Lectures 8 – Housing (continued)

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1 User cost of capital in presence of income taxes

Calculations of user costs become more complicated if one accounts for the impacts of income taxes.

1. Question: Does the income tax system favour owner-occupied housing or rental housing?
2. Income taxes (US and UK tax law).
   (a) Income taxes affect the user cost of capital because costs and income associated with owning a house impact taxable income and hence impact how much income tax one pays.
   (b) In general, rental housing and owner occupied housing are treated differently.
      i. In both the US and the UK, rental income is not taxed for owner-occupied housing while it is for rental housing.
      ii. In the US, both landlords and homeowners can deduct real estate taxes and mortgage interest from their income.
      iii. In the UK, tenants pay council taxes, these are not deductible from income, and owner occupiers cannot deduct mortgage interest from income.
      iv. Landlords can deduct all maintenance costs from taxes.
      v. Landlords can deduct "depreciation".

vi. Capital gains are untaxed for most homeowners while they are taxed for rental owners.

3. User cost of owner-occupied housing in US (with income taxes).

   (a) Interest cost $= (i^r + \pi)(1-t)V$.

      i. Suppose buy house and borrow M, pay E where $V = M + E$.

      ii. Annual foregone interest is $(i^r + \pi) E (1-t)$.

      iii. Annual mortgage interest is $(i^r + \pi) M$, but reduce taxes by $t(i^r + \pi) M$, net cost is $(i^r + \pi)(1-t) M$.

   (b) Property tax is also deductible for homeowners, property tax cost is $T(1-t)V$.

   (c) Other costs not tax deductible: cV.

   (d) Capital gains not taxed: cost $= -(g^r + \pi)V$.

   (e) Total user cost of owner-occupied housing in US

$$\begin{aligned} R &= ((i^r + \pi)(1-t) + T(1-t) + c - g^r - \pi)V \\ &= ((i^r + T)(1-t) - \pi t + c - g^r)V. \end{aligned}$$

   (f) Higher inflation benefits homeowners because it increases nominal interest rates, which increases nominal interest payments, which lowers taxes. Increased costs due to higher interest payments are offset by increase in value of home.

   (g) Higher income taxes lower the user cost of owner occupied housing.

4. User cost of owner-occupied housing in UK (with income taxes).

   (a) Interest cost $= (i^r + \pi)V - t(i^r + \pi)E$.

      i. Suppose buy house and borrow M, pay E where $V = M + E$.

      ii. Annual foregone interest is $(i^r + \pi) E (1-t)$.

      iii. Annual mortgage interest is $(i^r + \pi) M$.

      iv. $(i^r + \pi)V - t(i^r + \pi)E$.

   (b) Council tax is not deductible, property tax cost is TV.

   (c) Other costs not tax deductible: cV.

(d) Capital gains not taxed: cost $= -(g^r + \pi) V$.

(e) Total user cost of owner-occupied housing in UK

$$\begin{aligned} R &= (i^r + \pi + T + c - g^r - \pi) V - t (i^r + \pi) E \\ &= (i^r + T + c - g^r) V - t (i^r + \pi) E. \end{aligned}$$

(f) Higher inflation lowers user cost of homeowners in UK because foregone interest is lower when nominal interest rates are high due to high inflation.

(g) Higher income taxes lower the user cost of homeownership because it lowers the opportunity cost of foregone interest.

5. Equilibrium rent for rental property in US (with income taxes).

(a) Landlord charges rent so that earns zero profits (competitive market assumption).

(b) Landlord is allowed to deduct dV from taxable income. d is the depreciation rate for tax purposes.

(c) Zero profit condition for landlord is

$$\begin{aligned} \textit{income} &= \text{direct costs } + \text{ indirect costs} + \text{income taxes} \\ R + g^r V &= i^r M + (T + c) V \ + i^r (V - M) + \text{income taxes} \\ R + g^r V &= (i^r + T + c) V + \text{income taxes} \\ \text{income taxes} &= t (R + (g^r + \pi) V - (i^r + \pi) V - (T + c) V - dV) \end{aligned}$$

$$\begin{aligned} R + g^r V &= (i^r + T + c) V + t (R + (g^r + \pi) V - (i^r + \pi) V - (T + c) V - dV) \\ R (1 - t) &= V (i^r + T + c - g^r) (1 - t) - tdV \\ R &= V (i^r + T + c - g^r) - \frac{t}{1 - t} dV. \end{aligned}$$

6. Assumes i, T, c, g, and t are same for both owner-occupiers and owner-landlords.

(a) Suppose $\pi = d = 0$

$$\begin{aligned} R_R &= ((i_R + T) (1 - t) + c_R - g_R) V. \\ R_O &= (i_O + T + c_O - g_O) V. \end{aligned}$$

(b) $c_R > c_O$ then $R_R > R_O$, in which case it is better to own.

(c) $g_O > g_R$ then $R_R > R_O$ better to own.

2 Equilibrium values of rent and value

1. Studied user cost owner occupied housing.
2. Competitive market rent.
3. In a perfectly functioning capital market, constant rents, no uncertainty, no income taxes, no transaction costs, prices adjust instantaneously
$$R = (i + T + c - g)\, V.$$
   (a) If value rises and rent does not everyone is better off renting than buying. That will drive the rent up and the value down.
   (b) If rent rises and value does not, everyone is better off buying than renting driving value up and rent down.
   (c) Look at picture. Rent and value don't move together in short run.
   (d) Short run, costs of moving, buying/selling, multiple types of housing, the above relationships may not hold in short run.
   (e) If you are owner-occupier and there are moving costs, if rent for equivalent property falls you may not switch to renting because of moving costs. Or, if the value of property is high now and you know it will fall in one year's time, you may not sell because of moving costs.

3 Rent vs. buy with transaction costs

1. Transaction costs.
   (a) Financial and time costs of search.
   (b) Cost of physically moving durable goods.
   (c) Legal and realtor fees.
   (d) Stamp duty.
   (e) Higher for buying/selling than for renting.
2. Decision whether to buy or rent depends on length of stay. If expect to stay longer, it is better to buy.

3. If expect to stay T years, must compare total cost of renting over T years to total costs of owning.

4. User costs not as simple to calculate when there are transaction costs.

5. Example.

   (a) Suppose you plan to stay in a flat for T years and suppose $V = V_0 = V_T$ where V_t is the value at time t.

   (b) Suppose the moving cost (transaction cost) you must pay to purchase a flat is m_{own} and the transaction cost to rent a flat is m_{rent}. Suppose $m_{rent} < m_{own}$.

   (c) Cost of owning for T years and then moving is

$$\begin{aligned} C_{own} &= m_{own} + V - \frac{V}{(1+r)^T} \\ &= m_{own} + V\left(1 - \frac{1}{(1+r)^T}\right) \end{aligned}$$

   (d) Cost of renting is

$$\begin{aligned} C_{rent} &= m_{rent} + R\left(\sum_{t=0}^{T-1}\left(\frac{1}{1+r}\right)^t\right) \\ &= m_{rent} + R\left(\sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t - \sum_{t=T}^{\infty}\left(\frac{1}{1+r}\right)^t\right) \\ &= m_{rent} + R\left(\frac{1+r}{r} - \left(\frac{1}{1+r}\right)^T\left(\frac{1+r}{r}\right)\right) \\ &= m_{rent} + R\left(\frac{1+r}{r}\right)\left(1 - \left(\frac{1}{1+r}\right)^T\right) \end{aligned}$$

6. It is better to choose ownership if

$$C_{own} < C_{rent}.$$

7. Since $m_{rent} < m_{own}$ by assumption, if $T = 0$, it is better to rent than to own.

8. If $V < R\left(\frac{1+r}{r}\right)$, then it is better to choose ownership if $T = \infty$. Therefore, there is some value of T^* such that

$$\begin{aligned} C_{own} &> C_{rent} \text{ for } T < T^* \\ C_{own} &< C_{rent} \text{ for } T > T^*. \end{aligned}$$

The time duration T^* is the length of stay for which the consumer is indifferent between renting and owning.

9. The choice between renting and owning depends on the value V, the rental price R, the interest rate r, and the expected length of tenancy.

10. The transaction cost is the fixed cost of living somewhere. The rent or the "user cost" is the marginal cost of staying one additional year. If one is going to consume the services of a flat for a long enough period of time, it makes senses to incur a high fixed cost and then pay the low marginal cost of ownership (assuming the marginal cost of an additional year in a flat is lower if owning then if renting). If one is only going to consume the services for a short period of time, then it may make sense to rent, at a high marginal cost, and pay a low fixed cost.

11. This tradeoff between fixed costs and marginal costs is obvious. We face decisions like this everyday. However, it is important to remember that the "classical" housing demand model assumes that fixed costs are nil. Thus, the classical model rules out the tradeoff between fixed costs and marginal costs. The classical model is useful because it is easy to analyse and makes clear the intertemporal determinants of value (i.e. net present value of future rents) and because as a rough approximation it is not bad in some circumstances. However, when analysing short run decisions between buying and renting, for example, transaction costs are important determinants of people's choices between renting and buying.

4 Rent vs. buy with utility maximisation

The rent vs. buy decision above was discussed in a model in which household minimise the cost of housing services. Implicitly the demand for housing is fixed at one unit. More generally, the choice can be framed within a utility maximisation problem. Consider the following example.

A household lives for 2 periods. In the first period, they consume a consumption good c_1 and housing h. In the second period they consume a consumption good c_2. In the first period they have assets a_1. The first period price of consumption is p_1. The first period price of housing is p_{h1}. They may also choose to save. If they save s and purchase housing h, then second period assets are $a_2 = rs + p_{h2}h + y_2$ where y_2 is non-savings income (labour income, pension income, public benefits, *etc.*). If they do not purchase housing, they may rent at rental price p_{r1}. If they rent, then second period assets are $a_2 = rs + y_2$. In addition, if they purchase housing in period 1, they must pay a fixed transaction cost F. If they purchase housing, the first and second period budget constraints are

$$\begin{aligned} p_1 c_1 + p_{h1} h + s &= a_1 - F \\ p_2 c_2 &= rs + p_{h2} h + y_2 \end{aligned}$$

If the rent housing, the budget constraints are

$$\begin{aligned} p_1 c_1 + p_{r1} h + s &= a_1 \\ p_2 c_2 &= rs + y_2. \end{aligned}$$

Households maximise the utility function $U_1(c_1, h) + U_2(c_2)$ subject to these two budget constraints. The problem can be analysed as follows:

1. Solve the problem for renters. Compute optimal consumption, housing and savings. Also, compute the indirect utility obtained by renters, $V_{rent}(a_1, p_1, p_{r1}, r, p_2, y_2)$

2. Solve the problem for owners. Compute optimal consumption, optimal housing, and optimal savings. Also, compute the indirect utility obtained by owners, $V_{own}(a_1 - F, p_1, p_{h1}, r, p_{h2}, y_2)$.

3. People will choose to rent if $V_{rent} \geq V_{own}$. Ownership requires the household to pay an additional transaction cost; this reduces utility. However, ownership may potentially still be optimal because ownership has two benefits: owning a house provides utility in period 1 and ownership produces additional assets in period 2.

5 Rent vs. buy with uncertainty

We can also use a similar 2 period model to analyse choices of housing in a world with uncertainty. Consider the following model.

A consumer lives for two periods. In the first period, they have initial assets a_1 and must either rent or buy one house. Demand for housing is fixed at one unit. If they rent the cost is p_r. If they buy, the cost is p_1. Remaining resources may be spent on first period consumption c_1 or savings s. In the second period, savings s pays gross return r. In addition, if they purchased a house, they may sell it in the second period for an uncertain value. With probability π_H the second period value is p_H and with probability $1 - \pi_H$ it is $p_L < p_H$. Thus, for owners, in the second period in the high house price state, consumption is $c_{2H} = rs + p_H$ while in the low house price state it is $c_{2L} = rs + p_L$. For renters second period consumption is $c_{2H} = c_{2L} = rs$ in both states. Consumers maximise utility. Utility is

$$u(c_1, c_{2H}, c_{2L}) = \ln c_1 + \beta[\pi_H \ln c_{2H} + (1 - \pi_H) \ln c_{2L}].$$

With this information one can work out the budget constraints for renters, and the demand functions for renters. One can also work out the first order conditions for the maximisation problem for owners. The general form of the indirect utility functions will be $V_{rent}(a_1, p_r, r)$ for renters and $V_{own}(a_1, p_1, r, p_H, p_L, \pi_H)$.

6 Public policy and housing

1. Tax policy gives incentive to own (income tax).
    (a) Tax policy lowers the user cost of owning relative to renting.
2. Positive question. Why is this the case?
    (a) What factors determine government actions?
        i. Goals of government (i.e. government utility function)
            A. Goals of government are determined by people who run government.

B. To some degree they act to carry out goals of voters. Tax incentives to owner occupied housing are politically popular because they benefit the middle class at the expense of the poor and the wealthy.

C. To some degree they act to maximise own utility.

ii. Beliefs about policy effects.

A. Government actors and/or voters may believe that policy A has impact X. This belief may or may not be correct.

B. For example, governments and/or voters may believe that tax incentives to own housing help low income people obtain housing. In the US, this is clearly not true. Tax incentives to owner occupied housing clearly benefit middle class.

C. Governments may believe there is a market imperfection that can be corrected by government intervention or that a policy succeeds in acheiving a desirable redistribution of income.

3. Normative question. Should tax policy give incentive to own?

(a) Is income tax benefit to ownership good or bad?

(b) Efficiency. Does such an incentive contribute to economic efficiency? In the absence of market failures, no. If there are market failures, maybe.

i. The subsidy in favour of owner occupied housing is a subsidy to remain in one place. If positive externalities are created by people remaining in one place (for example, when they remain in one place they may get to know their neighbours and create a network or community that creates positive social benefits.), then this could improve welfare. So, do stable communities create positive externalities? Do they create negative externalities?

(c) Equity. Does such an incentive result in a desirable redistribution of wealth?

i. Does this subsidy help the government achieve its goals for wealth distribution? Does it do this at low cost? To answer

this we must answer who benefits and who loses from this tax policy, what alternatives are available, and what are the costs of the alternatives.

4. Many other public policies have direct impacts in the housing market.
   (a) Subsidisation of housing demand or housing supply.
   (b) Regulation of housing quality or housing prices.
   (c) Land use controls.
   (d) Policies toward police protection, schools, parks, and other local public services.

7 Housing demand and supply subsidies.

1. Governments often subsidise housing either by subsidising the supply of housing or by subsidising the demand for housing.
   (a) Demand subsidies
      i. Housing benefit
   (b) Supply subsidies
      i. Public provision of housing.
      ii. Public subsidy to private provision of housing.

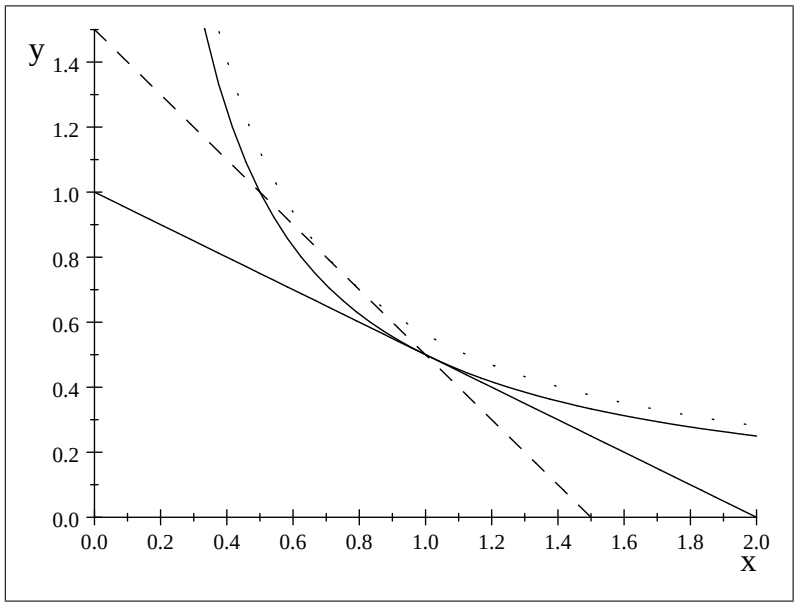
2. Normative theory of housing demand subsidies: Should the government subsidise housing?
   (a) If goal is to reduce poverty or redistribute wealth, cash transfers are preferable, more efficient
      i. Draw food/housing picture. Higher welfare can be achieved at lower cost with direct cash transfer.
      ii. Consumer maximises $U(c, h)$ subject to $c + p(1 - s)h = I$.
      iii. This is a housing demand subsidy.

iv. Suppose $I = 1$, $p = 1$, and $s = 0.5$. Further suppose $U(c, h) = c^{0.5}h^{0.5}$. Consumer demand is

$$c = \frac{1}{2}I$$

$$h = \frac{1}{2}\frac{I}{p(1-s)}.$$

The optimal choice looks like this.



Utility gain from moving to lump sum income transfer

v. The consumer consumes $c = 0.5$, $h = 1.0$. The cost to the government is $s \cdot h = 0.5$. The consumer utility is $v_0 = \left(\frac{1}{2}\right)^{0.5} \cdot 1 = 0.707$.

vi. Suppose instead the government, gave the consumer $m = 0.5$ and set $s = 0$. Then the consumer would choose $c = \frac{1}{2} \cdot (1 + 0.5) = 0.75$ and $h = \frac{1}{2}\frac{1.5}{1} = \frac{3}{4}$. The cost to the government is the same. The utility is $v_1 = \left(\frac{3}{4}\right)^{0.5}\left(\frac{3}{4}\right)^{0.5} = 0.75$. The consumer obtains higher utility at the same cost to the government.

(b) If the government is paternalistic and believes that consumers should consume housing instead of other goods and commodities, then it may be better to subsidise housing.

(c) Lack of housing or consumption of low quantities or qualities of housing may lead to other bad outcomes which have bad social consequences (crime, low productivity). Hence, there may very well be negative externalities caused by low housing consumption.

(d) Consumption of housing by some groups (e.g. low wealth households) may be low because capital-market imperfections prevent them from borrowing against future income. Subsidisation of housing could potentially improve social welfare to the extent it reduces inefficiencies associated with capital market imperfections. However, housing subsidisation may not be the best method to address these imperfections and could make them worse.

(e) If housing subsidy is tied to a particular place, which it often is, this can inhibit consumer's ability perhaps to move to a new job.

(f) This is true of all benefit programs, but, eligibility restrictions give public housing consumers incentives not to work or not to declare income. If declared income is too high, one does not qualify for public housing and so loses housing benefit. This, in essence is a high marginal tax rate. This is important in the UK and in US.

3. UK housing benefit

(a) In 1997/1998 around 4 million households claimed housing benefit with total payments amounting to £10 billion.

(b) The housing benefit is paid to low income households to assist with the cost of rental housing. The amount paid depends on a maximum benefit, $HB_{\max}$, household income, and "fair market rent" in the location the household lives. Fair market rent, R_{fair}, is determined by local authorities. For every, household the maximum housing benefit, $HB_{\max}$ depends on age and household structure. Part of the schedule defining this maximum is given

here.

$$HB_{\max} = \left\{ \begin{array}{cc} \text{Pounds per week} & \text{Criteria} \\ 43.25 & \text{if single and age} < 25 \\ 54.65 & \text{if single and age} \geq 25 \\ 85.75 & \text{if in a couple} \\ +38.50 & \text{if the household has a child} \end{array} \right\}.$$

For each household there is also an income threshhold, I_1. This threshhold depends on the characteristics of the household including household assets. Households with income below the threshhold qualify for the full housing benefit equal to

$$HB = \min\left\{HB_{\max}, R_{fair}\right\}.$$

That is, the full benefit is equal to the minimum of $HB_{\max}$ and R_{fair}. Households with income above the threshold and below I_2 qualify for a housing benefit equal to

$$HB = \min\left\{HB_{\max}, R_{fair}\right\} - 0.65\left(I - I_1\right).$$

Households with income above I_2 do not qualify for any benefit. The complete schedule of the benefit then is

$$HB = \left\{ \begin{array}{cc} \min\left\{HB_{\max}, R_{fair}\right\} & \text{if } I < I_1 \\ \min\left\{HB_{\max}, R_{fair}\right\} - 0.65\left(I - I_1\right) & \text{if } I_1 \leq I < I_2 \\ 0 & \text{if } I \geq I_2 \end{array} \right\}.$$

(c) For incomes above I_1 and below I_2 the benefit is reduced at the rate of 0.65 per additional pound of income. For those with incomes in this range, this, effectively is an additional marginal tax on income of 0.65.

(d) The council tax benefit is similar to the housing benefit. The council tax benefit schedule is

$$CTB = \left\{ \begin{array}{cc} CTB_{\max} & \text{if } I < I_3 \\ CTB_{\max} - 0.20\left(I - I_3\right) & \text{if } I_3 \leq I < I_4 \\ 0 & \text{if } I \geq I_4 \end{array} \right\}.$$

The council tax benefit threshholds are in general different than the housing benefit threshholds. The reduction in council tax benefit from incomes above I_3 is at a rate of 0.2.

8 Housing supply subsidies.

1. Demand subsidies

   (a) housing benefit (£10 billion in 1997/1998).

   (b) income support for mortage interest payments for low income home-owners (£900 million in 1997/1998).

   (c) discounts to help tenants purchase social housing (£900 million in 1997/1998).

2. How large are housing supply subsidies in the UK?

   (a) Net central and local government support for housing costs other than spending on housing benefit was about £8 billion in 1997/1998.

   (b) This includes spending in several categories.

      i. capital allocations to local authorities (£754 million in 1997/1998) for the renovation of housing stock, grants to Registered Social Landlords (RSL's) to build social housing, cash incentives to help social housing tenants purchase housing, grants to renovate private homes, and grants to carry out adaptations for disabled people.

      ii. expenditure on houisng from regeneration programmes (£1.3 billion in 1997/1998).

      iii. funding for RSL's through the Housing Corporation to support development of social housing (£673 million in 1997/1998).

      iv. renewal fund (£100 million in 1997/1998) to improve poorer quality council housing estates.

      v. subsidy for local authority Housing Revenue Accounts (£640 million in 1997/1998).

      vi. other spending by local authorities on housing (£1.1 billion in 1997/1998).

3. Overall, a large amount is spent on supply subsidies and is spend in a variety of ways.

4. Much evidence and theory suggests that housing supply subsidies are inefficient.

5. Same result can be obtained by demand subsidies which give consumers more choice of housing. Public supply usually is less flexible than private supply. If consumers' live in public housing and want to move to a different location or to a larger home, this can be very difficult. Publicly provided housing tends to limit the options available to public housing consumers.

6. Evidence in US suggests that government provision of housing is more subject to inefficiency/corruption than privately provided housing.

   (a) Why? Poor incentives to people who run housing to make efficient decisions.

   (b) Extreme example. In the late 1990's the Chicago public housing authority was taken over by the US federal government because the local authority had been siphoning money meant for public housing in Chicago into building condominiums in Florida. Large numbers of public housing units in the city were uninhabitable and had been uninhabitable for decades.

   (c) Another example It is usually cheaper to provide low income housing through buying and refurbishing old housing than through construction yet most publicly provided housing in the past has been through new construction. Incentives to housing authorities are not usually based on meeting demand of customers at minimum cost.

7. Counter arguments in favour of public provision of housing.

   (a) Possible economies of scale from public provision. This might be the case for instance if the public sector can force through changes in planning laws on a large scale or force many property owners to sell their land to create a large project.

   (b) High income people may want the government to provide low income housing in locations that are far from their own residences.

   (c) Market failures in private rental markets

      i. Fraud: Low income households may be victims of fraud perpetrated by private landlords.

ii. Imperfect contract enforcement: low income moves in, landlord promises low rent. Household moves in, landlord raises rent. Household pays or else faces eviction or high moving costs.

iii. Imperfect insurance market for risk of volatile housing rents. Housing prices and rents are volatile. Purchasing insurance against such volatility is difficult because insurance markets for such risk are under-developed. Government provided housing can in part correct this market failure by offering insurance against rent volatility.

iv. Asymmetric information in housing markets: It might be easier to ensure the quality of the low income housing supply through government provision than through private provision. On the other hand, government provision of housing is no guarantee of housing quality.

8. Public supply through subsidisation of private production of low income housing.

   (a) New construction is costly and is usually not the most efficient method to provide low income housing.

   (b) Problems of flexibility are reduced.

   (c) Problems of corruption/inefficiency are often reduced.

   (d) Less efficient at transfering wealth to low income than direct cash payments or housing demand subsidies.

   (e) Need an argument as to why private providers are underproviding housing.

9 Rent regulation or rent control

1. Many cities have rent control. These policies limit how much rents can increase over time.

2. In the UK, tenants who let their flat before 1989, pay mostly regulated rents. Rent increases are limited to inflation or to being tied to improvements in the quality of the property.

3. In San Francisco for example, rent increases are limited to the rate of inflation unless major repairs are made or the tenant moves out.
4. Draw picture of effects
   (a) Reduces the supply of housing
   (b) Creates excess demand for housing. This must be rationed somehow.
   (c) Deadweight loss
5. Other impacts
   (a) People don't want to move. Many rent control laws only apply to existing tenants.
   (b) People get around rent control by selling rights. To the extent they do, rent control, is a pure transfer from landlord to existing tenants
      i. If market rent increases, landlord pays tenant to leave
      ii. In 1999, Kelly, who had lived in the same flat in Manhattan for 7 years, was paid $12,000 by her landlord to move out of her flat who promptly raised the rent
      iii. John, a landlord in SF, only rented to tenants who appeared likely to remain for a short tenure.
   (c) Limits ability of market to adjust to changing market conditions
   (d) Tax on renting a property discourages long term development of rental housing
6. Cash transfers and housing vouchers are both preferable methods of subsidizing housing demand.

10 Quality or quantity controls

1. Concern about housing for poor being of too low quality or too small
   (a) NYC no splitting up of flats
   (b) Result restrict supply at low end of market, live in illegal housing
   (c) Correct solution again is cash transfer to poor or demand subsidy

11 Other housing regulations

1. Building code and other regulations of rental market
   (a) Minimum quality, safety, size, sanitation standards
   (b) Concern about fire hazard
      i. Fire is externality
      ii. N houses in a community
      iii. Ideal: minimise costs of fire and fire protection

$$C = \min_{\{e\}} \left\{ e + \left(\sum_{i=1}^{N} F_i \right) * P(e) \right\}$$

         A. e = investment in fire protection
         B. F_i = loss to person i
         C. $P(e)$ = probability of fire. $\frac{dP}{de} < 0$, $\frac{d^2P}{de^2} > 0$
         D. Social optimum first order condition

$$1 + \left(\sum_{i=1}^{N} F_i \right) \frac{dP}{de} = 0$$

      iv. Private decision $\min_{\{e_i\}} \left\{ e_i + F_i * P\left(e_i + \sum_{j \neq i} e_j \right) \right\}$

$$1 + F_i \frac{dP}{de} = 0$$

      v. Draw picture: Subsidize fire protection or tax failure to do so
      vi. Problems:
         A. Might be hard to measure $P(e)$, F_i, or e
         B. F_i might change when e changes: moral hazard
         C. Use known technology with known effects on P to combat A.)
   (c) Concern about housing for poor being of too low quality or too small.Concern that purchaser or renter cannot see many aspects of quality, costly to inspect.
      i. Performance standards vs material/technology standards similar to fire problem.