



CPB Discussion Paper | 350

# Tax arbitrage incentives for mortgage prepayment behavior:

## Evidence from Dutch micro data

Stefan Groot  
Arjan Lejour



# Tax arbitrage incentives for mortgage prepayment behavior: Evidence from Dutch micro data

Stefan Groot\* and Arjan Lejour\*\*

\*CPB Netherlands Bureau for Economic Policy Analysis, the Netherlands

\*\*CPB Netherlands Bureau for Economic Policy Analysis and Tilburg University

*11 April 2017*

## **Abstract**

This paper exploits a unique set of Dutch micro data to analyze the response in prepayment behavior to changes in incentives for prepaying. The paper shows that the effect of mortgage interest rates on the value of prepaying a mortgage (also taking taxes and returns on savings into account) is equivalent to a change in the tax rate on financial wealth. This feature is used to estimate tax elasticities (i.e. the elasticity of changes in wealth tax revenues resulting from changes in prepayment with respect to the wealth tax rate). Using a linear probability model with the Arellano-Bond estimator, the paper finds that the prepayment probability increases by 0.5% point if the prepayment value as a fraction of the mortgage increases by 1% point. The effect is about six times as high for households owning more than 200,000 euro and it is not statistically significant for households with little financial wealth.

*Keywords:* housing market, mortgages, prepayment behavior, tax arbitrage

*JEL codes:* D14, G21, H26

We thank Erik Floor, Jan Möhlmann, Machiel van Dijk, Jan Rouwendal and Wolter Hassink for their constructive comments on earlier versions of this paper.

## 1. Introduction

In the 1980s and 1990s it was generally unfavorable for Dutch households to prepay mortgages, because of the high interest rates and the generous mortgage interest deductibility. The most common Dutch mortgages have fixed interest rates for at least 5 to 20 years, which are expensive to refinance.<sup>1</sup> Due to the decline in interest rates in the 2000s, especially in the aftermath of the great recession, prepayment has become optimal for many households maximizing their financial wealth.<sup>2</sup> The reason is that the differential between (existing) contractual mortgage interest rates and the returns on savings has become much larger. This is especially the case for households paying a personal wealth tax<sup>3</sup>, because the tax system exempts housing wealth and the corresponding mortgage from this tax. Mortgage prepayment could thus be a major instrument to reduce the burden of personal wealth taxes for households. Decreased inflation has also made prepaying more attractive, because low inflation reduces the benefits of deducting the nominal interest rate expenses.

The aim of this paper is to analyze to what extent prepayment behavior of households is driven by financial incentives. As taxes on financial wealth are an important component of these incentives, we are able to estimate the sensitivity of wealth tax revenues to changes in the effective tax rate – through the channel of prepayment. The Dutch case is particularly interesting because on the one hand households can deduct mortgage interest prepayments from taxes on labor income, while on the other hand housing wealth is exempt from personal wealth taxation. This paper uses a novel approach by deriving the differential in individual contractual (fixed term) mortgage interest rates and individual short-term interest rates on savings accounts, taking also into account various types of taxation. This differential is used as a determinant for the prepayment probability within a panel of Dutch households. The estimated impact of the tax rate differential on the prepayment probability is used to determine tax elasticities. To exploit the panel structure of our data and to account for endogeneity of the prepayment value, we apply the Arellano-Bond generalized method of moments (GMM) estimator.

Even though the topic has been studied before, the literature on prepayment behavior mostly takes the perspective of financial institutions as a starting point.<sup>4</sup> Prepayment behavior has important implications for mortgages in terms of cash flows and profits, depending on the pattern of the market interest rates (either by using their own means or by refinancing).<sup>5</sup> Forecasting prepayment behavior is therefore an essential part of the valuation of mortgage portfolios. In this literature, the possibility

---

<sup>1</sup> Households have to pay a fine related to the lost interest income for the mortgagor.

<sup>2</sup> Most Dutch mortgage contracts allow prepayments of 10% to 20% of the principal amount in a year without a fine.

<sup>3</sup> Officially the Netherlands does not levy a wealth tax, but a 30% tax rate on a presumptive return on financial wealth of 4% (box 3 of the income tax). Since 2017 the level of the presumptive return is changed, but that is not relevant for the time period investigated in this paper.

<sup>4</sup> Green and Shoven, 1986; LaCour-Little, 1999; Green and laCour-Little, 1999; Hall, 2000; Charlier and Van Bussel, 2003; Koijen et al., 2009; Kuijpers and Schotman, 2006 and 2007; Followil and Olsen, 2015.

<sup>5</sup> Note that we are able to distinguish changes in mortgage payments due to refinancing from prepayments.

to prepay (parts of) a mortgage is considered as a put option that has a certain value. With the notable exception of Charlier and Van Bussel (2003), the literature generally does not explicitly take the effects of (changes in) the fiscal treatment of mortgages into account. A more recent branch in the literature analyzes whether and when households should prepay (Amromin et al., 2007, and Michelangeli, 2012). These papers consider the option to prepay or to invest (in tax-deferred pension plans or otherwise) as an optimal portfolio choice faced by the household.

This paper also takes the portfolio choices of households as a starting point and extends it to the field of tax arbitrage. We argue that under reasonable assumptions, it can be shown that changes in the differential between fixed term mortgage interest rates and short term interest rates on savings accounts have the same incentive effects as changes in the tax rate on personal wealth in the Dutch taxation system. Therefore, behavioral effects of rational and utility maximizing households could be similar as well, a feature that offers the possibility to estimate tax elasticities. A distinguishing feature of this paper is the availability of a large set of unique micro data on household finances that were made available through Statistics Netherlands (CBS). By combining data from various registries on individual and household characteristics, income and tax data, wealth, as well as data on mortgages including interest payments, we are able to analyze the financial behavior of households in-depth. The panel structure of our data also allows us to analyze the prepayment behavior over time.

The paper finds that the prepayment probability increases only by 0.5% point if the value of prepayment (as a percentage of the mortgage) increases by 1% point. The latter is a large change in the value of prepayment, while a change of 0.5% point is relatively small compared to the observed change in prepayments following the financial crisis. Our findings thus suggest that the increase in prepayment probability between 2006 and 2014 is only to a limited extent explained by the higher prepayment value. This adds to the evidence that prepayment behavior of households does not always seem rational from an optimal portfolio perspective (Green and LaCour-Little, 1999; Amromin et al., 2007; Andersen et al., 2015). The weak link between the option value of prepayment and prepayment behavior implies that the tax-elasticity is low. The average effect of 0.5% points depends heavily on household wealth. For households with hardly any savings, the effect is not statistically significant, but for households who own more than 200.000 euro the effect is six times as large.

The remainder of this paper is organized as follows. The next section provides an overview of the existing literature on prepayment and the corresponding features of optimal tax strategies. Section 3 describes the Dutch tax and mortgage system. Section 4 discusses choices regarding the optimal tax strategy that households face, and introduces our empirical strategy. Section 5 presents data and descriptives. Estimation results are discussed in Section 6, and Section 7 concludes.

## 2. Literature review

Green and Shoven (1986) are one of the first authors investigating changes in the prepayment probability in response to changes in interest rates. They employ duration models and measure the dependence of the mortgage duration on the implicit unrealized capital gain of mortgage holders resulting from interest rate changes while mortgages have a fixed interest rate. The authors use data of mortgage holders in California between 1975 and 1982. Green and LaCourt-Little (1999) examine why households fail to prepay their mortgages when prepayment is substantially cheaper. They use a large data set of loans with relatively high interest rates from the 1980s that have failed to prepay by 1996. Although housing prices did decline significantly during the late 1980s and early 1990s, they find evidence that only about 25% of non-refinancing households might have been constrained by declining collateral values. LaCour-Little (1999) digs further into the characteristics of loans and borrowers to explain refinancing behavior, by including borrower credit scores, LTV-ratios and borrower mobility. These characteristics matter most if the mortgage value more or less coincides with the prepayment option (e.g. when the option to prepay is at the money).

Amromin et al. (2007) explore the tradeoff between prepaying the remaining mortgage and saving in tax-deferred accounts (TDAs) used for retirement. Tax arbitrage could play a role here, because of the tax deductibility of mortgage interest and tax-exemption of retirement savings. Amromin et al. document that a significant share of households who prepay mortgages instead of saving in TDAs forgo a profitable tax arbitrage opportunity. An important conclusion of the literature is that the prepayment behavior of households often does not seem to be rational from an optimal portfolio perspective (Green and LaCour-Little, 1999; Amromin et al., 2007; Andersen et al., 2015). Possible explanations are a lack of knowledge about – or care for – financial decisions (this is consistent with the finding that financial illiteracy among households is widespread, c.f. Lusardi and Mitchell, 2007). Amromin et al. (2007) argue that this behavior might also be related to household reluctance to participate in financial markets.

Most of the literature focuses on the US. An exception is Andersen et al. (2015) who find that many Danish households do not refinance their mortgages in spite of the availability of cheaper options and low obstacles. Younger, better educated, and higher-income households are more willing to exploit favorable refinance condition of their mortgages. Financial wealth and housing wealth have opposite effects on refinance behavior, but if housing wealth is relatively high, households are more willing to refinance. Charlier and Van Bussel (2003) study prepayments on savings and interest-only mortgages of Dutch households between 1989 and 1999. Their results indicate that prepayment behavior depends on interest rates and the age of the mortgage contract, and that prepayment peaks in the month December, just before the end of the fiscal year. Van Leuvenstein and Hassink (2009) analyze the impact of income and wealth constraints on the mark-up on mortgage interest rates of households that

are covered for the risk of default by the Dutch national mortgage guarantee (NHG). They argue that the mark-up mostly reflects the prepayment risk for these households. They find that income constraints have a strong impact on the mark-up, while housing wealth constraints are of little importance. Using Swiss data, Brüllhart et al. (2016) analyze financial wealth-tax elasticities directly. They find that a 0.1% increase in effective tax rates decreases reported financial wealth by about 3.4%, and argue that wealth-tax elasticities might be larger than often thought in the literature.

Besides the empirical literature on prepayment behavior, this paper builds upon a series of findings on the literature on portfolio choice. Feldstein (1976) concludes that the personal income tax has a significant effect on the portfolio assets of households. The marginal tax rates do not only affect the size of savings, but also the allocation of savings. There are two main channels through which the marginal tax rate can affect portfolio choice (Poterba, 2002). The first advertises that a higher-taxed asset will become less attractive compared to other assets. The second channel is that a higher marginal tax implies that the government shares to a larger extent the investment risks and this increases the demand for risk-bearing assets (c.f. Sandmo, 1985). The empirical literature finds in general that higher marginal taxes induce higher participation in risky assets. However, the effects on the intensive margin that are found in the literature are often small and sometimes statistically insignificant.<sup>6</sup>

### **3. Context: the Dutch tax and mortgage system**

With the income tax reform of 2001 (Cnossen and Bovenberg, 2001) the Netherlands abandoned its synthetic income tax system in which combined labor and capital income was taxed progressively. The reform introduced three income components, called ‘boxes’, which are taxed differently. In box 1 income from labor, retirement pensions and social benefits is progressively taxed. Fictitious income from an owner-occupied house is also added to taxable income in this box. Interest payments on the mortgage for this house are deductible (MID) from the tax base. Four tax rates apply and the top marginal rate is 52%. Since 2013 the top marginal rate of MID is lowered by 0.5% per year until 38% in 28 years. The aim is to limit the generous fiscal treatment of mortgages. In 2012 the tax advantages for owner-occupiers amounted to 10.5 billion euro (about 1.5% of GDP). Box 2 is for reporting distributed profits of own incorporated businesses, for owners who hold at least 5% of the shares. It has a fixed rate of 25%. Box 3 applies to (most) other sources of capital income. It is referred to as a capital income tax with a tax rate of 30%. However, a presumptive return of 4% is assumed on all categories of wealth.<sup>7</sup> Thus, box 3 amounts, de facto, to a wealth tax of 1.2%. It applies mainly to savings, stocks, bonds, second homes and other investment goods. Individual wealth below 21,139 for singles (2014) and 42,278 for fiscal partners is exempt.

---

<sup>6</sup> See King and Leape (1998), Poterba and Samwick (2002), Hochguertel et al. (1997) and Alan et al. (2010) among others.

<sup>7</sup> Since 2017, box 3 has become progressive and assumes returns of 2.871% (for wealth up to 75,000 euro), 4.6% (75,001 to 975,000) and 5.39% (975,001 and above). The first 25,000 euro of financial wealth is not taxed. However, we have data up to 2014, so the policy change is not relevant for the remainder of the paper.

In the 1990s interest-only mortgages became popular in the Netherlands, which were often attached to a (tax exempted) saving or investment plan. These mortgages make optimal use of MID. The maximum duration of the MID is limited to 30 years since 2001, and mortgages arranged after 2012 have to be repaid according to an annuity scheme to be eligible for MID. The generous fiscal treatment of mortgages for owner-occupiers together with increasingly relaxed borrowing criteria during the 1980s and 1990s have led to a surge in mortgages and higher demand for home ownership. Increased availability of favorable mortgage types also contributed to increased demand. Housing prices have increased substantially until 2008, due to increasing demand and restricted supply due to strict planning rules. Market tendencies may also explain part of the rise in housing prices prior to the crisis, as trends in housing prices are highly heterogeneous (see, for example, Droes and Hassink, 2003). Thereafter, prices plummeted by about 20% and the number of transactions collapsed. In spite of these recent developments, household mortgage debt increased by about 30% between 2006 and its peak in 2012, while nominal GDP increased by only 10% in the same period.

A standard clause in Dutch mortgage contracts is that the mortgagor is allowed to prepay penalty-free 10% to 20% of the original loan amount each year.<sup>8</sup> With prepayment, households benefit less from the MID. Households can make various decisions regarding the period during which the mortgage interest rate is fixed; most common is 5, 10 or 20 years. As discussed before, there is a penalty to refinance the mortgage against a lower interest rate.

For the large majority of owner-occupied households, holdings in savings accounts are the main component of financial wealth in box 3. However, interest rates on savings accounts have plummeted, making them less attractive. The – at prevailing interest rates – high tax rate in box 3, due to the presumptive return of 4%, also contributes to very low after-tax returns on savings. This could induce households to save less and prepay their mortgages. Moreover, media attention for the high mortgage debt, ‘under water mortgage’ problems of many households after the housing crisis, and policy changes towards lower mortgages and paying off mortgages could also have changed the public perception towards less mortgage debt. This is discussed more extensively in the rest of the paper.

#### **4. Methodology**

Households face a comparatively complex optimization problem when they have to decide whether to prepay on their mortgage or not. On the one hand, the deductibility of mortgage interest payments makes it attractive to put money in a savings account rather than prepaying. On the other hand,

---

<sup>8</sup> Note that around one third of Dutch mortgages are savings mortgages, where households may also be allowed to make additional deposits in the saving or investment plan that is attached to their mortgage. We do not count these deposits as prepayment, due to a lack of data on such deposits. This may result in a substantial underestimation of the true effect of incentives to prepay, as it will generally be more favorable for households to make a deposit in their investment plan rather than prepaying on their mortgage loan.



prepaying provides owner-occupiers with a way to shield assets from being taxed. Whether or not it pays off to prepay therefore depends on the marginal income tax rate in box 1, the mortgage interest rate, the short-term interest rate (which determines the returns on savings accounts), and the tax rate in box 3.

The value  $V_{i,t}$  for household  $i$  in year  $t$  of investing in housing wealth rather than a savings account (as a percentage of the amount that is prepaid rather than saved) can be expressed as follows,

$$V_{i,t} = (1 - T^{\text{box1}}_{i,t})R^{\text{mort}}_{i,t} - R^{\text{sav}}_{i,t} + T^{\text{box3}}_{i,t}, \quad (1)$$

where  $T^{\text{box1}}_{i,t}$  is the marginal tax rate on labor income (box 1)<sup>9</sup>,  $R^{\text{mort}}_{i,t}$  the mortgage interest rate,  $R^{\text{sav}}_{i,t}$  the rate of return on savings, and  $T^{\text{box3}}_{i,t}$  the tax rate in box 3 (which equals 0 when wealth is below the exemption threshold, and 1.2% when it is above the threshold). An important observation is that  $V_{i,t}$  is linear with slope 1 with respect to the rate  $T^{\text{box3}}_{i,t}$  at which assets are taxed in box 3 when not prepaying. This implies that changes in  $V_{i,t}$  due to a change in the tax rate  $T^{\text{box3}}_{i,t}$  are the equivalent of changes in  $T^{\text{box1}}_{i,t}$ ,  $R^{\text{mort}}_{i,t}$  and  $R^{\text{sav}}_{i,t}$  that have an equal effect on  $V_{i,t}$ . We exploit this feature to estimate the tax elasticity of the box 3 wealth tax. In the remainder of this paper, we refer to the right hand side of equation (1) as the interest rate differential. An important question is which interest rate could be a proxy for  $R^{\text{sav}}_{i,t}$ . Differences between household mortgage interest rates and the interest rates on their savings accounts also reflect the fact that interest rates on savings accounts are flexible, whereas mortgage interest rates are generally fixed for some time. Therefore, from an economic perspective, mortgages could be best compared to savings products with a similar duration. However, the use of fixed term deposits is relatively uncommon in the Dutch consumer market. From the perspective of households, and the choices they face, the individual interest rate on savings accounts is likely to be their most important point of reference. Therefore, we use the individual rate of return on bank savings for this purpose.

During the last decade, the average difference between mortgage interest rates and fixed term savings deposits with a similar duration was equal to 1.1%-points (DNB Statistics).<sup>10</sup> Compensation for inflation is not part of the true economic costs of loans, because higher inflation also reduces the real debt. Hence, higher nominal interest rates due to *expected* inflation can be considered as additional prepayment of a mortgage in real terms. Because households are allowed to deduct all nominal mortgage interest payments, effective interest deductibility in real terms will be higher than the

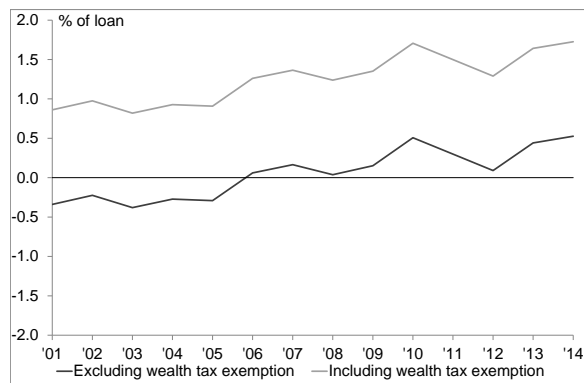
<sup>9</sup> In households where both partners work it is assumed that households optimize their tax statement and deduct exemptions at the marginal tax rate of the highest earner.

<sup>10</sup> Comparing new mortgages with a  $\leq 1$  year fixed interest rate to deposits with a  $\leq 1$  year fixed interest rate. In our econometric analyses we compare the actual interest rates on savings accounts to the actual mortgage interest rate paid by individual households. Even though this compares interest rates with a different duration for most households, it is likely to reflect the actual inputs in the decision making process of households – which do not often invest in fixed term deposits.

marginal tax rate at which households are allowed to deduct mortgage interest payments. High real interest rates also increase the overall value of the MID, because the risk-premium is (in part) independent from the real interest rate.

Figure 1 shows how the yearly value (as defined by right hand side of equation 1) of prepaying a mortgage in the current year developed over time.<sup>10</sup> The figure shows the value both with and without the additional tax advantage of the wealth tax exemption of 1.2%. Until 2005, prepaying was generally unfavorable for households with personal wealth that did not exceed wealth tax exemptions. However, declining interest rates have made prepaying increasingly attractive. Since the start of the crisis, prepaying rather than saving at the short-term interest rate has even become attractive for households with wealth that is tax exempt. In 2014, the average gain of prepaying amounted to 1.7% for households paying taxes in box 3. At a short-term interest rate of 1.3%, the real after-tax return on savings accounts amounted to -0.9%, whereas prepaying would yield a real after-tax return of 0.8%.

*Figure 1. Value of prepaying a mortgage in the current year rather than in the next year, 2001-2014<sup>11</sup>*



Source: own calculations based on tax data and CBS and DNB Statistics.

To estimate the behavioral response to a change in the effective after-tax interest differential between mortgages and savings, we estimate the following model,

$$P(\text{Prepay}=1)_{i,t} = \alpha + \beta X_{i,t} + \gamma V_{i,t} + u_{i,t}, \quad (2)$$

where  $X_{i,t}$  consists of a set of control variables related to borrower characteristics,  $V_{i,t}$  is the interest differential (e.g. the value of prepaying) from equation 1, and  $u_{i,t}$  the error term. For reference, we start by estimating a probit model with random effects. However, in the presence of endogenous regressors such models will yield inconsistent estimates (c.f. Arellano and Bond, 1991). Due to a lack

<sup>11</sup> Because long term-data on average mortgage interest rates is not available, the average mortgage interest rate on 5-year newly issued mortgages in the current and 5 previous years is used as an approximation. The marginal tax rate on labor income has been determined by applying the 2014 distribution of pre-tax wages for the upper 5 deciles (which includes most home owners) on average annual wages and appropriate tax rates in each year.

of external instruments, we apply an estimation strategy that is based on the sequential moment conditions of the Arellano-Bond GMM estimator using a linear probability model, which uses lags of endogenous variables as instruments. When applying this estimator,  $\mathbf{X}_{i,t}$  also includes lags of the dependent variable.

The regression estimates are used to compute the expected effect of a 1% change in the interest rate differential on average prepayments each year (which equals the product of the expected change of the prepayment probability and the average prepaid amount). Using the appropriate population weights provided by Statistics Netherlands, the change in prepayment can be translated to the macro level. A prepayment-elasticity is subsequently derived by dividing the expected change in prepayment by total observed prepayment in each year. For the tax elasticity, we first compute the change in box 3 tax revenues (at the micro level). Similar to the prepayment elasticity we then aggregate the expected change in tax revenues and divide this by the actual revenues.

Following Green and Shoven (1986), various studies have used duration models to analyze prepayment.<sup>12</sup> With some exceptions (for example, Quigley, 1987), most studies use semi-parametric proportional hazard models. However, proportional hazard models may only be applied when certain criteria are met.<sup>13</sup> Exploratory testing of the proportional hazard-assumptions for various model specifications on our data, by application of the Therneau and Grambsch test, showed that the conditions that allow the use of proportional-hazard models were violated.<sup>14</sup> The use of non-proportional hazard models may solve this problem, but it is not clear to what extent. Another disadvantage of proportional hazard models is that tools to address unobserved heterogeneity and endogeneity are not generally available. We therefore focus on explaining the probability of prepayment using linear probability and probit models.

## 5. Data

This paper uses various data sets that are made available by Statistics Netherlands (CBS). At the core of the data are the 2006–2014 editions of the Dutch Income Panel (*Inkomens Panel Onderzoek, IPO*), which has been merged with the Integral Asset Registry (*Integraal Vermogensbestand, IVB*) and various other registries. Even though all data cover at least the years 2006–2015, we use only data up to 2014. The reason is that Integral Asset Registry only provides the asset values at January 1 in a year. Therefore, we are unable to determine prepayments and changes in assets during the year 2015..

---

<sup>12</sup> See amongst others, Quigley (1987), Hall (2000) and Charlier and Van Bussel (2003).

<sup>13</sup> An overview of the methodology of duration and survival models can be found in Therneau and Grambsch (2001) or Klein and Moeschberger (2005).

<sup>14</sup> The literature generally lacks a discussion of such test, which suggests some of their estimates might be inconsistent if proportional hazard assumptions were not met.

The Income Panel is an annual administrative survey, which contains detailed data on income sources, paid taxes (as well as deductions), and social contributions. Because this survey has a rotating panel structure, households can be followed over time. Different types of capital income are also included. Even though income from capital is included in IPO, it does not include consistent data on the value of different types of assets. The Integral Asset registry includes the value of various types of assets of all households on January 1 of each year. The registry is composed by Statistics Netherlands from different data sources, mainly from the tax authority and from financial institutions. Both IPO and IVB include data on different types of debt.

From the Income Panel, we use the box 3 taxable capital income (a variable that originates from tax statements), interest from savings accounts or bonds, dividends (separated in dividends from majority shares or other shares, which is important due to the tax base of the box 3 capital income tax), income from real estate, paid mortgage interest, and other paid interest. Total income is defined as the pre-tax income from labor, pension and social benefits (*box 1*), major participations (*box 2*) and financial wealth (*box 3*) according to IPO. From the Integral Asset registry, we use data on the value of savings accounts, bonds, stocks (again a distinction between majority shares and other shares is made), the value of the primary residence, value of other real estate, and the value of other assets. Mortgage debts on the primary residence as well as other debts are also available. We distinguish two types of wealth. The first is box 3 financial wealth, defined according to the rules of the Dutch tax authority. There are exemptions for the wealth of the primary residence, venture capital, and for social or green investments. Also, box 3 does not tax capital that is taxed elsewhere (such as majority shares).

Additional data have been added from a number of registries, which are derived from census data (*Gemeentelijke Basisadministratie, GBA*). These include the type and size of households, addresses (which are needed to detect whether households have moved or not, and when<sup>15</sup>), and the age of the head of the household (and his or her spouse). Appendix 1 sets out the merging process of the different datasets.

The literature has shown that the prepayment strategy of households is often suboptimal (see Section 2), with households sometimes prepaying when this does not seem advantageous to them. The literature has explained this by a lack of understanding about financial markets, and also to an aversion to participate in financial markets (c.f. Amromin et al., 2007). We have included two explanatory variables that are related to the financial behavior of households. First is a rough approximation of the individual saving rate of households (see the previous section and Appendix 1). Second, we take into account whether households participate in the stock or bonds market. After

---

<sup>15</sup> Addresses of households prior to 1995 are unavailable. For households who last moved prior to 1995 – which account for around 10 percent of our dataset – we assume that they moved to their current address in 1995.

correcting for wealth and other household characteristics, this should provide an indicator for the (lack of) aversion of households against financial markets. From the Income Panel, we have created a balanced panel by requiring that households are included with the same adult composition in our data set in all years between 2006 and 2014. Creating a balanced panel is needed to enable us to reliably distinguish prepayments from regular mortgage repayments.<sup>16</sup> Finally, we have excluded households that do not live in owner-occupied housing, as well as household that did not have a mortgage on their primary residence at any point in time because prepayment behavior is irrelevant by definition in these cases.

Table 1 shows the descriptive statistics for the total sample, households who did not make a prepayment, and those who did make a prepayment. Households who prepay have substantially higher average incomes compared to those who don't. Also, their financial wealth is about a third higher. In addition to this, home owners who prepay are older on average, and have slightly more expensive houses. Loan-to-value (LTV)-ratios of prepaying households (at the start of the year, before prepayment) are slightly higher, even though older households – who typically have low LTV-ratios – are overrepresented in prepaying households.

*Table 1. Descriptive statistics*

	All observations	No prepayment	Prepayment
#Observations	143,964	129,872	14,092
Age oldest adult	51.13 (11.44)	50.85 (11.44)	53.69 (11.12)
Total pre-tax income (euro)	62,262 (45,878)	61,139 (43,883)	72,612 (60,308)
Box 3 wealth (euro)	70,822 (227,113)	67,958 (225,695)	97,218 (238,184)
House value euro)	284,328 (200,046)	282,131 (188,774)	304,581 (282,766)
Mortgage (euro)	166,444 (134,601)	164,626 (130,466)	183,190 (167,063)
LTV-ratio	0.609 (0.372)	0.608 (0.366)	0.614 (0.416)
Interest rate differential	0.013 (0.020)	0.013 (0.020)	0.016 (0.020)
Mortgage interest rate	0.049 (0.014)	0.049 (0.013)	0.048 (0.016)
Marginal tax rate (labor income)	0.396 (0.126)	0.398 (0.123)	0.385 (0.185)
Saving rate	0.053 (0.695)	0.002 (0.661)	0.523 (0.819)
Owns stocks or bonds	0.376 (0.484)	0.371 (0.483)	0.417 (0.493)
Years since moving	9.79 (5.04)	9.73 (4.98)	10.38 (5.44)

*Note:* standard deviations are in parentheses.

<sup>16</sup> The creation of a balanced panel introduces a certain bias in our data set, primarily because changes in relationship status are an important reason that a household may not be present in all years. These people are likely to be more often either very young or very old. When strong interaction effects exist, this may somewhat affect results.

While the average household in our dataset has a rather low saving rate, households who prepay are characterized by very high saving rates. This may also be because they received gifts or sold non-investment goods in the year in which they prepaid (resulting in a high increase in observed net assets as a percentage of income). In the year before prepaying the average saving rate was 0.24 and thus also much higher than saving rate of households who did not prepay. Prepaying households are more likely to own bonds or shares. This indicates that they may be more active in managing their assets in a way that maximizes returns. The interest rate differential is slightly higher for prepaying households compared to households who did not prepay, but the difference is not large.

Table 2 shows how prepayments have developed over time. The share of households that prepays ranges from 5.1 to 20.8%. When the crisis started, households did not start to prepay immediately (as might be expected given the often stated hypothesis that households wanted to deleverage). Rather, the number of prepayments increased more gradually, and rose in particular since 2011. The average yearly prepayment was between 21 and 38 thousand euro. The average annual prepayments correspond to 1.5% of the total mortgage debt (not shown in table). The average prepayment amount of households that prepaid does not show a consistent pattern. Interestingly, even though housing prices decreased and households started to prepay more often, average mortgage debt still increased during the housing market crisis. This is explained by upward mobility of households in the housing ladder within our balanced panel. After the crisis, it took until 2010 before the interest rate differential started to rise. It reached its highest level in 2014, mostly due to the continuing declining saving rates.

*Table 2. Prepayment behavior and wealth between 2006 and 2014*

	2006	2007	2008	2009	2010	2011	2012	2013	2014
#Observations	15,996	15,996	15,996	15,996	15,996	15,996	15,996	15,996	15,996
Share prepaying	0.059	0.051	0.056	0.063	0.076	0.091	0.125	0.152	0.208
Interest rate differential	0.014 (0.022)	0.013 (0.021)	0.010 (0.022)	0.008 (0.021)	0.013 (0.018)	0.015 (0.018)	0.014 (0.018)	0.014 (0.018)	0.020 (0.016)
Mortgage (euro)	152,772 (119,422)	155,746 (120,474)	161,583 (127,045)	167,008 (132,050)	170,387 (137,961)	172,045 (139,418)	173,309 (141,732)	173,244 (144,405)	171,898 (144,242)
Prepayment of prepaying hh. (euro)	24,305 (47,136)	20,981 (47,405)	20,999 (48,097)	22,765 (50,482)	21,669 (49,074)	22,144 (52,395)	20,226 (38,736)	21,958 (37,222)	37,924 (65,544)
Housing value (euro)	272,568 (143,281)	295,640 (318,081)	308,615 (185,704)	308,735 (154,302)	293,642 (323,824)	286,360 (140,919)	283,817 (138,876)	255,166 (124,786)	254,413 (131,611)
Box 3 wealth (euro)	59,901 (216,989)	65,188 (233,949)	66,523 (231,070)	68,104 (211,621)	72,662 (222,087)	74,175 (227,041)	74,274 (216,886)	77,048 (234,590)	79,528 (246,973)

*Note:* standard deviations are in parentheses.

The four panels in Figure 2 show the relations between the key variables pooled over the years 2006 to 2014. Panel A shows an ambiguous relationship between the interest rate differential and the share of prepaying households. There does not seem to be a strong relationship between the prepayment probability and the interest rate differential (including the effects of income and wealth taxes at the individual household level), except for households where the interest rate differential is very large. It is somewhat surprising that a substantial share of households choose to prepay their mortgages even when the interest differential is negative. These households are by definition worse off, as keeping their money on a savings account with short-term interest rate would have resulted in a higher payoff. In addition, they also lose the option to use their savings for a different purpose in the future.<sup>17</sup> This seemingly irrational behavior, at least from an optimal portfolio perspective, is also found elsewhere in the literature; see for example, Amromin et al. (2007). Households who experience a high value of prepaying might choose not to prepay because they may want to preserve savings for future consumption, or may not have the means to prepay.

Panel B shows the relationship between age and prepayment. For spouses, age represents the age of the oldest partner. Young people are far less likely to prepay their mortgages compared to households with older members. Until the age of 65 the probability to prepay increases more or less linear with age, after which it remains constant. It is however a partial relationship, as older people typically had their mortgage interest rates fixed further in the past, when interest rates were considerably higher. DNB (2014) has found that a large part of the increase in prepayments since 2009 is explained by interest arbitrage of older and relatively wealthier households. Due to the historically low interest rates, prepaying yields substantially higher risk-free returns for those households compared to saving.

Panel C shows a slightly U-shaped relation between the LTV-ratio (on January 1 of each year) and the probability that a household will prepay during that year. The fact that households with low LTV-ratios are more likely to prepay is most likely due to a reverse causality. Households that prepaid in the past have below-average LTV-ratios. Furthermore, households with a low LTV have negotiated their mortgages longer ago (both due to house price appreciation and repayments), which results in a positive relationship with the interest rate differential.

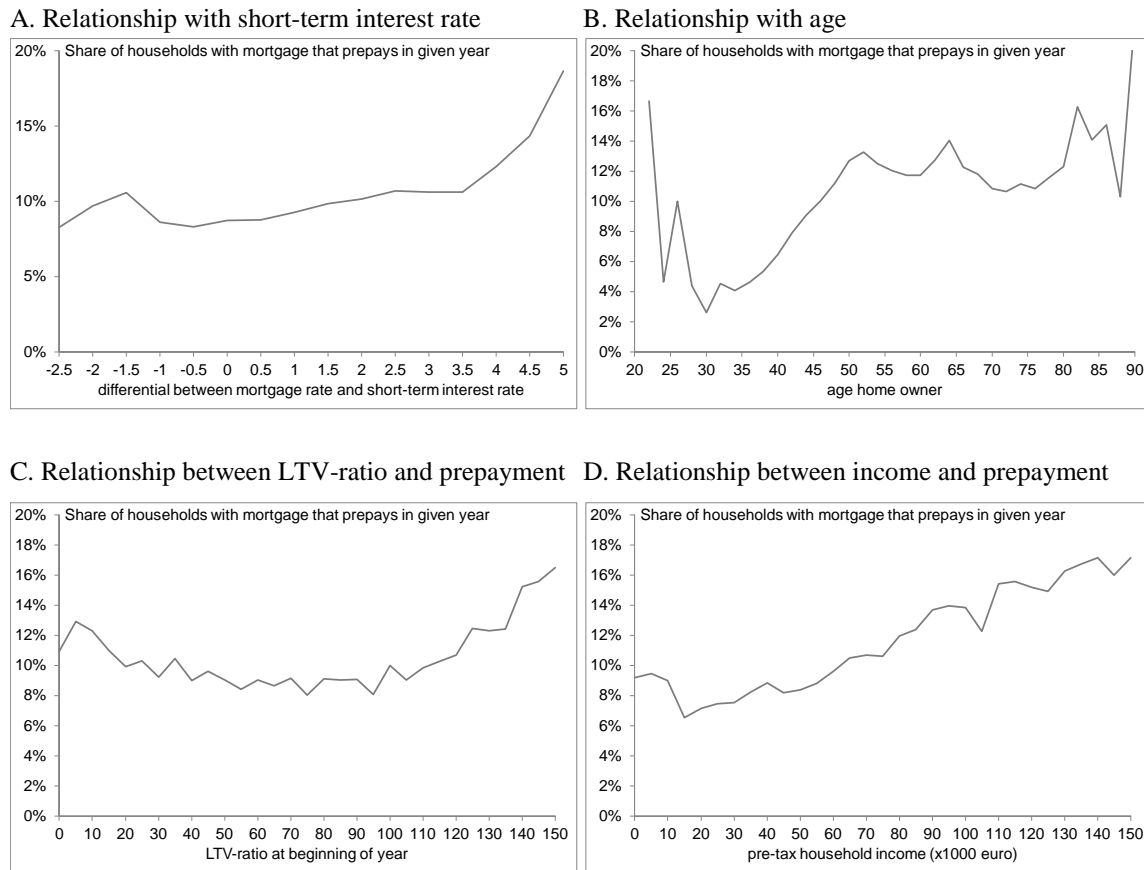
Panel D shows the relationship between (pre-tax) household income and prepayment rates. Households with higher incomes are considerably more likely to prepay. Again, this may also be because high-income households tend to be older and are therefore more likely to have bought their houses at a time when mortgage interest rates were high. Appendix 2 shows pairwise cross-

---

<sup>17</sup> There might also be non-financial explanations for this behavior. For example, it could be that households prepay because as a way to commit themselves to saving.

correlations between all relevant (continuous) variables. The household saving rate, household income, and age are the variables with the strongest correlations with mortgage prepayment.

*Figure 2. Relationship between prepayment rate and selected variables*



Source: own calculations based on CBS micro data.

The stylized facts presented in this section are consistent with the finding from the literature. Prepayment behavior does seem to be driven by incentives to prepay to some extent, but incentives are only a part of the story and prepayment behavior does not seem to be fully rational from an economic point of view (Green and LaCour-Little, 1999; Amromin et al., 2007; Andersen et al., 2015).

## 6. Results

Table 3 presents outcomes for four different specifications. Column I presents the outcomes of a probit specification with random effects. The presented coefficients are average marginal effects. Column II shows a linear probability model with random effects (which relies on the GLS estimator). The high similarity between the marginal effects of the probit estimates and the results in column II indicates that the application of linear probability models is appropriate. Also, linear predictions



(which are clustered around the mean prepayment probability of 0.098) are between 0 and 1 in 91% of the observations.

Columns III and IV present linear probability models that are estimated using the Arellano-Bond GMM estimator. The GMM estimator takes account of the possible endogeneity of the independent variables, such as the interest differential. In these specifications, two lags of the dependent variable have been included (which explains the lower number of observations). The Arellano-Bond test for zero autocorrelation in first-differenced errors rejects the null-hypothesis of no autocorrelation of order one ( $p=0.000$ ), and fails to reject the null-hypothesis of no autocorrelation of order two ( $p=0.089$ ).<sup>18</sup> The Arellano-Bond specifications are our preferred specifications. Column IV presents an extension to specification III, where we interact the interest rate differential with three levels of box 3 wealth. This enables us to account for possible nonlinearities in the effect of the interest rate differential. To avoid problems with multicollinearity we also include dummies for levels of box 3 wealth (different intercepts) and a variable slope for log box 3 wealth in this specification.

The interest rate differential has the expected sign and a statistically significant effect in all specifications. A coefficient of 0.548 (column III) implies that an increase of the interest rate differential by 1%-point increases the probability of prepayment by 0.548%-point. A change of 1%-point in the interest rate differential is rather large from an economic perspective. For example, the value of the exemption for housing wealth in box 3 (which equals the marginal tax rate) is 1.2%, and the increase in the interest rate differential during the financial crisis amounted to about 1%-point. A change of prepayments by 0.548%-point is 5% increase in the average prepayment probability of 9.8%. The increase in the financial incentive to prepayment during the crisis explains thus only a minor part of the increase in prepayments of more than 10%-points. As might be expected, column IV shows that the effect of the interest rate differential is larger for households with higher wealth. For households with wealth above 200,000 euro, the elasticity is six times as high as the average elasticity. The elasticity is relatively low and not statistically significant for households with box 3 wealth up to 50,000 euro, while it is three times the average elasticity for households with wealth between 50,000 and 200,000.<sup>19</sup> Households who experience liquidity constraints do not have the necessary means to prepay on their mortgage even when this would be very profitable, which could explain why the elasticity is relatively low for them. Households with more financial wealth are not

---

<sup>18</sup> When only one lag of the dependent variable is included in the Arellano-Bond specification, the assumption of zero autocorrelation of order two is not met. Violation of this assumption results in inconsistent estimates.

<sup>19</sup> The results presented in column IV could potentially be affected by the box 3 wealth exemption, which 21,139 for singles (2014) and 42,278 for fiscal partners. Therefore, we have estimated the same specification while including an additional dummy that indicates whether the box 3 wealth of the household exceeded the exemption in a given year. This results in very similar parameter estimates for the interest rate differential: 0.349 ( $z=1.2$ ) for households with wealth <50,000; 1.553 ( $z=2.7$ ) for households with wealth 50,000–199,999 and 3.095 ( $z=3.3$ ) for households with wealth  $\geq 200,000$ .

only less constrained, but the value of optimizing their financial portfolio is also higher because more wealth is involved.

The saving rate of households is by far the independent variable with the highest explanatory power. Households with high personal saving rates are much more likely to repay compared to households saving less, even at given levels of financial wealth and independent of the value of prepaying. Note again that a high saving rate could also be due to sudden wealth shocks, as these result in high savings as a percentage of income if households do not change their consumption by much. Ownership of stocks or bonds is negatively related to the prepayment probability (albeit the effect is not statistically significant in specifications I and II). An explanation for this could be that the higher returns on stocks and bonds are perceived as a substitute for prepaying by households who are active investors. It is also consistent with the suggestion of Amromin et al. (2007) that the prepayment behavior of some households is explained by their reluctance to participate in financial markets as either a borrower or a lender. Households who own stocks and bonds are less likely to display such an aversion.

Interestingly, the effect of income on prepayments varies across specifications. In specifications I and II, households with higher pre-tax incomes have a significantly higher probability to prepay as might be expected from a theoretical perspective. In specifications III and IV, in contrast, the effect of income is in fact negative at given levels of wealth, housing value, and mortgage debt. It is not clear what could explain such a negative relationship. Higher financial wealth is positively associated with prepayment behavior in specifications I and II, but not associated to prepayment behavior in our preferred specifications. This is somewhat surprising, as one would expect that households with higher financial wealth are less financially constrained and therefore more likely to prepay. Specification IV does show a positive relation between financial wealth and prepayment probability for households with high wealth, but this relation does not show up for households with low wealth.

Households with high mortgages – after controlling for their loan to value ratio, and thereby for the value of their home – have a higher probability to prepay. The loan to value ratio, on the other hand, has little effect on prepayments except for households with a very low loan to value ratio, who are more likely to prepay. The size of their mortgage (after taking into account income, wealth, and other controls), therefore seems to be more relevant to prepayment behavior than the amount of mortgage debt as a percentage of the value of the house.

Table 3. Estimation results (dependent: prepayment dummy)<sup>20</sup>

	Probit RE (I)	Linear Prob. RE (II)	Arellano-bond GMM	
			(III)	(III)
#Observations	143,964	143,964	95,976	95,976
Prepayment dummy (t-1)			0.215*** (19.4)	0.207*** (18.9)
Prepayment dummy (t-2)			0.065*** (8.8)	0.062*** (8.4)
Interest rate differential	0.125** (2.7)	0.143*** (3.3)	0.548* (2.1)	
hh. with box 3 wealth <50,000				0.243 (0.8)
hh. with box 3 wealth 50,000-199,999				1.549** (2.7)
hh. with box 3 wealth ≥200,000				3.001** (3.2)
Log pre-tax income	0.022*** (8.4)	0.020*** (8.6)	-0.098*** (3.9)	-0.098*** (3.9)
Log box 3 wealth	0.008*** (9.2)	0.009*** (9.7)	-0.004 (0.6)	
hh. with box 3 wealth <50,000				-0.004 (0.6)
hh. with box 3 wealth 50,000-199,999				0.166*** (4.7)
hh. with box 3 wealth ≥200,000				0.499*** (5.9)
Log mortgage	0.019*** (9.2)	0.019*** (7.7)	0.080* (2.1)	0.106** (2.9)
Saving rate	0.064*** (59.0)	0.081*** (58.5)	0.053*** (6.1)	0.056*** (6.8)
Owens stocks or bonds	-0.004 (1.7)	-0.004 (1.4)	-0.075*** (5.3)	-0.048*** (3.3)
<i>Dummies LTV-ratio</i>				
LTV-ratio 40-60	-0.014*** (4.8)	-0.020*** (6.9)	-0.040*** (5.3)	-0.049** (2.9)
LTV-ratio 60-80	-0.018*** (5.5)	-0.029*** (7.8)	-0.059** (2.7)	-0.064** (2.9)
LTV-ratio 80-100	-0.017*** (4.5)	-0.035*** (8.0)	-0.074** (2.7)	-0.074** (2.7)
LTV-ratio ≥100	-0.019*** (4.4)	-0.039*** (6.8)	-0.079** (2.4)	-0.079* (2.2)
Age dummy's (5-yr groups)	Yes	Yes	Yes	Yes
Dummy's box 3 wealth <sup>a</sup>	No	No	No	Yes
Year fixed effects	Yes	Yes	Yes	Yes
FE's years since last moving <sup>b</sup>	Yes	Yes	Yes	Yes

Note: z-values are in parentheses. Source: own calculations based on CBS micro data. Significance levels of 0.05, 0.01 and 0.001 are denoted by \*, \*\* and \*\*\* respectively. <sup>a</sup> Two dummies were included, for box 3 wealth 50,000–199,999 and for wealth ≥200,000 euro.

<sup>b</sup> Five dummies were included for households who last moved between 1 and 2 years ago, 2–5 years, 5–10 years, 10–15 years and ≥15 years.

<sup>20</sup> Fixed effects for age, box 3 wealth, year and year since last moving are presented in appendix 3.

As a robustness check, Table 4 presents the results of various alternative specifications. These results correspond to the results presented in columns III and IV of Table 3 (e.g. the linear probability Arellano-Bond specifications). As discussed in section 5, the use of a balanced panel results in a bias in our data because the composition of older households changes less often and they are therefore less likely to leave the panel. Therefore, we have also estimated the model on a larger sample, which includes all households which remain in our panel for at least 5 years. A disadvantage of this approach is that it becomes more difficult to observe the regular mortgage payment scheme of households. The outcomes are broadly the same, but the effect of the interest rate differential is no longer statistically significant. In the specification where we interact the interest rate differential with financial wealth the effect of the interest rate differential is statistically significant for the highest wealth category.

We have also estimated all specifications on a subsample of our balanced panel which only includes households who bought their 2006 residence after 1995. The reason is that we do not observe the capital in the investment plan that is attached to their mortgage when households have a savings or investment mortgage. Therefore, when the mortgage matures and the mortgage is paid off from the investment plan, we would observe this as a prepayment in our data. Because mortgages with a maturation of less than 20 years are extremely rare in the Netherlands, we exclude households who moved to their current residence before 1995. Again, results are very similar to those presented in Table 3, but the estimated effect of the interest rate differential is not statistically significant. Given the similarity in the estimated coefficients the lack of statistical significance can probably be explained by the lower number of observations. However, the lack of robustness indicates that the findings presented in Table 3 should be interpreted with caution.

Based on the estimated parameters in Table 3 (column III and IV), and based on some additional statistics for our sample, we have determined the elasticity of the tax base of box 3. Elasticities have been calculated for all households, and for household with different financial wealth. We use three inputs for this purpose: the box 3 tax base for each group, their total observed prepayments, and the elasticities of prepayment with respect to changes in the interest rate differential (the prepayment elasticities presented in Table 5 correspond to those in Table 3). The elasticity of the box 3 tax base follows from the prepayment elasticity multiplied by observed average prepayments, and divided by the box 3 tax base of each group. This implies the assumption that savings are exogenous: if households choose to prepay, their prepayments are subtracted from the tax base.

Table 4. Robustness checks for Arellano-Bond specifications (dependent: prepayment dummy)<sup>21</sup>

	Non-balanced panel		Subsample of households who bought their residence after 1995	
	Arellano-Bond GMM (III.A)	Arellano-Bond GMM (IV.A)	Arellano-Bond GMM (III.B)	Arellano-Bond GMM (IV.B)
#Observations	168,031	168,031	66,612	66,612
Prepayment dummy (t-1)	0.225*** (21.4)	0.206*** (20.0)	0.208*** (16.4)	0.196*** (15.4)
Prepayment dummy (t-2)	0.071*** (11.1)	0.063*** (10.0)	0.065*** (7.4)	0.061*** (6.9)
Interest rate differential	0.285 (1.2)		0.459 (1.5)	
hh. with box 3 wealth <50,000		-0.255 (1.0)		0.189 (0.5)
hh. with box 3 wealth 50,000-199,999		0.921 (1.8)		1.298 (1.9)
hh. with box 3 wealth ≥200,000		4.858*** (5.8)		2.423* (2.2)
Log pre-tax income	-0.064*** (3.3)	-0.042* (2.4)	-0.067* (2.5)	-0.019 (0.8)
Log box 3 wealth	-0.014 (2.6)		-0.0004 (0.1)	
hh. with box 3 wealth <50,000		-0.001 (0.2)		-0.001 (0.2)
hh. with box 3 wealth 50,000-199,999		-0.003 (0.1)		0.154*** (3.9)
hh. with box 3 wealth ≥200,000		0.350*** (4.2)		0.574*** (5.6)
Log mortgage	0.099* (2.8)	0.164** (4.7)	0.064* (1.4)	0.116** (2.6)
Saving rate	0.070*** (9.9)	0.068*** (10.2)	0.068*** (6.8)	0.064*** (6.7)
Owns stocks or bonds	-0.106*** (7.9)	-0.086*** (6.3)	-0.075*** (4.5)	-0.051** (3.0)
<i>Dummies LTV-ratio</i>				
LTV-ratio 40-60	-0.128*** (6.9)	-0.132*** (7.2)	-0.035 (1.8)	-0.041* (2.2)
LTV-ratio 60-80	-0.198*** (7.9)	-0.201*** (8.2)	-0.045 (1.8)	-0.049 (1.9)
LTV-ratio 80-100	-0.250*** (8.1)	-0.252*** (8.4)	-0.060 (1.9)	-0.058 (1.8)
LTV-ratio ≥100	-0.299*** (8.0)	-0.303*** (8.3)	-0.067 (1.7)	-0.060* (1.5)
Age dummy's (5-yr groups)	Yes	Yes	Yes	Yes
Dummy's box 3 wealth <sup>a</sup>	No	No	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
FE's years since last moving	Yes	Yes	Yes	Yes

Note: z-values are in parentheses. Source: own calculations based on CBS micro data. Significance levels of 0.05, 0.01 and 0.001 are denoted by \*, \*\* and \*\*\* respectively. <sup>a</sup> Two dummies were included, for box 3 wealth 50,000–199,999 and for wealth ≥200,000 euro.

<sup>b</sup> Five dummies were included for households who last moved between 1 and 2 years ago, 2–5 years, 5–10 years, 10–15 years and ≥15 years.

<sup>21</sup> In our non-balanced panel specification, we require a minimum of 5 observations per household.

As explained in Section 4, the behavioral effects from a higher interest rate differential by 1% are the same as from a 1% higher wealth tax. Table 5 presents the various elasticities. A 1% increase in the interest rate differential is associated with a 0.548% point increase in prepayments, and (assuming that prepayments reduce taxable wealth by an equal amount), reduces total wealth taxes that were collected by 0.019%. Elasticities for households with higher financial wealth are much higher compared to households with wealth below 50,000 euro. However, because households with wealth above 200,000 euro have comparatively low mortgages compared to their financial wealth, the estimated tax elasticity is in fact the highest (0.055%) for households with wealth between 50,000 and 200,000 and somewhat lower for those with higher wealth (0.041%).

The finding that tax elasticities are modest corresponds to other results in the literature. Zoutman (2014) finds that a 1% increase in the tax on financial wealth decreases the share invested in financial wealth by only 0.033% and his negative elasticity with respect to the after-tax return on housing is economically negligible. In a more recent paper Zoutman (2015) finds a somewhat larger, but still modest effect of 0.10% to 0.17%. Also the empirical results on portfolio choice models are modest or even negligible (see footnote 5). Our elasticities have to be interpreted as an under bound. The tax base is financial wealth, but we only consider possible shifts between prepayment behavior and financial wealth. Tax increases could also induce households to consumer more, invest more in tax-favoured pension plans, etc.

*Table 5. Elasticities capital income with respect to the interest rate differential*

	Elasticity of prepayment	Elasticity tax base box 3
All households in sample	0.548*	0.019*
Households with box 3 wealth < 50,000	0.243	0.020
Households with box 3 wealth 50,000–199,999	1.549**	0.055**
Households with box 3 wealth ≥200,000	3.001**	0.041**

Significance levels of 0.05 and 0.01 are denoted by \*, \*\* respectively.

Green and Shoven (1985) find that prepayment behavior is to a large extent driven by market interest rates. Charlier and Van Bussel (2003) find similar results analyzing the Dutch mortgage market. Even though their findings may seem to contrast with ours at first sight, this may be because these papers don't distinguish refinancing and prepayment by their own capital. In our work, prepayment does not include refinancing. It is likely that refinancing decisions more often based on optimal portfolio decisions, because (i) the net costs before and after refinancing might be easier to compare for households, and (ii) because refinancing often involves cost comparisons made by mortgagors. The added complexity of tax rates on both labor and capital income in the decision process – as is the case in our work and that of, for example, Amromin et al. (2007) – may make the decision to prepay more

complex, which may result in less accurate decision making by households without assistance of financial advisors.

## **7. Conclusion**

Dutch mortgagors generally allow homeowners to prepay 10 to 20 percent of their mortgage annually without any costs. From a theoretical perspective, the option value that is created by this possibility should be a major driving force behind prepayment behavior because the value of prepaying has increased due to decreasing market interest rates in recent years. However, the literature that addresses prepayment behavior has consistently shown that financial behavior of households is not always rational, especially prepayment behavior (Quigley, 1987; Hall, 2000; Charlier and Van Bussel, 2003). Our findings suggest that the willingness to prepay is in part independent from the option value of prepaying. This finding is also consistent with Van Dijk (2015), who shows that households underestimate opportunity costs of housing equity.

Our findings add to this literature, albeit from a different perspective. Patterns in prepayment behavior are not well explained from an optimal portfolio perspective. Even though we find a statistically significant effect of the incentives to prepay – as measured by the interest differential (e.g. the after tax difference in the interest rate that households pay on their mortgage minus the interest rate they receive on their savings account) – on prepayment, it explains only a minor part of total prepayments and the effect is not entirely robust.

As explained in Section 4, changes in the after-tax difference between mortgage interest rates and the short-term interest rate and the effect of changes in the value of prepaying due to changes in wealth taxation have equivalent effects on the value of prepaying. This enables us to use our estimation results to derive elasticities of prepayment and wealth tax revenues with respect to changes in the tax rate. The average tax elasticity is 0.02 and it is about 3 times as high for households with financial wealth above 200,000 euro. This suggests that on average the tax elasticity is probably low, but that the behavioral effects of rich households should not be neglected. Because we only consider prepayment behavior and portfolio choices, the overall tax elasticity of financial wealth could be higher.

## Literature

- Alan, S., K. Atalay, T.F. Crossley and S.H. Jeon. (2010). New evidence on taxes and portfolio choice. *Journal of Public Economics*, 94, pp. 813–823.
- Amromin, G., J. Huang and C. Sialm (2007). The tradeoff between mortgage prepayments and tax-deferred retirement savings. *Journal of Public Economics*, 91, pp. 2014–2040.
- Andersen, S., J.Y. Campbell, K.M. Nielsen and T. Ramadorai (2015). *Inattention and inertia in household finance: evidence from the Danish mortgage market*. CEPR Discussion Paper 10683, London.
- Arellano, M. and S. Bond (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies*, 58, pp. 277–298.
- Brüllhart, M., J. Gruber, M. Krapf and K. Schmidheiny (2016). *Taxing wealth: Evidence from Switzerland*. NBER Working Paper 22376, Cambridge.
- Charlier, E. and A. van Bussel (2003). Prepayment behavior of Dutch mortgagors: An empirical analysis, *Real Estate Economics*, 31, pp. 165–204.
- Cnossen, S. and A.L. Bovenberg (2001). Fundamental tax reform in the Netherlands. *International Tax and Public Finance*, 7, pp. 471–484.
- DNB (2014). *Overzicht financiële stabiliteit voorjaar 2014*. Amsterdam.
- Droes, M.I. and W. Hassink (2013). House price risk and the hedging benefits of home ownership. *Journal of Housing Economics*, 22, pp. 92–99.
- Feldstein, M. (1976). Personal taxation and portfolio composition: An econometric analysis. *Econometrica*, 44, pp. 631–650.
- Followill, R.A. and B.C. Olsen (2015). A closed-form, after-tax, net present value solution to the mortgage refinancing decision. *The Engineering Economist*, 60, pp. 165–182.
- Green, J. and J.B. Shoven (1986). The effects of interest rates on mortgage prepayments. *Journal of Money, Credit and Banking*, 18, pp. 41–59.
- Green, R.K. and M. LaCour-Little (1999). Some truths about ostriches: Who doesn't prepay their mortgages and why they don't. *Journal of Housing Economics*, 8, pp. 233–248.
- Hall, A. (2000). Controlling for burnout in estimating mortgage prepayment models. *Journal of Housing Economics*, 9, pp. 215–232.
- Hochguertel, S., R. Alessie and A. van Soest (1997). Personal taxation and portfolio composition: An econometric analysis. *Scandinavian Journal of Economics*, 99, pp. 81–97.
- King, M.A. and J.I. Leape (1998). Wealth and portfolio composition: theory and evidence. *Journal of Public Economics*, 69, pp. 155–193.
- Klein, J.P. and M.L. Moeschberger (2005). *Survival analysis: techniques for censored and truncated data*, Springer Verlag, New York.
- Koijen, R.S.J., O. van Hemert and S. van Nieuwenburg (2009). Mortgage timing. *Journal of Financial Economics*, 93, pp. 292–324.



- Kuijpers, B.H.M. and P.C. Schotman (2006). *Valuation and optimal exercise of Dutch mortgage loans with prepayment restrictions*. LIFE Working Paper.
- Kuijpers, B.H.M. and P.C. Schotman (2007). Optimal prepayment of Dutch mortgages. *Statistica Neerlandica*, 61, pp. 137–155.
- LaCour-Little, M. (1999). Another look at the role of borrower characteristics in predicting mortgage prepayments. *Journal of Housing Research*, 10, pp. 45-60.
- Lusardi, A. and O. Mitchell (2007). Financial literacy and retirement preparedness: Evidence and implications for financial education. *Business Economics*, 42, pp. 35–44.
- Michelangeli, V. (2012). Should you pay off your mortgage or invest? *Economics Letters*, 115, pp. 322–324.
- Poterba, J.M. (2002). Taxation, risk-taking, and household portfolio behavior. In: A. Auerbach and M. Feldstein (eds.). *Handbook of Public Economics*, Elsevier, Amsterdam.
- Poterba, J. M., and A. Samwick (2002). Taxation and household portfolio composition: US evidence from the 1980s and 1990s. *Journal of Public Economics*, 87, pp. 5–38.
- Quigley, J.M. (1987). Interest rate variations, mortgage prepayments and household mobility. *The Review of Economics and Statistics*, 69, pp. 636–642.
- Sandmo, A. (1985). The effects of taxation on savings and risk taking. In: A. Auerbach and M. Feldstein (eds.). *Handbook of Public Economics*, Elsevier, Amsterdam.
- Therneau, T.M. and P.M. Grambsch (2001). *Modeling survival data: extending the Cox model*. Springer Verlag, New York.
- Van Dijk, M. (2015). *Estimating the weight of opportunity costs in housing consumption*. CPB Discussion Paper 314, The Hague.
- Van Leuvenstein, M and W. Hassink (2009). The importance of income and housing wealth constraints for future residential mobility. *Housing Studies*, 26, pp.575–591.
- Zoutman, F. (2014), *The Effect of Capital Taxes on Household's Portfolio Composition and Intertemporal Choice: Evidence from the Dutch 2001 Capital Income Tax Reform*, Norwegian School of Economics, Discussion paper 23.
- Zoutman, F. (2015), *The elasticity of taxable savings*, mimeo

## Appendix 1. Merging process and construction of variables

To merge the various data sets that are used in this paper, the following procedure has been followed. As a first step, we have merged IPO to the Household registry, to obtain a comprehensive list of all individuals that are part of households that are represented in IPO.<sup>22</sup> Before IPO is matched to the Integral Asset registry, certain types of households are split. In this step, members of households who aren't children or a spouse or partner of the main resident of the household, as well as institutionalized household members, are put into separate households. IPO is merged to assets on January 1 of the current year, and also to assets on January 1 of the next year. The change in mortgage debt is used to identify prepayments according to the procedure discussed later in this appendix. Merging to both the start and the end of the year is also relevant when determining the box 3 property tax.

An important problem when merging IPO and asset data – and also when constructing a panel data set – is that the composition of households may have changed over time. Therefore, we have defined our panel identifier in such a way that it remains the same if and only if adult members (other than grown up children) are the same at different points in time. After finishing the merging process but before creating a balanced panel, close to 94% of all households in the IPO dataset remain in our data selection because they could be matched successfully across datasets. Atypical households – such as institutionalized households and student households – account for a major share of households that were excluded due to mismatches.

A number of variables have been constructed from various alternative variables and data sources. The way they are defined deserves some extra attention. Firstly, we have defined mortgage repayments as the difference between the mortgage debt on January 1 of the current year and January 1 of the next year in case this difference is positive. As a measure for the normal repayment behavior of the household, we take the lowest repayment. We consider a repayment a prepayment if it is (i) more than 10 percent higher than the lowest repayment, *and* (ii) it is at least 1,000 euro higher than the lowest repayment, *and* (iii) the address of the household did not change during the year. We have also tested with using the median repayment to identify the regular prepayment schedule, but because of the relatively low number of years in our dataset this increases the probability that the median prepayment is not a regular repayment. If all three criteria are met, the size of the prepayment is defined as the difference between the lowest prepayment and the actual amount repaid by a household in a year.

The saving rate of households is used as a control in our research. Households who are more prone to save may also be more likely to prepay. The savings rate is defined as all combined savings of the

---

<sup>22</sup> This step is also important because (fiscal) households in the Integral Asset registry are represented by a random household member. In order to obtain a successful match with IPO it is therefore required that the attempted match is based on all members.

household during the period under observation divided by the sum of income from all capital and labor. While income is observed directly, savings must be derived from the value of assets at different points in time. Starting point for savings is the sum of the change in the value of all asset categories in each year. The value of real estate has been reduced by the general trend in Dutch housing prices (using the house price index of Statistics Netherlands), while the value of stocks has been reduced by the MSCI World index. The reason for these corrections is that an increase in housing prices cannot be considered as an indicator for savings morale.

## Appendix 2. Cross correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Prepaid (dummy)	1.000											
(2) Prepaid (amount, euro)	0.429	1.000										
(3) Age	0.074	0.019	1.000									
(4) Pre-tax income box 1, 2, 3	0.075	0.112	-0.112	1.000								
(5) Financial wealth box 3	0.038	0.081	0.072	0.440	1.000							
(6) Value primary residence	0.033	0.074	0.039	0.314	0.230	1.000						
(7) Interest rate differential	0.037	0.019	0.156	-0.046	0.058	0.008	1.000					
(8) LTV-ratio	0.005	0.109	-0.389	0.158	0.005	-0.094	-0.155	1.000				
(9) Marginal tax rate	-0.030	0.007	-0.461	0.362	0.049	0.056	-0.203	0.356	1.000			
(10) Mortgage	0.041	0.194	-0.259	0.478	0.252	0.377	-0.117	0.642	0.363	1.000		
(11) Personal saving rate	0.225	0.235	0.025	0.052	0.043	-0.026	0.032	0.102	-0.015	-0.068	1.000	
(12) Yrs. since last moving	0.038	-0.029	0.326	-0.045	-0.007	-0.096	0.100	-0.347	-0.163	-0.367	0.006	1.000

### Appendix 3 – Fixed effects Table 3 (age, box 3 wealth, year and year since last moving)

	Probit RE (I)	Linear Prob. RE (II)	Arellano-bond GMM	
			(III)	(III)
#Observations	143,964	143,964	95,976	95,976
Age 30–35	–0.032 (1.7)	–0.033* (2.4)	–0.066* (2.1)	–0.063* (2.4)
Age 35–40	–0.031 (1.6)	–0.046*** (3.3)	–0.115*** (3.9)	–0.110*** (3.7)
Age 40–45	–0.024 (1.3)	–0.046*** (3.3)	–0.119*** (3.7)	–0.114*** (3.6)
Age 45–50	–0.017 (0.9)	–0.042** (3.0)	–0.122*** (3.6)	–0.122*** (3.7)
Age 50–55	–0.002 (0.1)	–0.025 (1.7)	–0.110** (3.1)	–0.113** (3.2)
Age 55–60	0.011 (0.6)	–0.011 (0.7)	–0.103** (2.7)	–0.110** (2.9)
Age 60–65	0.019 (1.0)	–0.001 (0.1)	–0.100* (2.5)	–0.109** (2.7)
Age 65–70	0.013 (0.7)	–0.003 (0.2)	–0.127** (3.0)	–0.122** (2.9)
Age 70–75	0.007 (0.3)	–0.013 (0.9)	–0.151*** (3.4)	–0.141** (3.1)
Age ≥75	0.012 (0.6)	–0.016 (1.0)	–0.182*** (3.8)	–0.162*** (3.4)
Box 3 wealth 50,000– 199,999				–1.932*** (5.1)
Box 3 wealth ≥200,000				–6.10*** (5.8)
Year 2007	–0.006** (2.6)	–0.0005 (0.2)		
Year 2008	0.004 (1.5)	0.014*** (5.9)		
Year 2009	0.008** (3.1)	0.015*** (5.8)	0.010** (3.1)	0.006* (2.0)
Year 2010	0.015*** (5.6)	0.020*** (7.2)	0.018*** (4.3)	0.009* (2.2)
Year 2011	0.022*** (8.0)	0.028*** (9.1)	0.029*** (5.2)	0.016** (2.9)
Year 2012	0.073*** (22.0)	0.082*** (23.4)	0.076*** (12.2)	0.063*** (10.1)
Year 2013	0.061*** (18.9)	0.074*** (19.1)	0.071*** (8.4)	0.057*** (6.9)
Year 2014	0.130*** (32.6)	0.148*** (35.1)	0.132*** (14.8)	0.117*** (13.2)
Years since last moving 1–2	–0.013** (2.8)	–0.012** (3.1)	–0.015 (1.9)	–0.014 (1.8)
Years since last moving 2–5	–0.016*** (4.1)	–0.014*** (3.8)	0.0002 (0.0)	0.001 (0.2)
Years since last moving 5–10	–0.021*** (5.5)	–0.019*** (5.2)	0.003 (0.3)	0.004 (0.5)
Years since last moving 10–15	–0.021*** (5.2)	–0.024*** (6.0)	–0.003 (0.3)	–0.003 (0.2)
Years since last moving ≥15	–0.026*** (5.6)	–0.034*** (6.5)	–0.017 (1.1)	–0.014 (0.9)

Note: z-values are in parentheses. Source: own calculations based on CBS micro data. Significance levels of 0.05, 0.01 and 0.001 are denoted by \*, \*\* and \*\*\* respectively. <sup>a</sup>Two dummies were included, for box 3 wealth 50,000–199,999 and for wealth ≥200,000 euro.



Publisher:

CPB Netherlands Bureau for Economic Policy Analysis  
P.O. Box 80510 | 2508 GM The Hague  
T (088) 984 60 00

April 2017 | ISBN 978-90-5833-772-6