THE HOUSING LADDER, TAXATION, AND BORROWING CONSTRAINTS[◇]

Job Swank[a,b,*]

Jan Kakes[a]

Alexander F. Tieman[a]

Abstract

Using a multi-tier model of the housing market, we show that both starters and movers benefit from mortgage interest deduction for higher income groups. However, such tax favouring also tends to facilitate house price explosions, especially when interest rates and downpayment ratios are low. More in general, the efficiency of implicit tax subsidies to homeowners depends critically on the price responsiveness of new construction, which is found to differ strongly from country to country. Irrespective of supply conditions, running down mortgage interest deduction is likely to detract from the profits of lending institutions.

JEL Classification: G12; G21; H20; R31
Keywords: House prices; Housing market; Mortgage lending; Taxation

Research Memorandum 0209

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1. Introduction

The tax treatment of owner-occupied housing is a recurrent theme in the economic literature. Not quite surprisingly, most studies in the field concern the US tax system, which is known for its generosity towards homeowners. Rosen (1979), for example, examines the efficiency and distributional implications of mortgage interest deduction on the basis of cross-sectional data from a panel of 2150 US households. He finds that elimination of the implicit tax subsidy for homeowners tends to reduce the demand for owner-occupied housing substantially and to level the distribution of disposable incomes. Capozza et al. (1996) also foresee large declines in mortgage borrowing (particularly by higher income groups) and house prices, which could cause significant problems for financial intermediaries.

While a total removal of tax deductibility of mortgage interest payments would clearly have far-reaching consequences for both households and the mortgage industry, it is not a foregone conclusion that tax favouring of homeowners delivers what it is intended to do. Since long, this issue has been under heated discussion among politicians and academics in the Netherlands, where the preferential tax treatment of homeowners is comparable with US practice. At the same time, time-inconsistency problems and electoral motives tend to prevent leading policy makers from reconsidering the tax advantage of owner-occupied housing on a fundamental score. However, similar debates in other countries have resulted in the curtailment (Denmark, Sweden) or abolishment (UK) of mortgage interest deduction. This would suggest that there are exit strategies that are politically feasible, in spite of vested interests of voters who are locked in by the former tax-preferred regime.

The aim of this paper is to analyse how the tax treatment of homeowners affects the working of the housing market, how it interferes with credit constraints imposed by lending institutions, and how it affects the profitability of the mortgage industry. We present a theoretical model discerning starters and movers on the owner-occupied housing ladder, who demand different home types, who have different incomes and who face different relative user costs of home owning. Since movers supply their former dwellings to starters, the two segments of the housing market are closely connected, and so are the respective property prices. With expectations of future home prices entering into the user costs of starters and movers, expectation formation turns out to be crucial for the emergence of stable equilibrium prices.

The theoretical analysis reveals that the effects of tax-preferred treatment of owner-occupied housing are conditional upon country-specific features of both housing and mortgage markets. Data limitations prevent us from estimating all relevant parameters of the model for various countries. However, the overriding conclusion following from the model is that the efficiency of implicit tax subsidies depends critically on the price elasticity of newly built dwellings. We make an attempt, therefore, to present some empirical evidence of housing supply conditions in a number of countries, which allows

us to judge whether or not the specific tax treatment of homeowners is warranted in the countries considered.

The rest of the paper is organized as follows. Section 2 presents the theoretical model. In section 3, the basic effects of tax deductibility of mortgage interest payments are discussed. Sections 4 and 5 introduce credit rationing and bank behaviour into the model. Section 6 presents tentative econometric results on the price responsiveness of newly built homes in a selection of countries. Conclusions are drawn in the final section.

2. A theoretical model of the market for owner-occupied housing

Following Ortalo-Magné and Rady (1999, 2001), two types of owner-occupied housing are distinguished: starter homes (henceforth "flats") and larger dwellings (henceforth "houses"). The supply of flats, S_f, equals the demand for houses (exerted by settled flat owners seeking to move up the housing ladder), D_h, plus newly built flats, N_f. This is eq. (1). The supply of houses, S_h, equals newly built houses, N_h, plus houses supplied by homeowners leaving the housing ladder due to exogenous factors (death, emigration etc.), $\overline{S}_h$. This is eq. (2). Physical decay of the existing stocks of flats and houses is ignored. The prices of flats, P_f, and houses, P_h, follow from equilibrium between demand and supply in the respective markets (eqs. (3) and (4)), provided that potential homebuyers are not rationed by lending institutions. This proviso is weakened later. Newly built flats and houses are linear functions (eqs. (5) and (6)) of the respective prices (relative to a suitable cost index captured by the slope coefficients α_1 and β_1) and of shift parameters representing all other influences. A more comprehensive approach would be to allow for partial adjustment,[1] and to explicitly identify cost factors (such as construction costs, residential land prices and building cost subsidies). However, these extensions would unduly obscure the theoretical analysis. We also abstract from speculation by homebuilders temporarily holding (part of) their completed dwellings from the market in anticipation of future increases in property prices.

Two types of house hunters are relevant for the dynamic process in the market for owner-occupied housing: "starters" and "movers". The decision process of potential starters is formalized by eq. (7), which elaborates on user-cost formulations by Pain and Westaway (1997, p. 594) and Poterba (1984, p. 732, fn. 6). Given his real (permanent) disposable income, $\overline{y}_s$ (assumed exogenous), a potential starter considers buying a flat

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[1] Hakfoort and Matysiak (1997) and Topel and Rosen (1988) give a theoretical underpinning. An overview of relevant arguments is contained in DiPasquale and Wheaton (1994, pp. 7-9).

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on the basis of the difference between the (exogenous) real rent of his current home, $\bar{R}$, and the real cost of owning a flat.[2] The latter is defined from the following assumptions:

i. When applying for mortgage credit, starters face binding downpayment requirements to the amount of δP_f, where δ is the minimum downpayment ratio. These downpayments are made from own funds with opportunity cost $i(1-\tau_{is})$, where i is the (expected) nominal yield of financial assets, and τ_{is} is the marginal tax rate on income from financial wealth faced by starters. The financing gap $(1-\delta)P_f$ is filled by a nonamortizable mortgage loan with after-tax interest rate $i_l(1-\tau_{ls})$, where i_l is the (fixed) nominal mortgage interest rate, and τ_{ls} is the effective rate of tax relief on mortgage interest payments faced by starters.

ii. Consistent with the life-cycle hypothesis, (potential) homeowners reckon by real rather than nominal interest rates, so that the after-tax interest rates have to be adjusted for the rate of expected future capital gains: $\varepsilon_f = P_f^e / P_f - 1$ for flats, where P_f^e is the expectation of the flat price for the next period, formed in the current period.

iii. The purchase of property and the arrangement of mortgage credit involve transaction costs, which also include stamp duty. These expenses are typically incurred in the period that a home is traded. We assume that transaction costs are fully borne by the buyer of property, that they can be expressed as a fixed proportion κ of the purchase price, and that they require an additional downpayment with opportunity cost $i(1-\tau_{is})$ for starters.

iv. For notational and analytical convenience, we disregard property and capital gains taxes, as well as taxation of imputed rent.[3] The costs of maintenance and depreciation are also ignored.

v. The real cost of owning a flat is obtained by deflating the nominal cost, or P_f for that sake, by the (exogenous) consumer price index (excluding housing services), P_c. To save on notation and verbiage, the current value of this index is set to unity ($P_c = 1$).

Turning now to the demand for houses (i.e. larger dwellings), the simplifying assumption is made that the purchase of a house is only attainable for a settled flat owner having real (permanent) disposable income $\bar{y}_m > \bar{y}_s$, where $\bar{y}_m$ is exogenous.[4] Besides, the decision to move is based on the difference between the real user cost

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[2] Taking rents as an exogenous variable is motivated by the fact that a significant part of the rental sector is subject to government intervention (housing programmes, rent control etc.).

[3] The ways in which these taxes are levied differ strongly from country to country and are sometimes quite complicated. This is especially true of imputed rent taxes, which may be subject to ingenious indexation schemes (the Netherlands is a case in point).

[4] It is also assumed that homeowners do not move down the housing ladder.

involved in buying a house (also including transaction costs) and the real user cost of staying in a flat. The incremental effective interest burden faced by movers depends on their past borrowing behaviour, on current financial conditions (liquid asset holdings, interest rates etc.), and on the tax treatment of borrowing on collateral appreciation. Since each mover has his own housing history, a continuum of mover cohorts should be distinguished, at least in principle, with the classification of movers depending on the time period in which they bought their flats. While this would undeniably add a lot of realism to the model, it would also render the analysis quite intractable. We choose, therefore, to consider only two extreme scenarios. The *first scenario* is one in which movers – as former flat owners – have consistently cashed in capital gains on their properties by raising their mortgages up to the maximum loan-to-value ratio $(1 - \delta)$. Such behaviour is typically found in an environment where the effective yield of financial assets exceeds the effective mortgage interest rate, usually owing to a tax regime that is friendly to both mortgagees and households investing in financial assets (τ_{lm} high and τ_{im} low): $i_l(1 - \tau_{lm}) < i(1 - \tau_{im})$, where τ_{lm} is the effective rate of tax relief on mortgage interest payments faced by movers, and τ_{im} is the marginal tax rate on income from financial wealth faced by movers. Under the circumstances, the remaining borrowing capacity of movers is $(1 - \delta)(P_h - P_f)$, which is fully utilized, motivated by the same arbitrage condition. As a consequence, an amount of $\delta(P_h - P_f)$ has to be brought in as own funds, so that the incremental effective interest burden faced by movers is $\{(1 - \delta)i_l(1 - \tau_{lm}) + \delta i(1 - \tau_{im})\}(P_h - P_f) = \sigma_m(P_h - P_f)$. This expression is contained in eq. (8), next to terms representing transaction costs and the rate of expected future capital gains ($\varepsilon_h = P_h^e / P_h - 1$), consonant with assumptions (ii) and (iii) above.[5] In the *second scenario*, movers use the full surplus-value of their flats as downpayments, which are assumed to satisfy the minimum requirement (δP_h).[6] The remaining financing gap is closed by a new mortgage loan, which comes on top of the existing loan arranged earlier for the purchase of a flat.[7] Such behaviour is typically found in an environment where the effective mortgage interest rate exceeds the effective yield of financial assets: $i_l(1 - \tau_{lm}) > i(1 - \tau_{im})$. Under these circumstances, arbitrage is not paying, and the incremental effective interest burden faced by movers is simply $i_l(1 - \tau_{lm})(P_h - P_f)$, which is mathematically equivalent to setting $\delta = 0$ in eq. (10). In the remainder, the first scenario is taken as our starting point, and we come back to the second scenario only on occasion.

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[5] Again, property prices are deflated by $P_c = 1$.

[6] By implication, the amount of capital gains to be realized on flat sales must at least be equal to $\delta(1 - \delta)^{-1}(P_h - P_f)$.

[7] So, apart from the payment of transaction costs, movers in this scenario are assumed not to have accumulated (or to use) liquid asset holdings for the purchase of a house.

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Now, the complete basic model reads:

(1) $\quad S_f = D_h + N_f$

(2) $\quad S_h = N_h + \bar{S}_h$

(3) $\quad S_f = D_f$

(4) $\quad S_h = D_h$

(5) $\quad N_f = \alpha_0 + \alpha_1 P_f$

(6) $\quad N_h = \beta_0 + \beta_1 P_h$

(7) $\quad D_f = \varphi_0 + \varphi_1 \bar{y}_s - \varphi_2 \{(\rho_s - \varepsilon_f)P_f - \bar{R}\}$

(8) $\quad D_h = \psi_0 + \psi_1 \bar{y}_m - \psi_2 \{(\rho_m - \varepsilon_h)P_h - (\sigma_m - \varepsilon_f)P_f\}$

(9) $\quad \rho_s = (1-\delta)i_l(1-\tau_{ls}) + (\delta+\kappa)i(1-\tau_{is})$

(10) $\quad \rho_m = (1-\delta)i_l(1-\tau_{lm}) + (\delta+\kappa)i(1-\tau_{im})$

(11) $\quad \sigma_m = \rho_m - \kappa i(1-\tau_{im})$

Throughout, it is assumed that α_1 and β_1 are non-negative and that $\varphi_1, \varphi_2, \psi_1$ and ψ_2 are positive. Combining eqs. (1) to (8) gives for P_f and P_h:

(12) $\quad P_f = \big(\{\psi_2(\rho_m - \varepsilon_h) + \beta_1\}(\varphi_1 \bar{y}_s + \varphi_2 \bar{R} + \varphi_0' + \psi_0') - \beta_1(\psi_1 \bar{y}_m + \psi_0')\big)/v_1$

(13) $\quad P_h = \big(\psi_2(\sigma_m - \varepsilon_f)(\varphi_1 \bar{y}_s + \varphi_2 \bar{R} + \varphi_0' + \psi_0') + \{\varphi_2(\rho_s - \varepsilon_f) + \alpha_1\}(\psi_1 \bar{y}_m + \psi_0')\big)/v_1$

(14) $\quad \varphi_0' = \varphi_0 - \psi_0 - \alpha_0$

(15) $\quad \psi_0' = \psi_0 - \bar{S}_h - \beta_0$

(16) $\quad v_1 = \{\varphi_2(\rho_s - \varepsilon_f) + \alpha_1\}\{\psi_2(\rho_m - \varepsilon_h) + \beta_1\} + \psi_2(\sigma_m - \varepsilon_f)\beta_1$

We assume that all real user costs are positive: $\rho_s > \varepsilon_f$, $\rho_m > \varepsilon_h$, and $\sigma_m > \varepsilon_f$. This premise can be avoided by substituting the expected future rates of change in flat and house prices in eqs. (7) and (8) by their definitions ($\varepsilon_f = P_f^e/P_f - 1$ and $\varepsilon_h = P_h^e/P_h - 1$), and solving the resulting equations for P_f and P_h:

(17)
$$P_f = \psi_2(1+\rho_m)\{\varphi_1 \bar{y}_s + \varphi_2(P_f^e + \bar{R}) + \varphi_0' + \psi_0'\}/v_2$$
$$+ \beta_1\{\varphi_1 \bar{y}_s - \psi_1 \bar{y}_m + \varphi_2(P_f^e + \bar{R}) - \psi_2(P_h^e - P_f^e) + \varphi_0'\}/v_2$$

(18)
$$P_h = \psi_2(1+\sigma_m)\{\varphi_1 \bar{y}_s + \varphi_2(P_f^e + \bar{R}) + \varphi_0' + \psi_0'\}/v_2$$
$$+ \{\varphi_2(1+\rho_s) + \alpha_1\}\{\psi_1 \bar{y}_m + \psi_2(P_h^e - P_f^e) + \psi_0'\}/v_2$$

(19) $\quad v_2 = \{\varphi_2(1+\rho_s) + \alpha_1\}\{\psi_2(1+\rho_m) + \beta_1\} + \psi_2(1+\sigma_m)\beta_1$

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The relevance of either eqs. (12) and (13) or eqs. (17) and (18) depends on the way in which expectations about future flat and house prices are formed. In case of rational expectations, eqs. (17) and (18) should be used as a basis for further analysis. Below, it is assumed that the expected *rates of change* in flat and house prices (ε_f and ε_h) are constant in that they are not affected by shocks, unless stated otherwise. By implication, the expected price *levels* of flats and houses respond to any impulse x according to $\partial P_f^e / \partial x = (1 + \varepsilon_f) \partial P_f / \partial x$ and $\partial P_h^e / \partial x = (1 + \varepsilon_h) \partial P_h / \partial x$ respectively. This corresponds to a simple (call it naive) form of adaptive expectations, which suffices for the greater part of the analysis.

Some basic features of the model are worth mentioning before addressing issues of taxability and credit rationing. It is easily verified that a rise in real disposable income of starters not only raises the price of flats ($\partial P_f / \partial \overline{y}_s > 0$) but also the price of houses ($\partial P_h / \partial \overline{y}_s > 0$). The latter effect occurs because the induced increase in the price of flats creates a capital gain, which reduces the financing gap of (potential) movers. As a consequence, demand for houses and, hence, the price of houses rise. Through the same mechanism, an increase in the real rent raises both the price of flats ($\partial P_f / \partial \overline{R} > 0$) and the price of houses ($\partial P_h / \partial \overline{R} > 0$). A rise in real disposable income of movers, on the other hand, raises the price of houses ($\partial P_h / \partial \overline{y}_m > 0$) while reducing the price of flats ($\partial P_f / \partial \overline{y}_m < 0$) provided that $\beta_1 > 0$. In fact, the incomes of movers act as a wedge between flat and house prices. This implies that starter homes become more affordable by rising mover incomes (other things being equal). However, the prospects of moving for remaining flat owners (also including starters) at some future point in time deteriorate because of higher house prices and smaller capital gains generated by existing property. Under rational expectations, the gap between house and flat prices may even explode. This can be seen by solving eqs. (17) and (18) recursively, using the law of iterated expectations, and determining, then, $P_h - P_f$. For purposes of illustration, we ignore transaction costs ($\kappa = 0$) and confine ourselves to the case where the supply of houses is completely price-inelastic ($\beta_1 = 0$):[8]

$$(20) \quad P_h - P_f \Big|_{\kappa = \beta_1 = 0} = \frac{\psi_1}{\psi_2 (1 + \rho_m)} \left(\overline{y}_m + \frac{\overline{y}_{m+1}^e}{1 + \rho_m} + \frac{\overline{y}_{m+2}^e}{(1 + \rho_m)^2} + \dots \right) + \frac{\psi_0'}{\psi_2 \rho_m}$$

So, the gap between house and flat prices depends on the sum of actual and discounted expected future incomes of movers, with the effective interest rate faced by movers serving as the one-period discount rate. Now, assume that real disposable income of movers is expected to grow at a constant rate g_m over each future time period, so that eq. (20) becomes:

$$(21) \quad P_h - P_f \Big|_{\kappa = \beta_1 = 0} = \frac{\psi_1 \bar{y}_m}{\psi_2 (1 + \rho_m)} \left(1 + \frac{1 + g_m}{1 + \rho_m} + \frac{(1 + g_m)^2}{(1 + \rho_m)^2} + ... \right) + \frac{\psi_0'}{\psi_2 \rho_m}$$

This "fundamental" solution converges if the expected future growth rate of real disposable income is smaller than the effective interest rate faced by movers $(g_m < \rho_m)$. If this condition is not met, we are left with an explosive process.[9] It is readily apparent from eq. (10) that tax deductibility of mortgage interest payments for (prospective) house owners does no good here, as it brings nearer the violation of the convergence condition. As a corollary, tax deductibility for higher income groups can have a devastating impact on housing market dynamics when the economy suddenly moves to an expansion path entailing higher (expected) growth rates of mover incomes, especially in an environment of low interest rates. This may serve as a rationale for the recent abolition or curtailment of tax deductibility of mortgage interest payments in a number of European countries. In fact, such policies are a sound anticipation of the awaited "new economy".[10] Note also from eq. (10) that a relaxation of (binding) downpayment requirements ($\Delta \delta < 0$) may also break the aforementioned convergence condition and thereby destabilize price formation in the housing market. This is especially likely to occur under a tax regime that strongly encourages arbitrage between mortgage borrowing and financial investment.[11] We return to the effects of borrowing constraints in section 5.

3. Basic effects of tax deductibility of mortgage interest payments

Tax deductibility of mortgage interest payments is often claimed to stimulate owner-occupied housing. The present section examines whether our model supports this aim. A broadening of tax deductibility is associated with an increase in τ_{ls} or τ_{lm}. First,

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[9]   If $\beta_1 > 0$, convergence is more likely to occur. For the sake of argument, assume that $\varphi_2 = 0$. Then, it is easily verified that $g_m < \rho_m + \alpha_1 \beta_1 (\alpha_1 + \beta_1)^{-1} \psi_2^{-1}$ is the relevant condition.

[10]   One qualification is in order. Macroeconomic equilibrium may require that a permanent rise in productivity and real income growth be accompanied by a permanent increase in nominal interest rates at given inflation levels. Note, however, that this affects the housing market only mildly as long as mortgage interest payments remain tax deductible. So, the point remains valid, apart from extreme scenarios where $\Delta \rho_m \geq \Delta g_m$.

[11]   For, $\partial \rho_m / \partial \delta = i(1 - \tau_{im}) - i_l(1 - \tau_{lm})$, which is larger as τ_{im} is lower and as τ_{lm} is higher. If there are no arbitrage opportunities (scenario 2), $\partial \rho_m / \partial \delta = 0$.

consider the effects of an impulse in the deduction of mortgage interest paid by starters (τ_{ls}):

(22) $\partial P_f / \partial \tau_{ls} = \left(\varphi_2 \{ \psi_2 (\rho_m - \varepsilon_h) + \beta_1 \} (1-\delta) i_l P_f \right) / \nu_1 > 0$

(23) $\partial P_h / \partial \tau_{ls} = \varphi_2 \psi_2 (\rho_m - \varepsilon_f)(1-\delta) i_l P_f / \nu_1 > 0$

(24) $\partial D_f / \partial \tau_{ls} = \partial S_f / \partial \tau_{ls} = \alpha_1 \partial P_f / \partial \tau_{ls} + \beta_1 \partial P_h / \partial \tau_{ls} \geq 0$

(25) $\partial D_h / \partial \tau_{ls} = \partial S_h / \partial \tau_{ls} = \beta_1 \partial P_h / \partial \tau_{ls} \geq 0$

As it turns out, fiscal accommodation of starters raises the prices of flats and houses unambiguously. With elastic supply of houses $(\beta_1 > 0)$, the price of flats rises more than the price of houses, provided that the expected future rates of change in flat and house prices do not differ too much $(\varepsilon_h - \varepsilon_f < \beta_1)$. Also, flat owning is boosted more than house owning, unless the supply of newly built flats is completely price-inelastic $(\alpha_1 = 0)$. In this last case, flat owning is only stimulated to the extent that the induced rise in the price of flats motivates settled flat owners to move to a house (through larger realized capital gains). If neither flat builders nor house builders are responsive to price changes $(\alpha_1 = \beta_1 = 0)$, implicit tax subsidies are totally inefficient. In that case, only mortgagees and settled homeowners profit.[12] One could argue that the government may take accompanying measures aimed at shifting the supply schedules autonomously (i.e. raising α_0 or β_0). But while such policies are (highly) effective in isolation, tax deductibility would still be pointless under the circumstances.

The effects of an impulse in the deduction of mortgage interest paid by movers (τ_{lm}) are:

(26) $\partial P_f / \partial \tau_{lm} = -\psi_2 \beta_1 (1-\delta) i_l (P_h - P_f) / \nu_1 \leq 0$

(27) $\partial P_h / \partial \tau_{lm} = \psi_2 \{ \varphi_2 (\rho_s - \varepsilon_f) + \alpha_1 \} (1-\delta) i_l (P_h - P_f) / \nu_1 > 0$

(28) $\partial D_f / \partial \tau_{lm} = \partial S_f / \partial \tau_{lm} = \psi_2 \varphi_2 (\rho_s - \varepsilon_f) \beta_1 (1-\delta) i_l (P_h - P_f) / \nu_1 \geq 0$

(29) $\partial D_h / \partial \tau_{lm} = \partial S_h / \partial \tau_{lm} = \beta_1 \partial P_h / \partial \tau_{lm} \geq 0$

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[12] It remains to be seen, of course, to what extent this is also true in a general equilibrium context, as fiscal accommodation of home owning has to be covered by an increase in tax collections or through other budgetary means. This raises complicated issues of income redistribution, which are beyond the scope of this paper.

Granted that the price of houses exceeds the price of flats, fiscal accommodation of movers drives up the price of houses unambiguously. This incites additional new housing development, provided that $\beta_1 > 0$, which enables the number of movers to increase. As a result, more flats become available to starters, so that the price of flats must fall in order to restore equilibrium. From these effects, it follows that limiting the deductibility of mortgage interest paid by higher income groups (e.g. to the effective rate of tax relief faced by starters) would be detrimental for all income groups seeking to move up the housing ladder. However, as has been demonstrated at the end of the previous section, there may be circumstances in which such a policy would still be wise so as to prevent price explosions in the housing market.

4. Credit rationing

As discussed by LaFayette et al. (1995) and Linneman and Wachter (1989), typical borrowing constraints imposed by mortgagees on their clients take the form of either income or wealth constraints. The model presented in section 2 has already a wealth constraint, formulated as a downpayment requirement. In line with actual practice in a number of countries (e.g. Canada, the UK, the US and the Netherlands), the present section imposes an income constraint in addition, specifying that a starter's before-tax mortgage interest payments must not exceed some fixed proportion, q, of his current before-tax nominal income, $\overline{Y}_s$. It is assumed that this restriction is binding for all starters, so that:

(30) $(1 - \delta) i_l P_f^* = q \overline{Y}_s$

where $P_f^* \ (< P_f)$ is the market price of flats under credit rationing. Lafayette et al. (1995, pp. 1-2) rationalize constraints like eq. (30) as follows: *"Because lenders base borrowing capacity on observable/verifiable current income and wealth rather than total tangible wealth plus human capital, a household's demand for housing may be constrained by a borrowing limitation in addition to the usual budget constraint. This is most likely true in the case of a younger individual whose future earnings are often significantly greater than his or her current income and accumulated wealth."* On a macroeconomic level, eq. (30) implies that the price of flats is entirely determined by lending institutions, given i_l and $\overline{Y}_s$, and that some would-be starters are quantity-rationed in the market for flats $(D_f > S_f)$. Now, eq. (30) replaces the market-clearing condition for flats, eq. (3), and can be combined with the other model equations to obtain the effects of a broadening of tax deductibility under credit rationing:

(31) $\partial P_f^* / \partial \tau_{ls} = \partial P_h / \partial \tau_{ls} = \partial S_f / \partial \tau_{ls} = \partial D_h / \partial \tau_{ls} = \partial S_h / \partial \tau_{ls} = \partial P_f^* / \partial \tau_{lm} = \partial D_f / \partial \tau_{lm} = 0$

(32) $\partial D_f / \partial \tau_{ls} = \varphi_2 \, q \, \overline{Y}_s > 0$

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(33) $\quad \partial P_h / \partial \tau_{lm} = (1-\delta) i_l (P_h - P_f^*) / (\rho_m - \varepsilon_h + \beta_1 / \psi_2) > 0$

(34) $\quad \partial S_f / \partial \tau_{lm} = \partial D_h / \partial \tau_{lm} = \partial S_h / \partial \tau_{lm} = \beta_1 \partial P_h / \partial \tau_{lm} \geq 0$

At first sight, fiscal accommodation of starters seems to be quite efficient in that the demand for flats is boosted, while both the price of flats and the price of houses remain unchanged. The snag is, of course, that this extra demand is not met by extra supply, as the price of flats does not accomplish equilibrium anymore. By implication, the only result is an increase in the number of would-be starters for whom there are no flats. One obvious remedy is to stimulate new development of flats or houses through autonomous policies aimed at raising α_0, α_1, β_0 or β_1. However, while the desired effects of such measures are indisputable, tax deductibility for starters adds nothing as long as the income constraint imposed on mortgage applicants keeps the price of flats below its market-clearing level. In other words, if rationing of potential starters persists, there is no point in boosting the demand for flats, whether supply-oriented policies are pursued or not. It is interesting to note from eq. (34) that fiscal accommodation of movers rather than starters can be of help here, provided that $\beta_1 > 0$. The reason is that the demand for (additional) mortgage loans of movers is not income-constrained (by assumption). As a consequence, a broadening of tax deductibility for higher income groups induces more eligible flat owners to move to a house, thereby increasing the supply of flats. It follows that restricting tax deduction to an upper limit may thwart the promotion of owner-occupied housing. By the same token, a cut in stamp duty (i.e. a reduction in κ) can deliver what tax deductibility for starters cannot under the circumstances:

(35) $\quad -\partial P_f^* / \partial \kappa = 0$

(36) $\quad -\partial P_h / \partial \kappa = i (1 - \tau_{im}) P_h / (\rho_m - \varepsilon_h + \beta_1 / \psi_2) > 0$

(37) $\quad -\partial D_f / \partial \kappa = \varphi_2 i (1 - \tau_{is}) P_f^* > 0$

(38) $\quad -\partial S_f / \partial \kappa = -\partial D_h / \partial \kappa = -\partial S_h / \partial \kappa = -\beta_1 \partial P_h / \partial \kappa \geq 0$

So, while a cut in stamp duty stimulates the demand for flats (just as a rise in τ_{ls} does), it also creates additional supply of flats through an increase in the number of movers. Clearly, the latter effect is greater as the supply of newly built houses is more price-elastic (i.e. as β_1 is larger).

In the typical case that competition in the mortgage market is imperfect, lending institutions are likely to gain from fiscal accommodation of movers or from a reduction in stamp duty. This can be seen as follows. Assume that there are *n* identical profit maximizing mortgagees displaying Cournot-behaviour. Marginal funding costs, *i*, are

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taken as given, and we adopt a quadratic resource cost function $C_j = \frac{1}{2}\gamma L_j^2$, with L_j the amount of mortgage loans supplied by the individual intermediary ($j = 1, \ldots, n$). We ignore risk, which is not essential to the argument. In this setting, the equilibrium mortgage interest rate is given by:

$$(39) \qquad i_l = \frac{n\theta}{n\theta - 1}(i + \gamma L / n)$$

where L is aggregate demand for mortgage loans, and $\theta = -(\partial L / \partial i_l)(i_l / L) > 0$.[13] Under credit rationing, L equals:

$$(40) \qquad L = (1 - \delta)\{P_f^* S_f + (P_h - P_f^*)D_h\}$$

We assume, as an approximation, that θ is constant and greater than 1.[14] Now, the profit for an intermediary on (new) mortgage lending, Π_j, is defined by:

$$(41) \qquad \Pi_j = (i_l - i)L_j - \frac{1}{2}\gamma L_j^2 = (i_l - i)L / n - \frac{1}{2}\gamma (L/n)^2$$

Upon substituting eqs. (39) and (40) into eq. (41), and differentiating Π_j with respect to τ_{lm} and $-\kappa$ gives:

$$(42) \qquad \partial \Pi_j / \partial \tau_{lm} = \left(\frac{\{ni + \gamma L(n\theta + 1)\} i_l}{n^2 \theta \{ni + \gamma L(\theta + 1)\}} \right) \frac{(1 - \delta)^2 i_l (P_h - P_f^*)(D_h + \beta_1 P_h)}{\rho_m - \varepsilon_h + \beta_1 / \psi_2} > 0$$

$$(43) \qquad -\partial \Pi_j / \partial \kappa = \left(\frac{\{ni + \gamma L(n\theta + 1)\} i_l}{n^2 \theta \{ni + \gamma L(\theta + 1)\}} \right) \frac{(1 - \delta)i(1 - \tau_{im}) P_h (D_h + \beta_1 P_h)}{\rho_m - \varepsilon_h + \beta_1 / \psi_2} > 0$$

These are virtually windfall profits for the industry. Note that mortgagees still benefit in case the supply of newly built houses is completely price-inelastic ($\beta_1 = 0$). Clearly, financial intermediaries have good reason to be set against policies aimed at limiting the deductibility of mortgage interest payments.[15] Their only comfort would be an appreciation of the collateral underlying outstanding mortgage loans to flat owners:

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[13] For a similar representation of bank market structure, see VanHoose (1988).

[14] It can be shown that $\theta = 1$ if $\alpha_1 = \beta_1 = \delta = \varepsilon_f = \varepsilon_h = \kappa = 0$. On less stringent conditions, however, θ tends to exceed 1 (by far) and to vary with interest rates, tax parameters etc. Note from eq. (39) that the monopoly solution ($n = 1$) only exists for $\theta > 1$.

[15] In principle, the same goes for settled house owners. However, their direct losses could be mitigated by transitional tax arrangements (grandfathering etc.), which are generally of no use to lending institutions.

$$(44) \quad -\partial P_f^* / \partial \tau_{lm} = \left(\frac{\gamma P_f^*}{ni + \gamma L(\theta + 1)} \right) \frac{(1 - \delta)^2 i_l (P_h - P_f^*)(D_h + \beta_1 P_h)}{\rho_m - \varepsilon_h + \beta_1 / \psi_2} > 0$$

The practical significance of this effect should not be overrated, as it entirely hinges on the assumption of increasing marginal resource costs ($\gamma > 0$).

As for eqs. (42) and (43), two qualifications are in order. First, these results should be considered upper limits in that an increase in profitability may induce market entry ($\Delta n > 0$), at least in the long run. This would erode the (short-term) gains from tax deductibility at the firm level.[16] Second, the results would be different, although with the same signs, if movers were not constrained by downpayment requirements. This case was referred to as the *second scenario* in section 2, and we leave it to the reader to check that the qualitative conclusions are robust.

5. A further look at the maximum debt-service ratio

Lending institutions as a group may have a firm grip on the prices of owner-occupied dwellings through mortgage qualification constraints like eq. (30). This is quite evident from recent experiences in the Netherlands, where growth rates of both mortgage lending and house prices have sky-rocketed over the past ten years or so, owing to a substantial easing of debt-service requirements. As a result, and facilitated by relatively large implicit tax subsidies to homeowners, outstanding mortgage debt per inhabitant in the Netherlands is now the second highest in Europe, after Denmark. Whether or not this has helped starters a lot, remains to be seen.

In what follows, we take the mortgage interest rate as given, which comes to the same thing as neglecting marginal resource costs ($\gamma = 0$) in eq. (39). Note first, from eq. (30), that an increase in the maximum debt-service ratio (q) raises the price of flats and the interest burden of starters equiproportionally (other things being equal).[17] Hence, starters who would already have succeeded in finding a flat under the former (more stringent) borrowing constraint are definitely worse off (to the credit of mortgagees). On the other hand, the induced rise in the price of flats reduces demand rationing in the market for flats through three channels, labelled (a), (b) and (c):

$$(45) \quad \frac{\partial (D_f - S_f)}{\partial q} = -\left(\underbrace{\varphi_2 (\rho_s - \varepsilon_f)}_{(a)} + \underbrace{\alpha_1}_{(b)} + \underbrace{\frac{(\sigma_m - \varepsilon_f)\beta_1}{\rho_m - \varepsilon_h + \beta_1 / \psi_2}}_{(c)} \right) P_f^* / q < 0$$

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[16] Under perfect competition ($n \to \infty$), the effects contained in eqs. (42) and (43) naturally disappear.

[17] This is a direct consequence of the assumption that the mortgage qualification constraint is binding for all starters.

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Channel (a) is a discouragement effect, containing that some tenants are no longer motivated to buy a flat. Channel (b) relates to price-induced new development of flats. Channel (c) contains that more settled flat owners move to a house because of larger realized capital gains, provided that the induced rise in the price of houses stimulates new development of houses ($\beta_1 > 0$). If the supply of newly built flats and houses is completely price-inelastic ($\alpha_1 = \beta_1 = 0$), only the discouragement effect is left, which is certainly not conducive to the promotion of owner-occupied housing. So, as with the efficiency of implicit tax subsidies, the allocational effects of an increase in the maximum debt-service ratio depend crucially on the price-responsiveness of new housing development.

Although a sustained increase in the maximum debt-service ratio causes a permanent shock in housing prices, such a shift in lending policy cannot be held responsible for the occurrence of an explosive process. The proof is straightforward. With credit rationing, the solution for the price of houses under rational expectations is:

$$(46) \quad P_h = \frac{\psi_1 \bar{y}_m}{\psi_2(1+\rho_m)+\beta_1}\left(1+\frac{1+g_m}{1+\rho_m+\beta_1/\psi_2}+\frac{(1+g_m)^2}{(1+\rho_m+\beta_1/\psi_2)^2}+....\right)+\frac{\psi_2(\sigma_m-g_s)P_f^*+\psi_0'}{\psi_2\rho_m+\beta_1}$$

where g_m is the expected periodical rate of growth in real disposable income of movers (as defined in section 2), and g_s is the expected periodical rate of growth in nominal income of starters. For the solution of P_h to be stable, it is necessary and sufficient that:

$$(47) \quad g_m - \beta_1/\psi_2 < \rho_m = (1-\delta)\{i_l(1-\tau_{lm})-i(1-\tau_{im})\}+(1+\kappa)i(1-\tau_{im})$$

As long as this inequality holds (and credit rationing persists), any increase in q will cause a finite change in the price of houses:

$$(48) \quad \partial P_h/\partial q = \{(\sigma_m-g_s)/(\rho_m+\beta_1/\psi_2)\}P_f^*/q$$

This change can be either positive or negative, depending on the sign of $(\sigma_m - g_s)$.

Like in section 2, the convergence condition contained in eq. (47) may be violated by changes in fundamentals such as a rise in the expected growth rate of mover incomes or a fall in interest rates. The result would be a boom in house prices, which the policy maker might be able to stop by curtailing or abolishing tax deductibility for movers (i.e. by lowering τ_{lm}). Evidently, such an explosive process is more likely to emerge as β_1 is smaller (relative to ψ_2). It follows, again, that implicit tax subsidies to higher income groups and inelastic supply of newly built houses are a bad combination from a viewpoint of stable housing market dynamics. High loan-to-value ratios of movers ($1 - \delta$) also turn out to be potentially destabilizing, at least under a tax regime that incites

arbitrage between mortgage borrowing and financial investment: $i_l(1-\tau_{lm}) < i(1-\tau_{im})$.[18]
This corroborates in an extreme sense empirical findings by Lamont and Stein (1999), who report that house prices at the US city level respond stronger to shocks to per-capita income as there are more highly leveraged homeowners.

6. Housing supply in a selection of countries: an empirical digression

One of the main conclusions that can be drawn from the previous sections is that fiscal accommodation of homeownership does not have the desired effect if the supply of newly built dwellings is price-inelastic. The aim of this section is to supplement our theoretical analysis with empirical evidence on housing supply conditions in a heterogeneous group of countries, consisting of Denmark, France, Germany, the Netherlands, the UK and the US. To bring the results into perspective, table 1 summarizes some relevant features of these countries.

Table 1. Country-specific characteristics housing and mortgage markets

Country	Owner-occupancy rate (1999, %)	Tax deductibility of mortgage interest payments[a]	Taxation of imputed rental income[a]	Typical LTV new mortgages (2001, %)	House price volatility[b]
Denmark	51	Gradually limited	Gradually lifted	80	0.13
France	54	-	-	75	0.07
Germany	41	-	-	65	0.05
Netherlands	51	Full	Mild	100	0.23
UK	67	Gradually lifted	-	70	0.24
US	66	Full	-	78	0.14

[a] From the mid-1980s onward. Minor (changes in) regulations are left aside.
[b] House prices deflated by CPI; variation coefficient over 1970-1999.
Sources: European Mortgage Federation (1997), OECD (2001).

As revealed by column 1, homeownership is particularly widespread in the UK and the US. Columns 2 and 3 capture two principal characteristics of the fiscal treatment of homeowners, which is most favourable in the US (interest payments fully deductible, imputed rental income untaxed) and the Netherlands (interest payments fully deductible, imputed rental income taxed relatively mildly), followed at a distance by Denmark. Quite interestingly, LTV-ratios in these three countries are the highest in our sample. Also striking are the differences in house price volatility. Real property prices have

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[18]   In the alternative scenario (the second one in section 2), movers are not constrained by downpayment requirements, implying that $\delta = 0$ in eq. (47). So, in that case, the argument is no longer valid.

been most stable in France and Germany – both countries having no history of noticeable tax favouring of homeowners – and relatively volatile in the Netherlands and the UK. These last two countries experienced a boom in the late 1970s and the late 1980s respectively, in both cases followed by a sharp correction.

Empirical evidence on the price responsiveness of new housing supply is scarce, which is primarily due to measurement problems (see DiPasquale, 1999). The total housing stock is not a suitable supply indicator, as the bulk of dwellings are not on the market. This is not to deny that a significant part of new housing supply may come from the existing stock of houses as a result of property division or the sale of rented dwellings to households. However, since time series data on these sources are scarce or absent, we focus on new construction, measured by the number of building permits issued per time period.[19] The relationship explaining this variable is derived in appendix 1 from a small structural model of price-taking construction firms aiming at maximum profits:

$$(49) \log(perm)_t = a_0 + a_1 t + a_2 \log(price)_t + a_3 \log(wage)_t + a_4 \log(cap)_t + a_5 conf_t$$

We have estimated this equation using quarterly data covering a period of two to three decades on housing permits issued (*perm*), residential house prices (*price*), wage costs (*wage*), capital costs (*cap*), approximated by a weighted average of short-term and long-term interest rates, and producer confidence (*conf*).[20] The equation for Germany also includes a reunification dummy, which is unity from the first quarter of 1991 onward and zero before that date. Note that equation (49) is unlikely to suffer from simultaneity problems, as the time lag between the acquisition of a building permit and the completion of a new house is usually over a year, rendering the explanatory variables virtually exogenous vis-à-vis the dependent variable.

Following the strategy proposed by Dolado et al. (1990), we have applied Augmented Dickey-Fuller (ADF) tests for unit roots and found out that a number of series are not (trend-) stationary in levels. Table 2 summarizes the results. We have decided, therefore, to estimate eq. (49) for each country in first differences of the series (seasonally adjusted where relevant).[21] Apart from Germany, using OLS caused serious problems of autoregressive conditional heteroskedasticity in the residuals, as revealed by Engle's (1982) LM test. This led us to extend the regression model by (first- or second-order) ARCH and GARCH terms. Besides an attempt to obtain more efficient estimators of the parameters, the adoption of an ARCH model may also be warranted on economic grounds in our case. To a certain extent, the decision to build a house is a

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[19] Poterba (1984) uses residential investment in new houses; Topel and Rosen (1988) use total housing starts; Hakfoort and Matysiak (1997) use unsubsidized housing starts.

[20] Appendix 2 describes the data sources; *t* stands for the quarterly time period.

[21] Adding cointegration residuals (where appropriate) did not yield meaningful results. Somewhat unexpectedly, the ADF-test detected two unit roots in the series for the US wage rate. We have nevertheless treated the series as I(1), also because the Phillips-Perron test convincingly indicated so.

speculative one. It depends – partly or wholly – on expectations about future house prices and construction costs, both of which are notoriously uncertain, even over a one-year horizon. Relatedly, and perhaps more importantly, our dependent variable (i.e. permits issued) is an imprecise – or rather conditional – measure of new housing supply, as it merely represents the right to build a house, which may or may not be asserted. As such, it can be given the interpretation of a put option with unspecified exercise price and expiration date. Hence, there is a clear affinity with financial time series analysis, where ARCH models have become generally accepted.

Table 2. Number of unit roots per series (5% significance level)

Country	log (*perm*)	log (*price*)	log (*wage*)	log (*cap*)	*conf*
Denmark	1	1	1	0	1
France	0	1	0	0	1
Germany	1	1	0	1	1
Netherlands	0	0	0	-[a]	1
UK	0	1	0	1	0
US	0	0	2	1	0

[a] Dutch interest rates disregarded because of wrongly signed parameter estimates.

The estimation results thus obtained are recorded in table 3. As it turns out, the price elasticities of new construction differ widely across countries.[22] They are relatively large in France, Germany and the US, and quite small and insignificant in the Netherlands and the UK. Denmark is somewhere in between. As far as the European countries are concerned, the three having the smallest price elasticities experienced the highest volatility in house prices over the past 30 years (see the last column of table 1), which is consistent with the theoretical analysis in previous sections. Moreover, all these countries (used to) have tax-preferred treatment of homeowners. It follows that both Denmark and particularly the UK were right to run down tax deductibility of mortgage interest payments, thereby reducing the chances of price explosions in the market for owner-occupied housing. Dutch fiscal policy is inscrutable in this regard, as new construction in the Netherlands does not significantly react to changes in house prices, nor to any other market force. This clearly reflects that housing supply in the Netherlands is largely determined – if not repressed – by sweeping government intervention. On top of that, Dutch lending institutions have an itch for lending excessively to new homeowners, judging from the extreme LTV-ratio recorded in table 1, thereby further destabilizing price formation in the housing market. Things are different in the US, probably the country having the most favourable tax regime for mortgage borrowers: a comparatively large price elasticity of new construction, a

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[22] Estimated price elasticities of housing supply also differ widely across studies for a single country, depending on definitions and the econometric methodology used. Ours are on the lower side. See DiPasquale (1999) for a review of empirical work on the US.

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moderate LTV-ratio and – by consequence – modest volatility in house prices (although considerably higher than in France and Germany, which have no major tax-preferences). So, with the possible exception of the US, tax favouring of homeowners is (or was) found in countries where housing market conditions least warrant it.

Table 3. Estimated elasticities of new housing supply[a]

Country	price (c_2)	wage (c_3)	cap (c_4)	conf[b] (c_5)	Standard error of regression	Wald-test[c] on $c_2 = -c_3 - c_4$	Sample period
Denmark	0.66 (4.4)	-1.01 (0.8)	-0.14 (3.4)	0.003 (4.9)	0.16	0.69	1980:2-1999:4
France	1.09 (2.6)	-0.83 (2.7)	-0.23 (2.2)	0.004 (2.5)	0.07	0.93	1981:2-1998:3
Germany	2.05 (2.2)	-0.33 (0.7)	-0.23 (1.9)	0.005 (3.3)	0.08	0.10	1976:2-1999:4
Netherlands	0.30 (0.9)	-0.57 (1.3)	-[d]	0.004 (1.1)	0.15	0.60	1976:2-1998:3
UK	0.45 (1.3)	-0.50 (0.8)	-0.31 (3.4)	0.004 (3.5)	0.13	0.43	1976:2-1999:4
US	1.40 (3.5)	-1.87 (1.8)	-0.20 (2.0)	0.006 (3.7)	0.09	0.48	1970:2-1999:4

[a] Absolute z-statistics in brackets (t-statistics for Germany).
[b] Semi-elasticity.
[c] Probability-values associated with the relevant χ^2-statistic.
[d] Suppressed because of wrong sign.

7. Conclusions

The main results of the paper can be summarized as follows:
- At given user costs, property prices in different segments of the market for owner-occupied housing are primarily driven by real disposable incomes of both starters and movers. Rising starter incomes tend to raise house prices over the entire housing ladder, whereas mover incomes act as a wedge between the prices of starter homes and houses in the more expensive segment. Under rational expectations, this gap may even explode. Such an event is more likely to occur as higher income groups are allowed to deduct mortgage interest payments at a higher tax rate and as nominal interest rates are lower. High loan-to-value ratios turn out to be destabilizing as well, at least under a tax regime that incites arbitrage between mortgage borrowing and financial investment.
- The efficiency of implicit tax subsidies to homeowners depends crucially on the price responsiveness of newly built houses.

- Limiting the deductibility of mortgage interest paid by higher income groups would be detrimental for all income groups seeking to move up the housing ladder, although there may be circumstances in which such a policy would still be wise so as to prevent price explosions in the housing market.

- As long as (all) starters are credit-rationed by lending institutions through an income constraint, there is no point in boosting their demand by implicit tax subsidies. The reason is that such a constraint prevents the price of starter homes to react to changes in the real effective interest rate faced by starters. However, under the circumstances, a cut in stamp duty can deliver what tax deductibility for starters cannot.

- In the typical case that competition in the mortgage market is imperfect, lending institutions are likely to gain from fiscal accommodation of movers or from a reduction in stamp duty, also in case the supply of newly built houses is completely price-inelastic. It follows that mortgagees have good reason to be set against policies aimed at limiting the deductibility of mortgage interest payments.

- Consistent with the results of our theoretical model, we find that the volatility in the prices of owner-occupied housing in a heterogeneous group of countries can be traced back to (a combination of) price-inelastic supply of newly built dwellings, preferential tax treatment of homeowners and high LTV-ratios. Quite remarkably, our econometric analysis reveals that the price responsiveness of new construction is smallest in the countries which (used to) have material tax deductibility of mortgage interest payments, with the notable exception of the US. As far as the European countries are concerned, it follows that this instrument is hardly effective in stimulating homeownership. It would seem that the authorities in Denmark and the UK have come to realize that, given their recent efforts to run down mortgage interest deduction. Judging by our results, the Netherlands would have a strong case to follow that example.

We acknowledge that both the theoretical model and the empirical analysis in this paper are fairly simple. For example, time dynamics only appear in the formulation of forward-looking behaviour with respect to the formation of expectations about future property prices. In actual practice, adjustment costs and nominal rigidities may give rise to partial adjustment of housing volumes and prices, possibly leading to lengthy divergences between short-run and long-run solutions. Furthermore, a complete assessment of the welfare effects of tax deductibility would ideally require a general equilibrium analysis that goes far beyond the scope of our undertaking (see, e.g., Nakagami and Pereira, 1996). We have also ignored land, both in the theoretical model and in the empirical analysis. Since most supply of newly built dwellings entails demand for land, mortgage interest deduction may be (partly) capitalized in residential land prices. Finally, although we believe that this paper produces convincing evidence that the tax-preferred treatment of owner-occupied housing has not been very effective in a number of European countries, our framework does not indicate what is the best way (and the best moment) to abolish those tax advantages. Such a policy assessment would require – at the least – an explicit account of the effects on the financial position of settled homeowners, which sets quite an agenda for future analytical work. One thing

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is sure, though. If the public is taken by surprise under the very conditions that rendered the tax deduction inefficient (i.e. conducive to booming house prices), the downward correction in house prices is likely to be huge. This argues in favour of a gradual dismantlement, announced well in advance of its implementation.

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Appendix 1. A model of new construction

Construction firms are assumed to maximize (expected) profits, subject to a decreasing-returns-to-scale Cobb-Douglas production function, relating new development (N) to labour (A) and capital (K). Land is ignored because of lack of appropriate time series data. We assume that the market for new construction is perfectly competitive and that there is no monopsony in the factor markets. Hence, the (expected) prices of output (*price*) and the respective factor inputs (*wage* and *cap*) are given to the individual construction firm. These assumptions lead to the following optimization problem (time-subscripts are suppressed):

(A1) $\max\limits_{A,K} \; price \, N - wage \, A - cap \, K$

subject to

(A2) $N = e^{\lambda_0 + \lambda_1 t} A^{\lambda_2} K^{\lambda_3}$ $(\lambda_1, \lambda_2, \lambda_3 > 0 ; \; \lambda_2 + \lambda_3 < 1)$

From the first-order conditions, and after taking logs, it follows that:

(A3)
$$(1 - \lambda_2 - \lambda_3) \log(L) = \log(price) - (1 - \lambda_3) \log(wage) - \lambda_3 \log(cap)$$
$$+ \lambda_0 + \lambda_1 t + \lambda_3 \log(\lambda_3) + (1 - \lambda_3) \log(\lambda_2)$$

(A4)
$$(1 - \lambda_2 - \lambda_3) \log(K) = \log(price) - \lambda_2 \log(wage) - (1 - \lambda_2) \log(cap)$$
$$+ \lambda_0 + \lambda_1 t + \lambda_2 \log(\lambda_2) + (1 - \lambda_2) \log(\lambda_3)$$

Upon substituting eqs. (A3) and (A4) into the logarithmic version of eq. (A2) gives:

(A5) $\log(N) = a_0 + a_1 t + a_2 \log(price) + a_3 \log(wage) + a_4 \log(cap)$

where $a_0 = (1 - \lambda_2 - \lambda_3)^{-1} \{\lambda_0 + \lambda_2 \log(\lambda_2) + \lambda_3 \log(\lambda_3)\}; \; a_1 = (1 - \lambda_2 - \lambda_3)^{-1} \lambda_1 ;$

$a_2 = (1 - \lambda_2 - \lambda_3)^{-1} (\lambda_2 + \lambda_3); \; a_3 = -(1 - \lambda_2 - \lambda_3)^{-1} \lambda_2 ; \; a_4 = -(1 - \lambda_2 - \lambda_3)^{-1} \lambda_3.$

Eq. (A5) is a long-run supply equation. Deviations from this relation may occur due to short-run fluctuations in demand, at least to the extent that construction firms can and will absorb such shocks through variations in factor utilization. This aspect is captured by adding to eq. (A5) a suitable indicator of producer confidence (*conf*), having zero average:

(A6) $\log(N) = a_0 + a_1 t + a_2 \log(price) + a_3 \log(wage) + a_4 \log(cap) + a_5 \, conf$

Since our measures of new construction and input prices are fairly rough, and also because of uncertainty about the actual production technology used by construction firms (which also includes land as a production factor), we have not imposed in our estimations the theoretical restriction that $a_2 = -a_3 - a_4$. However, according to a Wald-test (recorded in table 3), the null hypothesis of this parameter restriction cannot be rejected at the 5% significance level for any country considered.

Appendix 2. Description of data sources

The data sources used for the estimation of eq. (49) are recorded below. The complete data set is available from the authors on request.

Country	Series	Source*
Denmark	Housing permits issued	OECD
	Residential house price	BIS
	Wage rate construction sector **	Datastream
	Capital costs (r_S) ***	IFS
	Producer confidence construction sector	EC
France	Housing permits issued	BIS
	Residential house price	BIS
	Wage rate construction sector	Datastream
	Capital costs ($0.1\,r_S + 0.9\,r_L$)	IFS
	Producer confidence construction sector	EC
Germany	Housing permits issued	BIS
	Residential house price	BIS
	Wage rate	Datastream
	Capital costs ($0.4\,r_S + 0.6\,r_L$)	IFS
	Producer confidence construction sector	EC
Netherlands	Housing permits issued	BIS
	Residential house price	BIS
	Wage rate construction sector **	IFS/Datastream
	Producer confidence construction sector	EC
U.K.	Housing permits issued	Datastream
	Residential house price	BIS
	Wage rate	IFS
	Capital costs ($0.6\,r_S + 0.4\,r_L$)	IFS
	Producer confidence	EC
U.S.	Housing permits issued	BIS
	Residential house price	BIS
	Wage rate	Bureau of Labor Statistics
	Capital costs ($0.2\,r_S + 0.8\,r_L$)	IFS
	Producer confidence	Institute for Supply Management

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*   BIS = Bank for International Settlements Database
       EC = European Commission
       IFS = IMF International Financial Statistics
**   Approximated on the basis of various series taken from the sources mentioned.
*** r_S = money market interest rate; r_L = capital market interest rate. The weights have been chosen such that the log likelihood is maximized.