Household Leverage and the Deductibility of Home Mortgage Interest: Evidence from U.K. House Purchasers

Patric H. Hendershott, Gwilym Pryce, and Michael White*

Abstract

Home mortgage interest deductibility has been phased out gradually in the United Kingdom. First, a ceiling was set on the size of mortgages eligible for interest deductibility. Later, the maximum rate at which interest under that ceiling could be deducted was reduced in four steps to zero. The combination of these changes gives a rich array of debt tax penalties for different households in different years. We analyze the effect of this penalty on more than 117,000 loans originated in the United Kingdom during 1988 to 1998 to finance home purchases.

Removal of deductibility is estimated to reduce initial loan-to-value ratios of unconstrained purchasers (and mitigate the rise in their weighted average cost of capital) by 30 percent. The reduction varies with household age, loan size, and tax bracket. Given the minimal response of constrained borrowers, the aggregate response is about half that estimated for U.S. data.

Keywords: Leverage; Mortgages; Tax penalty

Introduction

Periodically people propose removal of the home mortgage interest deduction in the United States (Follain and Melamed 1998). The primary motivation for such proposals is recapture of tax revenue lost by the deduction—it is a major tax expenditure. According to Follain and Melamed, the official annual expenditure in the mid-1990s was $40 to $50 billion; by the early 2000s, it was $67 billion.[1] Moreover, the expenditure is skewed sharply toward higher-income households that are more likely to own their homes and finance large houses. Numerous special interest groups would prefer to use these funds in a multitude of different ways.

On the other hand, the mortgage interest deduction encourages homeownership, and some argue that homeownership provides many positive externalities and, thus, ought to be encouraged. These positive externalities include better dwelling maintenance and children who do better on achievement tests and have fewer behavioral problems (Haurin, Parcel, and

* Patric H. Hendershott is Professor of Property Economics and Finance at the University of Aberdeen, Professor of Finance at Melbourne University, and a Research Associate at the National Bureau of Economic Research. Gwilym Pryce is a Senior Lecturer at University of Glasgow Department of Urban Studies. Michael White is a Lecturer at University of Aberdeen Department of Land Economy.

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[1] Inland Revenue estimated the expenditure in the United Kingdom to be nearly £8 billion in 1990/91 (Devereux and Lanot 1998).

Haurin 2002). Moreover, eliminating the mortgage interest deduction would not remove the fundamental tax advantage to homeownership—the favorable tax treatment of capital gains and imputed rents (Hendershott and Slemrod 1983)—but would restrict the advantage to wealthy households that do not need to use debt financing (Woodward and Weicher 1989).

This article is not about the appropriateness of the mortgage interest deduction. Rather, it is about the effect of the deduction on the use of debt to finance house purchases. This topic is crucial both to the amount the deduction lowers government tax revenue and to the effects of removing deductibility on homeownership, housing consumption, and house prices. If households sell their taxable bond holdings to mortgage lenders and pay off their entire mortgage debt in response to elimination of deductibility, the government gains no tax revenue, and the cost of financing homeownership would be unchanged (assuming households and lenders pay the same tax rate). Portfolio reallocations with no tax consequences would be the sole result. At the other extreme, if households do not reduce their leverage, both the cost of homeownership and government tax revenues will rise significantly. Estimating where household behavior lies between these polar extremes is the purpose of this article.

This estimation is based on a large sample of U.K. loans to new purchasers. The loans originated during two periods, 1988 to 1991 and 1995 to 1998, when the United Kingdom was in the process of removing the deductibility of mortgage interest. We begin the article with a discussion of the taxation of owner-occupied housing in the United Kingdom and the United States and how it has changed over time. We then describe our database, including how we deal with credit rationing. Finally, we report our results based on the 1988 to 1991 and 1995 to 1998 U.K. loan samples and summarize.

Taxation of Owner-Occupied Housing in the United Kingdom and United States

The fundamental tax advantage to owner-occupied housing is the generally low taxation of the return on the equity invested in the house (Hendershott and White 2000). The magnitude of this advantage is directly related to the level of nominal pretax asset returns in the economy and household marginal income tax rates. As the level of returns and tax rates increases, the low taxation of the returns on owner-occupied housing becomes more valuable. Because the tax advantage increases as the marginal tax bracket of the household increases, the demand for owner-occupied housing is greater the higher the tax bracket of the household (holding after-tax income constant). The housing tax advantage is clearly less in countries with flat (low) tax rate schedules than in countries with high tax rate schedules.

When income taxation was reintroduced in the United Kingdom in 1842, there was no tax advantage. Imputed rent was set equal to an assessed value, which equaled an estimate of market rent and was taxed under Schedule A of the income tax system, and mortgage interest (all household interest payments) was fully deductible (Hills 1991). Reassessments were made every five years until 1935. By forgoing reassessments during the next quarter century, the United Kingdom sharply reduced the relative taxation of equity-financed owner-occupied housing. When the next reassessment was considered in 1961, imputed rent had been eroded by inflation to only about a third of market rent. In 1963, the Conservative government abolished

taxation of imputed rents altogether, increasing and making permanent the low taxation of this component of return. The tax advantage to the capital gains component of return commenced when the capital gains tax, introduced in 1965, exempted gains on owner-occupied housing.[2]

The deductibility of home mortgage interest is a means of extending the fundamental tax advantage of owner-occupied housing (the low taxation of the return on equity invested in housing) to the numerous younger, less wealthy households that cannot finance their purchases entirely with equity. Most developed countries allow a mortgage interest deduction, although many European countries limit it to a fixed amount or allow the deduction to be taken only at a tax rate less than that of many household marginal rates. In contrast, the Commonwealth countries—Australia, Canada, New Zealand, and now the United Kingdom—do not allow this interest deduction.

Mortgage interest in the United Kingdom was fully deductible until 1974. At that time, a £25,000 ceiling was introduced on the size of mortgages eligible for interest deductibility. Given that the mean house price was £10,000, this ceiling affected few households. However, because the ceiling was not indexed, it progressively became more binding as nominal house prices rose, and by 1990 it affected half of purchase loan originations. In addition, in 1993, the tax rate at which interest on debt below the ceiling could be deducted was lowered to below the maximum rate at which income was taxed. In 1999, this rate was lowered to zero; thus deductibility was eliminated altogether.

Interest has never been *fully* deductible in the United States. Low-income households or households with low mortgage debt that live in states with low house prices and low taxation (state taxes and mortgage interest are the two largest deductible expenses) would not choose to itemize expenses because taking the standard deduction would lower their taxes (Ling and McGill 1998). Further, even if a household did itemize, not all mortgage interest was effectively deductible (the amount of interest that raised total deductible expenses to the standard deduction was wasted). After the 1986 tax act, the amount of wasted interest (and the number of households that chose not to itemize) grew for two reasons (Hendershott, Follain, and Ling 1987). First, a number of expenses that previously were deductible could no longer be itemized; probably the most important expense affected was the interest on consumer credit debt. Second, the standard deduction was increased sharply. The 1986 act also phased out itemized deductions when household income rose above threshold levels, limiting deductibility for very high-income households to as little as 20 percent of their interest paid.

Follain, Ling, and various associates have used the change in the effective deductibility of mortgage interest induced by the 1986 tax act to test the hypothesis that household leverage is sensitive to the tax penalty associated with debt (Dunsky and Follain 2000; Follain and Dunsky 1997; Follain and Ling 1991; Ling and McGill 1998). In each case, the leverage of individual households was found to be related significantly to the effective deductibility of mortgage interest. Using the Dunsky and Follain estimates, Follain and Melamed (1998) built a

[2] During the 1980s, the United States, United Kingdom, and many other countries sharply increased the relative taxation of equity-financed owner-occupied housing by significantly cutting the tax rates applied to other capital income.

simulation model and predicted that removal of the mortgage interest deduction would lower mortgage debt by 41 percent.

This work, which requires forecasting various unavailable household expenses and determining whether households would choose to itemize deductions or take the standard deduction, is innovative. However, the observed limitation on deductibility is restricted to lower-income households in states with a combination of low house prices and low state taxes, and to high-income households that are required to perform a rather sophisticated tax calculation. Moreover, the analysis is not of households at their decision point (when the loan is originated). Given all these complications, one reasonably could wonder whether the 41 percent estimate is the likely effect of removing deductibility.

The 1988 to 1998 period of gradual removal of interest deductibility in the United Kingdom, when households faced substantially different degrees of deductibility, is an ideal period to study the sensitivity of homeowner leverage to the deductibility of interest, and to draw some inferences about the likely effect of the removal of interest deductibility on debt usage and the weighted average cost of capital (WACC) for owner-occupied housing. To do this, we examine loan-to-value ratios (LTVs) of house purchasers, those who necessarily are making an explicit decision regarding their leverage.

The Debt Tax Penalty and Form of the Estimation Equations

As noted above, mortgage interest deductibility is a means of extending the fundamental tax advantage of owner-occupied housing to households that use debt financing. Deductibility does not make debt cheaper than equity; rather, it maintains tax equality between the two costs. Thus, to the extent that the deduction is limited, there is a tax cost or penalty to using debt, and usage should be less.

Measurement of the Tax Penalty on Debt

This argument can be formalized in the following way. In general, the WACC for owner-occupied housing is an average of the costs of debt (CD) and equity (CE), where the weights are LTV and 1 − LTV:

$$\text{WACC} = \text{LTV}(\text{CD}) + (1 - \text{LTV})(\text{CE}). \tag{1}$$

If the costs, CD and CE, both equal the after-tax interest rate, $(1 - t)i$, then WACC = $(1 - t)i$ (we abstract from risk premia). However, if a tax penalty at rate p is imposed on debt usage, its cost is $(1 - t + p)i$, and

$$\text{WACC} = (1 - t)i + \text{LTV}(p)i. \tag{2}$$

If the penalty is the nondeductibility of interest, then $p = t$, and WACC is increased by the product LTVti.

How much the imposition of the tax penalty raises WACC depends on how much households change their LTV in response to the loss of deductibility. The more households reduce their LTV, the less the cost increases and, thus, the less the reduction in homeownership and housing demand (also, the less revenue the government gains by imposing the tax penalty). Estimating LTV response is the primary purpose of this article.

During the past quarter century, the mortgage interest deduction in the United Kingdom has been limited in two ways. First, in 1974, the deduction was restricted to that on a £25,000 mortgage (and the deductibility of interest on other household debt was eliminated). In 1983, the limit was raised to £30,000; the median U.K. house price level had nearly tripled to £29,400 since 1974. Subsequently, the limit was never raised again in spite of rising house prices (the median house price tripled again to £87,300 in 1999). As can be seen in table 1, by 1988 to 1991, about half the new mortgage originations were above the limit, and by 1995 to 1998, two-thirds were above the limit. Second, the maximum tax rate at which interest could be deducted was cut from the 40 percent maximum income tax rate to 25 percent in 1992, to 20 percent in 1994, to 10 percent in 1995, and finally to zero in 1999. Because there were only two household income tax brackets during this period, 25 and 40 percent, after 1993, no household paying taxes could deduct mortgage interest at its full marginal income tax rate (table 2).

Table 1. **Limits on Amounts Deductible**

Year	Limit (£)	Median House Price (£)	Percent of Mortgages above Limit
1974	25,000	10,800	0
1983	30,000	29,400	5.4
1988 to 1991	30,000	63,000	48.4
1995 to 1998	30,000	73,800	67.4

Table 2. **Limits on Rate Deductibility**

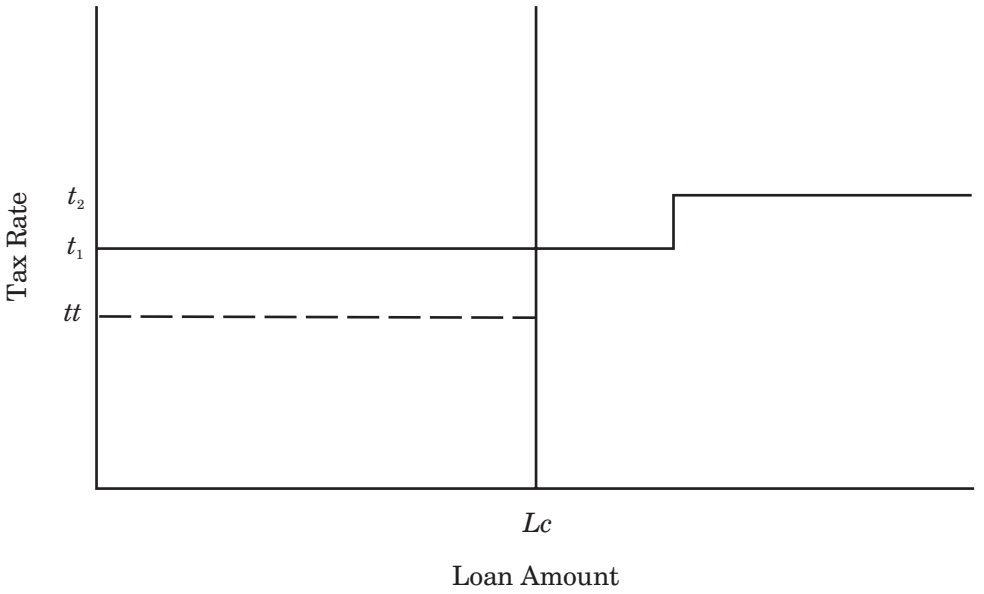
Year	Tax Rate (Percent)	Maximum Deductible Percent	Percent of Mortgages above Maximum
1988 to 1991	25, 40	25, 40	—
1992 to 1993	25, 40	25	26
1994	25, 40	20	100
1995 to 1998	23, 24, 25, 40	10	100
1999	23, 40	0	100

Of the mortgage interest deduction ceiling and the tax rate maximum, the former has been far more important for new borrowers who have reasonably high initial LTVs (the average of our sample is about 0.75). With a median house price from 1995 to 1998 of £60,000 to £70,000 outside the London/Southeast area and £85,000 to £115,000 in London and the Southeast,

most households had initial loans above the £30,000 mortgage limit and, thus, could not deduct interest at the margin.

Figure 1 illustrates how the debt tax penalty varies with loan size. Tax rates are on the vertical axis, and loan amount is on the horizontal axis. The top line is a household's marginal tax rate. If house value is held constant, the larger the mortgage loan, the more interest is deductible (unless the loan is above the ceiling, *Lc*). If the household's taxable investments are larger, then the taxable interest income is higher. As long as the ceiling is not binding, taxable income is at least roughly independent of loan size. When the loan exceeds the ceiling, the larger the loan (and, thus, taxable investments), the higher is the household's taxable income. At some point, the household could move into a higher tax bracket, as the shift from t_1 to t_2 illustrates. The dashed tt line in the figure indicates the lower maximum tax rate introduced in 1993 at which mortgage interest on the loan amount below the ceiling can be deducted.

Figure 1. **The Tax Penalty Variable**



Note: This figure shows how the tax penalty varies with loan size. *Lc* is the loan ceiling above which interest is not deductible (and, thus, the tax penalty is the household tax rate, t_1 or t_2). In the 1988 to 1991 period, there is no tax penalty below *Lc*, and in the 1995 to 1998 period the tax penalty is the tax rate (t_1) less the deductible rate (*tt*).

The tax penalty for loans above *Lc* is the product of the household's tax rate and the interest rate. This penalty on large loans is the opposite of that existing in the United States, where the tax penalty applies only if a loan is sufficiently small that a household minimizes its tax liability by taking the standard deduction instead of itemizing. The penalty below the ceiling is the product of the interest rate and the maximum of $t - tt$ or zero (the latter for households with $t < tt$). The difference $t - tt$ is independent of loan size. Before 1993, there was no penalty

on loans below the ceiling. In the United States, $tt < t$ exists only for households with income sufficiently high that interest expense is not fully deductible.

Estimation Strategy

To disentangle the characteristics of borrowers who have loans above the ceiling from characteristics that are caused by *being* above the ceiling, we first estimate a logit equation predicting whether the borrower's loan amount exceeds the ceiling. Then we use the predicted probability that the loan amount exceeds the ceiling, rather than whether the loan actually does, in computation of the tax penalty variables for use in the leverage estimation. This is an attempt to address the simultaneous determination of the tax penalty facing the borrower and his or her LTV. Although similar variables appear in both the LTV regression and the logit, we use a different transformation of them in each. Combined with the nonlinearity of the logit and the nonlinear way in which the predicted probability enters the LTV regression, the incidence of multicolinearity between the tax variable and the other variables is minimized. The plausible signs and magnitudes of coefficients, the stability of the regressions, and the high t-ratios confirm that multicolinearity is not a problem (Greene 1993, 267).

The logit equation takes the form

$$\text{CEIL}(0/1) = f(\text{income, ageDUMs, previous owner, regionDUMs, yearDUMs}), \tag{3}$$

where income and previous owner both are entered separately and interacted with the age dummies (< 25, 25 to 34, 35 to 44, 45 to 54, > 54). Income and age give a prediction of housing demand by the household; the greater this demand, the more likely the loan exceeds the ceiling. The effect of being a previous owner is unclear. On one hand, a household with equity from a previous house can use this to make a larger down payment and, thus, is less likely to have a loan above the ceiling. On the other hand (if income, age, etc., are held constant), the more equity one has from a previous house, the larger the house one can purchase. The regional dummies are introduced to reflect the effect of differences in regional house prices, and the year dummies are introduced to capture the variation in the level of house prices across the years of origination. The higher the house price, the more likely the ceiling will bind. Two equations are estimated: one for loan originations in "low" house price regions and another for those in "high" house price regions (see the Data section).

The leverage estimation equation is

$$\ln\text{LTV} = g(\text{basic determinants}) - \boldsymbol{\gamma}\text{T\_above} - \boldsymbol{\beta}\text{T\_below}, \tag{4}$$

where the basic determinants are variants on those in equation 3, the two tax penalty variables are defined as $\text{T\_above} = ti(\text{prob})$ and $\text{T\_below} = \max(t - tt, 0)i(1 - \text{prob})$, and prob is the predicted probability of having a loan above the ceiling. We allow for the tax penalty responses, $\boldsymbol{\gamma}$ and $\boldsymbol{\beta}$, to vary with the borrower's age. The logarithmic form is convenient for two reasons. First, the form prevents negative values. Second, the percentage reduction in leverage in response to the nondeductibility of interest is simply $(1 - e^{\text{pen}})100$, where pen is the product $\boldsymbol{\gamma}t(i)$. Another reason for preferring the use of lnLTV (rather than LTV) as the

dependent variable is that preliminary estimation with LTV as the dependent variable resulted in lower statistical significance of the key explanatory variables.

The household tax rate used in this estimation, t, must be independent of LTV. We compute the tax rate on the first dollar of housing finance (opportunity cost of own equity invested unless the house is 100 percent debt financed) by adding an estimate of the income the household would have earned on the equity invested in the house, i(HOUS – LOAN), to reported income. In a progressive tax system, this is the highest possible estimated tax rate.[3]

Data

We use the Council of Mortgage Lenders (CML) 5 percent random sample of mortgage loan origination data, which has 20,000 to 40,000 loans per year. The underlying database contains information on all loans originated by commercial banks, building societies, and others. The data have been collected annually since 1974. The key variables included in the CML data set are

1. Mortgage data: date, amount, type, initial rate, maturity, amortization pattern, and type of advance (whether new mortgage, remortgage, further advance, or top-up loan)

2. Dwelling data: purchase price, location of house, and dwelling characteristics

3. Borrower data: number, income, and age of borrowers and previous tenure of main borrower

A wide variety of mortgages exists in the United Kingdom, with products varying by repayment (standard, interest only, and endowment), term, and adjustment period. The major types of repayment are interest only, fully amortizing, and endowment. The endowment mortgage is interest only, but the homeowner pays a constant monthly premium on a life insurance policy that presumably covers repayment at the end of the mortgage.[4] The adjustment periods are monthly or fixed for various lengths. We have much detail on 1995 to 1998 loans but less for 1988 to 1991. Between the periods, the mean mortgage term fell from 23.4 to 20.5 years. The percentage of loans that were fully amortizing rose from 17 to 40 percent, and interest-only loans increased from less than 4 to 19 percent. Endowment loans, on the other hand, fell from 62 to 37 percent. From 1995 to 1998, two-thirds of the loans were fully variable, while few were fixed for as long as five years.

[3] The Institute for Fiscal Studies at Cambridge University has U.K. tax rules from 1973 to the present posted on its Web site (http://www.ifs.org.uk). We used this information to compute the tax rates for our households. There were only two marginal tax rates throughout the period, 0.25 and 0.4, but the tax breakpoints varied.

[4] See Devereux and Lanot (1998) for an analysis of household choice between endowment and other mortgages.

[5] In 1988, the deductibility of interest on loans for renovation was eliminated, as was the ability of both members of an unmarried couple to deduct interest on loans of up to £30,000 (removing a marriage tax penalty by increasing the tax on nonmarrieds). It is difficult to determine whether a multiple-adult household before 1998 faced a £30,000 or £60,000 fully deductible ceiling.

We analyze new mortgage data (mortgages to finance house purchases) from 1988 to 1991 and from 1995 to 1998.[5] By dealing with house purchasers, we avoid the problems of controlling for or estimating how long it takes existing owners to adjust their leverage level in response to changes in interest deductibility (Ling and McGill 1998). The two periods differ in levels of house price (percent of loans more than £30,000) and in the debt tax penalty. From 1995 to 1998, mortgage interest on loans below the £30,000 ceiling was deductible at the 10 percent rate ($t^* = 0.1$), rather than at the marginal income tax rate of most households. Thus, the tax rate penalty was either 0.3 or 0.15 for households with loans below the ceiling versus 0.4 or 0.25 for households with loans above the ceiling. From 1988 to 1991, the tax penalty varied from zero for households with loan sizes less than the ceiling to the highest marginal tax rate of households with loan sizes greater than the ceiling. Because the tax penalty was less dependent on whether a loan was above or below the ceiling from 1995 to 1998 than during 1988 to 1991, estimates from 1995 to 1998 are less dependent on the accuracy of the estimated logit than estimates from 1988 to 1991.

Figure 2 plots constant-quality U.K. house prices during 1980 to 1998 for 10 regions. Prices grew steadily (nearly 10 percent per annum) during the 1970s and 1980s and were relatively flat during the 1990s.[6] At all times, prices in London and the Southeast are significantly greater than those in the rest of the United Kingdom, and during the late 1980s, prices in the Southwest and East Anglia were also relatively high. Loans from these four areas are designated as the high-price group, and loans from the other regions are labeled as the low-price group during the 1988 to 1991 period. Only London and the Southeast are classified as high–house price areas during the 1995 to 1998 period. Because households in high–house price areas are far more likely to have loans above the £30,000 ceiling, we estimate separate logit equations for data in the high- and low-price areas. We believe it is especially important to analyze samples with wide variation in the debt tax penalty, so we estimate a single equation for each period to explain household LTVs.

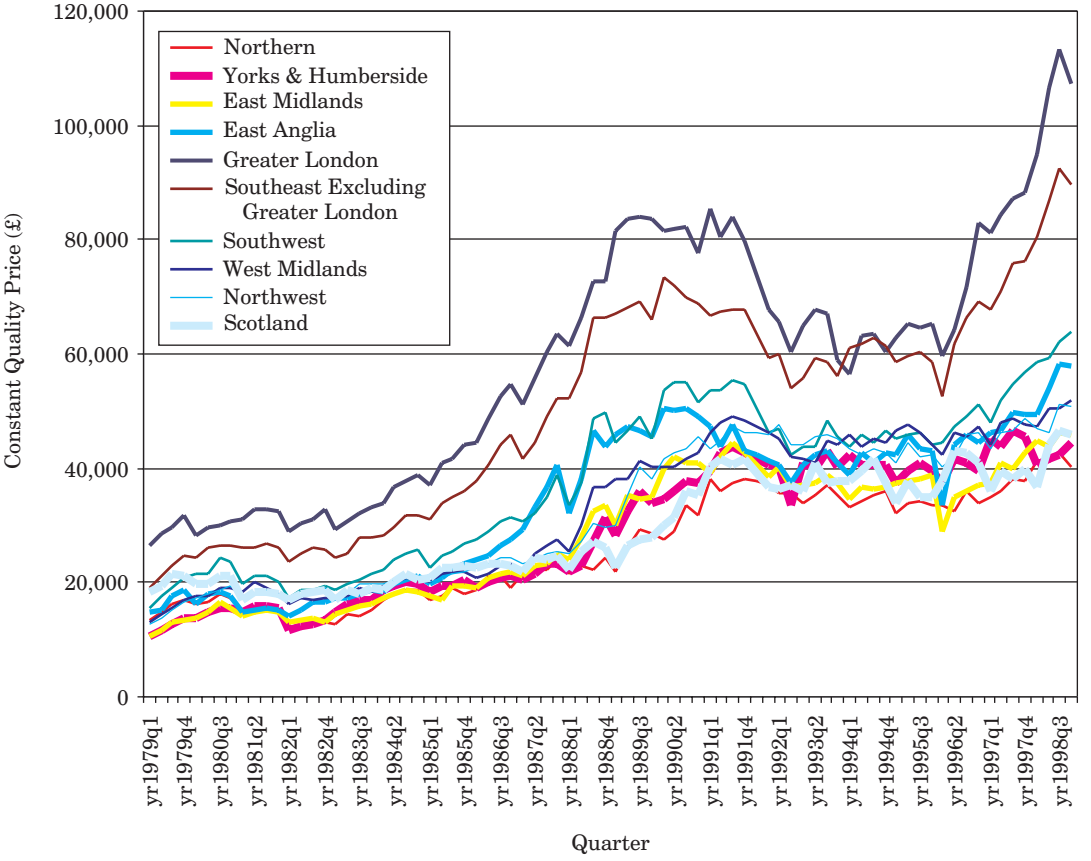
We restrict the data set in a number of ways. First, to exclude investment properties, we delete loans that finance houses not occupied by the borrower. Second, we delete observations with missing values for some of the variables needed for the logit estimations. Third, we eliminate borrowers who are likely to have had their borrowing decision dictated by lender borrowing limits (borrowers who are at or near the maximum allowable LTV or loan-to-income ratio). Constrained borrowers are unlikely to be able to respond to the tax penalty.

The deletion of credit-constrained borrowers involves three steps. First, we identify a clearly unconstrained subset of borrowers. Second, we estimate housing demand functions for these households. Third, we predict housing demand for the rest of the sample (the *possibly* constrained borrowers). Borrowers who have demand equal to or greater than that predicted are defined as unconstrained and are added to the clearly unconstrained subset to form our total sample. Sample selection effects were captured using the Heckman estimation procedure.

[6] The movement in real house prices is substantially different. In particular, real prices cycled sharply during the 1972 to 1976 and the 1985 to 1993 periods and otherwise grew at a fairly steady 2.5 percent between 1970 and 1997. This 2.5 percent barely exceeds the 2 percent drift in the United States that Hendershott and Thibodeau (1990) attributed to new houses being of higher quality than old ones and old houses being renovated. That is, median house price inflation exceeds constant-quality house price inflation by 2 percent annually.

Here we discuss how the clearly unconstrained subset was identified. The housing demand estimation is contained in appendix A, which describes the procedure fully.

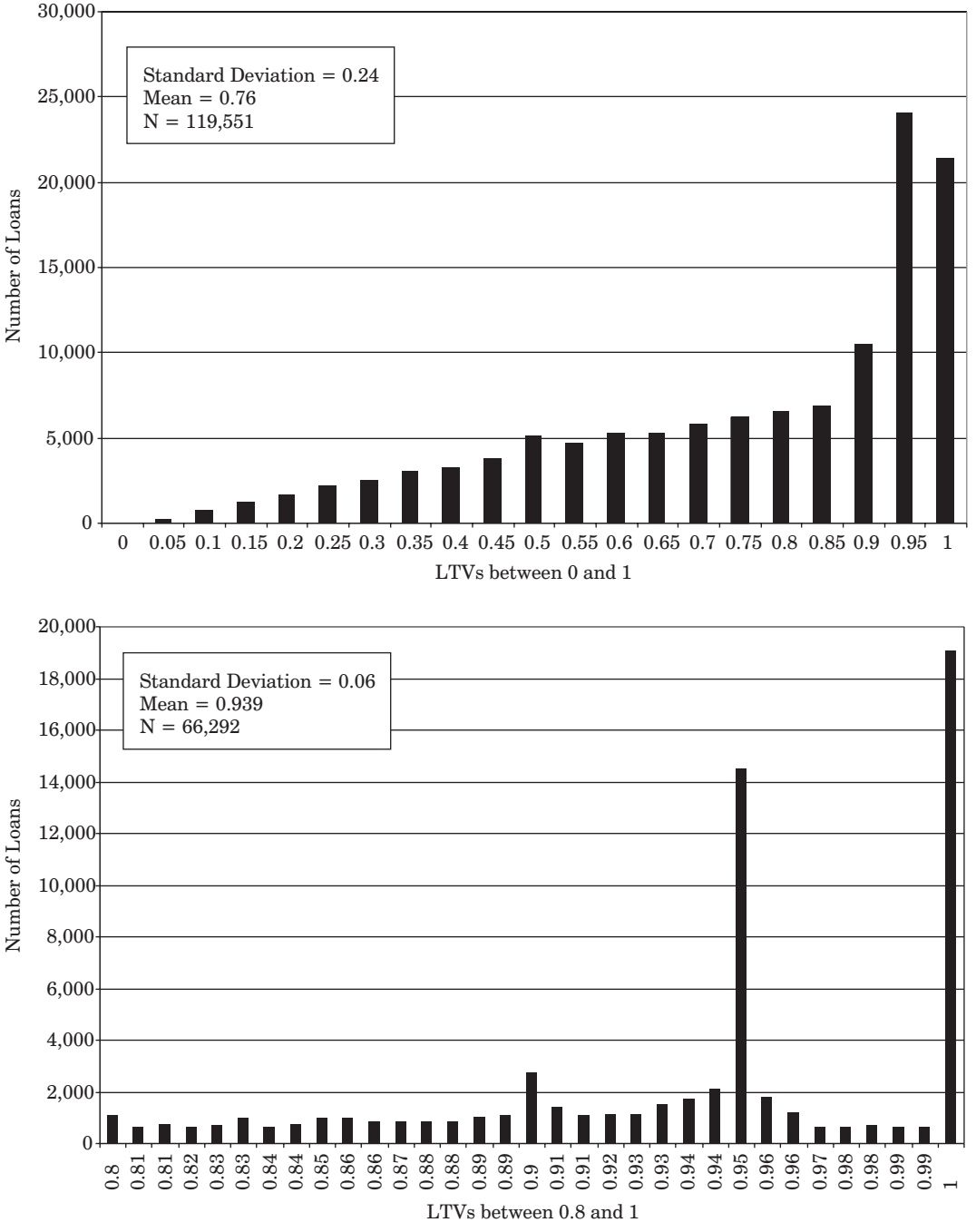
Figure 2. **Constant-Quality Nominal House Price Series for United Kingdom**



Source: Data from Council of Mortgage Lenders.
Note: This figure plots constant-quality U.K. house prices for 10 regions from 1980 to 1998.

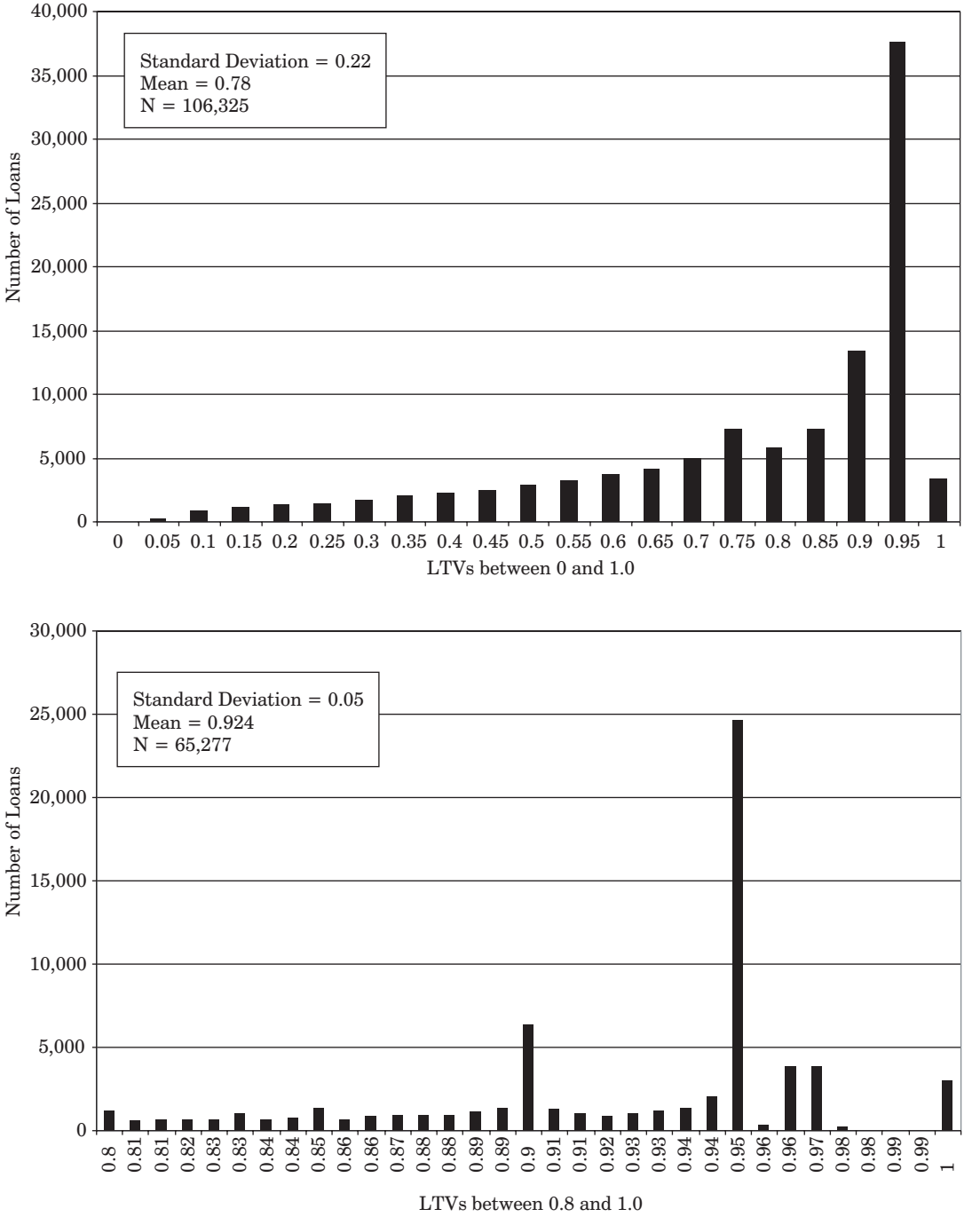
Figures 3 and 4 contain the distributions of loans by LTV between zero and unity (the top half of the figure) and between 0.8 and 1.0 (the bottom half) for the 1988 to 1991 and 1995 to 1998 samples, respectively (high- and low-priced regions are similar). The concentration of borrowers at the 90 percent and especially at the 95 and 100 percent values in the earlier period is obvious. This reflects both the increase in borrowing costs (required default insurance contracts) as those values are exceeded and, definitely for the 100 percent concentration, the maximum loan that lenders will make. The deregulation of financial institutions in the early 1980s had a major effect. In 1979, of the loans with LTVs higher than 80 percent, only 20 percent had LTVs of more than 90 percent, and less than 4 percent had LTVs of more than 95 percent. In our full database, two-thirds of loans with LTVs higher than 80 percent had LTVs of more than 90 percent, and more than a quarter had LTVs of more than 95 percent.

Figure 3. **Number of 1988 to 1991 Loans with Loan-to-Value Ratios (LTVs) between 0 and 1**



Source: Data from Council of Mortgage Lenders.

Figure 4. **Number of 1995 to 1998 Loans with Loan-to-Value Ratios (LTVs) between 0 and 1**

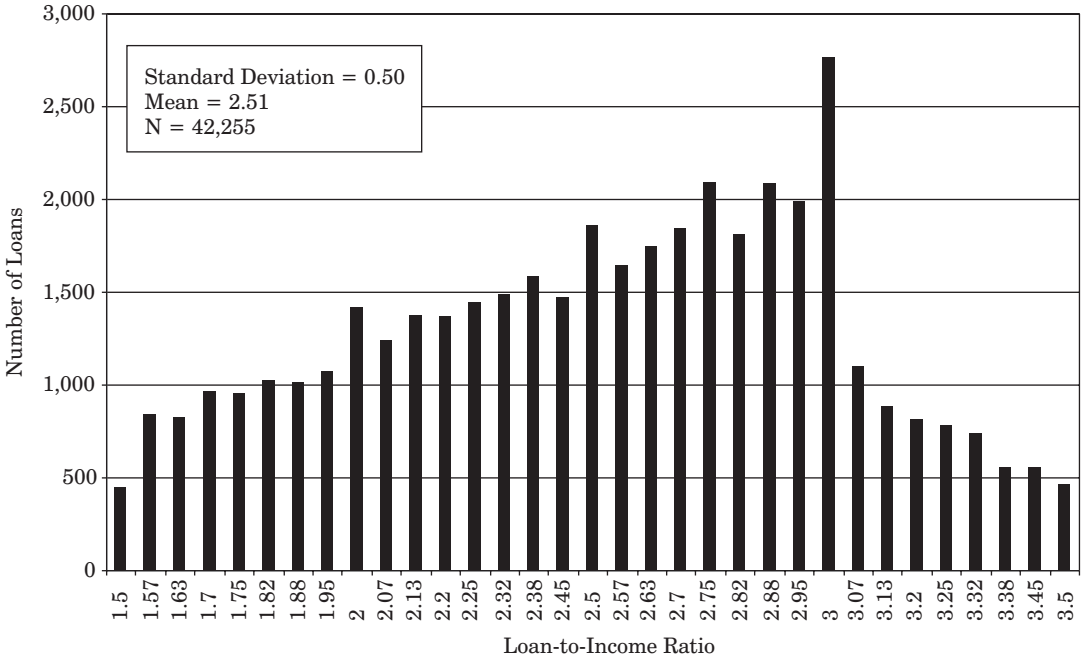


Source: Data from Council of Mortgage Lenders.

Figure 4 suggests a tightening of the LTV maximum in the mid-1990s. Very few loans with LTVs higher than 95 percent were originated in the 1995 to 1998 period, whereas 15 percent of 1988 to 1991 loans had LTVs of 100 percent. Nonetheless, in the later period, 75 percent of loan originations had LTVs higher than 80 percent, versus only 57 percent in the 1988 to 1991 period. That is, although there was a sharp reduction in 100 percent loans, credit was still amply available.

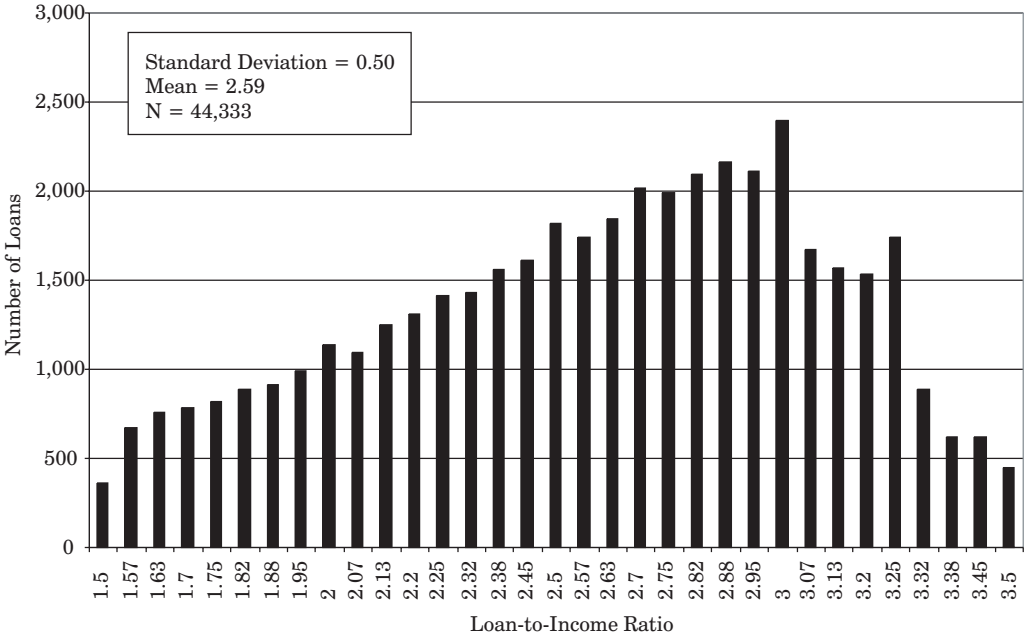
Figures 5 and 6 give the distributions of the sample with ratios of loan size to income between 1.5 and 3.5 for single-earner households for 1988 to 1991 and 1995 to 1998, respectively. The distributions for high– and low–house price areas are similar. As can be seen, the distribution falls off sharply after 3.0 in the first period but remains high until 3.25 in the second. It appears that lending standards were loosened between the two periods. Figures 7 and 8 give the distributions for the loan-to-income ratio between 1.5 and 3.5 for multiple-earner households for 1988 to 1991 and 1995 to 1998, respectively. In both periods, the distribution drops off abruptly at 2.5, although significant numbers of borrowers obtain ratios up to 3.0, and some have ratios far higher than 3.0.

Figure 5. **Loan-to-Income Ratios for Single Earners, 1988 to 1991**



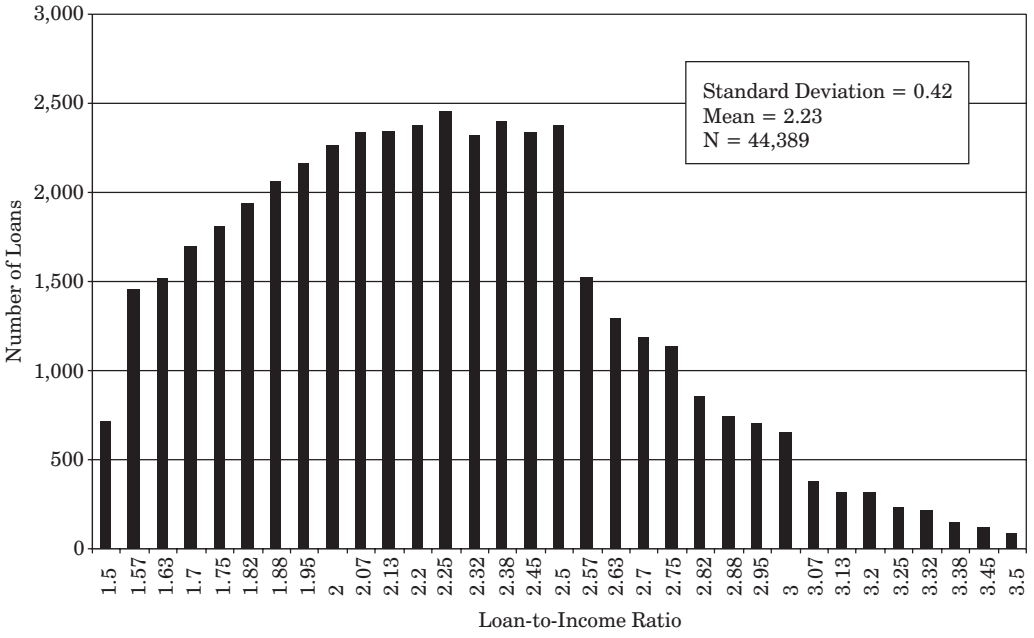
Source: Data from Council of Mortgage Lenders.
Note: This figure gives distribution of the sample with ratios of loan size to income between 1.5 and 3.5 for single-earner households.

Figure 6. **Loan-to-Income Ratios for Single Earners, 1995 to 1998**



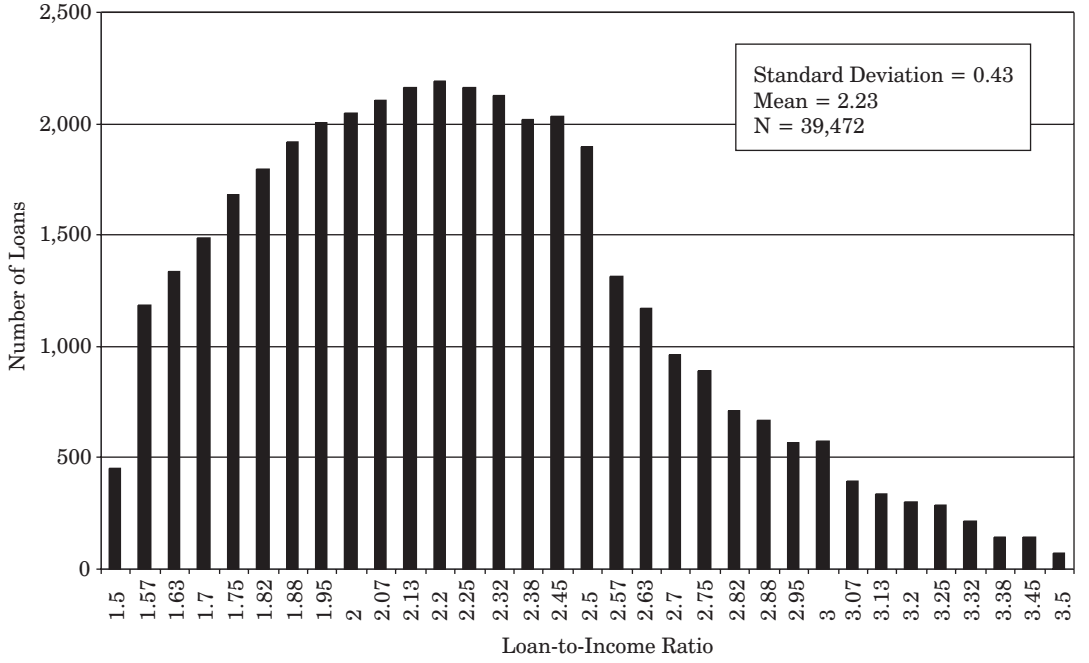
Source: Data from Council of Mortgage Lenders.
Note: This figure gives distribution of the sample with ratios of loan size to income between 1.5 and 3.5 for single-earner households.

Figure 7. **Loan-to-Income Ratio for Multiple Earners, 1988 to 1991**



Source: Data from Council of Mortgage Lenders.
Note: This figure gives distribution of the sample with ratios of loan size to income between 1.5 and 3.5 for multiple-earner households.

Figure 8. **Loan-to-Income Ratio for Multiple Earners, 1995 to 1998**



Source: Data from Council of Mortgage Lenders.
Note: This figure gives distribution of the sample with ratios of loan size to income between 1.5 and 3.5 for multiple-earner households.

The "certainly unconstrained" borrowers in the sample are defined as those with LTVs below 0.89 and acceptable loan-to-income ratios. Based on the above analysis, different loan-to-income constraints are applied for single- and multiple-earner households. For the 1988 to 1991 period, we restrict the sample to borrowers with loan-to-income ratios less than 2.75 (single earners) and 2.4 (multiple earners). For the 1995 to 1998 period, we increase the limit for single earners to 2.9 but maintain 2.4 for multiple earners.

Table 3 presents summary data on the samples and how they have been produced. For each of the two house price groups for the two time periods, we report both the number of loans we define as certainly unconstrained and the additional number we estimate to be unconstrained. As can be seen, we drop roughly 45 percent of the sample as we move from the logit estimation to the LTV estimation. For the unconstrained borrowers, we list the percent with loans above the £30,000 ceiling, the percent who are previous owners, and the percent that are multiple-earner households. We also list the percentage distribution by age class.

Not surprisingly, the percentage of loans exceeding the £30,000 ceiling is greater in high-price areas than in low-price areas, and it is greater in the 1995 to 1998 period than in the 1988 to 1991 period (especially in low-price areas). The age distribution of borrowers is similar in high- and low-price areas, but it shifts significantly over the two time periods, with the share of loans to borrowers who are younger than age 25 falling, and the share of loans to borrowers from

ages 35 to 44 rising. In both the low– and high–house price regions, the share of loans to borrowers who are younger than age 25 is 12 percent in the 1988 to 1991 period. By 1995 to 1998, this share is only 9 percent (low price) and 5 percent (high price). This shift at least partially reflects the aging of the baby boomers. The percentage of loans to previous owners in low-price areas falls by five percentage points, whereas the percentage in high-price areas rises by four percentage points. The latter is consistent with the sharp drop in loans to those younger than age 25.

Table 3. **Descriptive Statistics**

	1988 to 1991		1995 to 1998	
	Low-Price Regions	High-Price Regions	Low-Price Regions	High-Price Regions
Total number of mortgages	62,522	49,349	64,058	39,830
Number of certainly unconstrained borrowers	24,762	17,293	23,175	14,277
Number of estimated unconstrained borrowers	9,827	9,484	14,034	4,488
Total number of unconstrained borrowers (= logit sample)	34,589	26,777	37,209	18,765
Percent of mortgages that are unconstrained	55.32	54.26	58.09	47.11
Characteristics of unconstrained borrowers:				
Percent with loans greater than £30,000	47.08	71.86	74.44	81.20
Percent who are previous owners	70.93	71.23	65.92	75.18
Percent who are multiple earners	45.70	48.96	48.34	45.60
Percent younger than age 25	12.06	12.27	8.60	5.05
Percent age 25 to 34	41.91	40.71	39.33	37.14
Percent age 35 to 44	25.40	26.02	27.60	30.25
Percent age 45 to 54	12.34	12.92	15.31	17.14
Percent older than age 54	8.01	7.79	9.17	10.42

Source: Data from Council of Mortgage Lenders.

Estimation

1988 to 1991

The estimates of the logit predicting whether a borrower's loan is above or below the £30,000 limit and the lnLTV estimates are listed in appendix B. Regarding the logits, 78 and 82 percent of the samples are predicted correctly in the low- and high-price areas, respectively. The distributions of the predicted probability of being over the ceiling and of the associated tax penalty variable are shown in figures 9 and 10. The predicted probability distribution is flat through about 0.7, and then rises sharply. The rise reflects the high level of nominal house prices in the Southeast regions. The variation in the predicted tax penalty variable is large. Although the variable is less than 0.03 for more than two-thirds of the sample, it ranges from 0.045 to 0.06 for a quarter of the sample. High values are for those borrowers in the 40 percent tax bracket with a high probability of having a loan above the ceiling.

Figure 9. **Predicted Probability of Being over the Loan Ceiling, 1988 to 1991**

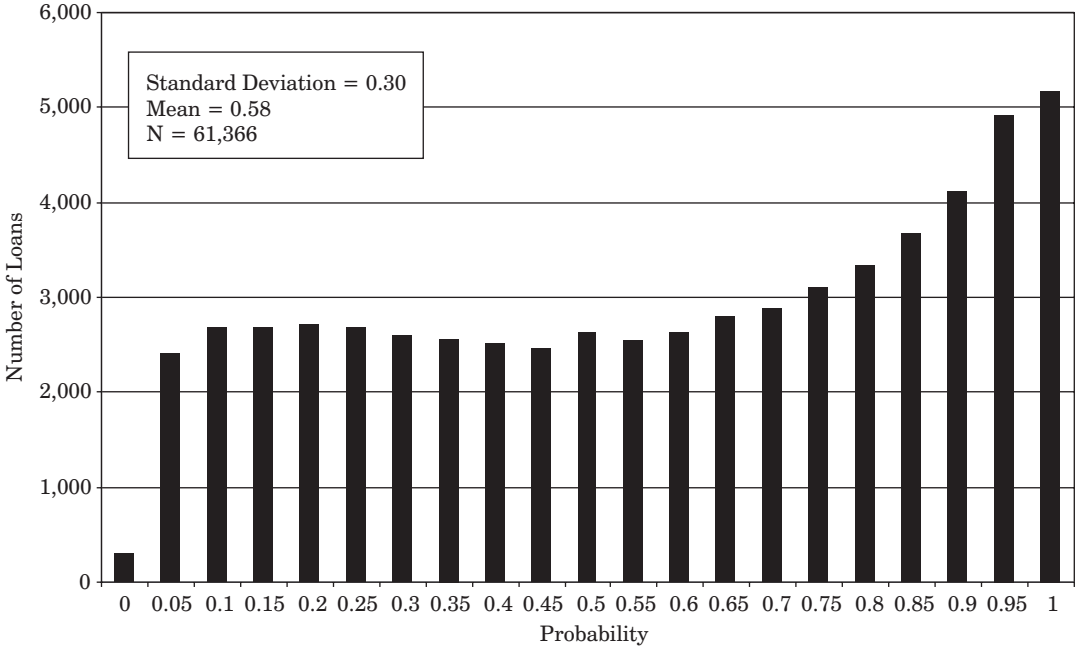
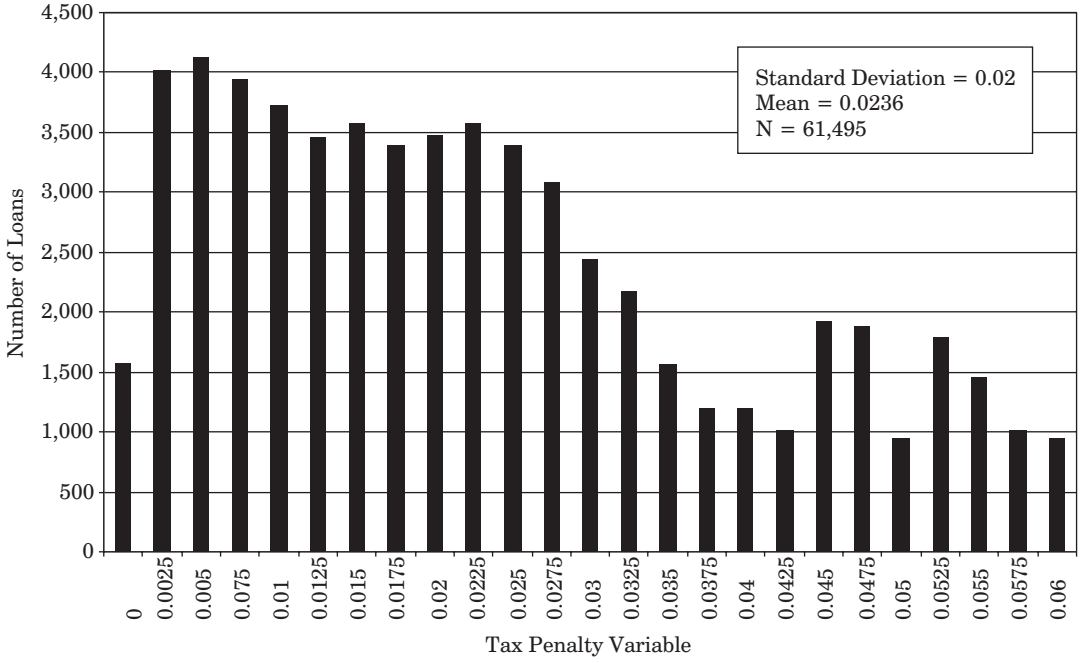


Figure 10. **Distribution of T_above, 1988 to 1991**



The adjusted R^2 for the lnLTV equation is 0.29. The key coefficient is, of course, that for the tax penalty variable, T_above. This coefficient is -6.4 with a t-ratio of 29. The percentage reduction in leverage for those with no interest deductibility (loans more than £30,000) is $(1 - e^{\text{pen}})100$, where pen is the product of the tax variable coefficient, the interest rate (0.12), and the household tax rate. For households with a high tax rate (40 percent), lnLTV is reduced by $-6.4(.12)(.4) = -0.307$. For households with a low tax rate (25 percent), the reduction is $-6.4(.12)(.25) = -0.192$. That is, leverage is reduced by 17 percent (for borrowers in the low tax bracket) to 26 percent (for borrowers in the high tax bracket).

The elasticities of LTV with respect to primary income and secondary income (income is measured in thousands), respectively, are 0.275 and 0.068. Higher-income households demand larger houses and choose to finance them with relatively greater leverage.[7] The lower leverage elasticity with respect to second incomes likely reflects the ability of households with second incomes to obtain down payment support from two families rather than one (we do not know if the individuals in the household are married). Previous ownership also reduces leverage—by a quarter for previous owners older than age 34, but by less than half that for younger owners. LTVs also decline sharply with age—by 30 to 35 percentage points as age increases from the 25 to 34 group to the 55 and older group. This type of decline is seen commonly in developed economies, but note that this decline is for new purchases, not for homeowners generally.

[7] On the other hand, the existence of a second earner in the household reduces leverage (lnLTV is lowered by 0.48). The level of second income at which leverage is unaffected is obtained by solving $0.48 = \ln(\text{INCL})0.068$. The solution is £1,095; for second incomes below this level, leverage declines.

1995 to 1998

Again, the basic logits and lnLTV results are listed in appendix B. Whether a borrower's loan is above or below the £30,000 ceiling is predicted correctly by the logit 83 to 86 percent of the time. Figures 11, 12, and 13 plot the distributions of the predicted probability of being over the ceiling and the associated tax penalty variables T_above and T_below. Owing to the rise in nominal house prices, the probability distribution now is skewed strongly to the right. Half the sample has a probability greater than 0.8. The tax penalty variables generally have lower values because the level of interest rates declined from 0.12 to 0.07. The right skewness of the probability of being over the ceiling results in a right skewness in T_above and a left skewness in T_below.

Figure 11. **Predicted Probability of Being over the Loan Ceiling, 1995 to 1998**

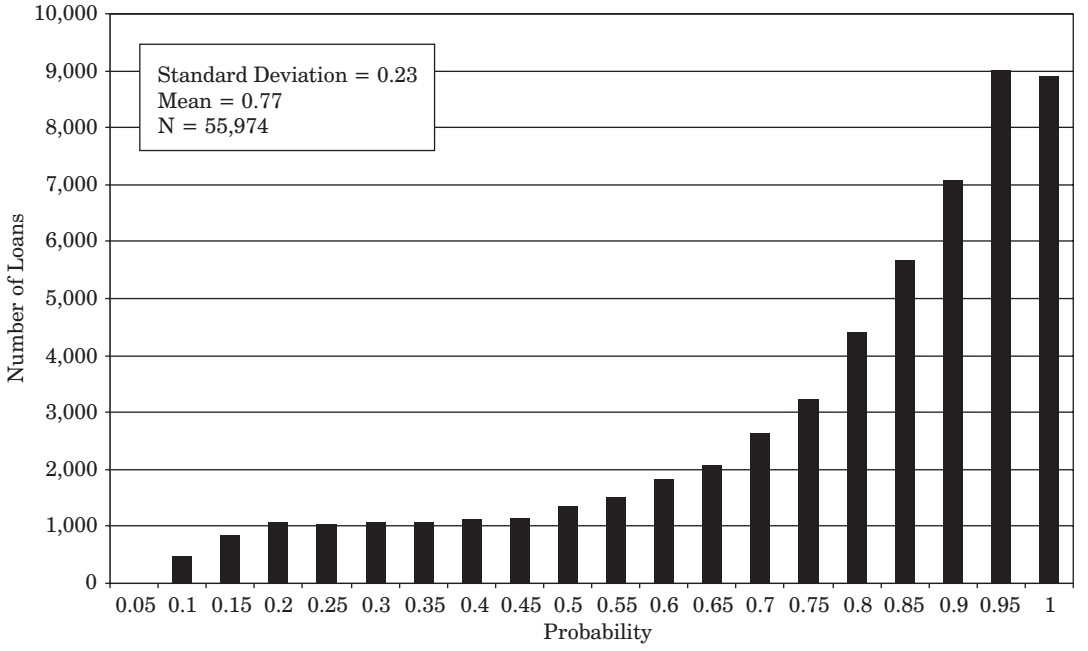


Figure 12. **Distribution of T_above, 1995 to 1998**

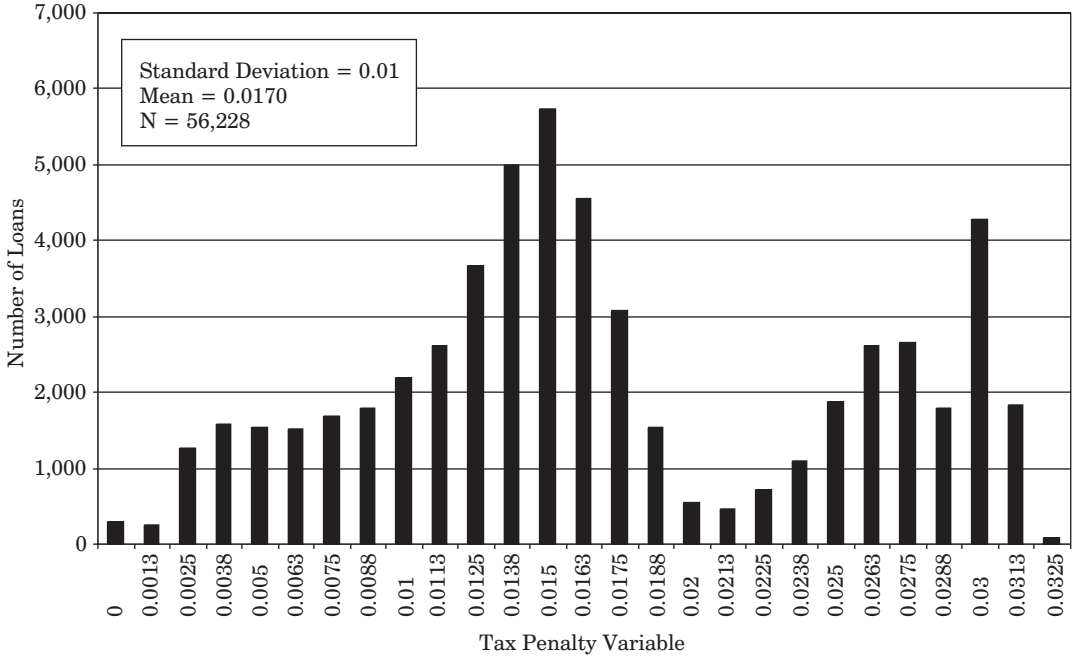
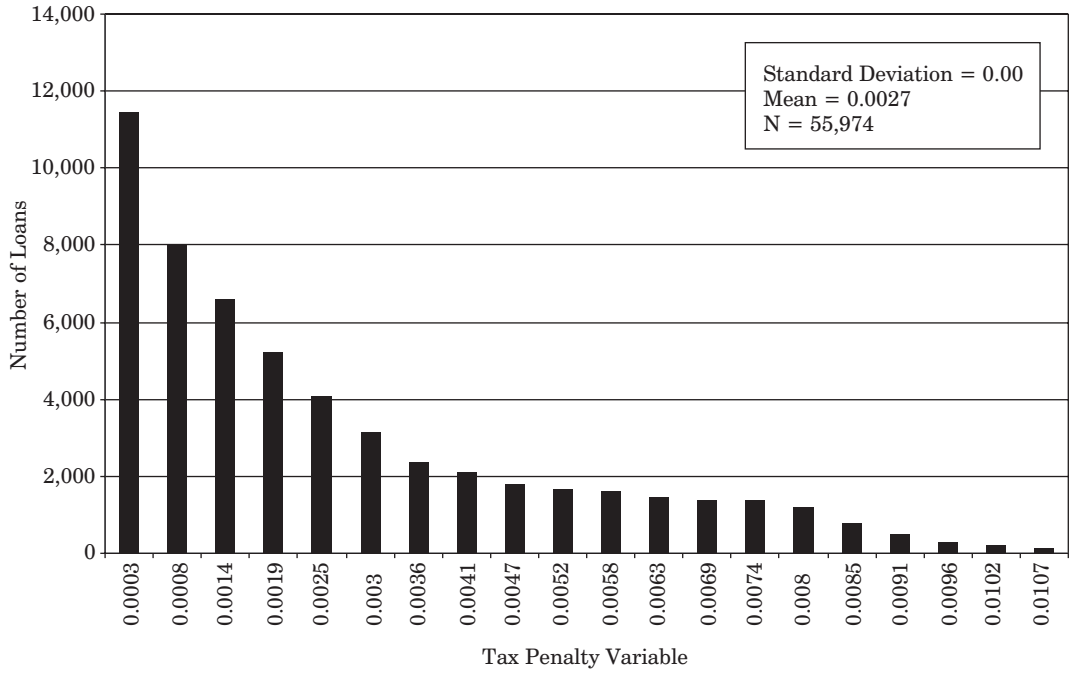


Figure 13. **Distribution of T_below, 1995 to 1998**



The adjusted R^2 for the lnLTV regressions is 0.31. Table 4 reports some calculations indicating the predicted variation in LTVs across three age groups (25 to 34, 45 to 54, and 55 or older) with average single incomes for their age classes, with and without a secondary earner with average income, and separately for first-time and previous owners. The calculations are for the dropped year (1998) and region (London) and assume no debt tax penalty. The first two rows give background data on mean incomes of first and second earners for the age groups, and the third row gives mean LTVs. Income rises from ages 25 to 34 to ages 45 to 54 and declines for those age 55 and older.

Table 4. **Predicted Variation in Loan-to-Value Ratio by Age, Number of Earners, and If a Previous Owner, 1995 to 1998**

	Age (Years)		
	25 to 34	45 to 54	55 and Older
Mean single income (£)	19,965	25,396	17,363
Mean secondary income for those with it (£)	12,028	11,811	8,233
Mean LTV	0.858	0.652	0.535
LTV for single-income first owner	0.889	0.984	0.799
LTV for multiple-income first owner	0.912	1.010	0.815
LTV for single-income previous owner	0.744	0.695	0.565
LTV for multiple-income previous owner	0.764	0.714	0.576

Note: This table indicates the predicted variation in loan-to-value ratios (LTVs) across three age groups with average single income for their age classes, with and without a secondary earner with average income, and separately for first-time and previous owners.

Multiple-income owners have only slightly higher LTVs than single-income owners (about two percentage points), and the changes by age class are virtually identical. However, LTVs are much higher for first-time owners than for previous owners. Middle-aged (45 to 54) first-time owners have an LTV that is 10 percentage points higher than young (age 25 to 34) first-time owners, whereas middle-aged previous owners have an LTV that is five percentage points lower than young previous owners. In contrast, LTV drops sharply for both first-time and previous owners between those who are ages 45 to 54 and those who are older than age 54, by about 18 points for first-time owners and 13 points for previous owners. Going from young (age 25 to 34) to older than age 54, the declines are about nine percentage points for first-time owners and twice that for previous owners.

The actual decline from those age 25 to 34 to those 55 years or older in the 1995 to 1998 data, shown in Table 4, is 32 percentage points, far greater than either 9 or 18 percentage points. This greater decline is due to the widespread tax penalty on the use of home mortgage debt—a penalty that exists whether one's loan is above or below the £30,000 ceiling—and a large estimated response to it. We have two tax penalty coefficients, and both are statistically significant with the expected negative sign. The response to the penalty when above the ceiling, T_above, is more than double that in the 1988 to 1991 period, −14.1 with a *t*-ratio of 29,

versus −6.4. The response when below the ceiling is much larger, −62.7 with a *t*-ratio of 41. Above the ceiling the penalty is t; below the ceiling it is $t - 0.1$ (both times $i = 0.07$). That is, the percentage declines are more than twice as great for those below the ceiling than for those above. Given that loans below the ceiling are smaller (half to a fifth on average), the percentage declines can be achieved with far smaller loan payoffs.

One possible reason for the larger responses to T_above in the 1995 to 1998 period than in the 1988 to 1991 period (−14.1 versus −6.4) is the decline in importance of borrowers younger than age 35 in the sample noted in Table 3 (from 54 to 48 percent of the sample in low-price areas and from 53 to 42 percent in high-price areas). If older households with greater wealth are more sensitive to the tax penalty, we expect the average sample response to increase as the sample ages. To test the hypothesis that older households are more responsive, we run a regression with each tax penalty variable entered both by itself and times a dummy variable equaling one for households older than age 34 and zero for younger households. The full results are reported in appendix B.

Interpretation

Table 5 reports the key coefficients on the tax penalty and penalty interaction variables and uses them to compute the effects of removing the deductibility of mortgage interest for borrowers younger than age 35 with loans above and below £30,000 and for borrowers 35 years and older with loans above and below £30,000. The tax variable coefficients and *t*-ratios are in the first two rows of the table, and the third row gives the cumulative coefficients (for "All Households" and for the sum of "All Households" and "Households Older than Age 34"). All four coefficients are large, negative, and have *t*-ratios ranging from 7 to 29.[8] The first two columns are for loans more than £30,000, and the third and fourth columns are for loans less than £30,000. The table reports the distribution of households and estimated average loan amounts in the absence of a tax penalty for these household groups separately by low (25 percent) and high (40 percent) tax brackets. Note that households in the high tax bracket are disproportionately older—slightly more than half are older than age 34—whereas 60 percent of households in the low tax bracket are younger than age 35. Also, the average loan size for households in the high tax bracket with loans more than £30,000 is more than twice that of households in the low tax bracket. Because older households in the high tax bracket respond more than younger households in the low tax bracket, this increases the aggregate response to removal of deductibility and reduces the revenue pickup.

[8] The age interaction tax penalty variable was tested with the 1988 to 1991 subsample, but its coefficient is insignificantly different from zero. For the 1995 to 1998 subsample, an interaction for those younger than age 25 was tested in addition to the interaction for those older than age 34. The coefficients for those younger than age 25 are positive, as expected, but small.

Table 5. **Predicted Leverage Responses to Removal of Interest Deductibility**

	Loan More than £30,000 T_above		Loan Less than £30,000 T_below	
	All Households	Households Older than Age 34	All Households	Households Older than Age 34
Coefficient	−12.05	−3.0	−49.4	−23.47
t-ratio	−22.6	−7.2	−29.5	−19.8
Cumulative coefficient	−12.05	−15.05	−49.4	−72.87
	Younger than Age 35	Older than Age 34	Younger than Age 35	Older than Age 34
Household share				
0.25 tax rate	0.3	0.11	0.05	0.12
0.40 tax rate	0.19	0.2	0.01	0.02
Average loan (£)				
0.25 tax rate	51,818	49,360	21,696	17,987
0.40 tax rate	96,440	90,478	18,185	19,304
Percent decline				
0.25 tax rate	19.0	23.2	40.5	53.5
0.40 tax rate	28.6	34.4	64.6	78.4

Note: This table reports the effects of removing the deductibility of mortgage interest for borrowers younger than age 35 with loans above and below £30,000 and for borrowers 35 years and older with loans above and below £30,000.

We compute the percentage reduction in leverage from removal of deductibility for the eight household classes as $(1 - e^{\text{pen}})100$, where pen is the product of the tax penalty response coefficient, the interest rate (0.07), and the household tax rate. For those with loans above the £30,000 ceiling, the reduction ranges from 19 to 29 percent for those younger than age 35 and from 23 to 34 percent for those 35 and older. These percentage declines are a little larger than the 17 to 26 percent declines based on the 1988 to 1991 sample, even though the level of interest rates was only 7 percent from 1995 to 1998 versus 12 percent from 1988 to 1991, and, thus, the tax penalty was less.

The declines in leverage for borrowers with loans below the ceiling (columns three and four) are much larger, 40 to 65 percent for young households and 53 to 78 percent for older households. Given that these are loans with smaller volume, the percentage declines can be achieved with smaller loan payoffs. The larger responses are because the greater estimated response to the tax penalty outweighs the smaller penalty (the tax rate less 0.1, rather than the full tax rate). Of course, because these loans are small, these large responses are not very important to the aggregate response.

The total loan volume before the removal of the mortgage interest deduction is the sum of the products of the eight household shares and loan amounts. The reduction of debt is the sum of the products of the shares, loan amounts, and percentage reductions. The ratio of the two (times 100) is the aggregate percentage decline in debt. The weighted average LTV response

for the eight household groups is a 30 percent decline. The aggregate percentage decline in tax revenues is computed the same way, except both products include the tax rate. The aggregate percentage decline in tax revenue is a greater 33 percent because households in the high tax bracket repay relatively more debt than households in the low tax bracket.

Loss of interest deductibility also would reduce the volume of single-family housing because of a rise in user WACC, our last topic. Initially, assume full deductibility, a mortgage rate of 8 percent, and an after-tax risk premium of 1 percent. Consider two households, one in the 40 percent tax bracket and the other in the 25 percent tax bracket. Their WACCs are 5.8 and 7 percent ($[1 - t]8 + 1$), respectively. Without deductibility, the WACCs rise to $(1 - t)8 + 1 +$ LTV$t8$. Table 6 gives the WACC for households in the two tax brackets, assuming two alternative initial LTVs—0.9 and 0.7—and three alternative percentage declines in leverage—20, 30, and 40 percent—in response to the removal of interest deductibility.

Table 6. **Effect of Removing Mortgage Interest Deductibility on the Weighted Average Cost of Capital**

	Full Deductibility		No Decline in LTV		20 Percent Decline in LTV		30 Percent Decline in LTV		40 Percent Decline in LTV	
	0.4 Tax Rate	0.25 Tax Rate	0.4 Tax Rate	0.25 Tax Rate	0.4 Tax Rate	0.25 Tax Rate	0.4 Tax Rate	0.25 Tax Rate	0.4 Tax Rate	0.25 Tax Rate
0.9 Initial LTV	0.058	0.070	0.087	0.088	0.081	0.084	0.078	0.083	0.075	0.081
0.7 Initial LTV	0.058	0.070	0.080	0.084	0.076	0.081	0.074	0.080	0.071	0.078
Percentage increase in WACC										
0.9 Initial LTV			50	26	40	21	35	18	30	15
0.7 Initial LTV			39	20	31	16	27	14	23	12

Note: This table reports user weighted average cost of capital (WACC) for households in the 0.25 and 0.40 tax brackets, assuming alternative initial loan-to-value ratios (LTVs) and alternative percentage declines in leverage in response to the removal of interest deductibility.

Of course, with no decline in LTV, the increases are the largest, being greater for the higher initial LTV. The percentage decline in LTV acts as a direct offset to the percentage increase in WACC—if LTV declines by 30 percent, the increase in WACC is only 70 percent of what it otherwise would have been. Consider the 0.9 LTV. With no change in leverage, removal of the deduction increases WACC by 1.8 to 2.9 percentage points, or 26 to 50 percent (the larger numbers are for households in the 40 percent tax bracket). With a 30 percent decline in leverage, the increase in WACC is reduced by 30 percent (a half to a full percentage point). That is, removal of interest deductibility raises the cost of financing housing, but the LTV response mitigates this response.

Changes in household leverage would significantly offset the negative effect of the removal of interest deductibility on house prices, housing consumption, and homeownership. To illustrate, consider the extreme case where all the increase in WACC causes a reduction in housing consumption. In appendix A, we estimate that the elasticity of housing demand with respect to WACC is -0.25 to -0.4. Thus, if WACC rises by 30 percent, the decline in housing consumption is 7.5 to 12 percent. On the other hand, if leverage adjustments offset half the rise in WACC, the decline in consumption is only 4 to 6 percent.

At the other extreme, the rise in WACC could simply lower real house prices. In this case, a 30 percent rise in WACC translates directly into a 30 percent price decline. Thus, halving the increase in WACC cuts the price decline in half. A mixture of consumption and price declines would be expected, but the declines, according to our estimates, would be reduced by about a third by the leverage response.

Summary and Conclusion

We analyze more than 117,000 U.K. loan originations split about equally between the 1988 to 1991 and the 1995 to 1998 periods. Because the tax penalty for debt varied during these periods depending on whether a borrower had a loan of more or less than £30,000, we first estimate logit equations explaining whether the loan exceeded £30,000, and then we use the predicted probability of the borrower's loan exceeding this amount when computing two tax penalty variables. The variables represent the penalty per unit of debt if the loan is more than £30,000 (the product of the tax rate and the interest rate) or less than £30,000 (the product of the interest rate and the difference between one's marginal income tax rate and the rate at which mortgage interest is deductible).

We establish a major sensitivity of leverage to the debt tax penalty created for many households (for all during the 1995 to 1998 period) by the partial deductibility of mortgage interest. This sensitivity exists for both time periods. Based on this, we infer what the effect of removing the interest deduction would be relative to having the full deduction. Because estimates for the later period are less sensitive to the accuracy of the logits used in computing the tax penalty variables, we view them as more credible. Our best estimate is that the leverage of borrowers with loans more than £30,000 would decline by 19 to 34 percent; the larger percentage applies to older (older than age 34) borrowers in the 40 percent tax bracket. For borrowers with smaller loans (under the £30,000 ceiling), the estimates are far larger—a 40 to 78 percent decline. Because 80 percent of loans are more than £30,000, the aggregate decline is about 30 percent.

Our analysis is based on new loans for home purchase. Homeowners with existing loans also will pay down their loans. Because these households are older, and many have smaller loans, they likely are more sensitive to removal of the mortgage interest deduction (although effective prepayment penalties would make this response slower in the United Kingdom than in the United States). On the other hand, we exclude 45 percent of new loans because the borrowers likely were income or wealth constrained. These borrowers are less sensitive to the tax penalty than unconstrained borrowers. Overall, our estimates of a reduction in the average

U.K. leverage of new purchasers—about 20 percent—is only half the 40 percent response found in earlier studies of Australian and U.S. borrowers.

The tax revenue gained by the government from removal of the home mortgage interest deduction will be less than the product of the average tax rate at which interest is deducted and the amount of debt not repaid. The average tax rate will decline because households in the high tax bracket will repay disproportionately larger fractions of their debt owing to having a larger tax penalty and having greater relative wealth to repay debt. Also, removal of deductibility will lower the volume of single-family housing to be financed and will lower house prices by raising WACC, although the debt response mitigates the rise in WACC.

Appendix A

Determining Credit-Constrained Borrowers

The LTV functions are estimated using a five-step procedure applied separately to each time period. The last two steps are discussed in detail in the text, so here we focus on the first three steps, relating to the treatment of rationed borrowers. Before detailing each step, it is worth summarizing the overall strategy. The goal is to develop a methodology for identifying unrationed borrowers. We first specify a subsample of borrowers who we believe are clearly unrationed because of their LTV and loan-to-income ratio. We then estimate a housing demand function for this group of borrowers and use this function to estimate the demand for each household in the rest of the sample and compare it to their actual demand. If actual demand equals or exceeds predicted demand, the household is added to the unrationed sample, on which the final LTV function is estimated. Sample selection effects are captured using the Heckman estimation procedure. This method translates into a five-step procedure.

Step 1: Estimate ψ_{bt}. ψ_{bt} is the predicted probability that the borrower's loan is less than or equal to the £30,000 ceiling on tax deductibility. This probability is needed in the construction of the user cost of capital variable in the demand regressions estimated in step 2.

ψ_{bt} is estimated by running logits (the dependent variable equals whether or not the borrower's loan exceeds the £30,000 limit) on a subsample of clearly unrationed borrowers. The selected borrowers are in the 1988 to 1991 (1995 to 1998) period with an LTV less than or equal to 0.89 (0.89) and either a primary-earner loan-to-income ratio less than or equal to 2.75 (2.9) or a total income loan-to-income ratio less than or equal to 2.4 (2.4). This results in a basic sample of unrationed borrowers from the 1988 to 1991 (1995 to 1998) period of 44,506 (38,836). Separate logits are run for low– and high–house price regions.

Step 2: Estimate Unconstrained Housing Consumption. The housing demand equation follows the one used by Hendershott and Pryce (2002):

$$\ln \mathrm{HC}_b = \beta_0 + \beta_1 \ln \mathrm{MCH}_b + \beta 2 \ln Y_b + \beta 3 \mathrm{AGE}_b + \beta_4 \mathrm{AGE}_b^2, \tag{A.1}$$

where lnHC is the log of housing consumption, lnMCH is the log of the marginal cost of housing, $\ln Y_b$ is the log of total income, AGE is the age of the main borrower, $\ln Y_b$ is the log of total income, the $\boldsymbol{\beta}_i$ are the estimated coefficients, and the subscript b refers to household b. We adopt Goodman and Kawai's (1982) method for calculating HC, defining it as the actual household house price (times a constant imputed rental rate that is absorbed in the constant term when logs are taken) divided by the constant-quality price. The latter is estimated using hedonic regressions of price on housing attributes and quarter dummies, run separately for each of the 10 regions and each year.

The marginal cost of housing is calculated as $\text{MCH}_t = \text{UCC}_t(\hat{P}_{rt}/\text{RPI}_t)$, where RPI is the monthly retail price index, and UCC is the user cost of capital, defined as the mortgage interest rate i, less the tax deductible component $\boldsymbol{\tau}$, plus the rate of depreciation (assumed to be 0.01 for all households), plus property taxes (0.02), and less expected capital gains, π^*_{rt}:

$$\text{UCC} = (1 - \boldsymbol{\tau}_{bt})i_t + 0.03 - 0.3\pi^*_{rt} \tag{A.2}$$

The expected rate of nominal house price change, π^*_{rt}, is estimated separately for each region using the backward-looking expectations approach of Ermisch, Findlay, and Gibb (1996). That is, $\boldsymbol{\Delta}\hat{P}_{rt}$ is regressed on $\boldsymbol{\Delta}\hat{P}_{rt}-1$ from 1979 quarter one to 1998 quarter four, where $\boldsymbol{\Delta}\hat{P}_{rt}$ is the four-quarter difference in the price index, $\boldsymbol{\Delta}\hat{P}_{rt} = \hat{P}_{rt} - \hat{P}_{rt-4}$, and the estimated parameters used to forecast expected house price inflation vary for each region in each quarter.

The constant-quality price house price index used for these calculations is constructed using the selling price and dwelling characteristics information from the CML Survey of Mortgage Lenders data. For each of the 10 regions, separate regressions are run on selling price for each year of the data since 1979 (explanatory variables are number of rooms, number of rooms squared, age of dwelling dummies, type of dwelling dummies, room-type interactive terms, and quarterly dummies on selling price), thus allowing marginal valuations of characteristics to change from year to year. These regressions (200 in total) have an average adjusted R^2 of 0.48 based on samples of around 1,500, depending on the region and the time period. We then predict the value of a constant-quality dwelling (a five-bedroom, semidetached, postwar dwelling) for each region in each quarter $= \hat{P}_{rt}$.

A weight of 0.3 is applied to π^*_{rt}, following Ermisch, Findlay, and Gibb (1996). The tax deductible component $\boldsymbol{\tau}$ is computed by multiplying the borrower's marginal income tax rate, T_b, by $\boldsymbol{\psi}_{bt}$, the predicted probability that the borrower's loan is less than or equal to the £30,000 ceiling on tax deductibility (computed in step 1). As in the final LTV regressions, the household tax rate used in this estimation, T_b, is computed as the tax rate on the first pound of housing purchased by adding an estimate of the income the household would have earned on the equity invested in purchasing the house to reported income.

The housing demand regression is run on the subsample of easily identifiable unrationed borrowers, and the estimated parameters (listed in table A.1) are used to predict unrationed housing demand. Missing values reduce the basic unrationed sample in the 1988 to 1991 (1995 to 1998) group by 3,065 (7,933) observations to 41,441 (30,903) cases. The estimated income elasticity is about 0.6, and the price elasticity is −0.25 (1995 to 1998) to −0.4 (1988 to 1991).

Table A.1. **Demand Regressions Used To Predict Unconstrained Housing Consumption**

	Demand Regression 1988 to 1991	Demand Regression 1995 to 1998
Intercept	−3.368	−4.221
	(−74.9)	(−56.4)
Log of total income	0.646	0.594
	(152.7)	(138.3)
Log of marginal cost of housing	−0.396	−0.252
	(−83.3)	(−30.8)
Age of main or first-named borrower	0.034	0.026
	(32.4)	(19.0)
Age^2	−0.0004	−0.0002
	(−29.4)	(−15.0)
N	41,441	30,903
Adjusted R^2	0.406	0.419

Note: The dependent variable is the log of housing consumption (see text). Figures in parentheses are *t*-ratios.

Step 3: Compare Actual and Predicted Demands for Households in the Remaining Sample. If actual demand (as recorded in the data) equals or exceeds predicted demand (the antilog of the predicted values from the demand regressions in table A.1), the household is added to the unrationed sample.

Step 4: Predict the Probability of Exceeding the Ceiling. The logits are rerun on the enlarged sample and the estimated parameters are used to predict the probability of exceeding the ceiling. This probability is used to construct the tax penalty variable in the LTV regression.

Step 5: Run the LTV Regression. Finally, using the Heckman procedure to account for selection effects, the LTV regression is run on the expanded unconstrained sample.

Appendix B

Underlying Logit and lnLTV Estimations

Table B.1. **Logistic Regression, 1988 to 1991**

	Classification for Low-Price Regions			Classification for High-Price Regions		
	Predicted			Predicted		
Observed	0	1	Percent Correct	0	1	Percent Correct
0	15,035	3,268	82.1	4,073	3,463	54.0
1	4,361	11,925	73.2	1,422	17,819	92.6
Overall percentage			77.9			81.8

	Low-Price Regions		High-Price Regions	
Variable	Coefficient	Standard Error	Coefficient	Standard Error
Previous owner	0.19	0.057	0.203	0.057
Basic income	0.123	0.008	0.092	0.006
Other income	0	0	0	0
Other income dummy	0.016	0.043	0.201	0.051
Age < 25	−0.02	0.191	1.585	0.19
Age 25 to 34	0.476	0.149	1.004	0.145
Age 35 to 44	0.787	0.146	0.626	0.134
Age 45 to 54	0.453	0.159	0.378	0.14
Income age < 25	0.232	0.016	0.115	0.016
Income age 25 to 34	0.145	0.01	0.116	0.009
Income age 35 to 44	0.057	0.009	0.066	0.008
Income age 45 to 54	0.017	0.01	0.024	0.008
Previous owner of age < 25	−0.277	0.095	−0.047	0.124
Previous owner of age 25 to 34	−0.16	0.072	−0.114	0.083
Yorks and Humberside	0.138	0.049		
East Midlands	0.488	0.052		
Northwest	0.226	0.049		
Scotland	0.042	0.053		
West Midlands	0.556	0.051		
Southeast			−0.061	0.053
Southwest			−0.142	0.056
East Anglia			−0.302	0.067
1988	−0.362	0.038	0.076	0.044
1989	−0.097	0.04	0.237	0.052
1990	0.007	0.041	0.195	0.05
Constant	−4.164	0.137	−2.909	0.12

Note: This table reports the fit and estimates of the logit predicting whether a borrower's loan is above or below the £30,000 limit.

Table B.2. **lnLTV Regression, 1988 to 1991**

Variable	Coefficient	Standard Error
Constant	−3.562	0.053
Previous owner	−0.284	0.007
Basic income	0.275	0.006
Other income	0.068	0.003
Other income dummy	−0.476	0.025
Age < 25	0.575	0.010
Age 25 to 34	0.501	0.009
Age 35 to 44	0.429	0.007
Age 45 to 54	0.188	0.008
Previous owner of age < 25	0.195	0.012
Previous owner of age 35 to 44	0.152	0.009
Yorks and Humberside	0.136	0.008
East Midlands	0.125	0.009
Northwest	0.149	0.008
Scotland	0.201	0.009
West Midlands	0.095	0.009
North	0.184	0.009
Southeast	0.004	0.007
Southwest	0.069	0.008
East Anglia	0.070	0.010
1988	0.009	0.005
1989	–0.009	0.005
1990	0.025	0.005
T_above	–6.383	0.221
Lambda	0.159	0.014
Number of observations	61,110	
Parameters	25	
Degrees of freedom	61,085	
Adjusted R^2	0.294	

Note: This table reports regressions of the log of the loan-to-value ratio (lnLTV) and shows the size and significance of the tax penalty variable (T_above).

Table B.3. **Logistic Regression, 1995 to 1998**

	Classification for Low-Price Regions			Classification for High-Price Regions		
	Predicted			Predicted		
Observed	0	1	Percent Correct	0	1	Percent Correct
0	4,821	4,689	50.7	1,469	2,059	41.6
1	1,786	25,913	93.6	563	14,674	96.3
Overall percentage			82.6			86.0

	Low-Price Regions		High-Price Regions	
Variable	Coefficient	Standard Error	Coefficient	Standard Error
Previous owner	−0.25	0.044	−0.382	0.066
Basic income	0.129	0.004	0.114	0.005
Other income	0	0	0	0
Other income dummy	0.16	0.045	0.116	0.068
Age < 25	0.306	0.21	0.479	0.4
Age 25 to 34	1.317	0.119	1.811	0.172
Age 35 to 44	1.492	0.108	2.11	0.148
Age 45 to 54	1.056	0.107	0.877	0.147
Income age < 25	0.171	0.018	0.12	0.03
Income age 25 to 34	0.062	0.008	−0.012	0.008
Income age 35 to 44	−0.002	0.006	−0.045	0.007
Income age 45 to 54	−0.037	0.006	−0.03	0.007
Previous owner of age < 25	−0.235	0.151	−0.933	0.241
Previous owner of age 25 to 34	0.042	0.071	0.047	0.119
Yorks and Humberside	0.243	0.062		
East Midlands	0.127	0.062		
Northwest	0.235	0.061		
Scotland	0.144	0.065		
West Midlands	0.236	0.062		
Southwest	0.326	0.06		
East Anglia	0.12	0.073		
Southeast			−0.145	0.05
1996	−0.08	0.041	−0.225	0.064
1997	−0.064	0.04	−0.331	0.063
1998	−0.125	0.043	−0.311	0.068
Constant	−2.761	0.093	−1.441	0.115

Note: This table reports the fit and estimates of the logit predicting whether a borrower's loan is above or below the £30,000 limit.

Table B.4. **lnLTV Regression, 1995 to 1998**

Variable	Coefficient	Standard Error
Constant	−2.015	0.076
Previous owner	−0.335	0.006
Basic income	0.196	0.007
Other income	0.022	0.003
Other income dummy	−0.189	0.029
Age < 25	0.226	0.012
Age 25 to 34	0.157	0.010
Age 35 to 44	0.189	0.008
Age 45 to 54	0.070	0.007
Previous owner of age < 25	0.112	0.018
Previous owner of age 25 to 34	0.160	0.008
Yorks and Humberside	0.167	0.008
East Midlands	0.168	0.008
Northwest	0.159	0.008
Scotland	0.174	0.008
West Midlands	0.117	0.008
North	0.084	0.008
Southeast	0.120	0.010
Southwest	0.191	0.010
East Anglia	0.026	0.007
1988	−0.108	0.005
1989	−0.126	0.005
1990	−0.149	0.005
T_above	−14.051	0.481
T_below	−62.669	1.543
Lambda	0.075	0.013
Number of observations	55,974	
Parameters	26	
Degrees of freedom	55,948	
Adjusted R^2	0.328	

Note: This table reports regressions of the log of the loan-to-value ratio (lnLTV) and shows the size and significance of the tax penalty variables (T_above) and (T_below).

Table B5. **lnLTV Regression Including Interactions of Tax Penalty Variables with Dummy Variable, 1995 to 1998**

Variable	Coefficient	Standard Error
Constant	−2.027	0.076
Previous owner	−0.321	0.006
Basic income	0.191	0.007
Other income	0.018	0.003
Other income dummy	−0.147	0.029
Age < 25	0.219	0.012
Age 25 to 34	0.153	0.011
Age 35 to 44	0.266	0.009
Age 45 to 54	0.165	0.008
Previous owner of age < 25	0.092	0.018
Previous owner of age 25 to 34	0.145	0.008
Yorks and Humberside	0.169	0.008
East Midlands	0.172	0.008
Northwest	0.162	0.008
Scotland	0.179	0.008
West Midlands	0.120	0.008
North	0.194	0.009
Southeast	0.030	0.007
Southwest	0.092	0.008
East Anglia	0.126	0.010
1996	−0.105	0.005
1997	−0.124	0.005
1998	−0.149	0.005
T_above	−12.047	0.532
T_below	−49.397	1.676
T_above and older than age 34	−2.998	0.419
T_below and older than age 34	−23.429	1.182
Lambda	0.078	0.013
Number of observations	55,974	
Parameters	28	
Degrees of freedom	55,946	
Adjusted R^2	0.334	

Note: This table reports regressions of the log of the loan-to-value ratio (lnLTV) and shows the size and significance of the tax penalty variables (T_above) and (T_below). These are interacted with dummy variables for borrowers who are older than age 34. It enables testing the hypothesis that older households are more sensitive to the tax penalty.

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