Housing Affordability and Transaction Tax Subsidies *

Anastasia Girshina† François Koulischer‡ Ulf von Lilienfeld-Toal§

January 1, 2021

Abstract

House prices have increased faster than average income in many countries over the last decade, raising concerns on the affordability of housing. We study the impact of transaction taxes on the real estate market and the effectiveness of tax subsidies to make housing more affordable. We show how the demand and supply elasticities for housing determine the price impact of tax subsidies and the distribution of gains between buyers and sellers. We then use data on all real estate transactions in Luxembourg from 2007 to 2018 to estimate the elasticity of housing supply and demand. For identification, we exploit discontinuities in the transaction tax schedule as well as rules on tax subsidies for new constructions. Our estimates suggest that the elasticity of house prices to transaction taxes is 0.27, so buyers capture a large part of the surplus from the subsidies. (141 words)

JEL Classification: G51, H71, R21, R31

Keywords: Real Estate, Transactions Taxes, Housing Subsidies, Housing Affordability

*We thank seminar participants at the University of Luxembourg, the Dutch Bureau of Economic Analysis (CPB) and the European Winter Meeting of the Econometric Society for comments. This project is supported by the Luxembourg National Research Fund (FNR project 11694226)

†Stockholm School of Economics, anastasia.girshina@hhs.se.

‡University of Luxembourg, Department of Finance, francois.koulischer@uni.lu.

§University of Luxembourg, Department of Finance, ulf.vonlilienfeld-toal@uni.lu.

1 Introduction

House prices have increased faster than income in many regions over the last decade. In the euro area, the ratio of house prices to median income reached an all time high in 2020. In the United-States, the price to income ratio has increased by more than 20% since its post-crisis low of 2012. The strong growth in house prices relative to income has led some observers to declare a "housing affordability crisis" where middle-income households are unable to climb the property ladder (see e.g. Reina, 2019 and JCHS, 2020).

Barriers to home ownership caused by relatively high house prices can lead to several adverse consequences. Housing is the main savings vehicle of the middle class and a lack of access to the housing market may reduce the wealth accumulation of households (Martinez-Toledano, 2019; Bernstein and Koudijs, 2020). Home ownership causes households to move up the housing ladder and to work harder (Sodini et al., 2016), so unaffordable housing may reduce the incentive benefits from home ownership. Unaffordable housing may also increase the debt burden of households and their exposure to declines in house prices (Rajan, 2011). This in turn increases the pro-cyclicality of consumption and the severity of economic downturns (Mian and Sufi, 2014).

To respond to these concerns, governments have set up a number of subsidies to make housing more affordable. These subsidies include direct transfers and tax breaks for home buyers. The resources allocated to these policies are sizeable, representing 0.5% of GDP in the United-States and 0.7% of GDP in the European Union. Despite the importance of these subsidies, there has been limited evidence so far on their effectiveness.[1] The main challenge to evaluate subsidies in the real estate market is to measure their impact on prices. If a 1% reduction in transaction taxes for buyers leads to an increase in house prices of 1%, the sellers will reap the full benefit of the tax subsidy. In this case, the tax subsidy will thus not be useful for making housing more affordable to home buyers.

In this paper, we study the impact of transaction tax subsidies on the real estate market and the implications for housing affordability. To assess the price impact tax subsidies, we must identify both the price elasticity of supply and the elasticity of demand. In a model of the housing market, we show that the response of house prices to changes in taxes can be captured as the ratio of demand elasticity to the sum of supply and demand elasticities. To estimate these parameters, we consider the case of the real estate market in Luxembourg, a country that allocates more than 2.5% of its GDP to housing tax subsidies. The case of Luxembourg is interesting for our study as the tax schedule for real estate includes a number of features such as reduced VAT for new constructions that allow to identify both the supply and the

[1] Poterba (1984) studies the implications of changes in inflation rates for the tax subsidies to owner occupied housing. Besley et al. (2014) and Best and Kleven (2018) study the impact of a reduction in real estate transaction taxes in the United-Kingdom during the global financial crisis. Kopczuk and Munroe (2015) and Slemrod et al. (2017) study the impact of transaction taxes on the demand for housing.

demand elasticities. Our estimates suggest that the final elasticity of prices to transaction taxes is 0.27, so that a 1% reduction of taxes is associated to a 0.27% increase in house prices. This suggests that the buyers capture a substantial part of the benefits of tax subsidies.

We begin the paper with a model of the housing market to guide the empirical analysis. Our model includes a stock of existing houses, a supply of new housing as well as transaction taxes that differ on each property type. Households are endowed with some labour resources and an amount of old (existing) housing. They use their endowments to consume an amount of old and new housing as well as a residual good. We assume that households are indifferent between new and old houses so that the prices of housing after tax in the old and new housing markets are equal. In equilibrium, the price of housing depends on the aggregate preference of households for housing and the tax on new houses, which set the price faced by constructors.

When the taxes on new and old housing are the same, we show that the impact of transaction taxes on the price before tax is equal to the ratio of demand elasticity to the sum of supply and demand elasticity. Since buyers pay the price after tax and sellers receive the price before tax, this is the main feature of the model to estimate in order to assess the effectiveness of tax subsidies and the distribution of the subsidy between buyers and sellers. If for instance both elasticities are equal, a one percent decrease in the tax rate leads to an increase in prices of 0.5% so buyers and sellers benefit equally.

We then estimate the elasticity of supply and demand using data on all real estate transactions in Luxembourg from 2007 to 2018. The data is maintained by the Registration Duties, Estates and VAT Authority of Luxembourg. It includes around 175,000 anonymized transactions and we focus our analysis on sales of apartments which are more comparable properties. To identify the elasticity of demand, we rely on a kink in the transaction tax schedule. While buyers must pay a 7% tax on the transaction price, first-time buyers are exempt from the first €20,000 of taxes. This creates a kink in the tax schedule at a price of €285,714 ($= 20,000/0.07$), where the marginal tax rate is zero before the threshold and 7% above. If demand is price elastic, the kink in the tax schedule will lead to a bunching of transactions below the threshold.

We show how the estimates of bunching can be used to recover the elasticity of demand for housing, building on the work of Saez (2010) and Chetty et al. (2011) on the elasticity of labour supply. We find a statistically significant bunching of transactions of existing apartments, particularly in the first years of our sample when the tax reduction was most salient. Our estimates suggest that the elasticity of demand is 0.18.

To identify the elasticity of supply, we rely on discontinuities in the value added tax (VAT) on new constructions. The standard VAT rate in our sample is 15% from 2007 to 2015 and 17% thereafter. New properties can however benefit from a reduced VAT rate of 3% on the construction costs, for a maximum tax advantage of €50,000. This creates a kink in the cost of construction, where construction costs up to €416,000 benefit from the 3% VAT while costs beyond this limit are subject to the full VAT rate. We find a significant bunching at the threshold, from which we estimate an elasticity of supply of 0.48.

Combined with our estimates of demand elasticity, this suggests that the price impact of taxes is 0.27. A 1% decrease in transaction taxes is therefore associated with a 0.27% increase in the price before tax so that buyers could capture as much as 73% of the surplus from the subsidies. We then discuss the implications of these findings for the affordability of housing. While a housing transaction tax can affect the cost of entry to home ownership, the impact on prices could also affect the distribution of wealth when the ownership of housing is concentrated. We illustrate this point using the model and data on household finances in Luxembourg from the Household Finance and Consumption Survey (HFCS).

Our work is related to several strands of the literature. A number of authors have used discontinuities in real estate tax schedules to estimate the demand for housing and the consumption response to lower tax rates. Besley et al. (2014) and Best and Kleven (2018) for instance study a stamp duty holiday in the United-Kingdom in 2008-2009. They combine the temporary tax break with discontinuities in the tax schedule to assess the response of housing transactions and consumption. Besley et al. (2014) in particular find that the average reduction in the after-tax sale price is found to be around £900 against the backdrop of an average tax reduction of about £1500. They calibrate their estimates to a bargaining model and show that about sixty percent of the surplus generated by the holiday accrued to buyers. Kopczuk and Munroe (2015) and Slemrod et al. (2017) also study the impact of the transaction taxes on demand for real estate, respectively in the case of New York and Washington DC.

One contribution of our work to these studies is to also consider the response of housing supply. The determinants of housing supply have been studied by Saiz (2010) who used sattelite data on terrain elevation and the presence of water to show that geography is a key determinant of the supply of housing. Gyourko and Krimmel (2019) and Glaeser and Ward (2009) have studied the impact of land use regulation on the supply of housing. Our setting allows to consider both the demand and the supply for housing, which is key to assess the price impact of taxes and the effectiveness of tax subsidies.

The impact of tax subsidies on the housing market have been studied by Poterba (1984) who examined the influence of inflation on the tax subsidies to owner-occupied housing, and found that the increased subsidies from high inflation in the 1970s could have accounted for as much as a 30% increase in real house prices. Subsequent papers emphasized the role of tax reform in the 1980s (Poterba et al., 1991; Poterba, 1992). Poterba and Sinai (2008) document the differences in tax savings associated with the mortgage interest and property tax deductions across age and income groups. Our paper provides further evidence on the distribution of the gains of tax subsidies between buyers and sellers and the implications with heterogeneous housing ownership.

A number of recent papers have studied the issue of housing affordability. Favilukis et al.

(2018) build a dynamic spatial general equilibrium model of the real estate market to study the welfare impact of different affordable housing policies. The authors find that tax credits are not a useful policy tool as they must be financed by higher taxes otherwise so that the net effect is muted. Imrohoroglu et al. (2018) use a calibrated DSGE model to assess the effects of a change in taxes in California on housing allocations, prices, and the welfare of households. Hsieh and Moretti (2019) use a spatial equilibrium model to assess the impact of land use regulations on aggregate productivity. Our work complements these general equilibrium model by identifying key parameters of the housing market, using methods developed by Saiz (2010) and Chetty et al. (2011).

The paper is structured as follows. In section 2 we introduce a model of the housing market with endogenous supply of new constructions. In section 3 we describe the data and institutional features that we use for identification. Section 4 then shows how the kinks in the transaction tax schedule can be used to recover the elasticity of demand from bunching estimates, and provides the estimation results of demand elasticity. Section 5 provides a link between the model and the data and shows how to recover the elasticity of supply from kinks in the reduced VAT rate on new constructions. It also provides the estimates of supply elasticity. Section 6 presents the final results on the price impact of transaction taxes and discusses their implications.

2 Model of Housing Transaction Taxes

To assess the effectiveness of transaction tax subsidies, we must understand their impact on real estate prices. In this section, we provide a simple framework to show how the price impact depends on the structure of the market. In the model, house prices are endogenous and there are two types of housing, old and new, each subject to its own transaction tax rate.

Setup

A continuum of households indexed by $i \in [0,1]$ is endowed with a house of size H_i^0 and financial resources W_i, which can be interpreted as cash or the net present value of future labour income. In what follows, we label W_i as labour resources. There are two types of houses in the economy, old (existing) houses and new houses. Households must choose a quantity of each housing type to consume, as well as an amount of residual consumption c_i.

House producers can build new houses sold at a price of p^{new} per housing unit. The supply of new housing is given by $(p^{new})^{\gamma} - 1$. The stock of existing houses is normalized to one so that the total supply of housing is given by $H^S = H^{new} + H^{old} = (p^{new})^{\gamma}$, where γ is the price elasticity of housing supply.

The purchase of housing is subject to a transaction tax paid by the buyer. Taxes are specific to each type of property so buyers pay $\left(1+\tau^{old}\right)p^{old}$ for each unit of old housing and $\left(1+\tau^{new}\right)p^{new}$ for each unit of new housing. In the context of the model, these taxes can be interpreted broadly as transaction taxes, property taxes or value-added taxes (VAT) on construction costs. In our application, the transaction taxes for new and old houses are the same but new constructions are also subject to a VAT for the construction costs. The government can therefore discriminate between old and new houses by combining the transaction tax and the VAT on construction costs. We derive the correspondance between our setup and a VAT regime in section 5.

Let H_i^{new} and H_i^{old} be the amount of new and old housing consumed by i. The household is indifferent to new and old houses and values the total quantity of housing consumed, $H_i = H_i^{new} + H_i^{old}$. Household i chooses H_i^{new}, H_i^{old} and c_i to maximize the quasi-linear utility

$$\max_{H_i^{old}, H_i^{new}, c_i} U_i\left(H_i, c_i\right) = \alpha_i^{1/\epsilon} \frac{H_i^{1-1/\epsilon}}{1-1/\epsilon} + c_i \tag{1}$$

where ϵ is the structural demand elasticity and α_i is a taste parameter such that $\int_0^1 \alpha_i di = A$. The household faces the budget constraint:

$$W_i + p^{old} H_i^0 = p^{old} H_i^{old}\left(1+\tau^{old}\right) + p^{new} H_i^{new}\left(1+\tau^{new}\right) + c_i. \tag{2}$$

Market clearing ensures that housing supply is equal to housing demand:

$$\left(p^{new}\right)^{\gamma} = \int H_i di. \tag{3}$$

Figure 1 summarizes the model and the timing. The housing endowment is allocated in period 0 while the labour resources are allocated in period 1. The household sells its initial house and chooses an amount of food and housing to consume in period 1.

Equilibrium

Since households are indifferent between new and old housing, the after tax price of old housing is equal to the after tax price of new housing.

Lemma 1. *The after tax prices of new and old housing are equal*

$$p^{old}\left(1+\tau^{old}\right) = p^{new}\left(1+\tau^{new}\right). \tag{4}$$

Let P denote the after tax price, so that $P = p^{old}\left(1+\tau^{old}\right) = p^{new}\left(1+\tau^{new}\right)$. In what follows we will use the lower case variable p to indicate the price before tax and the upper case P to indicate the price after tax. Combining equations (1) and (2), total demand for housing

H_i is given by

$$H_i = \alpha_i P^{-\epsilon}. \tag{5}$$

and the equilibrium is as follows.

Proposition 1. *The after tax price of housing is given by*

$$P = A^{\frac{1}{\gamma+\epsilon}} \left(1 + \tau^{new}\right)^{\frac{\gamma}{\gamma+\epsilon}}$$

and the pre-tax price of new housing is $p^{new} = A^{\frac{1}{\gamma+\epsilon}} \left(1 + \tau^{new}\right)^{\frac{-\epsilon}{\gamma+\epsilon}}$. *Total supply of housing is* $H = (p^{new})^{\gamma}$. *The consumption of housing and residual good by household* i *are given by*

$$\begin{cases} H_i & = \alpha_i A^{\frac{-\epsilon}{\gamma+\epsilon}} \left(1 + \tau^{new}\right)^{\frac{-\epsilon\gamma}{\gamma+\epsilon}} \\ c_i & = W_i + A^{\frac{1}{\gamma+\epsilon}} \left(1 + \tau^{new}\right)^{\frac{\gamma}{\gamma+\epsilon}} \left(\frac{H_i^0}{1+\tau^{old}} - H_i\right). \end{cases}$$

Proof. Using the budget constraint (2) and Lemma 1, we may rewrite the problem of the household as

$$\max_{H_i} U_i\left(H_i\right) = \alpha_i^{1/\epsilon} \frac{H_i^{1-1/\epsilon}}{1-1/\epsilon} + W_i + p^{old} H_i^0 - H_i P.$$

The first order condition (FOC) with respect to H_i yields the demand for housing

$$H_i = \alpha_i P^{-\epsilon}. \tag{6}$$

The market clearing equation (3) and lemma 1 imply that

$$\begin{cases} \left(p^{new}\right)^{\gamma} = A P^{-\epsilon} \\ P = \left(1 + \tau^{new}\right) p^{new} \end{cases}$$

The after tax and pre-tax prices are thus

$$P = A^{\frac{1}{\gamma+\epsilon}} \left(1 + \tau^{new}\right)^{\frac{\gamma}{\gamma+\epsilon}} \tag{7}$$

$$p^{new} = A^{\frac{1}{\gamma+\epsilon}} \left(1 + \tau^{new}\right)^{\frac{-\epsilon}{\gamma+\epsilon}}. \tag{8}$$

Combining (6) and (7), housing consumption is given by:

$$H_i = \alpha_i A^{\frac{-\epsilon}{\gamma+\epsilon}} \left(1 + \tau^{new}\right)^{\frac{-\epsilon\gamma}{\gamma+\epsilon}} \tag{9}$$

and the construction of new houses is given by:

$$S^{new} = \left(\alpha_i A^{\frac{-\epsilon}{\gamma+\epsilon}} \left(1 + \tau^{new}\right)^{\frac{-\epsilon\gamma}{\gamma+\epsilon}}\right)^{\gamma}.$$

Food consumption is given by the budget constraint (2) combined with (7).

$$c_i = W_i + A^{\frac{1}{\gamma+\epsilon}} \left(1+\tau^{new}\right)^{\frac{\gamma}{\gamma+\epsilon}} \left(\frac{H_i^0}{1+\tau^{old}} - H_i\right).$$

□

The after tax price of housing is increasing in the taxes on new houses τ^{new} but is independent of the tax on old houses τ^{old}. The reason for this is that supply of old houses is fixed and thus inelastic, so that any increase in taxes τ^{old} reduces the price before tax of old housing p^{old} without changing the after tax price P. If the tax on new houses τ^{new} increases, this increases the after tax price of housing P and reduces the price before tax p^{new}.

When both taxes are equal ($\tau^{new} = \tau^{old}$), the price impact depends on the supply and demand elasticities in a simple expression as summarized in the next proposition.

Proposition 2. *If taxes on old and new houses are equal ($\tau^{new} = \tau^{old} = \tau$), the elasticity of the price before tax is given by:*

$$-\frac{\partial \log p^{new}}{\partial \log(1+\tau)} = -\frac{\partial \log p^{old}}{\partial \log(1+\tau)} = \frac{\epsilon}{\gamma+\epsilon}.$$

A higher elasticity of demand ϵ increases the price impact of taxes. A higher elasticity of supply decreases the price impact of taxes.

Proof. From equation (8), take the log of p^{new} and derive with respect to τ^{new}. □

Figure 14 illustrates the market equilibrium and the price impact of taxes (propositions 1 and 2). The equilibrium price is determined by the familiar upward sloping supply curve and the downward sloping demand curve. Higher taxes lead to a shift in the demand curve, illustrated here by the red curve. This increases the price after tax (the upper horizontal dotted line) and lowers the price before tax (the lower horizontal dotted line).

Since buyers pay the price after tax and sellers receive the price before tax, the burden of higher taxes on buyers and sellers will therefore depend on the elasticities of supply and demand γ and ϵ. If both are equal (as in the case of Figure (14)), the increase in price for the buyers will be equal to the decrease in price for the sellers. If supply were instead more elastic, the buyers would suffer more from the tax increase than the sellers.

Optimal taxation of new and old houses

If the government can discriminate between old and new housing, how should it set taxes τ^{new} and τ^{old}? We consider here a simple case where the government chooses τ^{new} and τ^{old} to maximize the utility of households subject to raising some amount of taxes T. Let us decompose this amount into the amount collected from old housing, T^{old}, and the amount collected from new housing, T^{new}. In this case we can derive a simple result on the relative taxation of old and new houses as a function of supply elasticity γ.

Proposition 3. *If $A > 1$ and $\epsilon > \gamma^2$, an increase in the elasticity of supply γ increases the optimal amount of taxes collected on old houses relative to new houses, $\partial T^{old}/\partial \tau^{new} < 0$.*

Proof. See appendix A. □

The intuition for proposition 3 is that taxes on old houses can be thought as a tax on the housing wealth endowments of households. Taxes on old houses affect the price of old houses before tax but leave the price after tax unchanged. The marginal welfare cost of taxing old houses is therefore independent of supply elasticity γ. Taxes on new houses on the other hand will reduce the supply of new houses by reducing the price p^{new}. The welfare cost is increasing with γ so that, all else equal, the government derives a larger share of its taxes from old houses if supply is elastic.

More generally, proposition 3 is consistent with the intuition that the welfare costs of taxation are high when supply or demand is elastic and that optimal taxation should focus on products whose supply or demand is inelastic.

3 Data and Institutions

The two key parameters to measure the price impact of real estate taxes are the elasticity of supply and demand, γ and ϵ. To estimate these parameters, we use data on all real estate transactions in Luxembourg from 2007 to 2018. Luxembourg is an interesting setting to explore transaction tax subsidies as the amount of resources allocated to housing subsidies is large, representing 3.4% of GDP in 2015. In addition, the taxes on real estate offer a number of discontinuities that allow to identify the elasticity of supply and the elasticity of demand.

Two of the most significant housing subsidies provided by the government in Luxembourg are the transaction tax break and the reduced VAT for new constructions. The transaction tax break was introduced in 2002 as the Bëllegen Akt. While real estate transactions in Luxembourg are subject to a 7% tax, the Bëllegen Akt exempts first time buyers of real estate from taxes up to a total of €20,000 per person. The tax break can be cumulated so that couples can benefit to up to €40,000 of tax exemption. The tax exemption creates a kink in the tax schedule of households. In the case of single persons, no tax is due up to a purchase price of €285,714 ($= 20,000/7\%$). After this price, households must pay a marginal tax rate of 7% for every euro increase in the transaction price. Couples face a similar kink at a price of €571,429. The exemption requires the buyer to live in the purchased property for a minimum of two years. The exemption can only be used once in the life of an individual and if the exemption has not been fully used in a first transaction, the individual may use the remainder in another purchase under the same conditions. It applies to all residents without conditions of income, wealth or characteristics of the house bought.

A second measure to address high house prices is the reduced Value Added Tax (VAT) of 3% on housing construction or renovation costs, relative to a normal VAT rate of 15% up to 2015 and 17% thereafter. The property benefiting from the lower VAT must be used as a main residence and the total VAT benefit cannot exceed €50,000 per built and/or renovated property. This threshold effectively creates a kink in the construction costs, where costs up to €416,000 benefit from the 3% VAT while costs beyond this limit are subject to the full VAT rate. For a normal VAT rate of 15% and a reduced rate of 3%, the tax advantage is 12% times the construction costs. A construction for €416,000 therefore benefits from the maximum tax advantage of €50,000 ($\approx 12\% \times 416,000$). After 2015, the tax advantage increased to 14% so that the maximum construction costs to benefit from the reduced VAT rate was lowered to €359,000 ($\approx 50,000/0.14$).

The transaction tax break and the reduced VAT rate together represent the most significant subsidy allocated to housing in Luxembourg, representing lost tax revenues of €164.5 million and €195.4 million respectively (Kaempff, 2018).

To analyze the impact of these tax subsidies on the housing market, we use data on all real estate transactions in Luxembourg from January 2007 to March 2018. The dataset is maintained by the Registration Duties, Estates and VAT Authority, who collects taxes on real estate transactions. The data is collected by the notaries who report transactions, ensure that the relevant taxes are paid and that the owners are registered in the cadaster. For each transaction, the data includes the municipality of the property, the legal right (mostly property rights but also other rights such as co-ownership). It also includes the surface of the plot of land, the size of the house and the property type such as constructed lands, fields or industrial buildings. For apartments, the data documents the presence of additional elements such as garage spaces or basements. Finally, the data includes the transaction price and indicates which units are "to be constructed" - new houses sold by developers that are not yet constructed.

Figure 2a shows a breakdown of the transactions by property right and property types, identifying in particular apartments. We furter distinguish between existing properties and new properties "to be built". During the 10 years in our sample, there were around 175,000 transactions of which 166,000 transferred the full property right. Apartments accounted for 40% of these transactions, of which roughly a third consisted of "future constructions". In the remainder of the analysis, we focus on apartment transactions which are the most straightforward to identify from the variable descriptions.

Figures 2c and 2d shows the evolution of the number of transactions and the total volume over time, with apartments highlighted in red. The number of transactions and the volumes have increased over time. The share of apartments remained broadly stable over time at 40%. The average price of apartments increased from €290,000 at the beginning of our sample to €509,000 towards the end of our sample.

4 Demand Elasticity

To identify the elasticity of demand, we use the kink in the transaction tax schedule created by the €20,000 tax break of the Bëllegen Akt. Under this framework, no taxes are due up to a price of €285,714 and buyers must pay a 7% tax on the amount above the threshold.

From the model of section 2, consider now a non-linear tax system where no transaction tax is due up to a threshold K, and the tax rate is τ for the amount above the threshold. Taxes on old and new houses are identical so that the market has a unique price of housing before tax p. In this case consumption in equation (2) is given by the budget constraint:

$$c_i = \tilde{W}_i - \min\left(pH_i, K\right) - (1+\tau)\max\left(pH_i - K, 0\right)$$

where the household pays no tax if the amount spent on housing is below or equal to K, and pays a tax τ beyond this. The initial endowment $\tilde{W}_i$ includes the potential housing wealth of the household (so $\tilde{W}_i = W_i + pH_i^0$).

The demand of households for housing in this case is given by the first order condition in equation (5):

$$H_i = \begin{cases} \alpha_i p^{-\epsilon} & \text{if } \alpha_i < \underline{\alpha} \\ \frac{K}{p} & \text{if } \alpha_i \in \left[\underline{\alpha}, \overline{\alpha}\right] \\ \alpha_i \left(p\left(1+\tau\right)\right)^{-\epsilon} & \text{if } \alpha_i > \overline{\alpha} \end{cases}. \tag{10}$$

Depending on its taste for housing α_i, the household i can be in one of three regimes. If the household has a low taste for housing α_i the demand of the household without taxes is below the threshold K, so the household consumes $\alpha_i p^{-\epsilon}$ and pays no taxes. If the taste for housing increases beyond a threshold $\underline{\alpha}$ but remains below $\overline{\alpha}$, the marginal utility of an additional unit of housing is lower than the cost with the taxes. The household thus chooses housing at the threshold size $H_i = K/p$ and does not pay any taxes. If $\alpha_i > \overline{\alpha}$, the household consumes $H_i = \alpha_i \left(p\left(1+\tau\right)\right)^{-\epsilon}$. The higher taxes thus lower demand above the threshold and create an excess mass at the threshold.

The estimates of the amount of bunching can be used to recover the elasticity of demand.

The type thresholds $\underline{\alpha}$ and $\overline{\alpha}$ are given by equation (10) as:

$$\begin{cases} \underline{\alpha} = & \frac{K}{p^{1-\epsilon}} \\ \overline{\alpha} = & \frac{K}{p(p(1+\tau))^{-\epsilon}} \end{cases} \tag{11}$$

Let the bunching B be the fraction of households that choose $H_K = K/p$. Let $F(\cdot)$ be the cumulative distribution function of house sizes in the absence of tax changes at the kink.[2]

$$B = F(H(\overline{\alpha})) - F(H(\underline{\alpha}))$$

Assuming that $F(\cdot)$ follows a uniform distribution around the kink, we have

$$B = (H(\overline{\alpha}) - H(\underline{\alpha}))\, f(H_K)$$

where $f(S_k)$ is the density at the threshold. This may be rewritten as:

$$B = \left(\overline{\alpha}\,(p)^{-\epsilon} - \underline{\alpha}\,(p)^{-\epsilon}\right) f(H_K).$$

Using $\underline{\alpha}$ and $\overline{\alpha}$ from (11), we find that

$$\frac{Bp}{Kf(H_K)} \simeq \epsilon \ln(1+\tau).$$

Let $G(\cdot)$ be the distribution of transaction prices. We have $g(K) = f(H_K)/p$ so that

$$\epsilon = \frac{B/g(K)}{K\ln(1+\tau)} = \frac{b(\tau)}{K\ln(1+\tau)} \tag{12}$$

where b is the fraction of individuals that bunch at the kink normalized by the counterfactual density. The demand elasticity ϵ can thus be recovered from the distribution of transaction prices and measures of bunching around the tax threshold K.

To estimate the excess bunching $b(\tau)$, we follow the work of Chetty et al. (2011). While the model predicts that households will bunch exactly at the tax threshold, the bunching of transactions is likely to be more diffuse below the threshold in practice. We first fit a polynomial to the counts plotted in the figure, excluding the data near the kink. To do so, we estimate the following polynomial:

$$C_j = \sum_{i=0}^{q} \beta_i^0 \cdot (Z_j)^i + \sum_{i=-R}^{R} \gamma_i^0 \cdot 1[Z_j = i] + \epsilon_j^0 \tag{13}$$

[2] In this setting the quantity of housing H_i is the house size, which may also be interpreted as a quality-adjusted size.

where C_j is the number of transactions in price bin j, Z_j is the house price relative to the kink in €10,000 intervals ($Z_j = \{-20, -19, \ldots, 20\}$), q is the order of the polynomial, and R denotes the width of the excluded region around the kink (measured in €10,000).[3] Let B denote the excess number of transactions at the kink. We define an initial estimate of the counterfactual distribution as the predicted values from (13) omitting the contribution of the dummies around the kink: $\hat{C}_j^0 = \sum_{i=0}^{q} \hat{\beta}_i^0 \cdot (Z_j)^i$. The excess number of individuals who locate near the kink relative to this counterfactual density is $\hat{B}^0 = \sum_{j=-R}^{R} C_j - \hat{C}_j^0 = \sum_{i=-R}^{R} \hat{\gamma}_i^0$.

Figure (3) shows the distribution of apartment transaction prices for the years 2007 to 2018, focusing on existing (old) properties. The figure is centered around the threshold of €286,000 and we group transactions into bins of €10,000. For example, we observe 829 transactions with a price between €186k and €196k, which corresponds to the bucket -10 in the figure. To construct the counterfactual distribution, we exclude the four points below and above the threshold and fit a polynomial of degree 7 on the remaining observations.[4]

We find a statistically significant bunching of transactions below the kink, with an excess mass b of 0.35 and a standard error of 0.14. Figure 15 in appendix shows a breakdown of the distribution of transactions over time, focusing on 3 year periods from 2007 to 2009, 2010 to 2012, etc. The bunching remains in all subperiods except for the most recent (2015-2018).

We can use equation (12) to compute estimates of the demand elasticity parameter ϵ as

$$\hat{\epsilon} = \frac{\hat{b}(\tau)}{K \ln(1+\tau)} = \frac{0.35}{28.6 \times 6.8\%} = 0.18.$$

This implies that a 1% increase in transaction taxes will lead to a 0.18% decrease in the demand for housing. The impact on the consumption of housing, however, will also depend on the response of prices. The elasticity of housing $H = A(p(1+\tau))^{-\epsilon}$ relative to housing taxes is given by:

$$-\frac{\partial \log H}{\partial \log(1+\tau)} = \epsilon \frac{\partial \log p}{\partial \log(1+\tau)} + \epsilon.$$

The impact of taxes on the demand for housing has two components. The first term in the previous equation is the change in demand due to the price impact. The second is the change in demand from the demand elasticity. Using proposition 2, we may rewrite this as

$$-\frac{\partial \log H}{\partial \log(1+\tau)} = \epsilon \left(\frac{-\epsilon}{\gamma + \epsilon}\right) + \epsilon.$$

If supply is perfectly inelastic ($\gamma = 0$), a change in taxes does not affect housing consumption (the quantities). If housing supply is perfectly elastic, the change in quantity will be

[3] In the estimation we fit a polynomial of order $q = 7$ and $R = 4$, i.e. excluding transactions between €246k and €326k.

[4] As in Chetty et al. (2011), we redistribute the excess density to the right of the threshold in order to ensure that the mass below the actual and the counterfactual densities are identical.

proportional to the change in demand.

5 Supply Elasticity

To assess the final impact of real estate taxes on prices and quantities, we must estimate the elasticity of housing supply γ. To do this, we use the reduced VAT rate on new constructions. As explained in section 3, new constructions benefit from a reduced VAT rate of 3% for a maximum tax reduction of €50,000. The normal VAT rate in our sample is 15% until 2015 and 17% thereafter. Before 2015, constructions costs up to €416,667 benefited from the 3% VAT rate, and were subject to a 15% rate beyond this amount. This corresponds to a VAT payment of €12,500. After 2015, the maximum VAT paid with the reduced 3% rate fell to €10,714.

For tractability, the model features two transactions taxes τ^{old} for existing houses and τ^{new} for new constructions. In practice, the government sets a common transaction tax rate for old and new houses but also imposes a VAT on the costs of constructing new houses. We can show that these two policies are in fact equivalent. Let c be the share of construction costs in the price of new homes. Let τ^v be the VAT. As in the model, new houses sell at a price before tax of p^{new} and old houses sell at a price p^{old}. The transaction tax on old and new houses is the same and set to τ.

In this case, the cost of an old house of size 1 is $p^{old}(1+\tau)$ and that of a new house is

$$p^{new} \times (1-c) \times (1+\tau) + p^{new} \times c \times (1+\tau^v) \times (1+\tau).$$

This can be rewritten as

$$p^{new} \times (1 + \tau + \Delta\tau^{new})$$

where $\Delta\tau^{new} = (1+\tau)(c \times \tau^v)$, so that a regime with a common transaction tax and a specific VAT on new constructions is equivalent to a regime with different transaction taxes on old and new houses.

The reduced VAT rate can be used to identify the elasticity of supply. In the model, new constructions depend on the price of new housing p^{new} as $H^S = (p^{new})^\gamma$. The price on new housing is linked to the after tax equilibrium price by lemma 1, so that changes in the tax rate on new houses τ^{new} (or changes in the VAT rate) directly affect the price of new housing p^{new}.

As in the case of the elasticity of demand, we may recover the elasticity of supply by assuming that transactions are uniformly distributed locally around the kink. The excess bunching at the kink then indicates how much supply shifts in response to taxes.

Figure 4 shows the distribution of VAT payments for new constructions in our sample, broken down by transactions that benefited from the low rate (to the left) and those that paid the normal VAT rate (to the right). While no pattern is present for the normal rate, we observe a substantial bunching of transactions at the €12,500 threshold, and to a lesser extent at the €10,714 threshold.

We compute the bunching in Figure 5 using transations before 2015 as the later period includes too few transactions. We focus on transactions with a VAT between €7,500 and €17,500, with 20 buckets of €250 on each side of the threshold. To compute the counterfactual distribution, we estimate equation (13) on the new distribution, fitting a polynomial of degree 7 to the observations (so $q = 2$) and excluding 4 groups around the threshold ($R = 2$). The calculations suggest that $\hat{b} = 2.9$ and is statistically significant.

Back of the envelope computations focusing on the highest €12,500 threshold suggests an elasticity of supply of 0.5. To see this, consider as before a uniform distribution around the threshold on VAT $\in [10,500;\ 12,000]$. The average number of transactions, excluding the observation just below the threshold, is 129. There are 342 transactions at the threshold so that the excess bunching is $\hat{b} = 2.65 = 129/342$. Using (12), given a bucket size of €300 in Figure 4a:

$$\hat{\gamma} = \frac{2.9 \times 250}{12,500 \times 12\%} = 0.48.$$

All else equal, a 1% increase in the price of housing leads to a 0.48% increase in the supply of housing.

6 Implications for Affordable Housing

Using the price impact formula of proposition 2 and the estimates of the elasticity of supply (0.18) and the elasticity of demand (0.48), we find that:

$$-\frac{\partial \log p^{new}}{\partial \log (1+\tau)} = \frac{0.18}{0.48 + 0.18} = 0.27.$$

If taxes fall by 1%, the price of housing before tax will increase by 0.27%. The price of housing after tax will instead increase by around 0.73%. This suggests that buyers still capture a substantial share of the surplus from tax subsidies. The main driver for this result is the high elasticity of housing supply relative to demand. The response of new constructions to changes in prices dampens the impact on the price before tax so the gains of sellers is less dependent on tax subsidies than that of buyers.

Measuring the price impact of real estate transactions taxes can help to assess the efectiveness of tax subsidies to address the issue of housing affordability. Since households are generally both buyers and sellers of real estate, the ownership structure of real estate will also influence the distributional implications of transaction taxes. In this section, we first review the real estate market in Luxembourg within the broader local economic context. We then return to the model of section 2 to explore the role of the distribution of housing wealth and labour income, and discuss the results in view of the statistics on household balance sheets in Luxembourg.

The real estate market in Luxembourg

House prices in Luxembourg have increased by more than 50% in the last decade. As shown in Figure 6a, the growth has been mostly uninterrupted and has in particular been stronger than the growth of house prices in the euro area. Countries such as the United-States or Germany, among others, have also experienced high growth in house prices in recent years.

In the case of Luxembourg, a common explanation for the strong growth in house prices is the mismatch between a strong demand and a limited supply of housing. As illustrated in Figure 6b, the Luxembourg economy created around 10,000 new jobs every year, a 2.3% annual growth so that the total workforce reached 450,000 workers in 2018. Over the same period, the housing market grew at an average of 3,000 new units delivered each year. The level of constructions is arguably below what would be required to meet the growth in employment and the mismatch between the growth of the labour and the housing markets has arguably contributed to the growth in house prices in Luxembourg.

In terms of geographical dispersion, the growth in house prices, the increase in economic activity and population grozth have been concentrated around the capital city, as illustrated in Figure 7. From 1999 to 2019, the population increased from 430,000 to 614,000 inhabitants, or a 1.8% annual growth. The municipality of Luxembourg city alone absorbed 21% of the population growth and the top 11 municipalities absorbed half of the population growth. These are located around the capital city and the second largest city located in the south of the country (Figure 7a). These municipalities also experienced the largest increase in housing units (Figure 7b) and house prices were also highest in those areas.

Housing policies

The strong growth in house prices is a source of concern for residents in Luxembourg. In an October 2019 poll, 82% of respondents cited high house prices as a source of concern, before other issues such as traffic congestion, education or climate change.[5] To address these concerns, the government has put in place a series of subsidies to ensure that housing remains affordable. These measures come in three categories.

The first category consists of direct support to buyers. These measures include direct transfers to buyers or subsidies to lower interest expenses. In order to incentivize municipalities to increase the housing supply, the central government has also put in place a housing pact ("pacte logement") in 2008. Municipalities that participate in the scheme must grow their

[5]Politmonitor poll by TNS-Ilres for "Luxemburger Wort" and "RTL", October 2019.

population by 15% over 10 years and must also meet specific targets related to the density of constructed land or the social mixity. If the targets are met, the government agrees to finance part of the costs of upgrading the local infrastructure such as playgrounds, sport halls or renovation of public spaces. The measure also provides municipalities with extended tools to purchase land for urban planning or the construction of low cost housing units. These measures represented a cost of €140 million in 2018.[6]

The second category consists of tax relief for buyers. We studied earlier the two main measures of tax relief: the €20,000 tax break on transaction taxes for first time buyers and the reduced VAT for new constructions (see section 3). These measures together represent the most significant subsidy allocated to housing, representing lost tax revenues for €164.5 million and €195.4 million respectively.

The third category consists of allowances to compensate for high housing costs, such as rental subsidies. The cost of these measures is relatively small (€10 million) but expected to increase in the coming years.

Together, the various measures represent large resources, with a total of 3.4% of GDP in 2015 allocated to housing subsidies. This places Luxembourg as one of the highest spenders on housing subsidies. In comparison, the Netherlands has set housing subsidies for a total of 2.6 % of GDP according to the OECD (Figure 8). As in Luxembourg, most of this amount is allocated through tax subsidies. similarly allocates substantial subsidies through tax reliefs. Housing subsidies in the United-States represent 0.6% of GDP and tax relief measures are also the largest type of subsidy. Other countries such as the United-Kingdom or France tend to allocate more resources to direct allowances instead of tax subsidies.

Housing affordability in the model

The dual role of housing as both a consumption and an investment good complicates the analysis of affordability. While high house prices are unattractive for households that must allocate a high share of their budget to housing, they also increase the wealth of households who own housing. The key issue of housing affordability is thus the heterogeneity in initial housing endowments H_i^0 and labour income W_i.

For simplicity, consider the case where all households have the same preference for housing, so $\alpha_i = A \; \forall i$. There are then two dimensions of heterogeneity across households: the initial housing endowments H_i^0 and labour income W_i. We consider for simplicity the case of a linear distribution of housing and wealth:

$$H_i^0 = 2i, \; i \in [0, 1] \, ,$$

[6] The cost estimates of the subsidies are taken from the "Budget Pluriannuel 2017-2021" (volume II), the 2017 activity report of the Housing Ministry and 2018-1 Bulletin of the Central Bank of Luxembourg.

$$W_i = 1 - i.$$

In this case, i can be interpreted as the age of the household. Young households (with low i) have little housing wealth but substantial future income. Older households have accumulated a higher housing wealth, but have fewer labour income. In Figure 9, we consider the case where house prices are such that all households have a same amount of resources, but the share of resources allocated to housing or labour varies with age i. The sum of the two lines, however, is constant.

Suppose now that the economy experiences an increase in the demand for housing, so $\alpha_i (= A)$ increases. The increase in demand will lead to higher real estate prices and will change the distribution of resources. Figure 10 illustrates the impact of the increase in demand on resources (LHS) and the share of resources allocated to housing (RHS). In the baseline case, the demand for housing is such that the distribution in resources is constant for all households. If demand increases, this increases the price which benefits more the older households. The distribution of resources becomes upward sloping, and younger households must allocate a higher share of resources to housing relative to older households.

Can real estate transaction taxes alleviate the redistributive effect of an increase in housing demand? Consider first the case where taxes on new and old housing are equal, $\tau^{new} = \tau^{old} = \tau$. Higher taxes will reduce the price before tax of housing, which owners earn when selling their housing endowment. As a result, higher taxes reduce the housing component of the heterogeneity in initial allocations. This point is illustrated in Figure 11

In this setting, all households will consume the same amount of food and housing, with $H_i = c_i = 1$.

Let us now study the resources available to households, $pH_i^0 + W_i$, are affected by changes in the transaction tax rate. Figure 11 (LHS) shows the resources available for housing and food consumption for different tax rates. The flat line ($\tau = 7\%$) corresponds to the baseline case where all households have similar resources. Lower taxes (here, $\tau = 0\%$) increase the price before tax and strengthens the heterogeneity in housing endowments. Higher taxes ($\tau = 12\%$) on the other hand reduce the role of housing endowments in the distribution of resources by reducing the price before tax.

While this would suggest that high transaction taxes are useful to make the distribution of resources more equal across households, this is not the end of the story however because households also consume housing. Since higher taxes increase the after-tax price of housing, they also increase the cost of housing for all households. The ultimate impact on the slope of the share of the distribution will then depend on the relative magnitude of the supply and demand elasticity. In the right hand side of Figure 11, we show the case where $\epsilon = \gamma$ so that buyers and sellers benefit equally from lower taxes. In this case, the endowment effect dominates and the slope of resources with low taxes is decreasing so that younger households allocate proportionally more resources to housing. If however we set the elasticity of supply sufficiently high, the price of housing after tax will fall more with lower taxes so that the younger buyers will benefit more, and the slope will become flatter or even increasing in age.

In practice, survey evidence seems in line with the predictions of the model. We illustrate this using data from the Household Finance and Consumption Survey (HFCS) of the Eurosystem. In Figure 12, we show the distribution of real estate housing wealth across age groups. The distribution is increasing, as in the model. The right hand side picture illustrates the debt service to income ratio (DSTI) across age groups. The DSTI can be interpreted as a first approximation of the share of resources allocated to housing. As in the model, the DSTI falls over age groups. While we summarized the heterogeneity of households by the age, there are many other potential dimensions which could be explored using the model, such as differences in income groups or differences between residents and newcomers in the real estate market. We hope to explore these dimensions in the next version of the paper.

Taxes on new versus old houses. Let us now consider discriminatory taxes on new and old housing, where $\tau^{old} \neq \tau^{new}$. The after tax price of housing in proposition 1 does not depend on the taxes on old houses:

$$P = A^{\frac{1}{\gamma+\epsilon}} \left(1 + \tau^{new}\right)^{\frac{\gamma}{\gamma+\epsilon}}$$

The price of old houses is determined by equation (4):

$$p^{old}\left(1 + \tau^{old}\right) = p^{new}\left(1 + \tau^{new}\right) = P.$$

For a given tax rate on new houses, an increase in the tax of old houses only reduces the price of old housing. While the equilibrium in the housing market remains unchanged, lower taxes on old houses however reduces the resources available to households. They thus dampen the heterogeneity in intitial resources coming from the distribution in housing. Figure 13 illustrates the impact of an increase in taxes on old housing only.

7 Conclusion

House prices have increased faster than average income in many countries over the last decade, raising concerns on the affordability of housing. In the euro area, the house price to income ratio reached an all time high in 2020 and in the United-States the price to income ratio has increased by more than 20% since its trough in 2012. To address the concerns on housing affordability, governments have put in place a number of subsidies including direct transfers and tax subsidies to first time buyers. The resources allocated to these subsidies are large, representing 0.5% of GDP in the United-States and 0.7% in the European Union.

In this paper, we analyze the effectiveness of transaction tax subsidies, where buyers benefit from reductions in the transaction taxes on real estate. The key to evaluate these policies is to understand their impact on house prices: if a 1% reduction in taxes paid by the buyers lead to a 1% increase in house prices, the government is merely providing a subsidy to the sellers.

We construct a model of the housing market that features a market for new and old houses and where households choose the amount of each housing to consume as well as the consumption of a residual good. The government sets taxes on old and new housing in order to collect a specific amount of taxes and households are indifferent between new and old housing so that the after tax price of the two housing types are equal. We derive the equilibrium prices and quantities and show that the final impact of changes in transaction taxes on house prices can be measured as the ratio of the elasticity of demand to the sum of the supply and demand elasticities.

We then estimate these elasticities focusing on the case of Luxembourg, a country that allocates more than 2.5% of its GDP to transaction tax subsidies for real estate. The case of Luxembourg is interesting for our study as the tax schedule for real estate includes a number of features that allow to identify the elasticities of housing demand and supply. To identify the elasticity of demand, we use a kink in the transaction tax where transactions up to a price of €286,000 are exempt from transaction taxes, while transactions above this threshold are subject to a 7% tax rate on the exceeding amount. We show that the bunching estimates from the distribution of transactions can be used to recover the elasticity of demand and our results suggest that the demand elasticity is around 0.18.

To estimate the elasticity of supply, we use a reduction in the VAT for construction costs. While the standard VAT rate stands at 15% until 2015, expenses related to new constructions were subject to a reduced VAT rate of 3% up to a level of total costs of €416,000. We find a substantial bunching of new constructions at this threshold, from which we recover an elasticity of supply of 0.48.

The elasticities of demand and supply suggest that the final price response to a change in transaction taxes is around 0.27, i.e. a 1% decrease in taxes is associated with a 0.27% increase in house prices. This suggests that home buyers capture around 73% of the surplus of the subsidies. We discuss the implications of these findings in the context of our model and illustrate how the heterogeneity in housing ownership could further influence the distributional implications of these subsidies.

References

Bernstein, A. and P. Koudijs (2020): "Mortgage Amortization and Wealth Accumulation," *Available at SSRN 3569252.*

Besley, T., N. Meads, and P. Surico (2014): "The incidence of transaction taxes: Evidence from a stamp duty holiday," *Journal of Public Economics*, 119, 61–70.

Best, M. C. and H. J. Kleven (2018): "Housing Market Responses to Transaction Taxes: Evidence From Notches and Stimulus in the U.K." *The Review of Economic Studies*, 85, 157–193.

Chetty, R., J. N. Friedman, T. Olsen, and L. Pistaferri (2011): "Adjustment Costs, Firm Responses, and Micro vs. Macro Labor Supply Elasticities: Evidence from Danish Tax Records," *The Quarterly Journal of Economics*, 126, 749–804.

Favilukis, J., S. Van Nieuwerburgh, and P. Mabille (2018): "Affordable Housing and City Welfare," .

Glaeser, E. L. and B. A. Ward (2009): "The causes and consequences of land use regulation: Evidence from Greater Boston," *Journal of Urban Economics*, 65, 265–278.

Gyourko, J. and J. Krimmel (2019): "The Impact of Local Residential Land Use Restrictions on Land Values Across and Within Single Family Housing Markets," .

Hsieh, C.-T. and E. Moretti (2019): "Housing constraints and spatial misallocation," *American Economic Journal: Macroeconomics*, 11, 1–39.

Imrohoroglu, A., K. Matoba, and S. Tuzel (2018): "Proposition 13: An Equilibrium Analysis," *American Economic Journal: Macroeconomics*, 10, 24–51.

JCHS (2020): "The State of the Nation's Housing," *Joint Center for Housing Studies of Harvard University.*

Kaempff, B. (2018): "Les interventions de l'etat sur le marche immobilier au Luxembourg," *BCL Bulletin, chapter 4.*

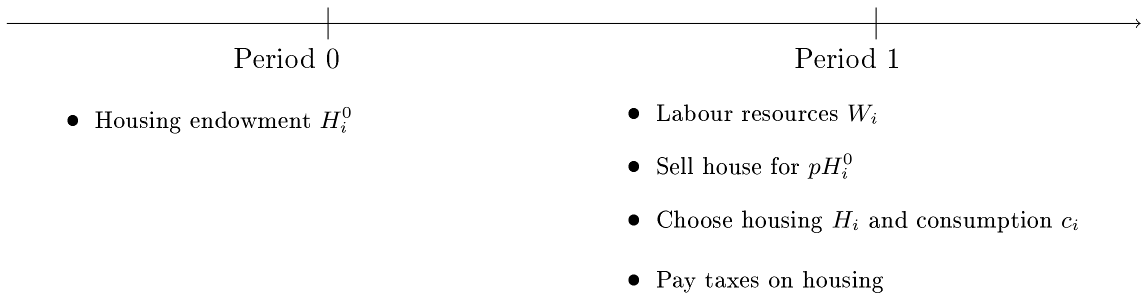
Kopczuk, W. and D. Munroe (2015): "Mansion Tax: The Effect of Transfer Taxes on the Residential Real Estate Market," *American Economic Journal: Economic Policy*, 7, 214–257.

Martinez-Toledano, C. (2019): "House Price Cycles, Wealth Inequality and Portfolio Reshuffling," in *Working Paper.*

Mian, A. and A. Sufi (2014): "What Explains the 2007-2009 Drop in Employment?" *Econometrica*, 82, 2197–2223.

Poterba, J. and T. Sinai (2008): "Tax Expenditures for Owner-Occupied Housing: Deductions for Property Taxes and Mortgage Interest and the Exclusion of Imputed Rental Income," *American Economic Review*, 98, 84–89.

Figure 1: Timeline



Poterba, J. M. (1984): "Tax Subsidies to Owner-Occupied Housing: An Asset-Market Approach," *The Quarterly Journal of Economics*, 99, 729–752.

——— (1992): "Taxation and Housing: Old Questions, New Answers," *The American Economic Review*, 82, 237–242.

Poterba, J. M., D. N. Weil, and R. Shiller (1991): "House Price Dynamics: The Role of Tax Policy and Demography," *Brookings Papers on Economic Activity*, 1991, 143–203.

Rajan, R. G. (2011): *Fault Lines: How Hidden Fractures Still Threaten the World Economy*, Princeton University Press.

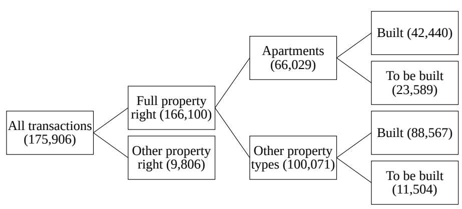
Reina, V. (2019): "The U.S. Needs a National Vision for Housing Policy," *Penn Wharton Public Policy Initiative*, 64.

Saez, E. (2010): "Do Taxpayers Bunch at Kink Points?" *American Economic Journal: Economic Policy*, 2, 180–212.

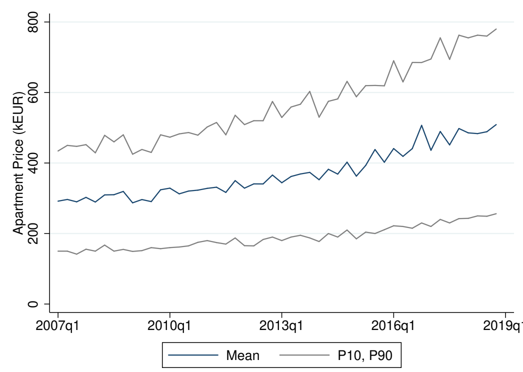
Saiz, A. (2010): "The Geographic Determinants of Housing Supply," *The Quarterly Journal of Economics*, 125, 1253–1296.

Slemrod, J., C. Weber, and H. Shan (2017): "The behavioral response to housing transfer taxes: Evidence from a notched change in D.C. policy," *Journal of Urban Economics*, 100, 137–153.

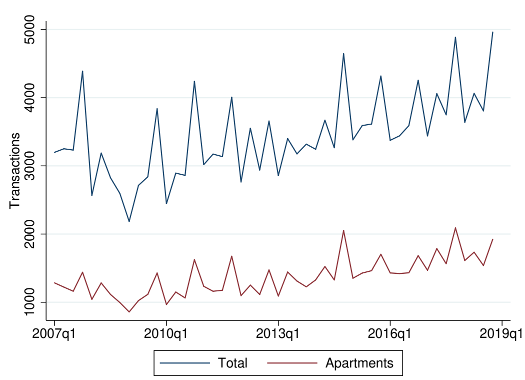
Sodini, P., S. Van Nieuwerburgh, R. Vestman, and U. von Lilienfeld-Toal (2016): "Identifying the benefits from home ownership: A Swedish experiment," Tech. rep.



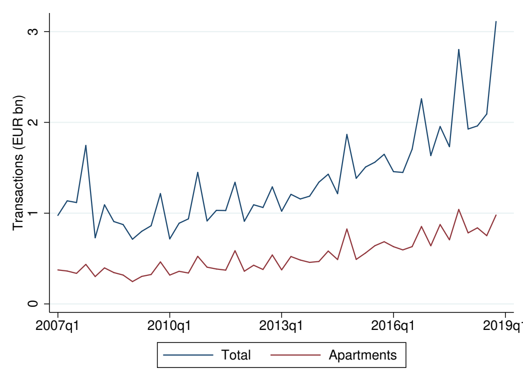
(a) Overview of Luxembourg real estate transactions, 2007-2018.



(b) Apartment prices



(c) Number of transactions per quarter



(d) Transaction volumes per quarter

Figure 2: Real estate transactions in Luxembourg.
Figures (b), (c) and (d) for apartments only.

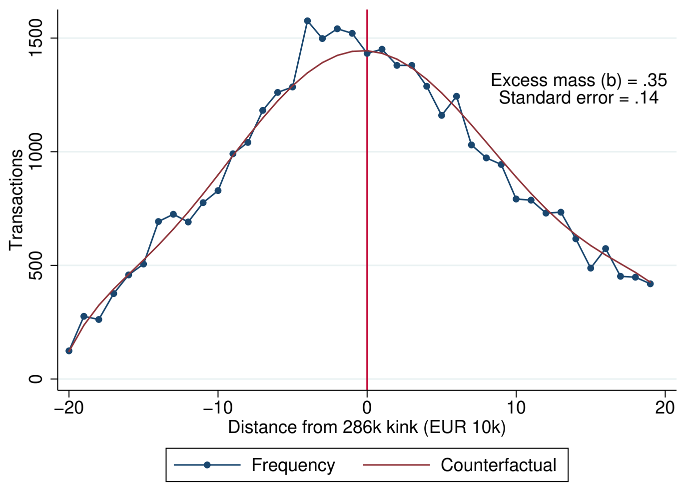
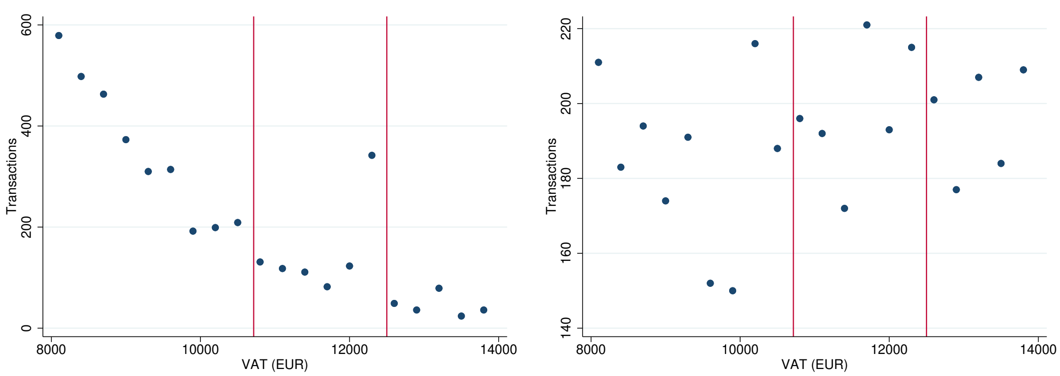


Figure 3: Distribution transaction prices of constructed apartment around the first threshold (2007-2018).
The sample consists of 28,848 transactions around the first threshold of €286k, ranging from €86k to €486k.



(a) Reduced VAT

(b) Normal VAT

Figure 4: Distribution of VAT payments for new constructions
The two vertical lines correspond to the maximum VAT payment benefiting of the 3% low rate (€12,500 before 2015 and €10,714 after)

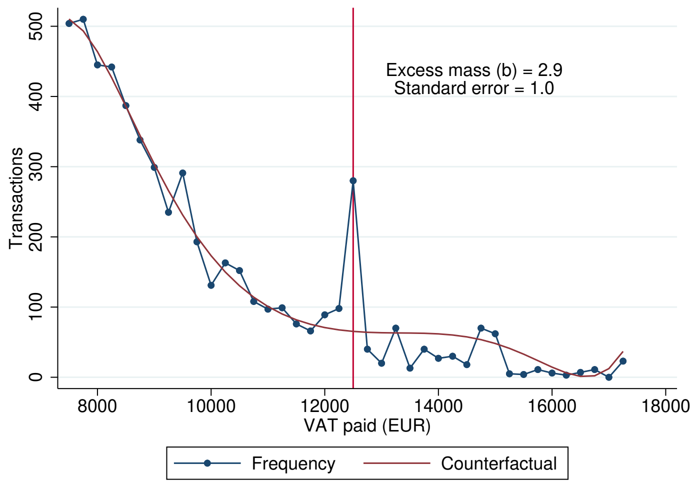
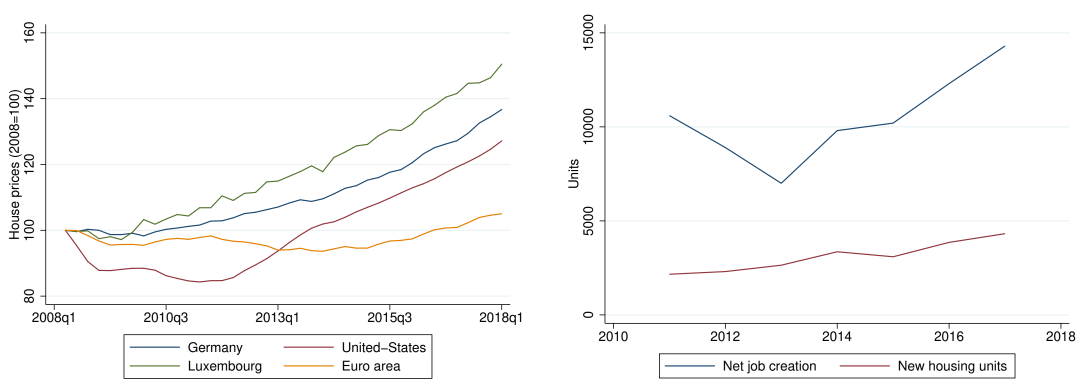


Figure 5: Distribution of VAT payments for new constructions before 2015

Before 2015, the construction costs for new apartments benefited from a reduced VAT rate of 3% until €12,500 (the vertical line). Parameters for the counterfactual in equation (13) are $R = 2$ and $q = 7$.

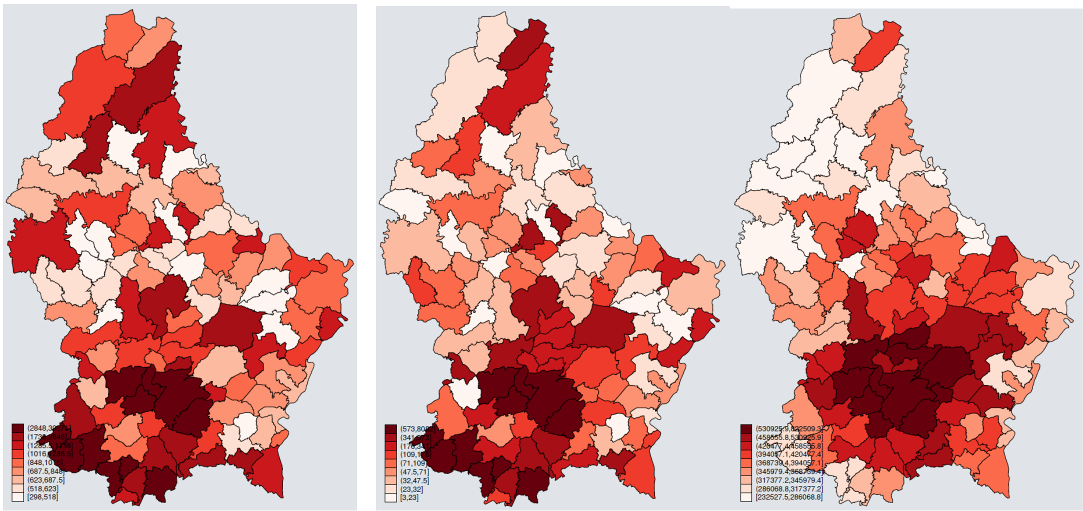


(a) Nominal house prices in Germany, the U.S., the euro area and Luxembourg

(b) Net job creation and new constructions in Luxembourg

Figure 6: (a) Nominal house prices in selected countries and (b) overview of the labour market and new constructions in Luxembourg.

(a) Nominal house prices from 2008 Q2 to 2018 Q1. Prices are normalized to 100 in 2008. Source: BIS. (b) Overview of the labour and real estate market, with annual net job creation and the number of new housing units constructed. Source: Statec.



(a) Population change (b) New constructions (c) Apartment prices

Figure 7: Geographical distribution of population growth, new constructions and apartment prices.
(a) Population change from 1999 to 2019 by municipality in thousand of inhabitants (Source: Statec). (b) Number of new constructions from 2007 to 2018 by municipality. (c) Average transaction price of apartments by municipality from 2015 to 2018.

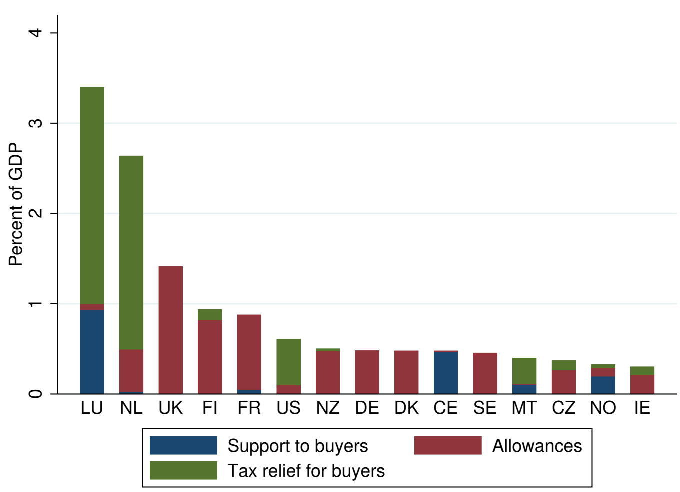


Figure 8: Housing subsidies in advanced economies.
Figures for Luxembourg are from author computations based on Kaempff (2018). Other countries are from the OECD.

Figure 9: Housing endowment pH_i^0 and labour income (wage) W_i in baseline case

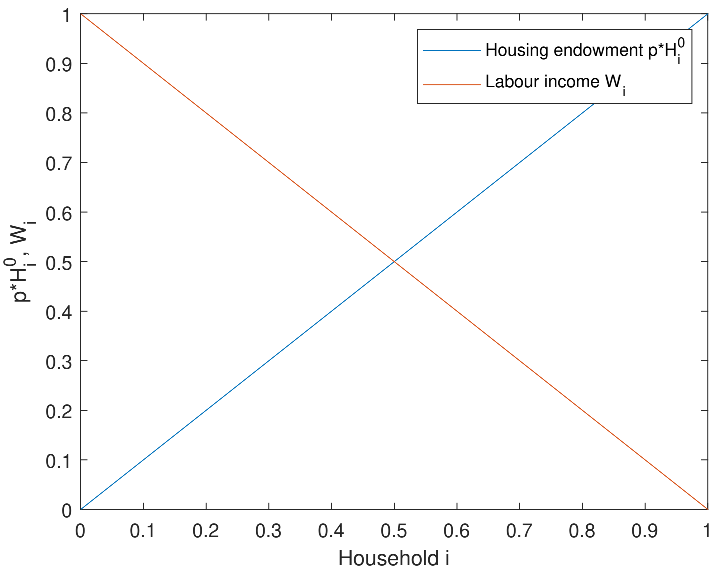


Figure 10: Impact of an increase in housing demand on household resources (right-hand side) and the share of resources allocated to housing (left-hand side)

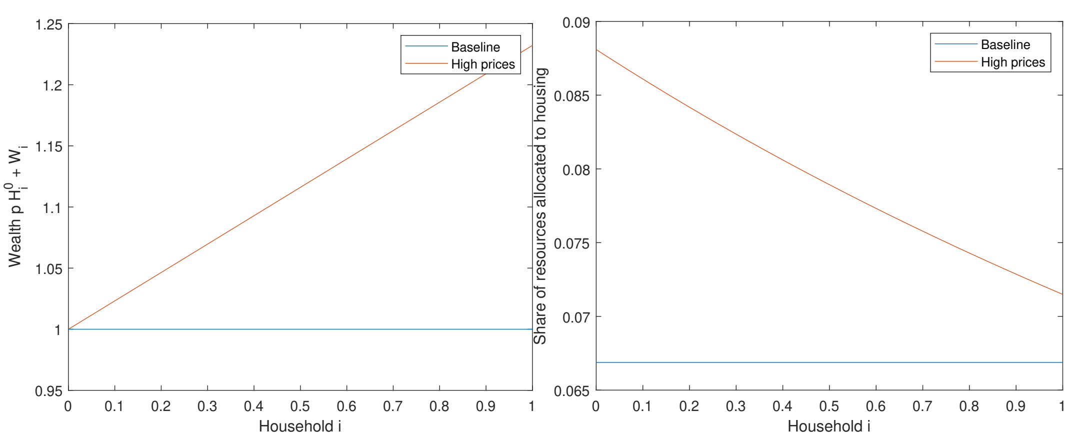


Figure 11: Resources available for housing and food consumption for different tax rates: low ($\tau = 0\%$), medium ($\tau = 7\%$) and high ($\tau = 12\%$).

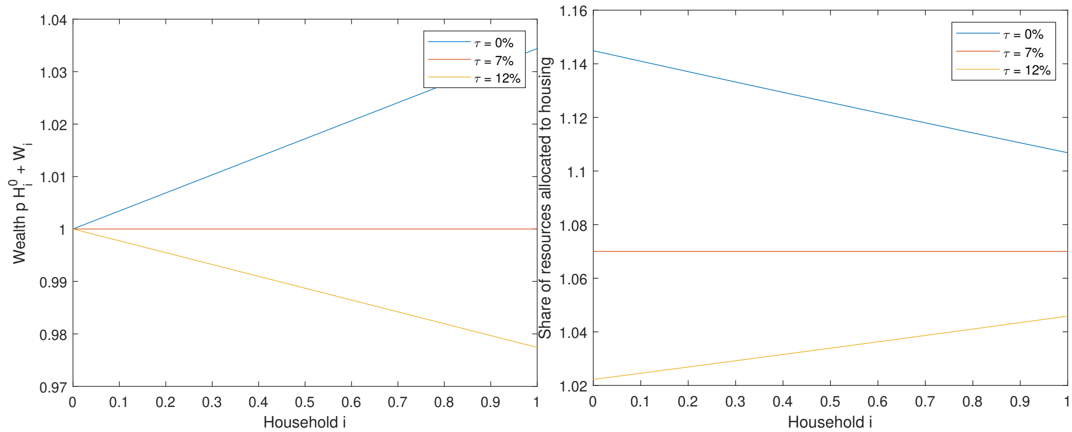


Figure 12: Distribution of housing wealth and debt service to income ratio across age groups in Luxembourg

Source: Household Finance and Consumption Survey, Second wave.

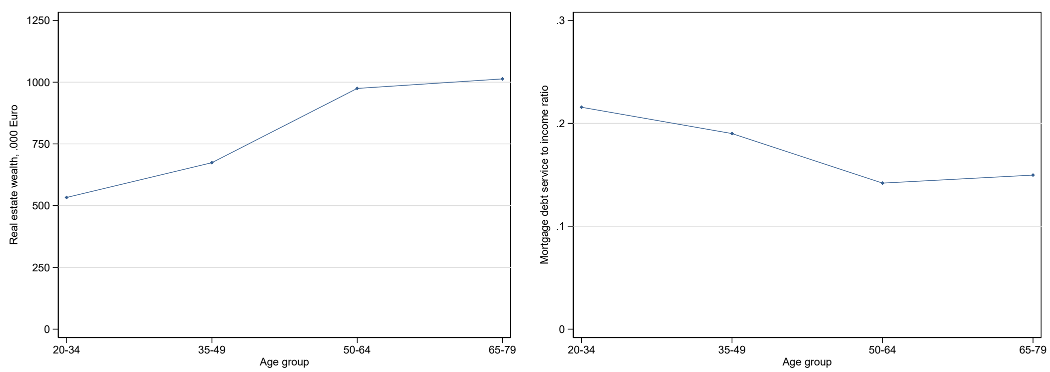
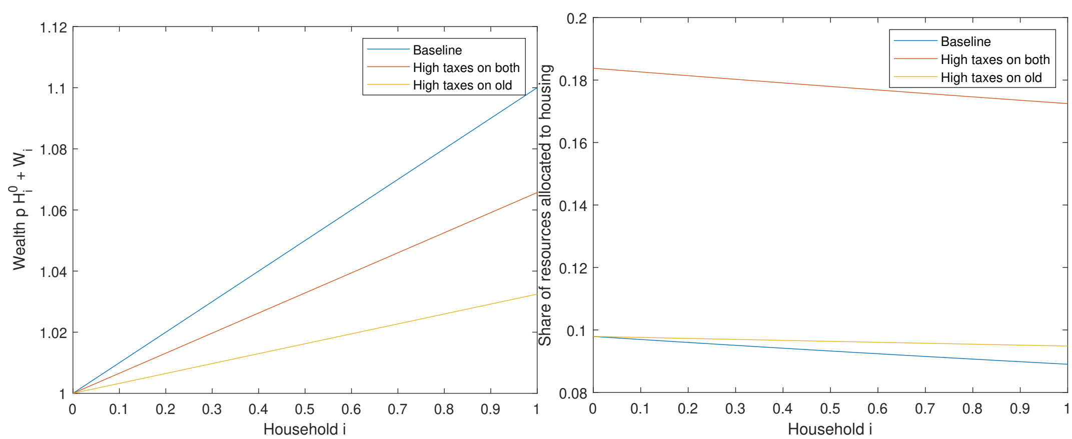


Figure 13: Comparative statics for taxes on old and new housing



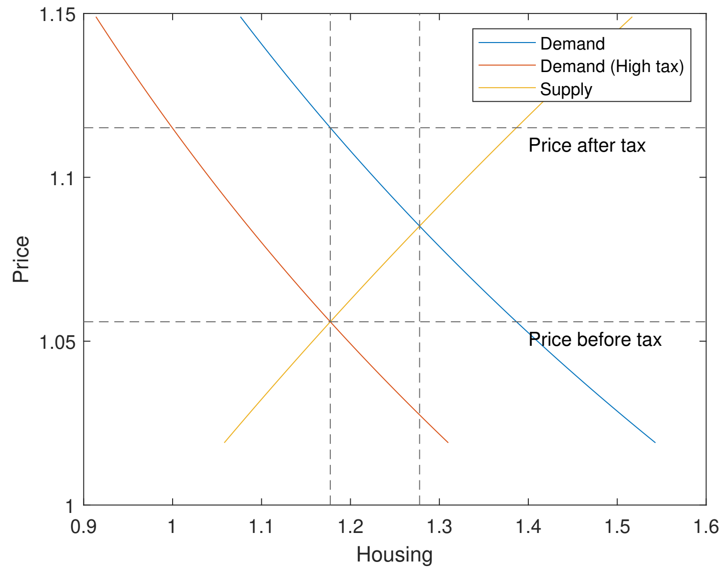


Figure 14: Supply and demand curves with high and low tax rates.

A Proof of Proposition 3 (Tax share on new and supply elasticity)

Proof. The problem solved by the government is to maximize welfare

$$\max_{\tau^{old},\tau^{new}} W = \int U_i\left(H_i, \bar{c}_i\right) di = \int \left(\alpha_i^{1/\epsilon} \frac{H_i^{1-1/\epsilon}}{1-1/\epsilon} + \bar{c}_i\right) di \tag{14}$$

such that

$$\tau^{old} p^{old} + \tau^{new} p^{new} \left(\left(\left(p^{new}\right)^{\gamma}\right) - 1\right) = T \tag{15}$$

and such that housing and food consumption are consistent with proposition 1.

The proof proceeds in three steps:

Show that taxes collected on old are equivalent to a lump sum tax on food and reformulate the government's problem.

Derive the tax rate τ^{new}

Show that the optimal amount of taxes collected from new houses T^{new} is decreasing in γ

Step 1

The first step is to rewrite the problem noting that taxes on old houses are equivalent to a lump sum tax on ownership of old houses H_i^0. The reason is that the after-tax price of housing, the consumption of housing and the housing supply are all independent of τ^{old} (Proposition 1). An increase in the tax rate on old houses will be compensated by a fall in the price of old houses so that the after tax price is constant. The tax will thus directly reduce the proceeds of the house available to the household in the budget constraint (2).

Let T^{old} be the amount of taxes collected on old houses and let $\overline{c}_{i,0}$ be food consumption with $\tau^{old}=0$. Denote aslo $T^{old}=\tau^{old}p^{old}$ as the taxes collected from old houses. The problem of the government can be rewritten as

$$\max_{T^{old},\tau^{new}} W=\int\left(\alpha_i^{1/\epsilon}\frac{H_i^{1-1/\epsilon}}{1-1/\epsilon}+\overline{c}_{i,0}\right)di-T^{old} \tag{16}$$

such that

$$T^{old}+\tau^{new}p^{new}\left(\left(\left(p^{new}\right)^{\gamma}\right)-1\right)=T \tag{17}$$

Step 2

The second step is to derive the optimal tax rate on new houses, τ^{new}. Combining equations (16) and (17), the government solves

$$\max_{\tau^{new}} W=\int\left(\alpha_i^{1/\epsilon}\frac{H_i^{1-1/\epsilon}}{1-1/\epsilon}+\overline{c}_i\right)di+\tau^{new}p^{new}\left(\left(\left(p^{new}\right)^{\gamma}\right)-1\right)-T.$$

Using the values of proposition (1), we may rewrite this as

$$\max_{\tau^{new}} W=\int\left(\alpha_i^{1/\epsilon}\frac{\left(\alpha_i A^{\frac{-\epsilon}{\gamma+\epsilon}}\left(1+\tau^{new}\right)^{\frac{-\epsilon\gamma}{\gamma+\epsilon}}\right)^{1-1/\epsilon}}{1-1/\epsilon}+W_i+\left(A^{\frac{1}{\gamma+\epsilon}}\left(1+\tau^{new}\right)^{\frac{\gamma}{\gamma+\epsilon}}\right)\left(H_i^0-\alpha_i A^{\frac{-\epsilon}{\gamma+\epsilon}}\left(1+\tau^{new}\right)^{\frac{-\epsilon\gamma}{\gamma+\epsilon}}\right)\right)di$$

The first-order conditions with respect to the tax rate τ^{new} are:

$$\left(\frac{\gamma\left(1-\epsilon\right)}{\gamma+\epsilon}\right)\left(\frac{\left(1/\epsilon\right)A^{\frac{1+\gamma}{\gamma+\epsilon}}}{1-1/\epsilon}\right)\left(1+\tau^{new}\right)^{\left(\frac{\gamma(1-\epsilon)}{\gamma+\epsilon}-1\right)}+\frac{\gamma}{\gamma+\epsilon}A^{\frac{1}{\gamma+\epsilon}}\left(1+\tau^{new}\right)^{\frac{\gamma}{\gamma+\epsilon}-1}=0.$$

We may derive the solution for τ^{new} from this equation as

$$1+\tau^{new}=A^{\frac{-\gamma}{(\gamma+\epsilon)(1+\gamma)}}. \tag{18}$$

Step 3:

In the third step, we show that the optimal amount of taxes collected on new housing is decreasing in γ. The amount of taxes collected on new houses is:

$$T^{new}=\tau^{new}p^{new}\left(\left(\left(p^{new}\right)^{\gamma}\right)-1\right).$$

T^{new} is decreasing in γ if τ^{new} and p^{new} are decreasing in γ, which we show below.

Comparative statics of τ^{new}. From 2:

$$\log\left(1+\tau^{new}\right)=\frac{-\gamma}{\left(\gamma+\epsilon\right)\left(1+\gamma\right)}\log A$$

Assuming that $A > 1$, taxes are decreasing in γ if the derivative is negative

$$-\log A \frac{((\gamma+\epsilon)(1+\gamma)-\gamma(1+2\gamma+\epsilon))}{((\gamma+\epsilon)(1+\gamma))^2} < 0$$

which is the case if $\epsilon > \gamma^2$.

Comparative statics of p^{new}. Using the price in proposition 1 and the optimal tax rate on new houses in equation 18, we can write p^{new} as

$$p^{new} = \left(A^{\frac{\epsilon\gamma+\gamma+\epsilon+\gamma^2+\epsilon\gamma}{(\gamma+\epsilon)(1+\gamma)(\gamma+\epsilon)}} \right)$$

If $A > 1$, the price p^{new} is decreasing in γ if:

$$(2\epsilon+1+2\gamma)(\gamma+\epsilon)^2(1+\gamma) - \left(2\epsilon\gamma+\gamma+\epsilon+\gamma^2\right)\left(2\gamma+2\epsilon+3\gamma^2+\epsilon^2+4\gamma\epsilon\right) < 0$$

This equation of degree 4 may be rewritten as

$$\underbrace{(2\epsilon+1+2\gamma)\left(\gamma^2+\epsilon^2+2\gamma\epsilon+\gamma^3+\epsilon^2\gamma+2\gamma^2\epsilon\right)}_{I} - \underbrace{\left(2\epsilon\gamma+\gamma+\epsilon+\gamma^2\right)\left(2\gamma+2\epsilon+3\gamma^2+\epsilon^2+4\gamma\epsilon\right)}_{II} < 0$$

The first term (I) is:

$$2\gamma^4+(6\epsilon+3)\gamma^3+\left(6\epsilon^2+8\epsilon+1\right)\gamma^2+\left(2\epsilon^3+7\epsilon^2+2\epsilon\right)\gamma+2\epsilon^3+\epsilon^2 \tag{19}$$

The second term (II) is:

$$3\gamma^4+(10\epsilon+5)\gamma^3+\left(9\epsilon^2+13\epsilon+1\right)\gamma^2+\left(2\epsilon^3+9\epsilon^2+4\epsilon\right)\gamma+\epsilon^3+2\epsilon^2 \tag{20}$$

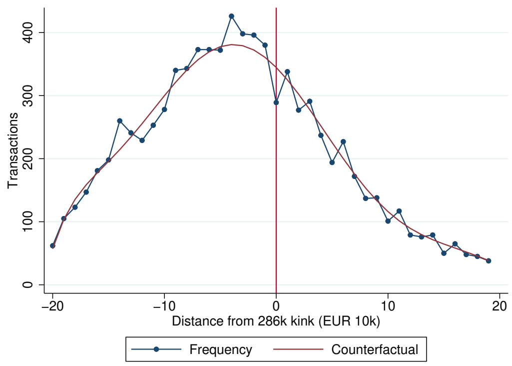
Substracting equation (20) from (19), we obtain:

$$-\gamma^4+(-4\epsilon-2)\gamma^3+\left(-3\epsilon^2-5\epsilon\right)\gamma^2+\left(-7\epsilon^2-2\epsilon\right)\gamma-\epsilon^3+\epsilon^2 < 0$$

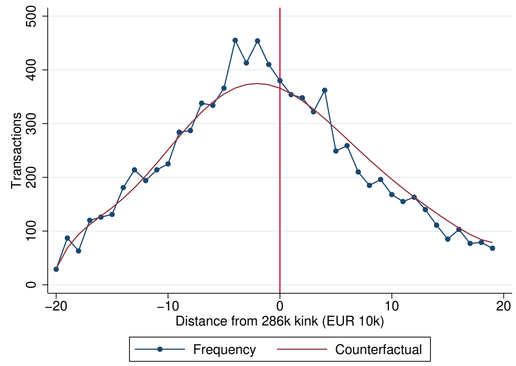
since $\gamma > 0$, $\epsilon > 0$. □

B Distribution

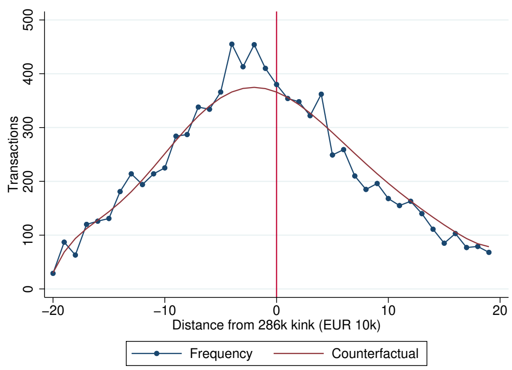
Figure 15 shows the distribution of transaction prices of existing apartments over time.



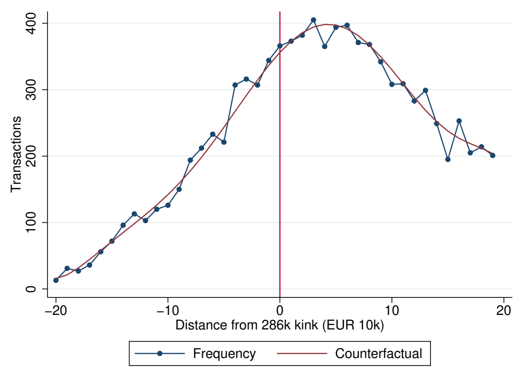
(a) 2007-2009



(b) 2010-2012



(c) 2013-2015



(d) 2016-2018

Figure 15: Distribution of transaction prices of existing apartments over time

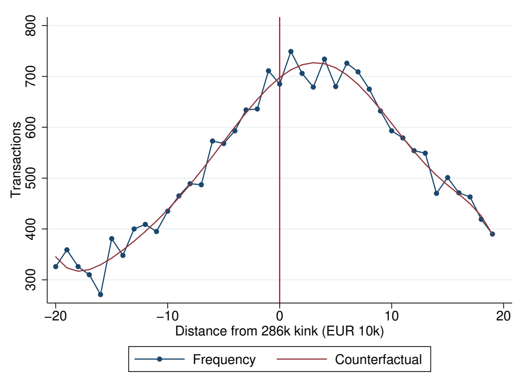


Figure 16: Distribution of transaction prices for new apartments, 2007-2018.