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# Exploring mortgage interest deduction reforms: An equilibrium sorting model with endogenous tenure choice

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ABSTRACT

In most equilibrium sorting models (ESMs) of residential choice across neighborhoods, the question of whether households rent or buy their home is either ignored or else tenure status is treated as exogenous. Of course, tenure status is not exogenous and households' tenure choices may have important public policy implications, particularly since higher levels of homeownership have been shown to correlate strongly with various indicators of improved neighborhood quality. Indeed, numerous policies including that of mortgage interest deduction (MID) have been implemented with the express purpose of promoting homeownership. This paper presents an ESM with simultaneous rental and purchase markets in which tenure choice is endogenized and neighborhood quality is partly determined by neighborhood composition. The public policy relevance of the model is shown through a calibration exercise for Boston, Massachusetts, which explores the impacts of various reforms to the MID policy. The simulations confirm some of the arguments made about reforming MID but also demonstrate how the complex patterns of behavioral change induced by policy reform can lead to unanticipated effects. The results suggest that it may be possible to reform MID while maintaining the prevailing rates of homeownership and reducing the federal budget deficit.

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## 1. Introduction

> *"The benefits of homeownership for families, communities and the nation are profound."* — Elizabeth Dole, former United States Senator, Housing and Urban Development hearing, 2003.

The promotion of homeownership has been a widespread and long-term focus of public policy (Andrews and Sanchez, 2011). Support for such policies derives both from political ideology and from a belief that homeownership delivers positive spillovers. Homeowners, it is argued, have greater incentives to invest in the physical and social capital of their communities, thus providing private and public benefits. There is a substantial body of empirical evidence that lends credence to this view. Homeownership is strongly correlated with property condition and maintenance (Galster, 1983), neighborhood stability (Dietz and Haurin, 2003; Rohe and Stewart, 1996), child attainment (Bramley and Karley, 2007; Green and White, 1997; Haurin et al., 2002), citizenship (DiPasquale and Kahn, 1999) and lower crime rates (Glaeser and Sacerdote, 1996; Sampson and Raudenbush, 1997).[1]

A wide variety of policy measures have been implemented to promote homeownership. Attempts have been made to encourage the supply of mortgage lending; for example, in the U.S. through the establishment of Government Sponsored Entities providing liquidity and security for mortgage lenders. Policies have also been implemented to encourage particular groups into homeownership; for example, in the U.K. through the Right to Buy scheme for social housing tenants and more recently the Help to Buy schemes for equity loans, mortgage guarantees and new buyers (NewBuy). Homeownership has also been promoted through the tax system e.g. through exemptions from capital gains tax on property sales and mortgage interest deduction (MID). MID, the focus of this paper, allows taxpayers to subtract interest paid on a residential mortgage from their taxable income.

MID is present in the tax laws of many countries including the U.S., Belgium, Ireland, the Netherlands, Switzerland and Sweden and was previously offered in the U.K. and Canada. It was introduced in the U.S. in 1913 when the homeownership rate was 45.9%. Under MID and numerous other initiatives, homeownership rose after the Second World War reaching a peak of 69% in 2004[2]. Currently, MID constitutes the second largest US tax expenditure[3] with the cost estimated to be some $104.5 billion dollars in foregone tax revenue in 2011 (Office of Management and Budget, 2011).

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[1] Of course, correlation is not causality. Doubts remain as to whether there is a direct causal link between homeownership and the observed positive spillovers or whether households who choose to own their homes are also more inclined to pro-social behavior.

[2] Source: U.S. Census Bureau.

[3] The largest being the exclusion of employer contributions for medical insurance and medical care.

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In the context of a large US fiscal deficit, MID has come under increased scrutiny. It has been argued that rather than encouraging homeownership the tax subsidy is simply capitalized into property values making properties no more and potentially less affordable than without the policy (Glaeser and Shapiro, 2002; Hilber and Turner, 2010). Furthermore, critics contend that MID most greatly benefits high-income taxpayers who would likely be homeowners irrespective of the tax incentives (Shapiro and Glaeser, 2003). Certainly higher income households are more likely to own their homes, hold larger mortgages and itemize mortgage interest payments on their tax returns (Poterba and Sinai, 2008). Of course, courtesy of their higher incomes, they also itemize at a higher rate (Glaeser and Shapiro, 2002). As a result, in 2004 the government paid an average $5459 in MIDs to households earning over $250,000 compared to $91 for households earning below $40,000 (Poterba and Sinai, 2008).

In the face of strong opposition, particularly on the part of financial services interests and housing lobbyists, repeated efforts to reform MID in the U.S. have borne little fruit Ventry (2010)[4]. Over the last three budget cycles the U.S. administration proposed reforms to MID, but on each occasion those initiatives have failed to pass into law. The key element of those proposals was to limit MID for households paying the top marginal rates of income tax. Other proposals for reform include; replacing MID with a system of tax credits (Dreier, 1997; Follain et al., 1993; Green and Vandell, 1999), scrapping MID in order to fund cuts in federal income taxes (Stansel, 2011) and replacing MID with a fiscal incentive open only to first time buyers (Gale et al., 2007).

The debate is fueled by a lack of clarity with regard to how such reforms will play out. Clearly, eliminating the MID will increase the cost of borrowing for the purposes of buying property and, *ceteris paribus*, cause demand for owned properties to fall. This reasoning underpins the National Association of Realtors claim that "eliminating the MID will lower the homeownership rate in the U.S."[5]. Of course, it is recognized that the impact of eliminating the MID also depends on supply conditions in the property market. The extent to which falling demand translates into reductions in homeownership as opposed to falling prices depends on the price elasticity of housing supply. Bourassa and Yin (2008) estimate that for some groups the negative effect of losing MID may be more than outweighed by the positive effect of falling property prices; homeownership amongst such groups could actually rise as a result of eliminating the MID.

What is less widely recognized is that changing market conditions in the property market will have ramifications in the closely associated rental market. Falling demand for homeownership can translate into rising demand for rental housing. More complex still is the interplay between homeownership and the desirability of residential locations. Since residential location choice is endogenous to the problem, eliminating MID may not only encourage the movement of individuals between ownership and rental but also the migration of households between neighborhoods.

While numerous attempts have been made to identify the impacts of eliminating the MID (e.g. Bourassa and Yin, 2008; Hilber and Turner, 2010; Toder, 2010) those studies have been based on a partial characterization of the problem. This paper develops a model that more completely describes the complex adjustments in spatially defined and interrelated property markets and uses that model to explore some of the possible ramifications of MID reform.

The model developed in this paper is an equilibrium sorting model (ESM) (Kuminoff et al., 2010). ESMs provide a framework within which it is possible to examine how households choose their residential location from a set of discrete neighborhoods. As reviewed in Section 2, ESMs have been developed to examine a number of economic issues relating to choice of residential location. As far as we are aware, however, our model is the first ESM to simultaneously model purchase and rental markets while endogenizing tenure choice. In Section 3 the innovations of the model are outlined in detail; particularly the specification of a neighborhood level of public good provision whose value depends, in part, on endogenous levels of homeownership and the development of an adjustment process to policy reform that accommodates capital gains.

To elucidate the pathways of adjustment that MID reform may initiate in property markets, Section 4 presents a simple two-jurisdiction calibration of the model based on the 2000 census data for Boston, Massachusetts. The calibrated model is used to simulate four different MID reform proposals; capping MID at a rate of 28%, replacing MID with refundable tax credits, scrapping MID and reducing income taxes and replacing MID with a lump sum payment to new owners. The simulations allow us to examine several important questions with regard to MID reform. In particular, to explore how reforms may impact property prices, levels of homeownership, the distribution of welfare across income groups and the mixing of income groups within and across jurisdictions.

Our analysis suggests that, contrary to existing claims, with the right policy design it may be possible to reform MID while maintaining the prevailing rates of homeownership, increasing public goods provision and contributing to a reduction in the federal deficit.

## 2. Equilibrium sorting models

In essence, equilibrium sorting models (ESMs) provide a stylized representation of the interactions of households, landlords and government within a property market. Originally developed to explain observed patterns of socio-economic stratification and segmentation in urban areas (e.g. Ellickson, 1971; Epple and Romer, 1991; Oates, 1969; Schelling, 1969; Tiebout, 1956), ESMs provide a formal account of the process whereby heterogeneous households sort themselves across the set of neighborhoods within a property market.

Neighborhoods, it is assumed, differ in quality according to the level of public goods each provides. Those public goods may reflect purely physical attributes of a location (for example, a neighborhood's proximity to commercial centers) or the levels of provision of local amenities (for example, the quality of local schools). An important distinguishing feature of ESMs is in allowing local amenity provision to be shaped by endogenous *peer effects*; that is to say, by the characteristics of the set of households that choose to locate in a neighborhood. Epple and Platt (1998), for example, present a model in which local taxes and lump sum payments are determined by the voting preferences of the residents in a neighborhood; these computationally complex models often have no closed form solution and are instead solved using numerical computation. Similarly, Ferreyra (2007) and Nesheim (2002), present models in which school quality is related to measures of the average income of households in a locality.

In an ESM, the mapping of households to quality-differentiated neighborhoods is mediated through property prices. Indeed, a solution to an ESM is taken to be a set of property prices that support a Nash equilibrium allocation of households to neighborhoods such that the supply and demand for properties are equated in all neighborhoods. While some simple ESMs have closed form solutions equilibria for more complex models, particularly those including endogenous neighborhood quality, are usually calculated using techniques of numerical simulation (Bayer et al., 2004; Ferreyra, 2007).

Over the last decade ESMs have increased in popularity and complexity. Recent modeling extensions allow for moving costs (Bayer et al., 2009; Ferreira, 2010; Kuminoff, 2009), overlapping generations (Epple et al., 2010) and simultaneous decisions in a parallel labor market (Kuminoff, 2010). In addition, the ESM framework has been used to explore empirical data on the distribution of households and property prices in order to derive estimates of the value air pollution (Smith et al., 2004), school quality (Bayer et al., 2004; Fernandez and

[4] In March 2011 Moe Veissi, the president elect of the NRA, launched a call for action to Preserve, Protect and Defend the Mortgage Interest Deduction http://www.realtor.org/governmentaffairs/mortgage interest deduction.

[5] Statement by NAR Chief Economist Lawrence Yun at the "Rethinking the Mortgage Interest Deduction" forum, Tax Policy Center, Washington, July 29, 2011.

Rogerson, 1998) and the provision of open space (Walsh, 2007). ESMs have also been used to explore policy issues such as school voucher schemes (Ferreyra, 2007), open space conservation (Klaiber and Phaneuf, 2010; Klaiber, 2009; Walsh, 2007) and hazardous waste site clean ups (Smith and Klaiber, 2009). A comprehensive review can be found in Kuminoff et al. (2010).

One area that has received relatively little attention in the ESM literature is that of tenure. Indeed, the vast majority of ESM applications make the assumption that households rent their properties from absentee landlords. Where different tenure statuses have been considered, those applications have treated tenure status as a fixed characteristic rather than a choice variable (Bayer et al., 2004; Epple and Platt, 1998). In reality, of course, households choose from a number of tenure options, with the key distinction being between ownership and renting. The joint decision of tenure and housing consumption has been examined in the real estate literature. For example, King (1980) estimated preferences for the UK housing market developing an econometric model of joint tenure and housing demand. Similarly, Henderson and Ioannides (1986) consider joint housing decisions in the US and Elder and Zumpano (1991) developed a simultaneous equations model of housing and tenure demand. For a number of issues, such as the reform of MID policy, the choice of tenure is the central consideration of the policy debate.

Accordingly, one of the key contributions of this paper is to describe an ESM in which tenure choice is endogenized. In our model, household choices whether to rent or purchase property are a function of market conditions, including the endogenous provision of local public goods. When policy reforms result in price changes in the property market, homeowners and renters are affected differently. In particular, homeowners will be impacted by capital gains (or losses) that are not experienced by renters. The modeling framework developed in the next section outlines a method for incorporating such distinctions.

## 3. The model

### 3.1. The economy

Consider a closed spatial economy consisting of a continuum of households. The model is closed insomuch as households may not migrate in or out of the economy. Households differ in their incomes, $y$. They also differ in terms of their preferences over the amount of housing they consume, $\beta$, and the value they attach to owning a property, $\boldsymbol{\theta}$. Ownership preferences represent the private returns to homeownership that are not realized when renting. Such private returns are motivated by numerous considerations including i) freedom to modify housing, ii) satisfaction from homeownership status and iii) anticipated financial returns from capital gains. The distribution of household types in the population is defined by the joint multivariate density function $f(y, \beta, \boldsymbol{\theta})$.

The economy is divided into a set of spatially discrete neighborhoods, $j = 1, \ldots, J$. In our model, each neighborhood is assumed to have its own local government. As such, we refer to these areas as jurisdictions. Each jurisdiction is characterized by a vector of local public goods, $g_j = \{z_{j,1} \ldots, z_{j,U}, q_{j,1}, \ldots, q_{j,V}\}$, comprising $U$ exogenous elements, $z_{j,u}$, and $V$ endogenous elements, $q_{j,v}$. The level of provision of endogenous elements is determined by the composition of the set of households that choose to reside within a jurisdiction. The provision of public goods is assumed to be homogenous within a jurisdiction.

### 3.2. The demand side

To reside in jurisdiction $j$ household $i$ must buy housing there. The decision to rent, $R$, or own, $O$, housing is referred to as tenure choice. We describe the set of tenure options as $T = \{R, O\}$ Accordingly, our model is characterized by households choosing to participate in one of a number of property markets each defined by a jurisdiction and tenure bundle, $\{j, t\}$.

Households also choose a quantity of housing; a decision approximating real life choices over the size and quality of home to buy or rent.[6] Housing is defined as a homogenous good that can be owned or rented from absentee landlords at a constant per unit cost, $p_j$, within a jurisdiction[7] (Epple and Romer, 1991; Epple and Sieg, 1998; Epple and Platt, 1998; Bayer et al., 2004; Ferreyra, 2007).

The quantity of housing demanded by a household in market $\{j, t\}$ is denoted $h_{j,t} = h(p, g, \tau_p; y, \beta, \boldsymbol{\theta}, m, \delta)$. The two arguments in that function yet to be explained ($m$ and $\delta$) concern the borrowing a household must assume in order to purchase a property. In particular, to become a homeowner a household must take out a mortgage[8] and pay mortgage interest, $m$, to the lender. Mortgage interest is paid only on the amount borrowed, where that borrowing is determined by the value of the housing purchased, $p_j h j_{,t}$ multiplied by a loan-to-value ratio, $\delta_i$. Differences in $\delta_i$ can be interpreted as representing the varying abilities of households to make a down payment. Property taxes $\tau_p$ are paid on both rented and purchased housing.

Homeowners are permitted to itemize mortgage interest costs and property taxes; that is, to deduct these costs from their taxable income. Since the marginal rate of tax increases with income, the implicit subsidy of itemization also increases with household income. However, not all households choose to itemize. We use the variable *item* to denote whether a household itemizes. Empirically itemization rates are higher amongst high-income households. To account for this the model includes the probability that a household itemizes, which is expressed as a function of household income,

$$Prob(item = 1) = \Psi(y) \tag{1}$$

where $\Psi(\cdot)$ denotes a cumulative distribution function and,

$$item = \begin{cases} 1 & \text{if a household itemizes} \\ 0 & \text{otherwise} \end{cases}$$

Accordingly, the implicit subsidy a household, $i$, receives by itemizing mortgage interest and property tax payments on their tax return, $MID(p, h, \tau_p, y, m, \delta)$, is endogenous to the household's decision and depends upon the purchase price of property (not including tax), $p$, the quantity of housing demanded, $h$, the property tax rate, $\tau_p$, and household income, $y$ (which in our model also determines the loan-to-value ratio, $\delta$, and the probability that a household itemizes).

Aggregate demand for housing in market $\{j, t\}$ is calculated by integrating across households,

$$H^D_{j,t} = \iiint h_{j,t}\left(p,\ g,\ \tau_p;\ y,\ \beta,\ \boldsymbol{\theta}, m, \delta\right) f(y, \beta,\ \boldsymbol{\theta}) dy\, d\beta\, d\boldsymbol{\theta} \tag{2}$$

### 3.3. The supply side

Housing supply is determined by property prices. Housing supply may differ between jurisdictions due to factors such as zoning restrictions and available land. To account for this possibility the housing supply function for a particular market $j$ is denoted,

$$H^S_j = H^s_j\left(p_j\right). \tag{3}$$

[6] This simplification is made at the cost of assuming, somewhat unrealistically, that housing is continuously divisible and can be reconfigured without cost.

[7] In reality housing is not homogenous, however, as Sieg et al. (2002) illustrated, if housing enters the utility function through a sub-function that is homogenous degree one, it is possible to construct a "housing quantity" index tantamount to an empirical analog to the homogenous housing unit, $h$.

[8] For simplicity, the model assumes that all households must take out a mortgage. In our simulations the mortgage interest rate is fixed and the loan-to-value ratio is a function of household income.

### 3.4. Government

Government operates at two levels, federal and local, serving the dual roles of redistributing income and providing local public goods. The federal government raises revenue through income taxes, charged at a series of marginal rates, $\boldsymbol{\tau_y}$, which are an increasing function of taxable income. The tax paid by a household is $tax_y = tax_y(y - MID, \boldsymbol{\tau_y})$. The total federal tax revenue is,

$$T_y = \iiint tax_y\left(y - MID, \boldsymbol{\tau_y}\right) f(y, \beta, \boldsymbol{\theta}) dy\, d\beta\, d\boldsymbol{\theta} \tag{4}$$

Federal tax revenues can be used to finance the provision of public goods or to implicitly fund MID. The revenue foregone to MID is equal to the integral of the MID payments across all households:

$$TMID = \iiint MID\left(p, h, \tau_p, y, m, \delta\right) f(y, \beta, \boldsymbol{\theta}) dy\, d\beta\, d\boldsymbol{\theta}. \tag{5}$$

It is assumed that the federal expenditure on local public good provision is organized so as to allocate an equal amount of revenue per household:

$$E_j^F = S_j T_y \tag{6}$$

where $S_j$ is the share of the population locating in jurisdiction $j$.

Local governments raise revenue through proportional property taxes, $\tau_p$,[9] which are levied on the value of property. As such, the total property tax revenue of jurisdiction $j$ is,

$$T_{p,j} = \tau_p p_j H_j^D. \tag{7}$$

Local tax revenues increase as property prices increase, holding aggregate housing demand fixed, and as aggregate demand increases holding prices fixed. Local tax revenues are used to finance expenditure on public goods.

$$E_j^L = T_{p,j} \tag{8}$$

Total expenditure on local public good provision, therefore, is equal to the sum of federal and local expenditure:

$$E_j = E_j^F + E_j^L. \tag{9}$$

### 3.5. Local public goods

Households derive utility from the combined provision of local public goods, represented by the index,

$$g_j = \Sigma_{k=1}^{U} \gamma_k z_{j,k} + \Sigma_{k=1}^{V} \gamma_k q_{j,k} \tag{10}$$

where $\gamma_k$ is the weight placed on the $k$th element in $g$. For simplicity we consider the case where $g_j$ consists of only one exogenous, $z$, and one endogenous, $q$, public good:

$$g_j = z_j + \gamma q_j \tag{11}$$

where $\gamma$ is the weight that households place on $q$ relative to $z$ and is uniform across households and jurisdictions. Our specification implies, therefore, that households agree on the ranking of jurisdictions in terms of the level of their provision of local public goods.

Endogenous public good provision within a jurisdiction is an increasing function of three inputs; government expenditure, $E_j$, the homeownership rate, $\rho_j$, and other characteristics of the community of households in that jurisdiction, $x_j$, such that,

$$q_j = q\left(E_j, \rho_j, x_j\right) \tag{12}$$

$$\frac{dq_j}{dE_j} \geq 0, \frac{dq_j}{d\rho_j} \geq 0 \text{ and } \frac{dq_j}{dx_j} \geq 0. \tag{12b}$$

Notice that our specification assumes that public good provision is increasing in the homeownership rate: a relationship that might imply homeownership has a direct effect on local public good provision or that homeownership simply proxies for unobserved inputs that themselves have a direct effect. The presence of $x_j$ in the public good production function defines a peer effect whereby community characteristics, perhaps median household income, affect the provision of public goods. Such peer effects have considerable empirical support (Nechyba, 2003) and have been incorporated in a number of existing ESM specifications (Nesheim, 2002; Ferreyra, 2007).

### 3.6. The household optimization problem

Households derive utility from local public goods, $g$, consumption of housing, $h$, and other consumption, $c$. Preferences for local public goods are determined by parameter $\alpha$, which is assumed to be constant across households. Meanwhile, housing quantity preferences are determined by parameter $\beta$, which is assumed to vary across households.

Our model also allows for the fact that households can derive more utility from housing when they own their home than when they rent it (or vice versa). Each household is characterized by values for the preference parameter set $\boldsymbol{\theta}$, which scales the utility derived from housing in the utility function for home owning.

Household utility is defined by the function,

$$U_{j,t} = U(h, t, c; y, \alpha, \beta, \boldsymbol{\theta}, g) \tag{13}$$

The household optimization problem can be decomposed into two stages. First, a household calculates its optimal housing and consumption choices for each market. The conditional maximization problem is,

$$\max_{h,c|j,t} U(h, t, c; y, \alpha, \beta, \boldsymbol{\theta}, g) \tag{14}$$

s.t.

$$y = \begin{cases} \tau_y + \left(1 + \tau_p\right) p_j h_j + c & t = R \\ \tau_y + \left(1 + \tau_p + m\delta\right) p_j h_j + c & t = O \end{cases}.$$

Notice that the model expresses the decision-relevant information in the form of yearly costs and benefits. Hence the objective function should be interpreted as an annual utility function and the constraints express the annual costs associated with either renting or owning. The optimization problem yields the following conditional indirect utility functions,

$$V_{j,t} = \begin{cases} V\left(p, g, \tau_p; y, \alpha, \beta\right) & t = R \\ V\left(p, g, \tau_p; y, \alpha, \beta, \boldsymbol{\theta}\right) & t = O \end{cases} \quad (j = 1, 2, \ldots, J). \tag{15}$$

Finally, households select the jurisdiction and tenure combination that maximizes their level of utility.

[9] Our model considers exogenous tax rates, the extension to endogenous rates, for example through a majority vote, would be an interesting avenue for future research (interested readers are directed to Epple and Romer, 1991; Epple and Platt, 1998 for previous ESMs with endogenous tax rates).

### 3.7. Equilibrium

An equilibrium of the model is defined by a one to one correspondence of households to the set of jurisdictions and tenure choices, and an associated house price (not including taxes), $p = \{p_1,..., p_J\}$, and property tax rate, $\tau_p$, for each jurisdiction, such that:

1. Each household resides in the jurisdiction and tenure that maximizes utility given the equilibrium vector of prices and endogenous public good provision.
2. All housing markets clear, $H_j^D = H_j^S, \forall j$.
3. All local government budgets balance, $E_j^L = T_{p,j}, \forall j$.
4. Federal government spending is equal to the tax revenue paid to the government, $T_y = \Sigma_{j=1}^J E_j^F$.
5. There is a perfectly elastic supply of mortgage loans.

### 3.8. Simulating responses to exogenous policy change

In reality policy changes occur in a world in which households already rent or own existing properties. That reality influences the outcome of a policy change in at least two ways. First, changes take place in the context of an existing housing stock whose quantity and location has been determined by households' initial choices. Second, a household's current tenure status determines whether their choices following the policy change are influenced by capital gains.[10] To see that more clearly, it is instructive to briefly contemplate how market changes impact differently on renters and owners.

Consider a change that leads to increased house prices. When prices go up existing renters are unable to afford their current consumption bundle. Households can respond in a number of different ways. They can alter their tenure choice, they can move to another location where property prices are lower or they can reduce their demand for housing and consumption. Indeed, they could do any combination of these. In contrast, owning a property prevents rises in prices from making the current consumption bundle unaffordable; homeowners are shielded against price increases. Instead, a rise in prices presents homeowners with the opportunity to sell-up and use the capital gains to increase consumption or relocate to a jurisdiction that provides more desirable public goods.

To simulate the process of adjustment in the property market within the context of what is essentially a static model requires some careful consideration. We first assume that the market is in a state of long-term equilibrium, an equilibrium achieved under the baseline policy. Households have optimally chosen where to live, whether to rent or own and how much housing to consume. To reflect that state of the world, we imagine a property market in which all the housing units demanded under that baseline policy have been constructed and that these existing housing units cannot be demolished in the face of a policy change (though they can be repackaged and new units may be constructed).

The policy change is introduced to this world at a point after homeowners have paid for their current properties at the pre-change prices but before rent has changed hands, consumption goods have been bought and taxes and mortgage interest have been paid. As a result of the policy change, households reconsider their choices of housing quantity, location and tenure status and the model is solved for the set of property prices that bring the market back to equilibrium under the changed conditions. For, households that were previously renting, things are relatively simple: they either buy or rent at the prices determined by the new equilibrium. In contrast, having bought at the prices characterizing the old equilibrium, households that previously owned must make their new housing decisions in light of the fact that the new price conditions may present them with capital gains or losses.

## 4. Simulating MID reforms

The model developed above provides a rich environment in which to explore the general equilibrium consequences of reforming MID policy. Within that environment the impact on government expenditure, patterns of community composition, homeownership rates and the levels and distribution of household welfare can be considered simultaneously. To undertake this exercise it is preferable to examine a model that replicates the real world. Such a model requires reasonable but tractable functional forms that can be calibrated to produce a model resembling a real world property market. Following the convention of Epple and Platt (1998) we specifically model Boston, using updated data for 2000. To provide a clear and accessible illustration of the pathways of change that operate in light of a policy reform it is prudent to consider a simple two-jurisdiction version of the model. While it is eminently possible to investigate problems with many more jurisdictions, this simplification enables us to most clearly characterize the chain of reactions that occur within property markets in response to policies that reform MID. The model is coded in Matlab[11] and uses simulation and iterative numerical techniques to solve for market clearing prices and provision of endogenous public goods (Lagarias et al., 1998)[12].

### 4.1. The proposed policy reforms

The current debate regarding reform of MID policy is motivated in part by the large U.S. deficit. Indeed, as part of plans to reduce that deficit, President Obama submitted federal budget proposals in 2011, 2012 and 2013 that advised capping itemized deductions, including MID, at 28%. Each time Congress has rejected the recommended tax reforms. All the same, we take the proposal of capping MID at 28% as our first potential policy reform. To be clear, under the current tax system homeowners are permitted to deduct mortgage interest and property tax payments from their taxable income when calculating their income tax bill. Those in the top three income tax brackets, therefore, are entitled to an implicit rebate on those expenditures at their marginal tax rates of 31%, 36% and 39.6% respectively. The cap limits that implicit rebate to 28%.

Three alternative MID-reform policies are also considered: a refundable flat-rate tax credit; an income tax reduction; and a New Owner Scheme. To compare the various proposed policies, we make the assumption that the central motivation for reform to the MID is reduction of the budget deficit. Accordingly, we calculate the reduction in deficit brought about by our baseline reform of a 28% cap on MID. The three alternative MID-reform policies are tailored to ensure that they facilitate the same reduction in the budget deficit as the cap.[13]

[10] Other authors have examined the importance of moving costs in equilibrium sorting models (Bayer et al., 2009; Kuminoff, 2009). Like capital gains, moving costs can vary depending on the household's initial position and have the potential to alter the shape of the equilibrium that results from a policy change.

[11] The Matlab code is available from the authors upon request. The authors would like to thank Kerry Smith, Dennis Epple and Maria Ferreyra for providing data and copies of their code for solving other ESMs.

[12] Epple and Romer (1991) demonstrated the existence and properties of a pure characteristics equilibrium sorting model. These properties are: i) stratification — each neighborhood is occupied by households within a certain set of income and preferences, ii) boundary indifference — ranking neighborhoods by price, there exists a locus of households defined by their income and preferences who are indifferent between any two consecutive neighborhoods and iii) ordered bundles — the price ranking of neighborhoods is the same as the ranking of neighborhoods by their public goods index. These properties hold under the assumption that indifference curves exhibit the single crossing property and utility is monotonically increasing in its attributes. Due to endogeneity, the uniqueness of the equilibrium is not guaranteed. One way to explore this is to alter the initial values used in the code. In the simulations discussed below, this procedure had no influence on the outcomes, suggesting uniqueness of each equilibrium.

[13] Revenue equivalent policies were found using a search process.

Let us briefly review the alternative MID-reform policies. First, replacing MID with a refundable[14] flat-rate tax credit has been advocated by both the Center for American Progress, who propose a 15% refundable tax credit, and the National Commission on Fiscal Responsibility (Moment of Truth, 2010), who propose a 12% non-refundable mortgage interest tax credit. For the purposes of our simulations, we model this reform as being a policy change in which MID is abandoned and, instead, all households who are owners can claim back a flat-rate percentage of their mortgage interest and property tax costs. As explained previously, the flat-rate we apply in our subsequent simulations is chosen such that federal budget savings achieved by this policy are identical to capping MID at 28%.

Our second alternative MID-reform policy follows the proposal made by the Reason Foundation (Stansel, 2011) to scrap MID and instead introduce a revenue neutral reduction in federal income tax for all households. Here, we consider a policy in which MID is abandoned and a portion of the savings in government expenditure are used to fund an equal percentage reduction in income tax for all households. Again, to ensure comparability across our policy simulations the level of income tax reduction is chosen such that the policy achieves the same reduction in the federal government budget deficit as the other proposed reforms.

Our final alternative MID reform policy takes motivation from the First Time Buyers scheme proposal made by Gale & Gruber (2007), which suggests scrapping MID and introducing a refundable payment to first-time buyers in the first year after a property is purchased. In the model this is achieved through a New Owner Scheme, which makes an equal lump sum payment to new homeowners. Again in our simulations the level of payments to these first time buyers is chosen so as to ensure comparability in the reduction of the federal budget deficit across reforms.

### 4.2. Calibration

To conduct the simulations, specific functional forms are selected for the structural equations of the model. Following Epple and Platt (1998), parameter values for the functions were calibrated such that our model approximates the reality of the Boston Metropolitan (PSMA) area; though in our application we take data for Boston from 2000 and not 1980. Table 1 presents a summary of important statistics for Boston in 2000 and Table 2 summarizes the parameters obtained by calibrating the model to that reality. The assumptions and methods used in deriving those parameters are explained in the following sections.

#### 4.2.1. Jurisdictions

To allow the pathways of response to MID reform to be studied with reasonable clarity, we explore a simple two-jurisdiction version of the model. Extensions to multiple-jurisdiction models are relatively easy to implement, but greatly reduce the tractability of interpretation. Again following Epple and Platt (1998), we begin by dividing the Boston Metropolitan area into two jurisdictions, labeled A and B. Jurisdiction A provides a higher level of exogenous local public goods provision, consequently attracting a larger share of the population. Competition for access to public goods increases the price of housing in A relative to B, which leads to some income segregation. As a result the median household income in jurisdiction A is higher than that of B.

#### 4.2.2. Households

Households in the model are characterized by three parameters; income, $y$, housing preference, $\beta$, and ownership preferences, $\boldsymbol{\theta}$. The first step in calibrating this model, therefore, is to establish the joint distribution of those parameters amongst the residents of Boston in 2000.

[14] Here the term ‘refundable’ indicates that households whose income tax liability is lower than the value of the credit actually receive a payment from the Treasury covering that difference.

**Table 1**
2000 Boston.

| | | 2000 Boston |
|---|---|---|
| $\bar{y}$ | Mean income | 74.119 |
| $y_{median}$ | Median income | 55.183 |
| $\rho$ | Homeownership rate | 0.72 |
| $z$ | Mean air quality (NOx) | 3 |
| $q$ | Mean school quality | 420 |

As made explicit shortly, a Cobb–Douglas utility function is assumed such that a household's housing preference, $\beta_i$, is related to the proportion of their income that they spend on housing. That data along with information on household income, $y_i$, is available from the census which provides a cross-tabulation of the share of income spent on rent (and equivalently on monthly owner costs for owner–occupiers) by income. Accordingly, to establish the joint distribution of $y$ and $\beta$ we use maximum likelihood estimation to fit a bivariate-normal distribution $f$ln$y$, $\beta) \sim N(\mu_f, \Sigma_f)$ to 2000 census data for Boston.[15] Parameter values from that estimation are recorded in the first row of Table 2. Notice that $\beta$ is negatively correlated with $y$, such that while high-income households spend absolutely more on housing than low-income households, that expenditure constitutes a smaller proportion of their income.

For simplicity, and due to a lack of existing empirical evidence, it is assumed that household ownership preferences, $\boldsymbol{\theta}$, are independent of income and housing preferences. Accordingly, values were drawn from a lognormal distribution $\ln(\theta) \sim N(\mu_\theta, \sigma_\theta^2)$ with mean and variance chosen such that the baseline model predicts homeownership rates comparable to those observed in Boston in 2000.[16] The parameters selected through that procedure are also recorded in Table 2. For the purposes of simulating our model, we create a sample of 2000 households with income, $y$, and preference parameters, $\beta$ and $\boldsymbol{\theta}$, drawn from the calibrated distributions.[17]

#### 4.2.3. Taxes

In 2000, Federal income taxes were structured into six marginal tax brackets. Those tax brackets are defined by a lower bound income, $y_{\tau_y}$, at which the marginal tax rates, $\tau_y$, becomes payable. The first bracket ranging from an income of \$0 to \$7350 has a marginal tax rate of zero. Accordingly, \$7350 is often referred to as the standard deduction. The tax brackets and associated marginal tax rates are recorded in Table 2. Table 3 illustrates how the income tax payable is calculated for households in each of the tax brackets.

The property tax rate, $\tau_p$, was set at the average level for Boston in 2000 using data supplied by the Massachusetts State Government. To capture the correlation between income and itemization rates, the probability of a household itemizing was calibrated using data on itemization rates by income from Poterba and Sinai (2008) which is reproduced in Table 2.[18]

In this calibration we model property taxes as if they are fully passed on to renters. This is aligned with a simplified interpretation of the economy in which housing is constructed and supplied at marginal cost including property taxes. In this situation, a competitive market would lead to the full incidence of the tax being levied upon renters.

[15] Property values for owners were transformed into annualized user costs using a Poterba (1984) factor.

[16] Equilibria were also characterized for a range of alternative calibrations to explore the sensitivity of the results to the parameterization and to allow consideration of the range of permissible outcomes. The results remain qualitatively unchanged and are not reported here, however a full set of results is available from the authors upon request.

[17] The baseline model was also run for population sizes of 500 and 10,000. This did not alter the results and conclusions drawn.

[18] MID is only itemized when the value exceeds \$50. Other than this constraint, we do not model a direct relationship between the probability of itemizing and the value of mortgage interest that a household is eligible to deduct. Future work may benefit from considering this potential endogeneity.

**Table 2**
Calibrated parameter values.

| Parameter | Description | Calibrated value |
|---|---|---|
| $(ln y, \beta) \sim N(\mu_f, \Sigma_f)$ | Income and Preference for Housing | $\mu_f = [10.604, 0.149]$,<br>$\Sigma_f = \begin{bmatrix} 1.045 & -0.0503 \\ -0.0503 & 0.007 \end{bmatrix}$ |
| $\alpha$ | Preference for Local Public Goods | 0.35 |
| $\gamma$ | Weight on School Quality in Public Goods Index | 0.03 |
| $\ln[\theta_1 - 0.88] \sim N(\mu_\theta, \sigma_\theta^2)$<br>$\overline{\theta_2}$ | Preference for Homeownership | $(\mu_\theta, \sigma_\theta^2) = (-1.40, 1)$,<br>$\overline{\theta_2} = 0.015$ |
| $m$ | Mortgage Interest Rate | 0.1339 |
| $\delta_0, \delta_1$ | Parameters of the Loan-to-Value Ratio Function | −0.3, 0.000006 |
| $w(y)$ | Probability of Itemizing | $< y <$ : $Prob(item = 1)$<br>35,000 : 0.234<br>72,000 : 0.661<br>120,000 : 0.855<br>240,000 : 0.984<br>240,000+ : 0.99 |
| $y_{\tau_y}$ | Income Tax Bracket (lower limits) | [0,7350, 21,925, 52,975, 80,725, 144,175] |
| $\tau_y$ | Marginal Income Tax Rate | [0,0.15, 0.28, 0.31, 0.36, 0396] |
| $\tau_\rho$ | Property Tax Rate | 0.5 |
| $\eta$ | Elasticity of Housing Supply | 1 |

**Table 3**
Income tax brackets 2000.

| Bracket | Income is greater than… | But less than… | Tax payable is …($tax_y$) | |
|---|---|---|---|---|
| 1st | 0 | 7350 | | 0 |
| 2nd | 7350 | 21,925 | 0 | +15% × amount over 7350 |
| 3rd | 21,925 | 52,975 | 2186.25 | +28% × amount over 21,925 |
| 4th | 52,975 | 80,725 | 10,880.25 | +31% × amount over 52,975 |
| 5th | 80,725 | 144,175 | 19,482.75 | +36% × amount over 80,725 |
| 6th | 144,175 | – | 42,324.75 | +39.6% × amount over 144,175 |

This assumption could be relaxed through further refinement of the property market model and the development of a buy-to-let market to expressly model differences in the tax burdens of owner–occupiers, landlords and renters.[19]

#### 4.2.4. Mortgages

In our model there is a perfectly elastic supply of mortgages such that the mortgage lending rate is unaffected by the demand for mortgages. The size of mortgage needed by a homeowner is determined by their loan-to-value ratio parameter, $\delta_i$. For the purposes of the simulation, the relationship between loan-to-value ratio and household income was estimated empirically using data from the Survey of Consumer Finances presented in Poterba and Sinai (2008). Using that estimated relationship the parameter $\delta_i$ was calculated as,

$$ln\ \delta_i = \delta_0 - \delta_y y_i \tag{16}$$

where $\delta_0$ and $\delta_y$ are the estimated regression coefficients presented in Table 2. Since $\delta_y$ is positive, wealthier households face lower loan-to-value ratios and, as a consequence, lower marginal costs of purchasing housing. The mortgage interest rate, $m$, was set to the average level for Boston in 2000 using data supplied by the Federal Housing Finance Association.

#### 4.2.5. Housing supply

Housing supply is specified using a Cobb–Douglas function following Epple and Romer (1991) and Epple and Platt (1998),

$$H_j^S = A_j p_j^\eta \tag{17}$$

[19] The sensitivity of our results to the assumption of a 100% tax incidence for renters was tested by varying this rate, the patterns of behavior remain the same for incidence rates between 60 and 100% although the magnitude of various effects are sensitive to this parameter.

where $A_j$ is a jurisdiction specific constant reflecting property market factors such as local zoning restrictions, $p_j$ is the user cost of a unit of housing in $j$ and $\eta$ is the price elasticity of housing supply. Based on the estimated housing elasticity for Boston in 2000, see Saiz (2010), $\eta$ is set to 1 in all markets for the baseline simulation.[20]

The assumption of a single housing supply function covering rental and purchase properties is motivated by considering the direct sale or rent of housing from a zero-profit housing constructor. If property is supplied in a single market, constructors must be indifferent between renting and selling properties. If they sell a property at marginal cost, they are no longer responsible for maintenance, depreciation and foregone interest. If the property is rented the constructor must include these costs in the rental price in order to break even. As a result, if housing for rent and purchase is produced for sale in a single market, both renters and purchasers must face the same per unit user cost of housing, although technically rents exceed purchase prices since homeowners pay the remaining user costs (e.g. maintenance costs) directly rather than to the constructor.[21]

#### 4.2.6. Local public goods

For simplicity, the calibrated model considers one exogenously determined local public good and one endogenously determined local public good. The extension to multiple local public goods is trivial, but adds complexity to the interpretation of the simulation results.

We use air quality to act as a representative exogenous local public good. In our simulation, air quality is defined in units of concentration of nitrogen oxides (measured in pphm) below the highest level observed in Boston in the Massachusetts Air Quality Report. Using that measure, the mean level for air quality in Boston in 2000 was 3. Accordingly we set air quality in jurisdiction B to that level but assume that jurisdiction A offers a slightly higher level of provision: 4.

In addition, we take school quality to act as a representative endogenous local public good; that is to say, a local public good whose level of provision is determined by the property market decisions of households choosing to reside in a jurisdiction. School quality is a natural choice in this regard since empirically it is correlated with many other measures of local public good provision (Bayer et al., 2004; Black, 1999; Bramley and Karley, 2007). Following Nechyba (2003), Nechyba and Strauss (1994), Ferreyra (2007) and Fernandez and Rogerson (1998) we model school quality as being determined by a production function whose arguments include government expenditure per pupil, $E$, and median household income, $y_{median}$. To that list of arguments we add a term relating to homeownership: an extension supported by an increasing body of evidence suggesting school quality is determined, in part, by levels of local homeownership (Dietz and Haurin, 2003; Dietz, 2002, 2003). Our school quality production function takes the form;

$$q_j = AE_j^{\phi_1} y_{median\,j}^{\phi_2} \rho^{1-\phi_1-\phi_2} \tag{18}$$

where $A$ is a constant and $\rho$ is the homeownership rate. This production function implies that the level of local public good provision is intimately related to property market choices: first through the income levels of those that choose to reside in a jurisdiction, second through the property taxes those individuals pay which determines budgets for local government expenditure, third through the levels of itemization those households pursue which determines federal contributions to local expenditure and finally through the direct effect of local rates of homeownership.

To calibrate the production function, we use an instrumental variables approach on a national-scale dataset, regressing a state-level measure of school quality (combined fourth grade mathematics and reading attainment score) against state-level measures of median household income, homeownership rates (both taken from 2000 census data) and data from the National Assessment of Educational Progress (NAEP) on expenditure per pupil. To deal with the potential endogeneity of median income and homeownership, we adopt an instrumental variables approach employing as instruments measures of the average median income, homeownership rate and expenditure per pupil of neighboring (geographically) states. The validity of the instruments was examined using the Stock and Yogo (2005) test, under the null hypothesis that the set of instruments is weak. Using both the 2SLS and LIML measures we reject the null hypothesis of weak instruments at the 5% significance level with an eigenvalue of 22.3873 and corresponding critical values at the 5% level of 16.87 (2SLS) and 4.72 (LIML). The resulting regression equation was,[22]

$$\begin{aligned} \ln(q) = \underset{(0.417)}{2.515} + \underset{(0.053)}{0.17} \ln(E) + \underset{(0.071)}{0.17} \ln(y_{median}) \\ + \underset{(0.088)}{0.66} \ln(\overline{\rho}). \end{aligned} \tag{19}$$

To test the sensitivity of our simulated equilibria to the assumption that homeownership directly impacts on local school quality, we explore two versions of the model. In the first version, a direct affect is assumed away. Rather homeownership is taken to proxy for a set of omitted factors that impact directly on school quality through channels that are independent of property market decisions. Since those omitted factors are taken to be unchanging, we progress by exogenously fixing the homeownership argument in the school quality production function at the observed Boston state average. In our simulations, the argument maintains that initial level despite adjustments in rates of homeownership that result from changes in MID policy. In the second version of the model the assumption of a direct affect is maintained. In our simulations, the homeownership argument in the school production function updates in response to changes in property market decisions brought about by reforms of MID policy.

The results reported in Section 4 are derived from the first model version, assuming local homeownership has no direct impact on school quality (although local endogeneity is still present through expenditure per pupil and median incomes). Comparable results from the second model version, with an endogenous homeownership feedback, are presented in Section 5.2. Additional results exploring the sensitivity of the results to sample size, the strength of preferences for public goods and alternative housing supply specifications are available from the authors upon request. As a general comment, the patterns of relocation suggested by the model are the same for both versions under each reform. It is notable, however, that when local homeownership rates are assumed to directly affect the provision of local public goods the magnitude of welfare gains associated with reforms that increase homeownership rates are sensitive to this assumption.

#### 4.2.7. Household preferences

The household utility function is specified as a Cobb–Douglas according to[23]:

$$U_{j,t} = \begin{cases} g_j h^{\beta} c^{1-\alpha-\beta} & t = R \\ g_j \theta_1 (h - \overline{\theta}_2)^{\beta} c^{1-\alpha-\beta} & t = O \end{cases} \tag{20}$$

[20] Alternatively, $\eta$ could be set to 0 to produce a completely inelastic housing supply.

[21] In alternative calibrations of the model we considered independent purchase and rental markets. Despite relaxing the arbitrage assumption we observed a high degree of price convergence between rent and purchase price in equilibrium. In reality the supply side is a compromise between the two extremes of a single property market model and an independent markets model.

[22] Standard errors are shown in parentheses. In the computed equilibria, income and expenditure are deflated to match the school production function, which was estimated in 2002 dollars.

[23] The authors would like to thank an anonymous reviewer for suggesting the structure of ownership preference.

where $\overline{\theta}_2$ is common across households, representing a minimum quantity of housing that must be purchased before additional utility from homeownership is realized and $\theta_1$ is a household specific ownership preference. Larger values of $\theta_1$ imply a greater preference for ownership.

Carbone and Smith (2008) show that when household preferences are assumed to be Cobb–Douglas, preference parameters for non-market goods can be retrieved using estimates of the implicit prices of those non-market goods taken from hedonic pricing exercises. While the procedure seems a little at odds with the general equilibrium nature of the equilibrium sorting model, the calibration technique can be shown to be valid under the assumption that the market in which the original pricing study was conducted was in equilibrium. Under those circumstances implicit prices for public goods provide direct evidence of preference structures. Here we take the implicit price of air quality, $p_z$, from the hedonic study by Harrison and Rubinfeld (1978) and the implicit price of school quality, $p_q$, from the hedonic study by Bayer et al. (2007)[24]. Following Carbone and Smith, preferences for public goods, $\alpha$, and the weighting parameter, $\gamma$, can then be calculated according to

$$\alpha = \frac{p_z z_0 + p_q q_0}{y + p_z z_0 + p_q q_0} \quad (21)$$

$$\gamma = \frac{p_q}{p_z} \quad (22)$$

where $p_z$ and $p_q$ are implicit prices for air quality and school quality respectively, and subscript 0 denotes a baseline value. The calibrated values from this procedure are 0.35 for $\alpha$ and 0.03 for $\gamma$.

### 4.3. Results

The long-run equilibrium under current policy conditions was calculated for our simulated sample of 2000 households.[25] The impact of MID-reform was then investigated using an iterative solution algorithm to calculate the new equilibrium characterizing the property market when each of our four proposed policy reforms was instituted from that baseline.

Tables 4 and 5 describe important features of the equilibrium in the baseline and for each policy-reform scenario. Table 4 presents a characterization of those equilibria in terms of the composition and characteristics of the households in each jurisdiction. Table 5 characterizes the equilibria from the perspective of households in each of the six tax brackets. Throughout our discussion of the results we will use the term “price” to refer to the price inclusive of property tax since this is the effective price faced by households.

#### 4.3.1. Baseline with MID

Consider the results displayed in the first rows of Tables 4 and 5 that describe the equilibrium that evolves under the current system of MID. In the baseline, jurisdictions A and B differ initially only in their exogenous provision of public goods (Column 1 of Table 4). The higher exogenous public good provision in jurisdiction A shapes the resulting equilibrium. Households prefer a greater provision of public goods which increases demand for housing in A relative to B. Consequently, the population of A is higher than the population of B, with 65% of all households residing there (Column 2 of Table 4). As the supply of housing in A is not infinitely elastic, relatively stronger demand in A drives the prices of housing in A above the prices in B. The purchase price of housing (including property tax) is \$7379 in A compared to \$5496 in B (Column 3 of Table 4).

Price differences between jurisdictions and tenure options precipitate the stratification of households. Column 4 of Table 4 confirms that households with relatively strong ownership preference, $\theta_1$, choose to purchase housing while those with relatively weak ownership preference rent housing. Similarly, as can be seen from column 5 of Table 4, households that spend a relatively large proportion of their income on housing, e.g. those with relatively high $\beta$, prefer lower housing prices and tend to choose to reside in jurisdiction B. Since $\beta$ is negatively correlated with income, this reinforces segregation by income. As shown in Columns 1 and 2 of Table 5, only 19% of households in the lowest income tax bracket (1st) choose to live in A compared to 96% in the highest tax bracket (6th). Consequently, the median income of households in A is almost 3 times that of B (Column 7 of Table 4).

Within each jurisdiction some households rent while others own. Recall from the calibration that households with higher incomes face relatively lower loan-to-value ratios and, under the existing MID policy, can itemize their mortgage interest and property tax costs at a relatively higher marginal rate. Accordingly, the marginal cost of purchasing housing is lower for higher-income households and, ceteris paribus, households with high incomes are more likely to become homeowners. As shown in Columns 7 of Table 5, only 52% of households with incomes below the standard deduction choose to own compared to 74% of households in the highest income tax bracket. This result is consistent with observed homeownership rates in Boston in 2000. Returning to Table 4, the concentration of higher income households in A leads the homeownership rate to be higher than in B (Column 8).

Recall from Eq. (5) that local property tax revenues depend on both purchase prices and the total quantity of housing demanded in a jurisdiction. In the baseline equilibrium, higher property prices in A are slightly offset by larger property sizes in B such that tax revenue per household in A is marginally lower than in B; \$22,266 and \$22,344 respectively (Column 10 of Table 4). Larger local tax revenues translate directly into higher levels of local government expenditure on the endogenous public good. However, since median income is higher in A than B, jurisdiction A benefits from relatively larger provision of the public good through a stronger peer effect (Column 11 of Table 4). Overall, provision of the endogenous public good is higher in A, with a school quality score of 498, than it is in B, at 379. Combined with the exogenous public good provision this indicates that the index of public goods provision is 32% higher in jurisdiction A. That difference in provision of the public good acts to further exaggerate the patterns of sorting initiated by the initial difference in public goods provision.

#### 4.3.2. 28% cap

Now let us consider how things change when MID is capped at a rate of 28%. Under the new policy those households in the top three tax brackets who had previously been able to itemize their expenditures on mortgage interest and property tax at 31, 36 and 39.6% respectively, would now be limited to itemizing at 28%. In the absence of other adjustments, the cap raises the per-unit cost of housing for the 86% of households in the top three income tax brackets that itemize MID on their tax returns in the baseline. Characteristics of the new equilibrium are presented in the second row of results in Tables 4 and 5.

The equilibrium outcome is the product of a number of forces: the immediate impact of the reform is to reduce demand amongst existing homeowners with a relatively strong housing preference. This reduction threatens to lower local expenditure on public goods through a reduction in property tax revenues, which precipitates the relocation of some renters from jurisdiction A to B, increasing housing demand

[24] These studies were chosen to approximate implicit prices for the Boston SMSA. The use of these figures relies upon the assumption that these implicit prices sufficiently approximate the implicit prices for Boston in 2000, which implies that those prices are invariant to the time and spatial displacement of our analysis. The sensitivity of the analysis to these parameters has been tested by varying the implicit prices. The patterns of behavior predicted by the model are generally robust. For example, halving the value of $\alpha$ does not alter the characteristics of the new equilibria or relative ranking of policy reforms. Further results are discussed in Section 5.2 on model sensitivity and are available from the authors upon request.

[25] In choosing a simulated sample size one faces a trade-off between small sample bias and computational efficiency. For the baseline scenario we experimented with larger population sizes up to 10,000, but found no significant changes in the characteristics of the equilibrium.

**Table 4**
Characterization of equilibria by jurisdiction.

| | | | Exogenous public good | Population share | Price of housing (inc. tax) | Mean preference for homeownership | Mean preference for housing | Mean income | Median income | Homeownership rate | Mean property size | Local expenditure | Endogenous public good |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | z | POP | $(1+\tau p)p$ | $\Theta$ | $\beta$ | $\bar{y}$ | $y_{median}$ | $\rho$ | h | e | q |
| | | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| *Baseline* | | | | | | | | | | | | | |
| a. | A. | Purchase | 4 | 0.49 | 7379 | 1.39 | 0.16 | 89,392 | 56,706 | 0.75 | 1.95 | 22,266 | 498 |
| | | Rental | | 0.16 | | 0.96 | 0.16 | 92,215 | | | 1.76 | | |
| | B. | Purchase | 3 | 0.25 | 5496 | 1.43 | 0.37 | 34,486 | 20,917 | 0.70 | 2.82 | 22,344 | 379 |
| | | Rental | | 0.11 | | 0.98 | 0.38 | 24,612 | | | 2.08 | | |
| *28% cap* | | | | | | | | | | | | | |
| b. | A. | Purchase | 4 | 0.49 | 7456 | 1.39 | 0.16 | 89,392 | 56,554 | 0.75 | 1.95 | 22,498 | 499 |
| | | Rental | | 0.16 | | 0.96 | 0.16 | 91,882 | | | 1.75 | | |
| | B. | Purchase | 3 | 0.25 | 5565 | 1.43 | 0.37 | 34,486 | 20,913 | 0.70 | 2.85 | 22,651 | 380 |
| | | Rental | | 0.11 | | 0.98 | 0.38 | 24,159 | | | 2.04 | | |
| *20.3% flat-rate tax credit* | | | | | | | | | | | | | |
| c. | A. | Purchase | 4 | 0.49 | 7379 | 1.39 | 0.16 | 88,390 | 56,554 | 0.75 | 1.86 | 22,448 | 499 |
| | | Rental | | 0.16 | | 0.97 | 0.16 | 94,920 | | | 1.83 | | |
| | B. | Purchase | 3 | 0.23 | 5496 | 1.4 | 0.37 | 35,268 | 20,933 | 0.66 | 2.94 | 22,537 | 380 |
| | | Rental | | 0.12 | | 1.08 | 0.38 | 24,410 | | | 1.99 | | |
| *4.2% income tax rebate* | | | | | | | | | | | | | |
| d. | A. | Purchase | 4 | 0.49 | 7482 | 1.39 | 0.16 | 89,052 | 56,706 | 0.76 | 1.94 | 21,747 | 496 |
| | | Rental | | 0.16 | | 0.95 | 0.16 | 93,296 | | | 1.78 | | |
| | B. | Purchase | 3 | 0.25 | 5564 | 1.43 | 0.37 | 33,929 | 20,917 | 0.71 | 2.78 | 21,819 | 378 |
| | | Rental | | 0.10 | | 0.96 | 0.38 | 25,548 | | | 2.15 | | |
| *$3620 new owner scheme* | | | | | | | | | | | | | |
| e. | A. | Purchase | 4 | 0.61 | 8502 | 1.3 | 0.16 | 81,363 | 6371 | 0.93 | 1.80 | 23,102 | 500 |
| | | Rental | | 0.05 | | 0.93 | 0.14 | 190,694 | | | 2.84 | | |
| | B. | Purchase | 3 | 0.34 | 6437 | 1.31 | 0.37 | 30,433 | 20,593 | 0.99 | 2.62 | 23,501 | 381 |
| | | Rental | | 0.00 | | 0.93 | 0.38 | 89,601 | | | 5.59 | | |

in B and pushing up property prices there. In turn, this redistribution of the population leads to higher median incomes in both A and B (column 7, Table 4), and increases local expenditure on public goods in both jurisdictions. Those affects combine in precipitating a rise in the endogenous public good (proxied here by school quality) of 1% in A (to a score of 499) and 0.3% in B (to a score of 380). The slightly larger increase in public good provision in A makes it more desirable relative to B, this stimulates a rise in prices in order to avoid relocation of households from B to A and maintain the balance of supply and demand. Overall, property prices rise by roughly 1.04% in A and 1.23% in B despite the removal of MID.

Comparing results in column 9 of Table 4 we can see that mean rental property sizes fall; this is a consequence of the relocation of households with relatively small housing consumption from A to B and the rise in prices[26]. However, as anticipated we also see a contraction in mean housing consumption across tax brackets four to six (see Table 5), however homeownership rates in A and B are left almost entirely unchanged (identical to 2 s.f.).

It is worth taking a moment here to reflect on the adjustment in prices. Intuitively, one might assume that the cap on MID increases the marginal cost of housing for individuals in the top tax brackets, which in turn leads to a contraction in their demand. It follows that from this partial equilibrium perspective one would expect property prices to fall. The equilibrium sorting model, however, shows that that logic is incomplete and results in an erroneous conclusion regarding the price impact of the policy. There are two key factors at play. First, households can move between jurisdictions. Accordingly, while a reduction in demand from the residents of a desirable area has the immediate effect of pushing down prices, those same price falls will encourage households from other jurisdictions to move into the area driving up demand and, as a result, prices. Second, the endogenous public good responds to changes in neighborhood composition and tax revenues. As a result, a policy that initially stimulates relocation can alter the relative provision of public goods across neighborhoods, a change that in turn can drive secondary demand and price adjustments. As demonstrated by our simulations, in an area where public good provision rises, housing becomes more desirable and those demand increases act so as to drive prices upwards.

Perhaps unexpectedly, despite policy reform constituting a significant (20%) reduction in federal government spending, within our simulation the knock-on effects of a policy capping MID at 28% actually precipitates general welfare increases for households in our simulated population. The endogenous tenure choice aspect of our model allows us to explore the impact of the policy change on patterns of renting and owning. Our model suggests that the key driver of the welfare increase provided by the 28% cap is the fact that a policy which increases mortgage costs for high-income households has very little impact on their demand for housing or homeownership. Consider the final column of Table 5, the rise in public good provision leads to utility gains for almost half of the households in the lowest tax bracket and the majority of households in the second to fourth income brackets. Moreover, despite being most directly and adversely affected by the cap, 78% of households in the 5th and 6th income tax brackets experience gains in utility, primarily through the increased local public good provision.

Table 6 presents a summary of the monetized changes of the policy in terms of the federal budget deficit, mortgage interest payments, landlords' rents and households' willingness to pay. Willingness to pay is calculated as the sum of the amounts of money that each household would pay, or would require in compensation, in order to leave them indifferent between their original position under MID and that after the policy change. In addition to providing a 20% reduction in the deficit, the 28% cap leads to a rise in mortgage interest payments and substantial gains in household welfare.

[26] This is partly due to the assumption that the housing stock is divisible and can be easily re-packaged, in reality this is like dividing a house into several flats etc.

**Table 5**
Characterization of equilibria by income tax bracket.

| | | Share renting in A | Share owning in A | Share renting in B | Share owning in B | Mean property size | Mean property size of owners | Homeownership rate | Mean endogenous quality | Cost of policy | Share gaining utility |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AR | AO | BR | BO | h | ho | ρ | q | C | ↑U |
| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| *Baseline* | | | | | | | | | | | |
| a. | 1st lowest | 0.093 | 0.093 | 0.389 | 0.426 | 0.48 | 0.24 | 0.52 | 392 | 0 | |
| | 2nd | 0.100 | 0.294 | 0.193 | 0.413 | 1.04 | 0.71 | 0.71 | 417 | 62 | |
| | 3rd | 0.158 | 0.477 | 0.101 | 0.265 | 1.74 | 1.29 | 0.74 | 446 | 403 | |
| | 4th | 0.172 | 0.632 | 0.031 | 0.165 | 2.49 | 2.06 | 0.80 | 467 | 1136 | |
| | 5th | 0.202 | 0.648 | 0.035 | 0.115 | 3.29 | 2.60 | 0.76 | 471 | 2060 | |
| | 6th highest | 0.258 | 0.702 | 0.000 | 0.040 | 4.44 | 3.44 | 0.74 | 484 | 3304 | |
| *28% cap* | | | | | | | | | | | |
| b. | 1st lowest | 0.093 | 0.093 | 0.389 | 0.426 | 0.48 | 0.24 | 0.52 | 402 | 0 | |
| | 2nd | 0.102 | 0.294 | 0.191 | 0.413 | 1.06 | 0.74 | 0.71 | 427 | 79 | |
| | 3rd | 0.160 | 0.477 | 0.099 | 0.265 | 1.74 | 1.30 | 0.74 | 456 | 409 | |
| | 4th | 0.172 | 0.632 | 0.031 | 0.165 | 2.48 | 2.06 | 0.80 | 476 | 1081 | |
| | 5th | 0.206 | 0.648 | 0.031 | 0.115 | 3.28 | 2.60 | 0.76 | 481 | 1532 | |
| | 6th highest | 0.258 | 0.702 | 0.000 | 0.040 | 4.43 | 3.44 | 0.74 | 494 | 2275 | |
| *20.3% flat-rate tax credit* | | | | | | | | | | | |
| c. | 1st lowest | 0.185 | 0.000 | 0.815 | 0.000 | 0.49 | 0.00 | 0.00 | 402 | 0 | |
| | 2nd | 0.091 | 0.305 | 0.147 | 0.457 | 1.09 | 0.83 | 0.76 | 427 | 330 | |
| | 3rd | 0.142 | 0.493 | 0.099 | 0.266 | 1.78 | 1.35 | 0.76 | 455 | 662 | |
| | 4th | 0.175 | 0.629 | 0.038 | 0.158 | 2.46 | 2.00 | 0.79 | 475 | 1020 | |
| | 5th | 0.209 | 0.641 | 0.038 | 0.112 | 3.19 | 2.43 | 0.75 | 481 | 1226 | |
| | 6th highest | 0.280 | 0.680 | 0.009 | 0.031 | 4.18 | 2.91 | 0.71 | 494 | 1473 | |
| *4.2% income tax rebate* | | | | | | | | | | | |
| d. | 1st lowest | 0.056 | 0.130 | 0.296 | 0.519 | 0.47 | 0.30 | 0.65 | 400 | 0 | |
| | 2nd | 0.100 | 0.294 | 0.195 | 0.411 | 1.04 | 0.71 | 0.71 | 425 | 46 | |
| | 3rd | 0.158 | 0.477 | 0.101 | 0.265 | 1.74 | 1.29 | 0.74 | 453 | 247 | |
| | 4th | 0.172 | 0.632 | 0.031 | 0.165 | 2.49 | 2.06 | 0.80 | 473 | 614 | |
| | 5th | 0.202 | 0.648 | 0.035 | 0.115 | 3.30 | 2.60 | 0.76 | 479 | 1222 | |
| | 6th highest | 0.258 | 0.702 | 0.000 | 0.040 | 4.45 | 3.44 | 0.74 | 492 | 3792 | |
| *$3620 new owner scheme* | | | | | | | | | | | |
| e. | 1st lowest | 0.000 | 0.194 | 0.000 | 0.806 | 0.72 | 0.72 | 1.00 | 404 | 1743 | |
| | 2nd | 0.000 | 0.407 | 0.002 | 0.591 | 1.12 | 1.12 | 1.00 | 429 | 1058 | |
| | 3rd | 0.000 | 0.648 | 0.000 | 0.353 | 1.74 | 1.74 | 1.00 | 458 | 935 | |
| | 4th | 0.034 | 0.770 | 0.007 | 0.189 | 2.46 | 2.37 | 0.96 | 477 | 585 | |
| | 5th | 0.119 | 0.742 | 0.021 | 0.119 | 3.19 | 2.78 | 0.86 | 483 | 353 | |
| | 6th highest | 0.236 | 0.724 | 0.000 | 0.040 | 4.31 | 3.51 | 0.76 | 495 | 80 | |

#### 4.3.3. 20.3% refundable flat-rate tax credit

A seemingly more progressive reform of MID would be to replace the current system with a refundable flat-rate tax credit. Under this policy, rather than being able to claim MID against income tax, the federal government reimburses all homeowners a fixed percentage of their mortgage interest payments. To maintain comparability with the MID cap reform discussed in the last section, we consider a refundable tax credit of 20.3% which leads to the same overall deficit reduction as the cap.

In contrast to capping MID, the introduction of a tax credit has immediate implications for all households. In the absence of any other adjustments, the marginal cost of purchasing housing reduces for households in the lowest two tax brackets and all non-itemizers. For itemizers in the top four tax brackets the marginal cost rises. For the top tax brackets, the MID cut is more severe than under the cap (down to 20.3% compared to 28%). Accordingly, as in the case of the cap, the reduction in MID leads to a contraction in housing demand amongst previous owners in the top tax brackets. At the same time, demand from households in the 2nd and 3rd tax brackets expands.

Most interestingly, in jurisdiction B expanding demand from households in the 2nd and 3rd tax brackets forces lower income households out of homeownership, leading to a reduction in the homeownership rate to 66% and a rise in the number of house units per homeowner in B (see Table 5). This effect is partially a product of the minimum house sizes that must be purchased to reap the gains from homeownership under the chosen functional form, in addition to the higher cost of owning relative to renting per unit of housing. Lower income households taking advantage of the tax credit also stimulates demand for homeownership in A, offsetting the contraction in demand from higher income households. The homeownership rate remains stable at 75% and the average number of housing units per homeowner falling only slightly from 1.95 to 1.86.

Moderate rises in tax revenues combined with an increase in the median income in jurisdiction A lead to small gains in public good provision with school quality rising by 1% in both A and B. This increased public goods provision provides some compensation for households in light of the higher cost of housing.

**Table 6**
Monetary value of policy reform ($).

| | Reduction in Federal debt | Change in mortgage interest | Change in landlord rents | Willingness to pay |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| a. | 28% cap | | | |
| | 388,900 | 13,850 | 0 | 6,596,200 |
| b. | 20.3% flat-rate tax credit | | | |
| | 388,900 | −3510 | 282,400 | −4,770,600 |
| c. | 4.27% income tax reduction | | | |
| | 388,900 | 13,050 | 36,300 | −712,280 |
| d. | New owner scheme | | | |
| | 388,900 | −7,066,400 | −2,626,500 | −779,730 |

The flat-rate tax credit stimulates changes in the tenure and location choice of almost 6% of the population. The progressive nature of the policy makes it unsurprising that the majority of the benefits are focused upon the lowest three tax brackets. What is surprising, however, is that a smaller proportion of households in the second and third income tax brackets benefit from the tax credit in comparison to the 28% cap. In addition, more substantial increases in the cost of housing result in losses for 66% of households in the top three income tax brackets.

As can be seen in Table 6, the flat-rate tax credit produces large reductions in welfare through higher costs of housing for renters and previous itemizers in the top four tax brackets; however the reform also leads to a reduction in total mortgage interest payments as overall homeownership rates decline. In comparison to the 28% cap, the flat-rate tax credit provides utility gains to a smaller proportion of households in every tax bracket except the 2nd and from a Kaldor–Hicks perspective the flat-rate policy is inferior to the 28% cap.

*4.3.4. 4.2% income tax rebate*

Consider next a policy that removes MID and uses the money saved first to reduce federal expenditure (by 20% to maintain comparability with the 28% cap) and second to reduce income taxes by cutting all household's tax bills by 4.2%.

For non-itemizers and renters, the design of this reform is potentially positive. Their lower income tax liability opens up the possibility of consuming larger properties or relocating to A to enjoy relatively higher levels of public good provision. For homeowners, the immediate impact of the reform depends on their taxable income. Households in the lowest tax bracket do not pay income tax and, as such, are not immediately affected by the policy reform.

The characteristics of the new equilibrium are presented in Tables 4 and 5. Overall, mean owned property size in B falls slightly as new owners purchase smaller properties than existing owners. The reform motivates a number of households to relocate from A to B in order to benefit from the relatively cheaper housing. This leads to an increase in the median income in both A and B and higher local tax revenues, supporting an increase in local public good provision. As a result, purchase prices rise by 1.5% to $7482 in A and 1.26% in B to $5564 as low income households (those in the first and second income tax brackets) enter the purchase markets. In jurisdiction B, higher housing demand increases homeownership by 1% (column 8, Table 4). However, lower demand from existing homeowners is not offset by the rise in price and increase in rental demand, as a result lower tax revenues contribute to a slightly decreased provision of endogenous public good in both jurisdictions.

Despite its seemingly regressive design, this policy increases utility for the majority of lower income households. For many higher income households, the utility benefits of the income tax cut are outweighed by the loss in MID. Indeed, the proportion of households in the top four income tax brackets who gain from this policy reform is lower than under the 28% cap.[27] Finally, considering Table 6, the income tax rebate reform increases mortgage interest payments and landlord's rental revenues, but creates moderate net reductions in welfare, relative to the other reforms, through the higher housing costs that are inflicted on wealthier households.

*4.3.5. $3620 new owner scheme*

This final policy reform replaces MID with a new owner scheme that pays a lump sum of $3620 to new homeowners. Again, this is revenue equivalent to the 28% cap. The characteristics of the new equilibrium under this policy appear in the final rows of Tables 4 and 5.

As with the other reforms, the removal of MID has the immediate effect of contracting housing demand amongst existing homeowners. The introduction of a New Owner Scheme, however, stimulates entry into homeownership amongst previous renters in the lowest tax bracket (as can been seen in columns 2 and 4 of Table 5). Simultaneously, the New Owner Scheme increases total housing demand and leads to a rise in purchase prices in both jurisdictions, rising by 15.2% in A and by 17.1% in B (column 3, Table 4). In turn, we observe decreases in the average units of housing demanded in the purchase markets, an increase in the average units of housing in the rental markets and substantially higher tax revenues in both jurisdictions. Despite relocation between A and B reducing median incomes in both jurisdictions, the provision of endogenous public goods rises by 2% in A and B (column 11, Table 4). Accordingly, previous homeowners who lose the MID are compensated in two ways: first, since property prices rise, they benefit from capital gains and second, they benefit from increased levels of public good provision.

While focusing on new owners, this policy reform results in welfare gains for households in the first three income tax brackets. The key pathways through which those gains are delivered is by supporting the movement of lower income households into homeownership and increasing property values and local tax revenues, thus facilitating a greater provision of local public goods. Despite this, the policy represents the greatest reductions in utility for homeowners in the top two income tax brackets: these households face the complete removal of MID and are ineligible for the New Owner Scheme. In addition, persisting renters face welfare losses as a result of higher house (rental) prices. Returning to Table 6, we observe that the New Owner Scheme produces large reductions in landlord's rental revenues and household welfare.

## 5. Discussion

This paper contributes methodologically to the existing equilibrium sorting literature by developing a model that incorporates an explicit endogenous tenure decision as well as endogenous local public goods. These innovations extend the range of policy problems to which ESMs can be applied to include those where tenure choice and the impact of policy reform on rates of homeownership are central. Moreover these innovations allow us to account for the influence of capital gains and housing stock constraints on the distribution of welfare changes.

A simplified model was calibrated using real world data to examine the possible consequences of reforms to the policy of MID in the U.S. This exploration begins to shed some light on the complex patterns of change that such reforms may precipitate in the property market and provides insights that help to inform some of the more acrimonious disputes surrounding the debate over MID reform. With regard to that debate, the calibrated simulations show that the impact of removing MID depends crucially on the nature of the policy that takes its place.

First, consider the argument that MID inflates property prices making homeownership less affordable (Glaeser and Shapiro, 2002). The simulation results suggest that while MID disproportionately reduces the cost of purchasing housing for higher income households, we do not find evidence to suggest that reforming MID would necessarily lead to reductions in house prices. To the contrary, our simulations indicate that entry into homeownership and greater public good provision could lead to rising property prices.

Second, supporters of MID argue that removing the policy would damage homeownership rates. This is where the key innovation of our model, the introduction of endogenous tenure choice, enables us to make a significant contribution to the policy debate. Our simulations suggest that the impact of reform on homeownership may be positive or negative. Indeed, for the cap, income tax reduction and New Owner Scheme we predict increased homeownership rates as new incentives for homeownership are introduced. Furthermore, despite the fact that the model accommodates changes in tenure as the relative costs of renting and owning change, we predict quite small changes in

[27] Although administrative costs are not explicitly included in this model, it would be interesting to see future work considering the additional advantage of the tax reduction's lower administrative demands and knock on effects for the labor market.

homeownership rates for the cap, flat-rate credit and the income tax rebate.

Third, critics of MID argue that it subsidizes excessive housing consumption amongst wealthy households, suggesting that the removal of MID would lead to a contraction in the average property size of owners in the top tax brackets. As with the homeownership rate, our simulations suggest that the nature of the policy reform has a strong influence on the mean property sizes demanded by homeowners in each income tax bracket. Contrary to previous predictions, however, in the cases of the 28% cap and the income tax rebate the mean property size demanded by homeowners in the top income tax bracket remains the same. In the cases of the flat-rate tax credit and New Owner Scheme, our conclusions are consistent with a reduction in the average purchased property size for households in the top income tax bracket.

### 5.1. Model sensitivity

The model presented in this paper provides a tool for analyzing policy reforms and exploring the types of market adjustments that would characterize the resulting equilibria. It is important to acknowledge that the calibrated model approximates many dimensions of the joint housing, tenure and location decision that are not well understood. To test the robustness of the simulation results, and to identify the most influential parameters we explored a variety of parameter values for i) the endogeneity of local public good provision, ii) the specification of housing supply, iii) the degree to which rental and owned property markets are connected, iv) household preferences, and v) the tax incidence of property taxes for renters. For the purpose of conciseness a selection of these results, exploring the first two points, is presented in Table 7, further results are available from the authors upon request.

Table 7 compares three specifications of local public good provision; i) calibrated feedback via local homeownership, ii) state level homeownership as a proxy and iii) an inverted calibration of the feedback effects, alongside two specifications of the housing supply function; i) fixed short term housing supply and ii) Cobb–Douglas housing supply function with elasticity of one.

Across the range of calibrated parameter values, including those not presented in Table 7, we find consistent patterns of change in homeownership rates, predominantly with increases in homeownership rates being achievable through a deficit reducing policy reform. This is consistent with Shapiro and Glaeser's (2003) assertion that MID subsidizes households who would be homeowners even in the absence of the policy. Likewise, our simulations consistently demonstrate that increases in public goods provision under several of the reforms serve to compensate households for the reduction in federal spending; the magnitude of this compensation is sensitive to the value of preferences for public goods, $\alpha$. Nonetheless, despite this sensitivity, our results consistently suggest that the proposed 28% cap leads to utility gains for the majority of households and would be supported, from a utility perspective, by the majority of households. Moreover, our results suggest that the benefits of the policy would be quite broadly distributed across the income tax distribution (see columns 8–13 of Table 7).

In contrast, the impacts of MID reform on property prices and the average property size of homeowners are sensitive to the calibration of the model. In the simulation results presented in Section 4 we find that property prices do not decrease and the average property size of owners in the top tax brackets decreases. This finding is quite robust for the cap, income tax rebate and New Owner Scheme. However, for the flat-rate tax credit and in calibrations where either rental and purchase markets have been defined independently or renters do not face the full property tax burden, the model predicts that property prices

**Table 7**
Model sensitivity testing.

| | Endogenous homeownership feedback | Housing supply specification | Policy rate | % change in price in A | % change in price in B | % change in homeownership rate in A | % change in homeownership rate in B | Share of tax bracket gaining utility | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 1st | 2nd | 3rd | 4th | 5th | 6th |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| *28% cap* | | | | | | | | | | | | | |
| a. i. | Calibrated endogenous | i. Fixed | 28% | 1.10 | 1.78 | 0.00 | 0.00 | 0.53 | 0.70 | 0.76 | 0.81 | 0.78 | 0.80 |
| | local feedback | ii. Elastic Cobb–Douglas | 28% | 0.47 | 0.88 | 0.00 | 0.00 | 0.52 | 0.70 | 0.76 | 0.81 | 0.78 | 0.82 |
| ii. | Homeownership as a | i. Fixed | 28% | 1.04 | 1.23 | 0.00 | 0.00 | 0.52 | 0.71 | 0.76 | 0.81 | 0.78 | 0.78 |
| | proxy | ii. Elastic Cobb–Douglas | 28% | 1.10 | 1.20 | 0.00 | 0.00 | 0.48 | 0.71 | 0.76 | 0.82 | 0.78 | 0.80 |
| iii. | Inverted endogenous | i. Fixed | 28% | 0.83 | 1.87 | 0.00 | 0.01 | 0.44 | 0.70 | 0.74 | 0.79 | 0.77 | 0.75 |
| | feedback | ii. Elastic Cobb–Douglas | 28% | 1.21 | 2.00 | −0.01 | 0.00 | 0.52 | 0.71 | 0.76 | 0.79 | 0.78 | 0.79 |
| *Flat-rate tax credit* | | | | | | | | | | | | | |
| b. i. | Calibrated endogenous | i. Fixed | 20.3% | 0.14 | −2.85 | 0.00 | 0.01 | 0.00 | 0.70 | 0.43 | 0.23 | 0.08 | 0.02 |
| | local feedback | ii. Elastic Cobb–Douglas | 20.1% | −0.10 | 0.14 | 0.00 | −0.04 | 0.00 | 0.72 | 0.43 | 0.23 | 0.08 | 0.02 |
| ii. | Homeownership as a | i. Fixed | 20.1% | −0.02 | −0.03 | 0.00 | 0.01 | 0.48 | 1.00 | 0.73 | 0.42 | 0.33 | 0.28 |
| | proxy | ii. Elastic Cobb–Douglas | 20.1% | −0.02 | −0.03 | 0.00 | 0.01 | 0.48 | 1.00 | 0.73 | 0.42 | 0.33 | 0.29 |
| iii. | Inverted endogenous | i. Fixed | 20.1% | 0.00 | 12.50 | −0.03 | 0.10 | 0.34 | 0.60 | 0.46 | 0.27 | 0.10 | 0.03 |
| | feedback | ii. Elastic Cobb–Douglas | 20.1% | 0.00 | 12.50 | −0.03 | 0.10 | 0.34 | 0.60 | 0.46 | 0.27 | 0.10 | 0.03 |
| *Income tax rebate* | | | | | | | | | | | | | |
| c. i. | Calibrated endogenous | i. Fixed | 4.27% | 1.40 | 1.37 | 0.00 | 0.01 | 0.12 | 0.53 | 0.65 | 0.49 | 0.42 | 0.57 |
| | local feedback | ii. Elastic Cobb–Douglas | 4.27% | 1.32 | 1.51 | 0.00 | 0.01 | 0.13 | 0.55 | 0.66 | 0.44 | 0.40 | 0.58 |
| ii. | Homeownership as a | i. Fixed | 4.27% | 1.50 | 1.26 | 0.01 | 0.01 | 0.17 | 0.48 | 0.62 | 0.44 | 0.45 | 0.58 |
| | proxy | ii. Elastic Cobb–Douglas | 4.27% | 1.48 | 1.26 | 0.00 | 0.02 | 0.17 | 0.48 | 0.62 | 0.44 | 0.45 | 0.58 |
| iii. | Inverted endogenous | i. Fixed | 4.26% | 1.36 | 1.32 | 0.01 | 0.03 | 0.21 | 0.54 | 0.62 | 0.47 | 0.40 | 0.58 |
| | feedback | ii. Elastic Cobb–Douglas | 4.26% | 1.34 | 1.32 | 0.01 | 0.03 | 0.21 | 0.54 | 0.62 | 0.47 | 0.40 | 0.58 |
| *New owner scheme* | | | | | | | | | | | | | |
| d. i. | Calibrated endogenous | i. Fixed | 3620 | 13.25 | 20.80 | 0.18 | 0.30 | 1.00 | 1.00 | 0.87 | 0.68 | 0.61 | 0.76 |
| | local feedback | ii. Elastic Cobb–Douglas | 3620 | 12.82 | 20.97 | 0.18 | 0.30 | 1.00 | 1.00 | 0.87 | 0.69 | 0.61 | 0.76 |
| ii. | Homeownership as a | i. Fixed | 3620 | 15.22 | 17.11 | 0.18 | 0.30 | 1.00 | 0.83 | 0.69 | 0.32 | 0.15 | 0.05 |
| | proxy | ii. Elastic Cobb–Douglas | 3620 | 15.16 | 17.03 | 0.18 | 0.30 | 1.00 | 0.83 | 0.69 | 0.32 | 0.15 | 0.05 |
| iii. | Inverted endogenous | i. Fixed | 3665 | 14.68 | 20.46 | 0.18 | 0.30 | 1.00 | 0.88 | 0.71 | 0.48 | 0.35 | 0.44 |
| | feedback | ii. Elastic Cobb–Douglas | 3660 | 14.60 | 20.40 | 0.18 | 0.30 | 1.00 | 0.88 | 0.71 | 0.48 | 0.35 | 0.44 |

could fall (consistent with the argument made by Bourassa and Yin, 2008) and the average property size amongst homeowners in the top tax brackets could increase under the 28% cap, flat-rate tax credit and income tax rebate reforms.

### 5.2. Concluding remarks

Examining a range of alternative policy reforms demonstrates the importance of policy design and the role of path dependency in shaping the outcome of those reforms. With regard to the latter, there are three key mechanisms at work. First, owning a property shields high-income households against rises in property prices and subsequently enables them to channel benefits through capital gains. Second, housing stock constraints fix the current capital stock of housing making it unresponsive to price changes, these constraints act to suppress price falls and stabilize homeownership in the face of contracting demand. Third, endogenous public goods can act as a mechanism for compensating households. As a result, the complex patterns of change precipitated by policy reforms in the property market can have quite unanticipated results. Policies designed to be progressive, such as the tax credit reform, may do less to benefit poorer households than those that appear to be regressive, such as the income tax reduction reform. Likewise, policies that economists would normally assume to have excellent efficiency improving qualities, such as the income tax reduction reform, may lead to significant net welfare losses. Taken as a whole, our investigation suggests that several reforms to MID could maintain the prevailing levels of homeownership while delivering more public goods and contributing to a reduction in the federal deficit.

Of course, these results relate to the calibration of a simplified two-community problem. Given our results, it would be interesting to see future work directed towards the estimation of a large-scale model with more formally quantified social returns to homeownership. With these extensions it would be possible to simulate economy-wide responses to the proposed reforms. Nonetheless, our results demonstrate the usefulness of the modeling framework and provide important insights into the broader implications of reforming MID.

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