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C. Peter Rydell
Kevin Neels

June 1982

P-6779

The Rand Paper Series

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The Rand Corporation
Santa Monica, California 90406

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C. Peter Rydell
Kevin Neels

The Rand Corporation
Santa Monica, California

Rent control confers its benefits early and extracts its costs late. Initially rent reductions are solely price reductions, with tenants getting the same quantity of housing for less money. Over time, however, landlords react to revenue losses by reducing maintenance expenditures. The resulting housing deterioration lowers the quantity of housing services tenants receive, gradually eliminating the price reduction benefit. We estimate that each year eight percent of the remaining relative price reduction gets converted into relative quantity reduction via undermaintenance.

INTRODUCTION

Rent control laws differ greatly, but they have the common feature that they limit the amount by which rents can increase. As a consequence, rents of controlled dwellings are less than they would be in the absence of rent control. We call this difference the "rent reduction" caused by rent control.

Landlords who elect to stay in business can respond to the rent reduction in two ways. First, they can operate their properties the same as they would without controls. In that case, tenants will continue to receive the same "quantity of housing services" (a summary measure of the shelter and amenities provided by a dwelling). Since they pay less rent for the same quantity of housing services, the "price" of those services is reduced.

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* Presented at "Rent Control in the 1980s: An Economic Assessment," a symposium at the University of California, Santa Cruz, 25 May 1982.

Second, landlords can reduce maintenance to partially offset their revenue losses. As a result of the lowered maintenance, dwellings deteriorate causing a drop in the quantity of housing services provided. We call this the "quantity loss due to deterioration."

In fact, both responses occur: some of the rent reduction benefits tenants by reducing the price paid for housing services, and some hurts tenants by reducing the quantity of housing services they receive. The balance between those responses shifts over time, however. Initially, all of the rent reduction conferred by rent control goes into price reductions. Then, gradually, deterioration caused by undermaintenance lowers the quantity of housing services produced by a dwelling and erodes the price reduction. Ultimately, the percentage quantity reduction equals the percentage rent reduction and no price reduction remains.

To trace the impact of rent control on the price and quantity of housing services we first present a model relating the output of housing services to the input of maintenance. Then we show how rent reductions caused by rent controls lead to undermaintenance and hence to reductions in housing services. We conclude by reviewing housing deterioration estimates made in a recent analysis of the Los Angeles rent control law.

MAINTENANCE AND HOUSING CONDITION

The key to measuring the relationship between maintenance and housing condition is recognizing that maintenance today affects housing condition tomorrow. Following the theoretical literature on the subject* we use a simple difference equation to relate the output of

* See, for example, Moorhouse (1972); Evans (1973, p. 104), and Kiefer (1980).

housing services a year from now to maintenance inputs today.

$$H(t+1) = H(t) + \alpha M(t)^{\lambda} - \beta H(t) \qquad (1)$$

where t = time (in years) since rent control began,

$H(t)$ = housing services produced per year,

$M(t)$ = maintenance inputs per year,

α = constant parameter (depends on units of measure),

λ = maintenance elasticity,

β = gross deterioration rate.

The maintenance elasticity, λ, gives the percent increase in sustainable housing output per one percent increase in maintenance. We derive that interpretation by fixing the level of maintenance at M and then solving Eq.(1) for the sustainable output of housing services.

$$H^{*} = \alpha M^{\lambda}/\beta \ , \qquad (2)$$

where H^{*} = output of housing services supported by annual maintenance M.

Using our empirical estimate that λ=0.171 (see Appendix A), we conclude that increasing maintenance by one percent increases the output of housing services supported by that maintenance by 0.171 percent.

The gross deterioration rate, β, gives the fraction of nonmaintained housing lost annually to deterioration. We derive that interpretation by substituting Eq.(2) into Eq.(1) to find how rapidly housing output approaches the sustainable level:

$$H(t+1) - H(t) = \beta \left[H^{*} - H(t) \right] . \qquad (3)$$

Using our empirical estimate that β=0.08 (see Appendix A), we conclude that if there is a gap between housing services currently being produced and the housing services that can be sustained by a given maintenance level, then eight percent of that gap closes per year.

DETERIORATION CAUSED BY RENT CONTROL

We assume that just before the start of rent control the quantity of housing services produced per dwelling was economically optimal, and that just enough maintenance was being done to preserve that level of production. In other words, we use the familiar microeconomics assumption that landlords seek to maximize profits, and hence that they have adjusted maintenance inputs until the marginal dollar spent on maintenance just yields a dollar of discounted revenues net of expenses (see Appendix B). In our analysis, the optimal output of housing services and the required input of maintenance are related by Eq.(2).

Furthermore, our analysis judges that under rent control, landlords undermaintain sufficiently for the output of housing services to eventually decline to the level that controlled rents support.* For example, if rent control reduces rents by 10 percent, landlords realize that they are effectively selling 10 percent of their output of housing services at a zero price and will stop maintaining that portion of their output. The nonmaintained portion of their output deteriorates and eventually disappears. The final result is a dwelling producing 90

* That judgment is based on the fact that under rent control the marginal maintenance dollar yields no revenue until the sustainable output of housing services has fallen by the same proportion as rent.

percent of the original output of housing services and renting for 90 percent of the original rent. There is then no price reduction.

Deterioration does not occur instantly, however. Consequently, during the deterioration process the percentage reduction in housing services is less than the percentage reduction in rents, and tenants receive price reductions. The size of those price reductions depends upon how rapidly deterioration occurs.

To find the pace of housing deterioration during rent control we apply the maintenance model of the previous section. Modifying the left side of Eq.(2) to reflect the level of output supported by controlled rents and the right side to include undermaintenance, yields the equation defining the undermaintenance caused by rent control.

$$F(t)\ H^{*} = \alpha\left[M - U(t)\right]^{\lambda}/\beta \qquad (4)$$

where $F(t)$ = controlled rent as a fraction of uncontrolled rent (i.e., the percent rent reduction caused by rent control is $100\ [1-F(t)]$),

$U(t)$ = undermaintenance per year (i.e., maintenance that would have occurred absent rent control less maintenance given rent control).

Then we solve that equation for the level of maintenance during rent control, M-U(t), and substitute the resulting expression into Eq.(1) in place of M(t), to find the annual housing deterioration caused by rent control:

$$H(t+1) - H(t) = - \beta \left[H(t) - F(t)H^{*} \right] . \qquad (5)$$

The difference, $H(t) - F(t)H^{*}$, is the gap between current housing services and those supported by controlled rents. Eq.(6) shows that each year deterioration eliminates eight percent of the gap between current housing services and those supported by controlled rents (because our estimate of β is 0.08).

Note that an explicit formula for the undermaintenance that causes the deterioration can be found by substituting Eq.(2) into Eq.(4) to obtain:

$$U(t) = M \left[1 - F(t) \right]^{1/\lambda} . \qquad (6)$$

QUANTITY REDUCTIONS VS. PRICE REDUCTIONS

As mentioned in the Introduction, rent control initially causes only price reductions but then over time deterioration gradually reduces the quantity of housing services and erodes the bargain tenants enjoy. Using Eq.(5) we can now quantify that argument.

The price of housing services equals the ratio of rent charged to housing services provided,

$$P^{*} = \frac{R^{*}}{H^{*}} , \qquad (7)$$

where P^{*} = price of housing services before rent control,

R^{*} = rent before rent control,

H^{*} = housing services before rent control.

That price decreases under rent control because rents decline more than housing services, i.e., F(t) declines more than H(t) in

$$P(t) = \frac{F(t)\ R^*}{H(t)} \quad , \tag{8}$$

where P(t) = price of housing services during rent control,

F(t) = controlled rent as a fraction of noncontrolled rent,

H(t) = housing services produced during rent control.

Then solving Eqs.(7) and (8) to find that $F(t)\ H^* = H(t)\ P(t)\ /P^*$, substituting that result into Eq.(5), and dividing both sides of the equation by H(t) we obtain

$$\frac{H(t+1) - H(t)}{H(t)} = -\beta \left[\frac{P^* - P(t)}{P^*}\right] . \tag{9}$$

That equation shows that the annual relative reduction in housing services, [H(t+1) - H(t)]/H(t) equals eight percent of the remaining relative reduction in price, $[P^* - P(t)]/P(t)$, because β=0.08. Finally, because reductions in housing services result in proportional increases in price, see Eq.(8), we arrive at the general conclusion: Each year eight percent of the remaining relative price reductions caused by rent control gets converted to relative quantity reductions caused by rent control.

For example, if rent control causes a 10 percent rent reduction, then the initial result is no change in quantity and a 10 percent price reduction. However, after one year, deterioration will have caused a

quantity reduction of 0.8 percent (8 percent of the 10 percent) and the price reduction will be 9.2 percent (10 percent less 0.8 percent).*

CONCLUSION

The revenue losses caused by rent control offer landlords an incentive to undermaintain their properties. In the long run, landlords allow that portion of their housing services that yields no revenue to disappear through deterioration. However, knowing that tells little about deterioration in the short or intermediate run. Rent control usually lasts for only a brief part of the life of a housing structure. If the pace at which housing deteriorates during rent control is slow enough, by the time housing starts to seriously deteriorate rent control will be gone taking with it the incentive for landlords to undermaintain.

Hence the key question is not whether rent control induces deterioration or by how much, but rather how rapidly it does so. This analysis estimates that deterioration occurs at a modest but meaningful pace: each year eight percent of the gap between the current level of housing services and the lower level supported by controlled rents is closed by deterioration.

Rent reductions cause price reductions to the extent that they are not offset by quantity reductions. Initially, all the rent reduction goes into price reductions. Then, over time, undermaintenance causes deterioration, eroding the price reduction and replacing it with a quantity reduction. We estimate that each year eight percent of the

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* Actually, the price reduction after one year will be 9.3 percent because the relation between price and quantity reduction is not strictly linear. The exact calculation divides rent, 1-0.1, by quantity, 1-0.008, to get a price, 0.907, which is 9.3 percent less than the reference price of 1.000.

remaining relative price reduction caused by rent control gets converted into relative quantity reductions.

The specific amount of deterioration caused by a rent control law depends on the size of the rent reductions generated by that law. Those rent reductions in turn depend not only on the detailed provisions of the law but also on the economic environment in which the law occurs.

To illustrate the way that rent reductions lead to quantity reductions we report some conclusions from a recent study of rent control in Los Angeles (Rydell, et. al., 1981). That analysis used the determination model discussed in this paper (together with other models) to reach its conclusions.

Rent control began in Los Angeles during 1978. The analysis was done during 1981 when the Los Angeles City Council was considering three alternatives: (a) end rent control in 1982, (b) extend the current law, and (c) tighten the law to magnify its rent reductions. In April 1982 the City Council chose the middle alternative and extended the current law with only minor modifications.

Los Angeles has a "second generation" rent control law that compensates landlords for almost all background price inflation in the economy. Consequently, the average effect on rents is small. The analysis estimated that rents were 1.2 percent lower than they would have been absent rent control in 1979, and 4.0 percent lower in 1982.

After 1982 the three alternatives differ. Ending the law in 1982 eliminates almost all rent reductions. (Deterioration during rent control that has not yet been removed by post-control upgrading causes the small post-1982 rent reductions.) Extending the current law holds the rent reduction almost constant. Tightening the law increases the rent reduction considerably.

The right hand column of Table 1 reports the rent reductions estimated to result from each alternative by the years 1979, 1982, 1986, and 1990. Those rent reductions are the same for all alternatives through 1982 because the alternatives represent different choices to be made in 1982.

The quantity reductions reported in the middle column of the table were estimated from the rent reductions, using this paper's Eq.(5). The price reductions in the left hand column were estimated using this paper's Eq.(8).

The consequences of rent control depend on the specific law and on the specific economic environment in which that law is imposed. The findings from the Los Angeles study cannot be applied elsewhere uncritically. However, general patterns in the findings can be transferred judgmentally.

First, the sum of the percentage quantity and price reductions is approximately equal to the percentage rent reduction. As mentioned earlier, under rent control rent reductions either go into quantity reductions or price reductions.

Second, during rent control deterioration steadily reduces the quantity of housing services and therefore diminishes the portion of rent reductions that can benefit tenants as price reductions. For example, the Los Angeles analysis estimated that although initially almost all rent reductions go into price reductions, by 1990 two-thirds of the rent reduction caused by the current rent control law will be offset by quantity reductions, leaving only one-third of the rent reduction to benefit tenants as reduced prices.

Table 1

PRICE REDUCTIONS AND QUANTITY REDUCTIONS CAUSED BY ALTERNATIVE RENT CONTROL LAWS: CONTROLLED RENTAL HOUSING, LOS ANGELES, 1979-1990

Year	Component of Rent Reduction: Price Reduction (%)	Component of Rent Reduction: Quantity Reduction (%)	Rent Reduction (%)
	End Law[a]		
1979	1.1	.1	1.2
1982	3.2	.8	4.0
1986	0	.6	.6
1990	0	.4	.4
	Extend Current Law[b]		
1979	1.1	.1	1.2
1982	3.2	.8	4.0
1986	2.1	1.6	3.7
1990	1.3	2.2	3.5
	Tighten Law[c]		
1979	1.1	.1	1.2
1982	3.2	.8	4.0
1986	8.8	3.2	11.7
1990	12.5	6.9	18.5

SOURCE: C. Peter Rydell, C. Lance Barnett, Carol E. Hillestad, Michael P. Murray, Kevin Neels, and Robert H. Sims, The Impact of Rent Control on the Los Angeles Housing Market, The Rand Corporation, N-1747-LA, August 1981, pp. 55-60.

NOTE: All entries are the percentage difference between what would have prevailed absent rent control and what occurs under rent control as of May of each year. The entries are related by the formula $(1-p/100)(1-q/100) = (1-r/100)$, where p = percentage price reduction, q = percentage quantity reduction, and r = percentage rent reduction.

[a] Control ended in May 1982, four years after start of rent control in Los Angeles.

[b] Current law (7.6 percent limit on annual rent increases if no vacancy, but no limit on a vacancy) extended beyond 1982.

[c] Controls revised in 1982 to impose a 5.6 percent limit on annual rent increases if no vacancy, and a 10 percent limit at a vacancy.

Appendix A

ESTIMATING THE MAINTENANCE ELASTICITY AND THE GROSS DETERIORATION RATE

Data from the Housing Assistance Supply Experiment,* together with a theoretical constraint, yield estimates of the parameters in the maintenance model defined earlier by Eq.(1). We estimate that the maintenance elasticity, λ, is 0.171; and that the gross deterioration rate, β, is 0.08. This appendix reviews the estimation procedure and shows that the estimates have both empirical and theoretical support.

Table A.1 gives estimates of the parameter β obtained from regression analyses that assume alternative values of the parameter λ. The measures of housing services per dwelling used in the regression analysis are discussed in Neels (1982).**

Note that the second regression, which estimates β to be 0.089, has the highest explanatory power. However, the explanatory power is almost the same for neighboring regressions.

To chose between alternative plausible parameter estimates, given the regression analysis evidence, we use the following theoretical

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* The Housing Assistance Supply Experiment (HASE) was conducted by The Rand Corporation for the Department of Housing and Urban Development to test housing market responses to demand subsidies. To estimate the parameters in this paper's maintenance model we drew on a data base constructed by HASE that contains four years of panel data for 2,000 rental residential properties in two metropolitan areas.

** The regression analysis implicitly assumes that as the quantity of capital inputs deteriorate, energy and other inputs to the production of housing services shrink proportionately.

Table A.1

ALTERNATIVE ESTIMATES OF PARAMETERS IN THE DETERIORATION MODEL

Regression	Maintenance Elasticity λ	Gross Deterioration Rate β	Variation Explained (%)
1	.05	.092 (.007)	5.90
2	.10	.089 (.007)	5.92
3	.15	.084 (.006)	5.76
4	.20	.077 (.006)	5.47
5	.25	.069 (.006)	5.12
6	.30	.062 (.005)	4.76
7	.35	.055 (.005)	4.40
8	.40	.048 (.005)	4.07
9	.60	.029 (.004)	3.00
10	.80	.018 (.003)	2.27
11	1.00	.011 (.003)	1.75

SOURCE: Regression analysis of Housing Assistance Supply Experiment data on changes in the quantity of housing services over time and on maintenance expenditures.

NOTE: The regression model is the following transformation of Eq.(1): $[H(t + 1) - H(t)]/H(t) = \alpha M^{\lambda}/H(t) - \beta$. It was estimated with OLS regression for alternative values of λ. Standard errors for β are given in parentheses.

relationship between λ and β:

$$\lambda = m \left[1 + \frac{r}{\beta}\right], \tag{A.1}$$

where m = optimal annual maintenance as a fraction of rent,

r = real discount rate.

Estimating that m = 0.114 and r = 0.04 makes Eq.(A.1) explicitly define a relationship between λ and β.* The alternative regression runs in Table A.1 define a second relationship. We let the intersection of the two relationships (β =0.08, λ = 0.171) determine the parameter estimates. Note that the chosen estimates are very close to the ones that maximize the explanatory power of the regression.

The theoretical relationship in Eq.(A.1) is a consequence of assuming that, absent rent control, housing is maintained at a level that maximizes its present value. Appendix B derives that equation.

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* For the estimate that the ratio of maintenance to rent, m, is 0.114 see Rydell, et. al. (1981, p. 116). For the estimate that the real discount rate, r, is 0.04, see Neels and Rydell (1981, pp. 13-16).

Appendix B

FIRST AND SECOND ORDER CONDITIONS FOR OPTIMAL MAINTENANCE

The theoretical relationship in Eq.(A.1) is a consequence of assuming that, absent rent control, housing is maintained at a level that maximizes its present value. The relationship is a transformation of the first order condition defining optimal maintenance. To complete this paper's analyses we derive both the first and second order conditions for optimal maintenance.

The differential equation version of Eq.(1), with a constant maintenance level, is

$$H'(t) = \alpha M^{\lambda} - \beta H(t). \tag{B.1}$$

Solving that differential equation for the time path of housing services as a function of initial housing services and a constant maintenance level yields

$$H(t) = \left[H(0) - \frac{\alpha M^{\lambda}}{\beta}\right] e^{-\beta t} + \frac{\alpha M^{\lambda}}{\beta} \quad . \tag{B.2}$$

The present value of future revenues less expenses is

$$V = \int_{t=0}^{\infty} \left[PH(t) - M - C\right] e^{-rt} dt \quad , \tag{B.3}$$

Where V = present value,

P = price per unit of housing services (depends on units of measure, implicitly defined as equal to 1.0 earlier in this analysis),

C = annual operating expenses besides maintenance.

Substituting Eq.(B.2) into Eq.(B.3) and integrating gives us present value as an explicit function of maintenance:

$$V = \left[\frac{1}{\beta + r}\right]\left[PH(0) + \frac{P\alpha}{r} M^{\lambda} - \left(\frac{\beta + r}{r}\right) M\right] - \frac{C}{r} . \qquad (B.4)$$

Setting the derivative of Eq.(B.4) with respect to maintenance, M, equal to zero yields the first-order condition for optimal maintenance:

$$\lambda P^{\alpha} M^{\lambda-1} = \beta + r . \qquad (B.5)$$

Assuming that the housing stock is not only being maintained optimally but is also at its optimal level--i.e., using Eq.(2)--enables us to transform Eq.(B.5) into Eq.(A.1). The transformation requires recognizing that m = M/PH.

Alternatively, the first order condition, Eq.(B.5), can be transformed into

$$M = \left(\frac{\alpha\lambda P}{\beta+r}\right)^{\frac{1}{1-\lambda}} \qquad (B.6)$$

That result reveals that our model of optimal maintenance is consistent with the common observation that maintenance is positively correlated with housing market conditions. As the price of housing services rises, optimal maintenance increases. Specifically, Eq.(B.6) shows that the elasticity of maintenance with respect to the price of housing services is $1/(1-\lambda) = 1.2$ (given our estimate that $\lambda = .171$).

Multiplying the elasticity of maintenance with respect to price, $1/(1-\lambda)$, by the elasticity of housing services with respect to maintenance, λ, gives the elasticity of housing services with respect to price when housing services are adjusted only by varying maintenance. That elasticity can also be described as the price elasticity of supply of housing services from the existing stock. Our estimate of that elasticity, 0.2 (1.2 times 0.171), is very close to the only previous estimate in the literature, 0.3 (Ozanne & Struyk, 1976). The agreement provides independent confirmation of this paper's empirical results.

The second order condition for optimal maintenance requires that the second derivative of Eq.(B.3) with respect to maintenance be less than zero. That requirement is met if and only if $0 < \lambda < 1$. Our estimate of λ, 0.17, is comfortably within this range.

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