Welfare Effects of Housing Transaction Taxes: A Quantitative Analysis with an Assignment Model

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Abstract

We evaluate the welfare cost of housing transaction taxes with a new assignment model based framework, where welfare effects are driven by distortions in the matching of houses and households. We calibrate the model with data from the Helsinki metropolitan region to assess the impact of a reform where an ad valorem transaction tax is replaced with a revenue equivalent property tax. The aggregate welfare gain from this reform increases rapidly with the initial transaction tax rate, with the Laffer curve peaking at about 10%. The proportion of households that lose out from the reform is nevertheless increasing in the tax rate. We compare our model-based counterfactual aggregate welfare results with welfare calculations based on reduced-form estimates from previous policy evaluation studies; they are broadly in line, despite the latter using data from different housing markets at various levels and changes of the tax rate.

JEL: D31, H20, R21.

Keywords: transaction tax, housing market, assignment model.

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1 Introduction

Economists tend to view transaction taxes as a particularly inefficient form of taxation. This is especially true for housing market transaction taxes, sometimes known as “stamp duties”. The usual argument is that they distort the allocation of houses across different households. For instance, the highly-regarded Mirrlees review states that “[...] transactions taxes are particularly inefficient: by discouraging mutually beneficial transactions, stamp duty ensures that properties are not held by the people who value them most.” Transaction taxes on housing stand out also because housing could be taxed in a relatively efficient manner using property taxation, yet they are common and as high as 10% of the transaction price in some countries.

In this paper, our aim is to estimate the welfare cost of transaction taxes at various tax rates and to characterize the associated Laffer curve quantitatively. We also consider the distributional effects of tax reforms that would replace the transaction tax with a revenue neutral property tax. Our approach is to construct model-based counterfactuals for a large range of tax rates. This is in the same vein as e.g., Trabandt and Uhlig (2011), who characterize Laffer curves for labour income, capital income and consumption taxes using the neoclassical growth model, or Holter et al. (2019) who use an overlapping generations model with idiosyncratic income risk to analyse how tax progressivity affects the labor income tax revenue. Our structural model accounts for how transaction taxes affect the equilibrium allocation of heterogeneous houses across heterogeneous households.

Our model depicts an urban area with a distribution of house types of different qualities and a population of households with different housing demands. The model builds on the one-sided assignment model in Määtänen and Terviö (2014), which we augment with transaction costs. (In a one-sided assignment model the same households are both buyers and sellers.) All households are endowed with an income and an indivisible house of a given quality, and utility is concave over two goods: houses and a composite good or “money”. The set of houses is exogenous. Not living in any house is not an option, but staying in the current house is. The inefficiency caused by a transaction tax is that the matching between houses and households may not be optimal.

The heterogeneity of demand for housing arises from differences in income (or, equivalently, from preference parameters that are additive with income). Our key simplifying assumption is that households agree on the quality of houses but differ in how they view the trade-off between housing and other consumption. While this is a stark simplification, we think it is a reasonable way to gain traction on a very complicated problem. Housing

\footnote{Chapter 16 in Mirrlees et al. (2011).}
quality (which subsumes location and size) is a normal good, so the most important reason why some households choose to live in more expensive houses is that they can better afford them.

In order to focus on the misallocation of house types across households as the source of welfare effects, we abstract away from other features such as credit constraints, search frictions, and life-cycle behavior. This allows our model to stay tractable despite featuring an unrestricted type distribution of indivisible houses which we can map to the data. Earlier structural analysis of housing market transaction taxes has not accounted for inherent heterogeneity in house types: Lundborg and Skedinger (1999) employed a search-and-matching model where houses are observationally identical whereas O’Sullivan et al. (1995) and Stokey (2009) focused on distortions to life cycle consumption behaviour as the source of welfare effects.

The reason why a household wants to trade in our setup is that something has changed since it chose its current house. We model this something as a shock that is additive with income. The most straightforward interpretation is that the shock captures a change in permanent income, but it can also be interpreted as a preference shock that affects the trade-off between housing quality and other goods. So what we refer to as “income shocks” for brevity can be understood as including any changes in household circumstances that alter their utility trade-off between housing and other goods.

We calibrate our model to income and house value data from the Helsinki metropolitan region. Given preferences, we specify the distributions of housing quality and income shocks so that the resulting equilibrium distributions and transaction volume match the data closely at the current level of transaction tax and other transaction costs. We experiment with different transaction tax rates to study the impact of changing tax rates.

There are some limitations to what welfare questions can be answered in this setup. The reason is that we can only reasonably estimate differences in house qualities but not their levels; hence we need to use welfare measures from which the absolute quality level factors out. In practice this means that we have to evaluate the welfare impact of a policy “ex post” at a point where each household knows its income and thus what its gains from trade would be under each tax regime. The unit-elastic case is an exception; there we can estimate expected “ex ante” welfare for households that face income risk and do not yet know whether they will want to trade.

Our baseline estimate of the aggregate welfare gain from the tax reform is about 13% of the tax revenue at the current 2% tax rate. The marginal cost of public funds (MCPF)

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2See Piazzesi and Schneider (2016) for a review of housing market models that incorporate some of these features.
for the transaction tax, i.e., the ratio of marginal welfare cost to marginal tax revenue, is about 1.3 at the current 2% rate. Hence, according to our analysis, a relatively low transaction tax is not very distortionary. However, distortions increase rapidly at higher tax rates. At a transaction tax rate of 7% the MCPF is already about 3, and the Laffer curve peaks between 10–11%. Some European countries have transaction tax rates close to these rates, so our results suggest that lowering the transaction tax rate could increase tax revenue in those countries.3

Several empirical studies have exploited time-variation or discontinuities in transaction tax schedules to estimate how a given change in transaction taxation affects the transaction volume. Most of these papers find lasting effects of transaction taxes on transaction volume or transaction tax revenue. These include Buettner (2017), Dachis et al. (2011), Fritzsche and Vandrei (2019), and Eerola et al. (2019) who use time-variation in transaction taxes, Hilber and Lyytikäinen (2017) who exploit discontinuities in the UK transaction tax schedule and Best and Kleven (2018) who exploit both discontinuities and time-variation in the UK tax schedule. However, Bérard and Trannoy (2018) who use regional variation and changes in transaction taxes in France, Besley et al. (2014) who study the UK stamp duty holiday in 2008 and 2009, and Slemrod et al. (2017) who exploit changes in notched transaction tax rates in Washington D.C., find only weak or no long-run effect.

These empirical estimates can be used to evaluate the welfare effects of (small) tax changes using the Harberger triangle approach. In studies with statistically significant findings this implied marginal cost of public funds varies between 1.06 and 1.84. By and large the incremental welfare costs appear higher at higher levels of the tax rate. We consider the same tax rate changes in our setup and show that our welfare results are roughly in line with the estimates that are based on the empirical results and the Harberger approach. We also show that the Harberger approach, which requires assuming linear transaction demand and constant house prices, provides a reasonably accurate approximation of our model-based welfare estimate.

In order to obtain quantitative results we need to specify the elasticity of substitution between housing and non-housing consumption, which is hard to pin down. Fortunately our results are not very sensitive to the assumed elasticity. This is no coincidence: if house quality matters less in the utility function (higher elasticity of substitution) then correspondingly the quality differences between houses must be larger to rationalize the observed price distribution as the equilibrium outcome in our model.

By contrast, the level of non-fiscal transaction costs makes a clear difference to our

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welfare results. Higher non-fiscal costs reduce the extent to which the transaction tax alone can distort the allocation, which in turn reduces the welfare cost of transaction taxation relative to property taxation at any given tax rate. For instance, increasing the non-fiscal transaction costs from 4% of house value to 6% decreases our estimated welfare gain from replacing the current 2% transaction tax with a property tax by about 25%. Fortunately it is relatively simple to pin down a reasonable range for non-tax transaction costs in the Finnish housing market (our baseline assumption is 4%).

Property taxation is non-distortionary in our setup so the aggregate welfare effect of using it to replace transaction taxation is, unsurprisingly, positive and increasing in the tax rate. Nevertheless, we find that not only is a large share of households worse off “ex post” under a property tax, but that this share of losers is increasing in the tax rate. In other words, the higher the initial transaction tax rate the larger the fraction of households who would lose out from a reform that replaces it with a higher property tax. The reason is that with a high transaction tax rate the commensurate property tax is also high; most “additional” trades that are enabled by the tax reform produce only a marginal welfare gain but households benefiting from these gains have to contribute a full share of the property tax. At low tax rates most households are worse off even “ex ante” before knowing their gains from trading.

2 Model

The model features a one-period pure exchange economy, where a unit mass of households consume two goods, housing and a composite good. Preferences are described by a concave utility function \( u \). Houses are indivisible, and utility depends on the exogenous quality of the house, denoted by \( x \). Every household is endowed with and wishes to consume exactly one house. A household’s endowment of the composite good \( y \) can be interpreted as its income or “money”. There are no informational imperfections, or other frictions besides transaction costs and the indivisibility of houses.

The aggregate endowment is described by the joint distribution of households over the consumption space, \( \mathcal{S} = X \times \mathbb{R}_+ \), where \( X = \{x_1, x_2, \ldots, x_n\} \) is the set of house quality levels, each owned by a mass \( 1/n \) of households. The distribution of income for households endowed with house type \( x_k \) has cumulative distribution \( F_k(y) \), which has full support over some interval \( [y_{\min}, y_{\max}] \), where \( y_{\min} > 0 \), for all \( k \). Households take prices \( p = (p_1, \ldots, p_n) \) as given. While \( u \) is the same for all households, its concavity implies that wealthier households have higher demand for house quality.

Consider first the problem of an individual household with endowment \( \{x_h, y\} \). Denote
the rate of ad valorem transaction tax by \( \tau_T \) and property tax by \( \tau_P \). (In our quantitative analysis, only one of the taxes will be held nonzero at any time). There is also a fixed non-tax transaction cost \( \xi_k \), which can depend on house type in a non-decreasing way. (The special case without taxes and transaction costs is essentially the model analyzed in Määttänen and Terviö (2014).) Household \( h \) selects house type \( k \) to maximize

\[
    u \left( x_k, y + p_h - (1 + \tau_P)p_k - (\xi_k + \tau_T p_k) \mathbf{1}_{\{k \neq h\}} \right)
\]

where the indicator function \( \mathbf{1}_{\{k \neq h\}} \) gets value zero if the household selects to live in its endowed house. Notice that household wealth \( y + p_h \) is endogenous, as it depends on the price of the endowed house.

### 2.1 Equilibrium

In equilibrium \( i) \) all households choose their utility-maximizing house quality \( x \) while taking house prices \( p \) as given and \( ii) \) the resulting allocation is feasible. The indivisibility of houses means that the distribution of house types cannot be altered by trading, so feasibility requires that, for all types \( k \), the fraction of households choosing to live in a house of quality \( x_k \) is equal to the fraction of households endowed with \( x_k \).

The price of the lowest quality house \( p_1 \) is pinned down by the opportunity cost of the marginal house, which is exogenous in the model. While land use inside the urban area is heavily restricted by zoning, building at the urban-rural fringe of the metropolitan region is possible; the value of the marginal house can be interpreted as the value at best available unbuilt location.

The following lemma is useful for understanding the model.

**Lemma 1** In equilibrium, for households that trade, there is positive assortative matching (PAM) by household wealth and house quality.

That is, for households that choose to trade, the ranking by wealth and by house quality must be the same. For proof, see the Appendix of Määttänen and Terviö (2014). In short, diminishing marginal rate of substitution guarantees PAM: of any two households that trade, the wealthier must end up in the better house, or else the two could engage in a mutually profitable trade. (In the absence of transaction costs this would cover all households.) The twist here is that the ordering by wealth is endogenous, because it depends on house values. So, despite PAM, the equilibrium matching is not obvious and depends on the shape of the joint distribution of endowments. (For a proof of existence see Appendix ibid.)
The equilibrium allocation is illustrated in Figure 1, with house quality on horizontal and income and non-housing consumption on vertical axes. All households that trade, trade to a region in consumption space between the two black “curves”. For each house type \( k \), there is a black vertical line between these curves that depicts the range of non-housing consumption levels for households that bought a house of that type, \( [y_k, \bar{y}_k] \). These bounds are increasing in the sense that equilibrium wealth and therefore the level of utility (mapped with the gray indifference curves) is higher at a higher quality house. This follows directly from Lemma 1: wealth and utility must be increasing in house quality; with continuous income distributions this holds as an equality for those at the margin. The wealthiest household choosing to buy a type \( k \) house has the same wealth as the poorest household choosing to buy a type \( k + 1 \) house: 
\[
p_k x_k + \bar{y}_k \leq p_{k+1} x_{k+1} + y_{k+1}.
\]

In the absence of transaction costs everyone except those “born” inside the “trade-to region” would trade. The existence of a thick trade-to region would then only due to the discreteness house types (and with a continuum of house types it would be a curve without thickness, \( y_k = \bar{y}_k \)). However, due to transaction costs, the “no-trade region” is wider than the trade-to region; it is depicted in red in Figure 1. The vertical lines between the red curves depict the range of incomes for households that are endowed with a house of type \( k \) and choose not to trade, \( [Y_k, \bar{Y}_k] \). Households in the no-trade region do not trade because it is not worth paying the transaction cost for what would be a relatively short move in consumption space.

Households above the no-trade region are relatively well endowed in money and will give up some of it in order to trade up to a better house; conversely, households below the curve are the net suppliers of quality: they are endowed with a relatively high quality house and will trade down in order to increase their consumption of the composite good. Figure 1 also depicts a budget curve for an example household. The endowment (green dot above the no-trade region) is above the rest of the budget curve, because even trading to a very similar quality house would entail a significant transaction tax burden.

### 2.2 Some Notes on the Model

**Preference heterogeneity** The model admits a simple type of preference heterogeneity with almost just a relabeling. The second argument of the utility function can be interpreted as including an additive household-specific preference parameter. The model and equilibrium conditions remain the same. In terms of the common utility function \( u \) the utility of household \( h \) is
\[
u_h(x, y) = u(x, y + \epsilon_h)
\]
This formulation allows households of the same income level to have different demand for housing versus non-housing, while still agreeing on the relative quality of different houses. Differences in household preferences can be due to demographic factors, such as family size, as well as tastes. A positive preference shock will have the same effect on housing demand as a positive income shock: it moves the household higher up in endowment space and so makes it demand higher quality housing.

**Real vs nominal wealth** In our closed economy the general price level of houses would be just “paper wealth” in the absence of ad valorem transaction costs. Everyone
has to live somewhere, so across-the-board changes in houses prices are inconsequential: all prices going up by a million has no real effects, because the million just washes out of all possible transactions. Only the price differences between different types of houses are “real,” in the sense that they have implications for consumption and welfare. The right way to think about prices in a one-sided matching model is in terms of the swapping costs. For example, how much does it cost to move from a house in the 10th percentile in the quality distribution to one in the 50th percentile? In the absence of taxes this is just the difference between the two house prices. Taxes affect welfare by affecting these swapping costs. With ad valorem taxes, even the common “paper wealth component” in prices gets taxed, so the price level matters for welfare. In our model the price of the lowest quality house is exogenous; it can be interpreted as the opportunity cost of the marginal house. In a classic monocentric city model it typically represents the cost of constructing an additional unit and the opportunity cost of marginal land at the urban margin.

**Nominal incidence** Whether a transaction tax is levied on the buyers or sellers does not matter for real outcomes. However, the equivalent tax rate depends on the incidence. Recall that the marginal house is priced at an exogenous opportunity cost: there are outside owners ready to sell potential houses of type $x_1$ at $p_1$. If buyers pay the tax then outside owners get the pre-tax price $p_1$, whereas if sellers have to pay the tax at rate $\tau_s$ then the pre-tax price has to be $p_1/(1 - \tau_s)$ for the outside owners to be indifferent. Therefore a tax levied on the sellers at rate $\tau_s$ is nominally equivalent to a tax levied on the buyers at rate $\tau_b = \tau_s/(1 + \tau_s)$. It is straightforward to check that, after this adjustment, all after-tax prices and tax revenues are unaffected by nominal incidence (for all possible trades, not just those involving $x_1$). In our notation the tax is paid by the buyer, as is the case in Finland.

**CES utility** For the quantitative exercise we assume CES utility,

$$u(x, y) = \left(\alpha x^{\frac{1}{\varepsilon}} + (1 - \alpha) y^{\frac{1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon - 1}}, \text{ where } \alpha \in (0, 1),$$

with the unit-elastic case defined in the usual fashion at $\varepsilon = 1$. When $p$ and $y$ are observed, then $x$ can be solved for (up to a constant) under a given elasticity parameter $\varepsilon$. The other CES parameter, $\alpha$, is absorbed by the units of $x$ and can thus be normalized away. We derive the formula for inferring $x$ from the data in Appendix A.
Solving the model Finding the equilibrium is complicated by the fact that transaction costs create a discontinuity in the budget set: households can avoid the transaction costs by choosing to consume their endowment. We determine the equilibrium numerically. Given the initial allocation, we first determine the post-trade curve and no-trade regions depicted in Figure 1. We then aggregate to find the demand for each house type given the price vector, which we find using a standard root-finding algorithm. We explain the procedure in detail in Appendix B.

2.3 Welfare

Our measure of welfare effects is based on compensating variation for changes between tax regimes. That is, we take a baseline tax regime and its associated equilibrium prices and ask how much additional money a household with a given endowment would have to be given in the baseline economy to be equally well off as in the comparison economy, taking into account that not just taxes but also equilibrium prices differ between the two economies. We measure aggregate welfare by taking the average of this compensating variation over all (homeowner) households.

A natural baseline economy for our quantitative analysis will be the actual economy with its 2% transaction tax and no property tax, and the comparison with the counterfactual of a revenue equivalent property tax is of specific interest to us. However, most comparisons we make are between two counterfactuals: we consider the baseline economy at a range of counterfactual transaction tax rates and compare them each with their revenue equivalent property tax regime. These revenue neutral comparisons allow us to interpret changes in aggregate household welfare as total welfare effects.

The timing of the welfare measurement turns out to be an important consideration here. In the quantitative exercise (which we describe in the next section) we consider a world where ex ante households are located on the equilibrium “trade-to” region but then simultaneously receive income shocks, which causes them to spread out in consumption space, which motivates a round of trading. We generally measure household welfare after households already know the realization of their shock, i.e., ex post, whereas measuring welfare ex ante before the income shock is realized is possible only in special cases.

Now consider a household with an endowment \{x_h, y\}. We keep endowments and preferences fixed throughout, and compare economies that differ by tax regime and their associated equilibrium price vectors \(p\). In each tax regime either \(\tau_T = 0\) or \(\tau_P = 0\). In the baseline economy where \(\tau_T > 0\) the household will consume some \(\{x(y|h), c(y|h)\}\) in equilibrium. In the comparison economy where \(\tau_P > 0\) the same household would in
equilibrium consume some other bundle \( \{x_0(y|h), c_0(y|h)\} \). This household’s welfare gain from a policy reform of switching from a transaction tax regime to a property tax regime is

\[
M(y|h) = m \text{ s.t. } \left\{ u(x(y|h), c(y|h) + m) = u(x_0(y|h), c_0(y|h)) \right\}.
\] (4)

Our measure of the aggregate welfare effect of a change in regime is the average of compensating variation over all households,

\[
W = \frac{1}{n} \sum_{h=1}^{n} \int_y M(y|h) f_h(y) dy,
\] (5)

where \( f_h \) is the PDF of the income distribution for those endowed with house type \( h \).

It is not possible to empirically identify the absolute “quality units” of housing in our setup, only their quality relative to each other. In practice this means that we have to assign one house type some arbitrary positive quality level against which all other house qualities are measured. This puts some limits on what kind of welfare questions the calibrated model can be used to answer. Naturally, we can only make empirical claims about questions where the answer does not depend on our arbitrary choice of \( x_1 = 1 \).

We evaluate household welfare as a compensating variation for switching from a world with one tax regime to another. The average over households, equation (5), evaluated after the income shocks have been realized, is independent of \( x_1 \). By contrast, the compensating variation that households would demand before knowing their shock depends on \( x_1 \), except in the special case of unit elasticity (log utility). We now introduce some notation that helps us explain why this is so. Consider households endowed with house type \( x_h \) and income \( y_h \). After the income shocks are realized—but before the possible trading—their income is distributed according to the density \( f_h \). Conditional on the realization \( y \), they will live in house type \( x(y) \) under “status quo” and in house type \( x_0(y) \) under the alternative “reformed regime”, and will have (after possible swapping costs and taxes) \( c(y) \) or \( c_0(y) \) for other consumption.

With CES-utility and \( \rho = (\varepsilon - 1)/\varepsilon \), the compensating variation from equation (4) becomes

\[
M(y|h) = \left( x_0(y|h)^\rho - x(y|h)^\rho + c_0(y|h)^\rho \right)^{\frac{1}{\rho}} - c(y|h).
\] (6)

To see how this depends on the estimated quality levels, use the inference formula for \( x_h \) (12) in Appendix A. The quality estimate for each house type \( h = 2, \ldots, n \) depends on data \( y_1, \ldots, y_h, p_1, \ldots, p_h \), the assumed elasticity of substitution via \( \rho \), and the quality level \( x_1 \). It is easy to see that the constant \( x_1^\rho \) cancels out of all quality differences \( x_i^\rho - x_j^\rho \). Therefore the realized welfare gain (6) is independent of \( x_1 \); it only depends on the data \( y_i, \ldots, y_j, p_i, \ldots, p_j \), and the elasticity.
Now consider the expected welfare gain evaluated before the income shocks are realized. This ex ante definition of compensating variation has to take into account that the level of house quality and other consumption depends on the income realization, and in potentially different ways under each regime.

\[
\bar{M}(h) = m \text{ s.t. } \left\{ \int (x(y|h)\rho + c(y|h)^\rho + m)^{\frac{1}{\rho}} f_h(y)dy = \int (x_\ast(y|h)\rho + c_\ast(y|h)\rho)^{\frac{1}{\rho}} f_h(y)dy \right\}.
\]

The solution of \( M \) depends in general on levels of \( x \), because the \( x^\rho \) terms cannot be grouped in a way that would eliminate \( x_1 \). Log-utility is the important exception: when \( \rho \to 0 \) then the inference formula yields the ratios \( \hat{x}_h/x_1 \) as functions of the data; see equation (13) in the Appendix. The expected welfare gain in (7) becomes \( \bar{M}(h) = m \text{ s.t.} \)

\[
\int (\alpha \log x(y|h) + (1-\alpha) \log c(y|h) + m) f_h(y)dy = \int (\alpha \log x_\ast(y|h) + (1-\alpha) \log c_\ast(y|h)) f_h(y)dy
\]

Subtracting \( \alpha \log x_1 \) from both sides shows that expected welfare depends on ratios \( \hat{x}_k/x_1 \) which in turn only depend on the data and not on \( x_1 \). This also demonstrates that the weight parameter \( \alpha \in (0, 1) \) is absorbed by the undefined \( x_1 \) and can thus be ignored.

3 Calibration

The main purpose of our calibration is to quantify the aggregate welfare cost of housing transaction taxes at various levels of the tax rate. We calibrate the model using data from the Helsinki metropolitan area and then use it to conduct policy experiments with counterfactual tax regimes. We solve for the equilibrium allocation at each transaction tax rate and define the welfare cost of taxation for each household as its “willingness-to-pay” (4) to switch from its equilibrium allocation in a world with the transaction tax to its equilibrium allocation in the world without the tax.

Calibrating the model means specifying an initial joint distribution of incomes and house qualities that is realistic and conforms to the assumptions about the initial endowments of the model in Section 2. Mapping our static model to the dynamic world requires some interpretation. In what follows, we first describe the general idea of the calibration and then provide details on the data and the implementation of our calibration procedure.

3.1 General idea

The starting point is that we observe the joint distribution of house prices and household incomes. We interpret the cross-sectional data as reflecting the equilibrium of our model.
Throughout this section, we assume that the number of house types is very large so that the trade-to region (see Figure 1) can be thought of as a curve. We first estimate the trade-to curve from the data by estimating the relation between average non-housing consumption (or a proxy measure for it) and house prices. For sure, in the presence of transaction costs, the relation between average non-housing consumption and house prices does not exactly correspond to the trade-to curve, because some households are off the trade-to curve in the no-trade region. However, since the trade-to curve is strictly contained in the no-trade region, the relation between the average non-housing consumption and house prices should give us a good approximation of the true trade-to curve.

We then use the estimated trade-to curve to infer house qualities. For a given elasticity parameter $\varepsilon$ of a CES utility function, there exists a unique distribution of relative house qualities that rationalizes the observed relationship between house prices and non-housing consumption as the competitive equilibrium of our model (see Appendix A). For a given value of $\varepsilon$, we can thus infer the implied house qualities (up to a multiplicative constant, which does not affect the welfare analysis).

In order to model trade, we consider an expanded model period which has the following three stages. In stage 1, households are all located on the estimated trade-to curve. In stage 2, every household with a house of type $x_h$ receive an income shock drawn from a smooth distribution $F_h$. After the shock, households with a given house type will have a nondegenerate distribution of incomes $y$. At this stage the situation conforms to the assumptions about the initial endowments of the one-period model in Section 2 and we can use it to conduct our policy experiments. In what follows, we refer to this distribution as the “post-shock” distribution. In stage 3, households have the opportunity to trade and the market for every house type clears at equilibrium prices. (The model is static, so households do not take into account that they face more shocks in the future.) In the end, all households are again content with their bundle of house type and non-housing consumption. Those who trade, are again on the trade-to curve. However, this curve is in general different than the estimated curve in stage 1.

The question is then how to determine the income shocks. The key idea behind our calibration is to choose the income shocks so that the resulting trade-to curve at the end of stage 3 is close to the estimated curve in stage 1, while requiring that the share of households that choose to trade, given realistic transaction costs, matches the observed level of trading in the data.

In other words, we assume that the estimated trade-to curve reflects a stationary equilibrium of the model that would be repeated if the income shocks were drawn from a time-invariant distribution. However, since we assume, for simplicity, that all households
are on the estimated post-trade curve in stage 1 (instead of somewhere in the no-trade region), the distribution in the end of stage 3 is necessarily different from the stage 1 distribution (or curve), as some households (those who receive a relatively small income shock) choose not to trade. That is, we can only approximate the stationary equilibrium of the model. We think this is a reasonable simplification, partly because the actual transaction costs in Finland are relatively low.

### 3.2 Data and transformations

We use Statistics Finland’s 2004 Wealth Survey to estimate the empirical relation between house prices and income or non-housing consumption. We consider owner households in the Helsinki metropolitan area (MA). The 2004 survey is the last one that includes self-reported house value and the length of stay in the current dwelling. In later surveys house values are estimated by the Statistics Finland. We believe that the self-reported house values are generally more accurate proxies of true market value than the estimated values. The estimated house values in later surveys are in many case smaller then the associated mortgage loans, which seems unlikely given recent housing market developments in Finland.

The data include register based data on household savings, debts and income and self-reported estimate of the market value of a household’s main residence, which we take as our house price measure. We proxy non-housing consumption by disposable monetary income. In the data, household disposable income accounts for wage income, transfers, taxes and capital income, but excludes interest expenses. We take debts into account by deducting implied cost of debt service from disposable income. There appear to be problems with data quality at the bottom of the price distribution, with some house prices observed in the range of a few thousands of Euros. For this reason, we exclude the bottom 5% of houses from the data.\(^4\)

Before estimating the relation between house prices and income, we need to make the units of yearly income comparable with house prices. This amounts to fixing the time horizon and the interest rate. We set the time horizon equal to the average length of stay in the current house for home owners, which is about 10 years in the data. Thus we measure income as the present value of 10 year’s annual income by multiplying the annual disposable income in the data by \( R = \sum_{t=0}^{T-1} (1 + r)^{-t} \), where \( r \) is the annual interest rate, which we set at \( r = 5\% \), and \( T = 10 \). This results in the empirical counterpart of the

\(^{4}\)The same problem afflicts the equivalent U.S. data (AHS). However, here, unlike in the AHS, house values are not top-coded.
non-housing consumption $y$ in the model. Similarly, we multiply the nominal house value by $rR$, to obtain the capital cost of housing for the 10-year period. (The same interest rate is used when computing the implied cost of debt service that is deducted from disposable income.) We set the property tax rate at zero.\(^5\)

In order to infer house qualities, we need a single-valued relation between house prices and non-housing consumption, which we proxy by disposable income. We first sort households according to the value of their house. We lump houses to discrete quality types that represent percentiles in our data. We use $\bar{p}$ to denote the vector of house values, with typical element $\bar{p}_h$ standing in for the $h$:th percentile. We reduce the relation of income and house value to a curve by using a kernel regression to estimate $\bar{y}_h$ as $E[y \mid F_{\bar{p}} = (h - 1/2)/100]$, where $F_{\bar{p}}$ is the empirical CDF of house values.\(^6\) The resulting vector $\bar{y}$ is the calibration target for the post-trade relation of housing and average non-housing consumption.

Assuming that the timing of trades is a Poisson process at household level, the 10-year average duration between moves implies that the share of households that engage in trade within a model period is 63%. However, the data include households that have moved to the Helsinki MA from other regions and these households are not accounted for by our one-city model. Currently these movers represent about 30% of the overall population. We therefore target a share of households that engage in trade equal to $63\% - 30\% = 33\%$. In the calibration we set the transaction tax at the actual 2% level.

We also need to specify other (non-fiscal) transaction costs. In Finland, the legal and administrative costs of buying and selling a house are relatively low. This may explain why typical broker fees are quite low as well, around 2%–3% of house value in Helsinki and why it is common for households to sell their house without an agent (buyer agents are unheard of). We set the vector of house-type specific transaction costs $\xi$ so that it corresponds to 4% of empirical house values. We conduct a sensitivity analysis with respect to non-fiscal transaction costs and the interest rate. (We leave non-tax transaction costs fixed when varying taxes; while broker fees may in reality change in response to changes in house prices we keep them fixed in order to have a clean interpretation of our estimated welfare effects.) We transform taxes and transaction costs to reflect the model period in the same as we have transformed house values and annual incomes. For instance, an ad valorem transaction tax $\tau$ translates into a transaction tax equal to $\tau/rR$ in the model.

\(^{5}\)There is a municipal property tax in Finland, but effective tax rates for dwellings are very low, partly because the taxable values are only a fraction of the market values. According to Peltola (2014), the average annual effective property tax rate in Helsinki is about 0.12%.

\(^{6}\)See Määttänen and Terviö (2014) for details.
3.3 Implementation

We assume CES-utility (expression (3)), and consider elasticity values $\varepsilon$ at $2/3$, $1$, and $4/3$.\footnote{The empirical estimates of this elasticity vary considerably. See for instance Li et al. (2015) and the references therein. However, as we show below, our main results are not very sensitive to the assumed elasticity.} We parameterize the distribution of income shocks as follows. Let $y_h$ denote the stochastic non-housing endowment of a household owning a house of type $h$ in the post-shock distribution. We assume that it is determined as $y_h = \bar{y}_h(1 + \delta_h)(e^\eta/s)$, where $\eta$ is normally distributed with mean zero and standard deviation $\sigma_\eta$, and $s$ is a scaling term that is chosen so that the expected value of $e^\eta/s$ equals one. Parameter $\delta_h$ represents a systematic component of income dynamics. We further assume that $\delta_h$ can be described as a third order-polynomial in the percentile $h$, so that $\delta_h = a_0 + a_1h + a_2h^2 + a_3h^3$.

We normalize $x_1 = 1$ and set $p_1$ exogenously at its empirical value. We are left with the polynomial coefficients $a$, the shock variance $\sigma_\eta$, and house qualities $x_2, \ldots, x_{100}$. We choose these parameters so that i) the resulting equilibrium house prices $p$ are close to the empirical distribution $\bar{p}$, ii) the average non-housing consumption for households with different house types is close to the empirical relation $\bar{y}$, iii) the share of households that engage in trade is $33\%$, and iv) average income equals the average income in the data.

We first infer housing qualities based on the estimated relation between household income and house prices. In the next step, we take the observed house prices as given, and find the optimal trading pattern for households with different initial housing and non-housing endowments. Given these household policies, and for any given post-shock distribution, determined by $\delta$ and $\sigma_\eta$, we can aggregate to find the post-trade relation between average non-housing consumption and housing, which we denote by $\tilde{y}$, and the share of households that engage in trade. We select the remaining five parameters (the standard deviation of the income shock $\sigma_\eta$ and the polynomial coefficients $a$) so as to minimize the sum of squared differences between the elements of $\tilde{y}$ and $\bar{y}$, subject to the constraint that the share of households engaging in trade equals $33\%$, and by requiring that average income equals the average income in the data. The latter constraint pins down one of the polynomial coefficients, given the other ones. By taking prices as given in this stage, we avoid the need to solve for equilibrium prices over and over again when varying these parameters. If we are able to closely replicate the empirical non-housing consumption curve, the associated equilibrium prices will also be close to the observed prices.
3.4 Evaluation of fit

Figure 2 illustrates the data and the calibrations with different elasticities of substitution between housing and non-housing consumption. Each calibration requires a different standard deviation $\sigma_{\eta}$. The standard deviations associated with $\varepsilon = 2/3$, 1, and 4/3 are approximately 0.40, 0.47 and 0.51, respectively. The share of households that trade matches the target 33% in all cases. For this and other figures that follow, we have rescaled house values, non-housing consumption, tax revenues, and welfare gains, so that they are comparable with actual nominal house prices and annual consumption, instead of reflecting the 10-year model period.

The top-left panel of Figure 2 shows the empirical price distribution $p$. The top-right panel shows the calibrated mean reversion $\delta$. In the calibrated model, $\delta_h$ is positive in the left-hand side of the distribution and negative in the right-hand side. Intuitively, there must be some regression toward the mean, or else the income distribution would widen with the shocks and we would not be able to replicate the estimated relation between household income and house values. The calibrated income shocks also imply that households with relatively low quality houses in the post-shock distribution tend to move upwards in the quality ladder, and vice versa.

The bottom-left panel compares the equilibrium price distribution in the model (prices in the end of stage 3) with the empirical one by showing the percentage difference between the data and the model (a negative deviation means that the price is lower in the model). The calibrated model matches closely the empirical price distribution, except for the most valuable houses. The bottom-right panel in turn shows the estimated relation of disposable money income and house quality, $\bar{y}$, and the relation of average post-trade consumption and house quality in the model, $\tilde{y}$. Again, the calibrated model replicates the empirical relation quite closely, especially below the 90th percentile or so. The mismatch near the top end could be a sign of non-homothetic preferences.

4 Aggregate effects of transaction taxes

Figure 3 displays the main aggregate effects of transaction taxes for the three calibrations with different elasticities of substitution between housing and non-housing consumption. The top-right panel shows how the transaction tax rate affects the trade volume. For instance, increasing the tax rate from 0 to 1% lowers the trade share from about 43% to 38%, or by about 12%. Increasing the tax rate from, say, 2% to 4% decreases the trade volume by 21%. The relation between the transaction tax rate and the trade volume is
almost the same at different elasticities.

The top-left panel shows the annual transaction tax revenue (per owner household) as a function of the tax rate. The assumed elasticity of substitution makes a difference to tax revenue only at higher tax rates. The higher is the elasticity, the lower is the tax revenue. However, the Laffer curve peaks around a tax rate of 10% in all cases, which is not far from actual rates in some European countries. Our results suggest that in those countries lowering the tax rate might not decrease tax revenue at all.

The bottom-left panel shows the average pre-tax house prices as a function of the transaction tax rate. Naturally, a higher transaction tax implies a lower average house price. Finally, the bottom-right panel shows the aggregate annual welfare gain from replacing the transaction tax with a revenue equivalent property tax. Hence, this curve displays the welfare cost of transaction taxes relative to property taxes, which in turn are

Figure 2: Empirical price distribution (top-left), calibrated $\delta$ (top-right), prices in the data vs. model (bottom-left), and average post-trade consumption implied vs. empirical relation of disposable income (annualized) and house quality.
non-distortionary. The ex-post welfare gain is measured as the average increase in non-housing consumption that would make households in the post-shock distribution indifferent between the equilibria associated with a given transaction tax or a revenue equivalent property tax. The welfare gain represented by the dashed line is based on expected or ex ante welfare before the income shocks are realized. For reasons explained in section 2.3, we consider ex ante welfare only in the unit elasticity case.

According to the ex post measure, replacing the current 2% transaction tax by a revenue equivalent property tax would increase household welfare by about 30 Euros in terms of non-housing consumption (in 2004 Euros). The welfare cost increases rapidly
as we increase the tax rate. For instance, according to the ex post measure, replacing a 6% transaction tax rate with a property tax would generate an average annual welfare gain of around 180 euro, for elasticities considered. Since the property tax is essentially a lump-sum tax, these welfare gains can be interpreted as the overall welfare cost of the transaction tax. The ex ante aggregate welfare gain is always smaller than the ex post gain. This reflects the concavity of the utility function together with the fact (illustrated below) that in absolute terms the reform tends to benefit those with a positive income shock the most.

So how distortionary is the transaction tax? One way to measure it is the ratio of the welfare loss to the gain in tax revenue. At the current 2% tax rate this ratio is between 12% and 14%, depending on the elasticity and using the ex post welfare measure. The relative welfare loss is steeply increasing in the tax rate; for example, going from a 2% tax to a 4% tax, the ratio of the increase in welfare loss to the increase in tax revenue is about 50%. Another way to measure the distortion is the marginal cost of public funds (MCPF), defined as the marginal welfare cost per euro of tax revenue. Figure 4 displays the approximated MCPF associated with the transaction tax in the model. It is the rate at which the aggregate welfare cost and the tax revenue increase as we increase the transaction tax rate. Since the welfare cost (or the private cost of public funds) includes the tax revenue, MCPF of a non-distortionary tax would equal to one by definition.

![Figure 4: Marginal cost of public funds as a function of the transaction tax rate.](image)

At a 2% tax rate, for instance, the MCPF is about 1.3. Hence, according to the model, the current transaction tax is not very distortionary. However, the MCPF increases rapidly with the tax rate. At a 7% tax rate the MCPF is already above 3 in all cases. Naturally, the MCPF approaches infinity, as the tax rate approaches its revenue
maximising level.

All the above results are relatively insensitive to the assumed elasticity of substitution. In order to understand this feature, recall that the quality distribution is inferred separately for different elasticities. The inference is based on the relation of house prices and income. Intuitively, if house quality matters less in the utility function (higher price-elasticity) then correspondingly the quality differences between houses must be larger to rationalize the observed price dispersion as the equilibrium outcome in our model. We vary some other parameters in section 6 below.

5 Comparison with earlier literature

We compare our results with earlier empirical literature based on the welfare effect of a transaction tax change relative to the change in tax revenue, also known as the cost of public funds. Most studies do not explicitly calculate this cost, but as long as changes in tax rate and trading volume are reported we can estimate the cost of public funds using the Harberger triangle approach. The Harberger triangle approach starts from the assumption of a linear demand curve for transactions. (For aggregate welfare it is, of course, immaterial how this reservation value or “gains from trade” is divided between buyers and sellers.) There is only one type of housing, or taxes don’t affect the composition of houses traded and \( p \) is their average price. For simplicity and consistency with earlier literature, let’s suppose that the pre-tax price level is constant at \( p \) throughout. There are two observed ad valorem transaction tax rates, \( \tau_1 < \tau_2 \), and two observed transaction volumes \( q_1 > q_2 \). The change in tax revenue is then \( \Delta T = p(\tau_2 q_2 - \tau_1 q_1) \).

The change in consumer surplus is \( \Delta CS = p\bar{\tau}(q_2 - q_1) \), where \( p\bar{\tau} \) is the average reservation value for those potential transactions that are realized only at the lower tax rate. If those reservation values are uniformly distributed, i.e., if the demand for transactions is linear, then the average is \( p\bar{\tau} = p(\tau_1 + \tau_2)/2 \) and the loss in consumer surplus is literally a triangle in quantity-value space.

The incremental welfare cost of increasing the transaction tax from \( \tau_1 \) to \( \tau_2 \) can be measured as a percentage of the incremental tax revenue,

\[
-\frac{\Delta CS}{\Delta T} = -\frac{p(\tau_1 + \tau_2)}{2} \frac{(q_2 - q_1)}{p(\tau_2 q_2 - \tau_1 q_1)} = -\frac{1}{2} \left( 1 + \frac{\tau_1 q_2 - \tau_2 q_1}{\tau_2 q_2 - \tau_1 q_1} \right)
\]  

(9)

Similarly, \( 1 - \Delta CS/\Delta T \) can be interpreted as the discrete equivalent of the marginal cost of public funds.

Table 1 lists papers that provide results that can be compared to ours relatively easily and that find statistically significant long-run effect of transaction taxes on the volume
of transactions (or moves). For each paper in the table, we show the transaction tax rate change in their study, the associated estimated change in the volume of transactions or moves, and the resulting cost of public funds we computed using (9) in the column “CPF (Harberger)”. We have tried to take the authors’ preferred estimate of the medium or long-run effect that should exclude short-run timing or anticipation effects.

Best and Kleven (2018) exploit discontinuities and time-variation in the UK transaction tax schedule focusing on a “stamp duty holiday” that eliminated a 1% transaction tax in a certain house price bracket. Dachis et al. (2011) compare the mobility of Toronto residents to the mobility of their suburban neighbors following the introduction of a “Land Transfer Tax” on real estate purchases in Toronto. Eerola et al. (2019) exploit a tax reform in Finland where the transaction tax rate was increased for housing co-operatives, but tax treatment of directly owned single-family houses remained unchanged. The authors complement their empirical analysis using a theoretical model to account for spillovers between between the market for directly-owned houses and co-operatives.\(^8\) Fritzsche and Vandrei (2019) use time variation in transaction tax rates by regressing transaction volumes for single-family homes on transaction tax rates in different German states while controlling for short-run timing effects; Table 1 shows the estimated effect of a one percentage point tax rate change around the average tax rate in their data. Finally, Hilber and Lyytikäinen (2017) estimate the effect of the transaction tax on household mobility by comparing households reporting house values below and above a cut-off value where the UK stamp duty tax rate jumps from 1 to 3 percent.

The last two columns show our model-based results. “CPF-Model Direct” refers to the aggregate ex post compensating variation and “CPF-Model Harberger” to the approximation based on (9). The fact that two measures are very close to each other, shows that the Harberger approach gives a very accurate approximation of the direct model-based welfare effect, at least for relatively small changes in the tax rate.

The empirically based welfare estimates are broadly in line with our model-based estimates. In particular, both estimates suggest that the cost of public funds increases quite rapidly with the tax rate. The model-based estimates are actually remarkably close to those based on Best and Kleven (2018), Dachis et al. (2011), Eerola et al. (2019).\(^9\) However, the baseline results in Hilber and Lyytikäinen (2017) imply a substantially

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\(^8\)The tax rate for housing co-operatives was increased from 1.6% to 2%. However, the tax base was also broadened to include housing co-operative loans. The authors estimate that the initial effective tax rate was therefore only about 1.5%.

\(^9\)Dachis et al. (2011) use a somewhat different approach to estimate the welfare effect. The figure they provide in the paper is 1 Dollar for every 8 Dollars in revenue, which translates into a cost of public funds equal to 1.125.
higher welfare cost and the results in Fritzsche and Vandrei (2019) a much lower welfare cost than the model.

<table>
<thead>
<tr>
<th>Study</th>
<th>Lower tax</th>
<th>Higher tax</th>
<th>Change in volume</th>
<th>CPF Harberger</th>
<th>CPF-Model Direct</th>
<th>CPF-Model Harberger</th>
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</thead>
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<tr>
<td>Hilbert and Lyytikäinen (2017)</td>
<td>0.01</td>
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<td>0.37</td>
<td>1,839</td>
<td>1,296</td>
<td>1,318</td>
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<td>Dachis, Duranton and Turner (2011)</td>
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<td>0.011</td>
<td>0.15</td>
<td>1,088</td>
<td>1,073</td>
<td>1,079</td>
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<td>0.07</td>
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<td>1,275</td>
</tr>
<tr>
<td>Best and Kleven (2018)</td>
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<td>0.01</td>
<td>0.10</td>
<td>1,055</td>
<td>1,067</td>
<td>1,073</td>
</tr>
<tr>
<td>Fritche and Vandrei (2019)</td>
<td>0.037</td>
<td>0.047</td>
<td>0.07</td>
<td>1,438</td>
<td>1,864</td>
<td>1,875</td>
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Table 1. Implied estimates for the welfare cost of public funds per unit of tax revenue (CPF) from previous studies, for a change between two tax rates; our calculation based on the change in volume reported by the authors and the Harberger formula. Last two columns show the CPF from the same change in tax rates in our calibrated setup, using the model results direct or applying the Harberger formula.

We can also the compare our model-based results to Buettner (2017). He regresses transaction tax revenues on transaction tax rates in various German states and uses the resulting estimate of the tax revenue elasticity to estimate the associated welfare cost around a 4% average tax rate. His preferred estimate, which includes possible tax sheltering effects, translates into a marginal cost of public funds equal to 1.67. The corresponding figure is 1.79 in our model with log-utility. However, we cannot compare our results directly with Borbely (2018) which studies the impact of progressive transaction taxes in Scotland using both price and time notches; he finds that a unit increase in effective tax rates leads on average to a 5.6% reduction in transaction volume. Equation (9) cannot be applied because this study does not report the average tax rate.

6 Distributional effects

Despite aggregate welfare gains from replacing the transaction tax with a property tax, some households may of course be worse off with such a reform. Figure 5 displays the ex ante welfare gain (top-left panel) and the share of households that are ex post better off (top-right) across different house endowments for initial transaction tax rates equal to 2% and 8%. It also displays the trade share (bottom-left) and the distributional house price impact of the reform. The top panels reveal that when the initial the transaction tax rate is 2%, many households are worse off both in the ex post and in the ex ante welfare comparison. However, the ex ante losses are all very small. When the initial transaction
tax is 8%, all households are better off ex ante, whereas many households are still worse off ex post.

Figure 5: Distributional effects from replacing a transaction tax with a revenue equivalent property tax, with quantiles of house quality on horizontal axis. The case with zero transaction tax in the bottom-left panel shows also the share of traders under any property tax rate.

The largest ex ante gains accrue to households endowed with the very best houses. This is natural since the welfare gains are measured in absolute terms and those households have the highest average utility levels. The ex ante welfare gain and the share of ex post winners are also positively correlated with the trade share, which varies somewhat across the initial house endowments. There are also price effects. In particular, the increase in the value of the very best houses benefits those who initially own them, as those households are more likely to trade down than up.

Figure 6 shows the overall share of households that would be better off with the reform
ex ante (left panel) and ex post for different initial transaction tax rates. Clearly, the two welfare comparisons provide very different results. In the ex ante comparison, the share of households that are better off with the property tax is increasing in the transaction tax rate (or, equivalently, the tax revenue requirement) and reaches 100% for transaction tax rates above 7%. In the ex post comparison, in contrast, the share of winners is decreasing with the tax rate.

![Benefits from reform (ex ante)](image1)

![Benefits from reform (ex post)](image2)

**Figure 6:** Proportion of households benefiting from a revenue neutral reform that replaces a transaction tax \( \tau \) with a property tax. Left panel shows the proportion ex ante before households know the realization of their income shock; this is calculated only for the unit elastic case. The right panel shows the proportion of winners after the realization of the income shock for different elasticities.

The fact that the share of ex post winners is decreasing in the transaction tax rate is perhaps surprising, especially given that we already showed that high transaction taxes are very distortionary in the model. However, while the exact share of households that benefit or lose from the reform certainly depends on the details of the calibration, this feature is robust; Figure 7 helps understand why. There we depict the impact of reform on the welfare for owners of one house type, with the pre-trade endowment of income represented on horizontal axes. So this picture captures households on one vertical slice of Figure 1 (in fact those at the median house type). The top panel shows a case where the transaction tax is 2% and the bottom panel a case where it is 8%.

The shaded areas show no-trade regions, i.e., households that don’t find it worthwhile to trade as their post-shock income is sufficiently “in balance” with their house type. The
Figure 7: Difference in welfare relative to the equilibrium under a transaction tax of 2% (top) and 8% (bottom) for households endowed with median house type. Household post-shock income on horizontal axes. Blue curves show the change in utility caused by a shift to a property tax.
lighter (red) shade shows the no-trade region under the transaction tax, it is naturally wider in the high-tax case. The darker (blue) shade shows the no-trade region under a property tax; it is the same in both cases because property taxes don’t distort trading decisions. This no-trade region stems only from the non-fiscal transaction costs and (to a small extent) from the discrete housing quality distribution. The impact of tax reform on trading is thus naturally higher in the high-tax case, where the no-trade area contracts from a wider starting point.

The first thing to understand is that everyone who does not trade is worse off under a property tax, and this loss of utility is larger the higher the tax rate because the revenue-equivalent property tax must be higher in the high tax case. For those who are still inside the no-trade region under the property tax this reduction welfare is the only change caused by the policy. Those who are trading in any case clearly benefit from the change: the same aggregate tax burden is divided over a larger number of tax payers.

Now consider those who are induced to trade by the tax reform. The new marginal traders, those at the boundary of the “new” no-trade region suffer the same reduction in welfare as the marginal non-trader, so they are clearly made worse off by the reform, and more so in the high tax case. As we move further out from the no-trade boundary the gain from trade increases and, eventually, it is large enough to catch up with the burden of the property tax. But the deeper the starting point—the higher the tax burden—the further out into the trading region is the point of catch-up. This means that there are fewer households beyond the break-even points where the curve crosses the horizontal axes and thus winners from the tax reform.

7 Sensitivity

In calibrating the model we set the non-fiscal transaction costs exogenously at 4% of the empirical house prices and the interest rate at 5%; next we explore how our results are affected by changing these parameters. We consider “low” and “high” cases where two percentage points are either subtracted from or added to our baseline assumptions. When varying these parameters (one at a time) we set the elasticity of substitution between housing and non-housing consumption at one and recalibrate the remaining parameters so as to match the same targets as above. For instance, at higher non-fiscal transaction costs we also need a higher variance for the income shocks in order to generate the same trade share as before.

Tables 2 and 3 display selected results at transaction tax rates of 2% and 8%. For completeness, we also present the results for the different elasticities of substitution con-
Table 2. Sensitivity Analysis: Tax revenue, trading volume, and prices.

<table>
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<tr>
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<th>Trade share</th>
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<tr>
<td></td>
<td>€/hh</td>
<td>%</td>
</tr>
<tr>
<td>( \tau )</td>
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<tr>
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<td>Low</td>
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<tr>
<td>High</td>
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<table>
<thead>
<tr>
<th>Welfare gain</th>
<th>Winners</th>
<th>E Welfare gain</th>
<th>E Winners</th>
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</thead>
<tbody>
<tr>
<td>€/hh</td>
<td>%</td>
<td>€/hh</td>
<td>%</td>
</tr>
<tr>
<td>( \tau )</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Low</td>
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<td>38.5</td>
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<td>High</td>
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<td>Low</td>
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<td>39.0</td>
<td>57</td>
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</table>

sidered throughout our main analysis. The bottom rows refer to the baseline calibration at unit elasticity.

Table 2 displays the average (annual) tax revenue per household, the share of households that trade, and the average house price. As was already seen in Section 4, the relationship between the transaction tax rate and trade share or tax revenue is not much affected by the elasticity. The same is true of the interest rate. By contrast, non-fiscal transaction costs (“Fixed cost”) make a clear difference to the calibration results. The higher they are the smaller is the share of a given transaction tax of the overall transaction costs. As a result, increasing the transaction rate from 2\% to 8\% lowers the transaction volume less and increases the tax revenue more when non-fiscal transaction costs are higher. The average house price is almost constant across all cases, because we always target the same empirical price distribution.

Table 3 displays the aggregate welfare gain associated with switching to a revenue
equivalent property tax and the share of households who would be better off with such a reform ("Winners"). The first two supercolumns ("Welfare gain" and "Winners") refer to the ex post welfare comparison and the last two ("E Welfare gain" and "E Winners") to the ex ante comparison. For reasons explained in Section 2.3, we conduct the ex ante welfare comparison only for the unit-elastic case.

One might reason that other transaction costs make transaction taxes more harmful. However, in the model higher non-fiscal transaction costs are associated with a lower aggregate welfare gain from the reform and also a smaller share of households that are better off with it. Higher non-fiscal costs reduce the extent to which the transaction tax alone can distort the allocation. This reduces both the ex ante and ex post welfare gains of the reform. With a high non-fiscal transaction cost and a relatively low initial transaction tax rate, the ex-ante welfare gain can even be negative. This reveals that ex post the reform tends to hurt especially those with a negative income shock thereby increasing the cost of income uncertainty in terms of expected utility. However, this negative welfare effect is quantitatively very small.

8 Conclusion

We evaluated the welfare effects of housing transaction taxes within a new one-sided assignment model framework. We used data from the Helsinki metropolitan region and considered a counterfactual tax reform, where the transaction tax was replaced with a revenue equivalent ad valorem property tax. The welfare gain from the reform is moderate at the 2% rate currently used in Finland, but steeply increasing in the tax rate.

Despite clear aggregate welfare gains from replacing the transaction tax with a property tax, many households are worse off with such a reform. Moreover, in the ex post comparison, the share of households that are worse off is increasing in the initial transaction tax rate, up to tax rates close to the peak of the Laffer curve. The ex post perspective naturally leads to an uneven distribution of the gains and losses from the tax reform as households that know they would not be trading even with the reform can only lose. In addition, the higher the tax burden the harder it is for the marginal traders who are induced to trade as a result of the tax reform to end up better off. This is because with a property tax they all need to contribute their share to the tax burden. It is not essential that the replacing tax be a property tax; the burden of practically any alternative tax is going to be more evenly shared between traders and non-traders.

The ex post view may seem contrived, as everyone knows for sure whether they are traders or not. However, the ex ante perspective to welfare gains is also quite “extreme”,

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as everyone is equally ignorant about their trading propensity. In reality, some households are more likely to trade than others, yet few are completely certain; this is consistent with political support for transaction taxes even at very high and distortionary rates.

In order to focus on the allocational effects of the transaction tax, we abstracted from other mechanisms that are also likely to be important channels of welfare effects. Therefore, we think of our results as a lower bound for the welfare costs of transaction taxes. In particular, our model does not address the impact of moving to better job opportunities; we treat incomes as exogenous so the model covers only one housing market with a common labor market. The rent-or-buy decision is also not part of our model. This margin can also be expected to be distorted by a transaction tax, because there is no tax on changing tenants. At the same time, however, there are strong tax incentives for owning over renting in many Western countries including Finland.

One aspect of taxation that we did not consider is administrative costs. The administrative costs of a transaction tax are arguably lower than those of a property tax, because the taxable value of a house is naturally up-to-date when it is based on a recent market transaction but may require a separate periodical assessment under a property tax. At the same time, reported transaction prices may be easier to manipulate than official assessed values. Nevertheless, at a sufficiently low tax rate the aggregate benefit from using a property tax could conceivably be overturned by a difference in administrative costs.

References


Appendix

A Inferring the quality distribution

Inference of house qualities $x$ is based on the idea that, with given incomes and preferences, the observed price difference between two neighboring house types in the quality order can be rationalized as an equilibrium price difference only with a particular quality increment. As long as there is trading there are some households that are indifferent between two neighboring house types. If there is trading then, due to the continuous income distribution, for any house type $j$ there must be trading households that are indifferent between moving to $j$ or its immediate neighbor in the quality order.

Consider a household endowed with a house of type $k \ll j$ (or $k \gg j + 1$) that is in equilibrium indifferent between moving to $j$ or $j + 1$. Using the notation introduced in Section 2, this household will have after trading either the highest level of non-housing consumption among those who traded to house type $j$, $\bar{y}_j$, or the lowest level among those who traded to house type $j + 1$, $y_{j+1}$. The incremental cost of trading to $j + 1$ as opposed to $j$ is $(p_{j+1} - p_j)(1 + \tau_T) + \xi_{j+1} - \xi_j$. When inferring the quality distribution, we assume that non-tax transaction costs are a constant fraction $\phi$ of the equilibrium purchase price, so this cost difference can be written as $(p_{j+1} - p_j)(1 + \tau_T + \phi)$. For this households we have the indifference condition

\[
u(x_j, \bar{y}_j) = u(x_{j+1}, \bar{y}_j - (p_{j+1} - p_j)(1 + \tau_T + \phi)). \tag{10}\]

Under CES-utility this can be solved for

\[x_{j+1}^\rho - x_j^\rho = \bar{y}_j - (\bar{y}_j - (p_{j+1} - p_j)(1 + \tau_T + \phi))^\rho. \tag{11}\]

Everything on the right hand side is either data or parameters for which we can assume reasonable values ($\rho = \varepsilon/(\varepsilon - 1)$, $\phi$). With a sufficiently fine grid $\bar{y}_j \approx y_j$ we can treat both as approximations of the same curve $y_j$, which captures the average non-housing consumption of households in house type $j$.\(^\text{10}\) The CES inference formula under transaction costs is

\[\hat{x}_h = \left( x_1^\rho + \sum_{j=2}^{h} ((y_{j-1} + (p_j - p_{j-1})(1 + \tau_T + \phi))^\rho - y_{j-1}^\rho) \right)^{\frac{1}{\rho}} \tag{12}\]

where $x_1$ is an arbitrary positive constant. It would be hard to come up with a reasonable range of values for this abstract quality measure. Crucially, $x_1$ washes out of all differences.

\(^{10}\)Caveat: The non-traders of type $j$ need not have an average $y$ in the traders’ post-trade range $[y_k, \bar{y}_k]$, but if transaction costs are low then the no-trade region is not very wide and they are close.
of the type $\hat{x}_h^h - \hat{x}_j^j$. Therefore the inferred quality differences between house types only depend on the data (prices $p_i$ and disposable incomes $y_i$ for $i$ in $j, \ldots, h$) and the elasticity of substitution between housing and other consumption.

With $\rho \to 0$, i.e., with log-utility, the inference formula becomes

$$\hat{x}_h = x_1 \prod_{j=1}^h \frac{\bar{y}_j}{y_j} - (p_{j+1} - p_j)(1 + \tau_T + \phi)$$

(13)

In this case $x_1$ cancels out of inferred quality ratios $\hat{x}_h/\hat{x}_j$, which therefore only depend on observed prices and incomes.

**B  Finding the equilibrium**

Let us first consider how to determine the aggregate demand for each house type given an initial allocation of houses and incomes and some price vector $p$, where $0 \leq p_k < p_{k+1}$. For simplicity, we abstract here from the property tax and use $\tau$ to denote the ad valorem transaction tax.

The tricky part of transaction costs is that they can be avoided if a household decides to consume its endowment, which creates a discontinuity in the budget set. However, this discontinuity is not relevant when considering only those who trade. The bounds of the trade-to region (see Figure 1) can be found by solving for the no-trade intervals in a “continuous” world where transaction costs are incurred even if the household does not trade. We thus solve the bounds of the trade-to intervals $y_k(p)$ and $y_k(p)$ from

$$\bar{y}_k(p) = \{y \text{ s.t. } u(x_k, y - \tau p_k - \xi_k) = u(x_{k+1}, y + p_k - (1 + \tau) p_{k+1} - \xi_{k+1})\},$$

(14)

$$\bar{y}_k(p) = \{y \text{ s.t. } u(x_k, y - \tau p_k - \xi_k) = u(x_{k-1}, y + p_k - (1 + \tau) p_{k-1} - \xi_{k-1})\}.$$  

(15)

Positive assortative matching implies that, in equilibrium, $\bar{y}_N = y_{\max}$ and $y_1 = y_{\min}$.

The bounds of the actual no-trade intervals extend wider because they include those who are deterred from moving by the transaction costs. Consider the $k$-type households, i.e., the households endowed with house $x_k$. As in the case of trade-to intervals, we need to find the bounds of the income interval at which a $k$-type will choose to not trade, denoted by $\bar{y}_k(p)$ and $\bar{y}_k(p)$. The crucial difference (which makes computation slower) is that it is no longer obvious which house type is the binding outside opportunity. For example, at the upper bound $\bar{y}_k(p)$ the binding option is to trade up, but the house might be of type higher than $k + 1$. Intuitively, it is not worth paying a transaction cost to swap to a house that is very similar to the current house.
We use the following procedure to find out the value of $Y_k(p)$.

First, notice that as long as transaction costs are strictly positive, $Y_k(p) > y_k(p)$.

Second, notice that those who trade will end up in one of the trade-to intervals

$$x = x_j, y \in [y_j(p), \bar{y}_j(p)].$$

Households with incomes above the upper bound of the no-trade interval will be trading up. We go through house types $x_{k+s}$, starting from $s = 1$, comparing autarky with bundles at the upper bounds of trade-to allocations $\bar{y}_{k+s}(p)$. The first question is, at which income level $y$ is a household endowed with a house $k$-type house exactly able to pay the price difference and the transaction tax in order to swap into a house of type $k+s$ and have just the amount of money left over to consume at the upper bound of the trade-to interval, $\bar{y}_{k+s}(p)$. The answer is

$$\tilde{y}_{k,s} = \bar{y}_{k+s}(p) + (1 + \tau) p_{k+s} + \xi_{k+s} - p_k.$$  

Next we need to check whether this feasible trade is at least weakly preferred to autarky. If

$$u(x_{k+s}, \bar{y}_{k+s}(p)) \geq u(x_k, \bar{y}_{k+s}(p) + (1 + \tau) p_{k+s} + \xi_{k+s} - p_k)$$

holds then we have found the lowest house type to which $k$-types trade up to; if it does not hold then we increment $s$ by one and redo this same procedure. We keep incrementing $s$ until we either find the upmarket neighbor of type $k$, or until we hit $\tilde{y}_{k,s} \geq y_{\text{max}}$ which would show that $k$-types don’t trade up so that $Y_k(p) = y_{\text{max}}$.

Suppose we have found the lowest $k+s$ with which any $k$-type will prefer trading to autarky. The preference of the household endowed with $\{x_k, \tilde{y}_{k,s}\}$ will almost surely be strict. Hence, now that we know $s$, we still need to find the exact upper bound by solving $Y_k(p)$ as the $y$ from equation

$$u(x_k, y) = u(x_{k+s}, y - (1 + \tau) p_{k+s} - \xi_{k+s} + p_k).$$

This implies that the $k$-type at the upper bound of the no-trade interval will trade into the interior of the trade-to interval of house $k+s$.

It is now possible that some types $k$ do not trade at all. Then $Y_k(p) = y_{\text{min}}$ and $Y_k(p) = y_{\text{max}}$.

Finding the lower bounds of the no-trade intervals and the downmarket neighbors is analogous, but done starting from the owners of the best house type and incrementing downwards.
Demand for type-$k$ houses is the sum of demands from each household type. Consider type-$j$ households endowed with income $y$. They will buy a type-$k$ house, where $k > j$, if the following two conditions are satisfied: 1) Their resulting non-housing consumption would be in the same range as the non-housing consumption of those type-$k$ households who would consume their endowment under unavoidable transaction costs, that is $y + p_j - p_k - \tau p_k - \xi_k \in [\bar{y}_k(p) - \tau p_k - \xi_k, \bar{y}_k(p) - \tau p_k - \xi_k]$; 2) Their income level is outside the no-trade interval of type-$j$ households.

Combining these requirements, the bounding inequalities for the interval from where households endowed with $j$-type houses trade up to house $k > j$ can be written as

$$y \leq y_k(p) + p_k - p_j,$$

$$y \geq \max\{y_k(p) + p_k - p_j, \bar{y}_j(p)\}. \tag{20}$$

Similarly, the bounding inequalities for $j > k$ who trade down to house $k$ are

$$y \leq \min\{y_k(p) + p_k - p_j, \bar{y}_j(p)\},$$

$$y \geq y_k(p) + p_k - p_j. \tag{21}$$

Finally, the own demand by $j = k$ (the no-traders) is from the interval

$$\bar{y}_k(p) < y \leq \bar{y}_k(p). \tag{22}$$

Total demand for type-$k$ houses is

$$Q_k(p) = \sum_{j=0}^{k-1} \max\left\{0, F_j(\bar{y}_k(p) + p_k - p_j) - F_j\left(\max\{y_k(p) + p_k - p_j, \bar{y}_j(p)\}\right)\right\}$$

$$+ F_k(\bar{y}_k(p)) - F_k(y_k(p))$$

$$+ \sum_{j=k+1}^N \max\left\{0, F_j(\min\{y_k(p) + p_k - p_j, \bar{y}_j(p)\}) - F_j(y_k(p) + p_k - p_j)\right\}. \tag{23}$$

Excess demand is $Z_k(p) = Q_k(p) - m_k$, where $m_k = F_k(y_{\text{max}})$ is the mass of type-$k$ houses. Equilibrium prices are solved by finding $p$ such that $Z(p) = 0$.

In order to find the equilibrium prices, we have written a Matlab function that returns the excess demand for each house type for a given price vector and a given initial (or post-shock) allocation of house qualities and incomes. This function first determines the trade-to and no-trade intervals described above. Using those intervals, it then determines the excess demand for each house. Since we are assuming that the income shocks are log-normally distributed, it is easy to determine the cumulative distribution $F_j$. We use this function together with Matlab’s fsolve algorithm to find the equilibrium price vector.