.164 | -0.044 | 0.038 | -0.012 | 0.800 |
| *education = 2* | 0.059 | 0.000 | 0.041 | 0.094 | 0.342 | 0.000 |
| *Helsinki region* [b] | 0.062 | 0.000 | 0.370 | 0.000 | 0.588 | 0.000 |
| *other urban regions* | 0.099 | 0.000 | 0.250 | 0.000 | 0.758 | 0.000 |
| *other densely pop.* | 0.059 | 0.000 | 0.175 | 0.000 | 0.457 | 0.000 |
| *transitional deduction* [c] | | | 0.106 | 0.001 | 3.505 | 0.000 |
| *log of floor area* | -0.047 | 0.000 | 0.232 | 0.000 | -0.233 | 0.000 |
| *log of wealth* | 0.005 | 0.003 | -0.019 | 0.006 | 0.008 | 0.470 |
| *log of spouse's income* | -0.014 | 0.000 | 0.004 | 0.710 | -0.054 | 0.011 |
| ***log of income*** | **0.185** | **0.000** | **0.307** | **0.000** | **1.735** | **0.000** |
| *year = 1992* [d] | -0.226 | 0.108 | -0.462 | 0.343 | 0.325 | 0.730 |
| *year = 1994* | 0.645 | 0.000 | 0.046 | 0.928 | 14.42 | 0.000 |
| *year = 1996* | 0.675 | 0.000 | 0.916 | 0.070 | 14.77 | 0.000 |
| *year = 1998* | 0.708 | 0.000 | 0.138 | 0.773 | 14.92 | 0.000 |
| *year = 2000* | 0.762 | 0.000 | 0.949 | 0.040 | 10.98 | 0.000 |
| ***income*year = 1992*** [e] | **-0.007** | **0.584** | **0.019** | **0.691** | **0.038** | **0.689** |
| ***income*year = 1994*** | **-0.167** | **0.000** | **-0.022** | **0.647** | **-1.575** | **0.000** |
| ***income*year = 1996*** | **-0.173** | **0.000** | **-0.095** | **0.055** | **-1.604** | **0.000** |
| ***income*year = 1998*** | **-0.179** | **0.000** | **-0.050** | **0.282** | **-1.570** | **0.000** |
| ***income*year = 2000*** | **-0.182** | **0.000** | **-0.111** | **0.012** | **-1.110** | **0.000** |
| *s-income*year = 1992* [f] | -0.001 | 0.733 | 0.001 | 0.924 | -0.053 | 0.075 |
| *s-income*year = 1994* | 0.011 | 0.000 | -0.002 | 0.914 | -0.070 | 0.022 |
| *s-income*year = 1996* | 0.012 | 0.000 | -0.008 | 0.542 | -0.052 | 0.063 |
| *s-income*year = 1998* | 0.012 | 0.000 | 0.006 | 0.662 | -0.065 | 0.019 |
| *s-income*year = 2000* | 0.013 | 0.000 | -0.009 | 0.470 | 0.037 | 0.162 |
| *Number of observations overall* | | 45 570 | *Pseudo* $R^2$ *for probit* | | | 0.22 |
| *Observations after truncation* | | 21 737 | $R^2$ *for OLS* | | | 0.29 |

*Notes: Results are from un-weighted regressions. Only owner-occupiers are included. Marginal and interaction effects are evaluated at the means of the covariates.*

[a] *Dummy variables where education refers to years of education after comprehensive school, 1 = 2–3 years, 2 = 4 years or more. Reference group is comprehensive school only.*

[b] *Regional dummy variables, reference group is rural areas.*

[c] *Dummy variable indicating that the household received the transitional deduction subsidy.*

[d] *Dummy variables, reference year is 1990.*

[e] *Interaction variables where log of income is multiplied by the year dummy.*

[f] *Interaction variables where log of spouse's income is multiplied by the year dummy.*

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