LAND USE REGULATION WITH DURABLE CAPITAL

By

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Abstract

This paper compares the level and distribution of the welfare changes from restricting the land available for residential development in a city. We compare the economic costs when residential capital is durable with the costs when capital is perfectly malleable and those when population is also freely mobile. Our simulation model, based on the stylized specification of an urban location model, suggests that in a more realistic setting with durable capital, the costs of regulation are substantially higher than they are when capital is assumed to be malleable or when households are assumed to be fully mobile. Importantly, the extent of wealth redistribution attributable to these regulations is much larger when these more realistic factors are recognized. When capital is durable, the results also imply that far more new development takes place on previously undeveloped land at the urban boundary, sometimes resulting in an increase in overall development.

JEL Codes: L51, R14, O21
I. Introduction

The economic impacts of regulations in the housing market depend crucially upon the ability of consumers and producers to anticipate and to adapt to the changed market conditions brought about by those regulations. Consumers’ willingness to pay for alternate housing depends on their ability to relocate within the affected region or else to move to new regions altogether. The response of suppliers in the housing market is dependent on the ability of producers to reallocate capital over space, as well as their expectations about future changes in economic conditions and in regulatory regimes. Policymakers attempting to measure the impacts of proposed policies must make assumptions concerning these important elements of behavior. Is the city open or closed? What is the cost of redevelopment? Can housing producers foresee changes in regulation? Or are they surprised?

More generally, the implications of household mobility, of the durability of capital, and of foresight for economic models of urban development have been emphasized by many authors, and a careful survey of these issues was provided by Brueckner (2000). In the simplest formulation, originally developed in the 1960s (e.g., Muth, 1968), capital is assumed to be malleable. Households may be mobile across cities (the “open-city” model) or within cities (the “closed-city”), and the model solves for the spatial distribution of population and housing, rents and capital intensities. A richer formulation, in which investment in housing capital is irreversible and developers have myopic expectations was developed by Anas (1978). This was extended to the case of perfect foresight (in which developers correctly anticipate the future evolution of urban
rents and agricultural rents in making current investment decisions) by Capozza and Helsley (1989).

Until quite recently, these models have not been employed to analyze the implications of land use regulation, except in the very simplest cases. In this paper, we extend the application of these models in evaluating an increasingly common form of land use restriction. We consider two crucial issues about the impact of land use regulation: who is affected by the regulations, and where are the impacts located within the region? As noted below, previous work has concentrated on the special case of a fully open city and on the case of perfectly malleable capital. We extend the analysis to consider a closed city with durable capital.

In many cases, land use regulations imposed improve the aesthetic, accessibility, or other attributes of neighborhoods, and this increases the value of the regulated land. In other cases, the benefits arising from regulations imposing density restrictions spill out into the broader community. Benefits may be regional, national, or even international in scope. For example, wetlands preservation may provide public benefits at the regional level, and residential density rules may reduce the costs of regional transportation systems. An extreme, but quantitatively important, example of the broad benefits of detailed regulation of residential densities includes those motivated by conservation and the preservation of endangered species – flora and fauna facing an imminent threat of extinction. In this case, the costs imposed by regulations preserving open space as habitat for species are borne locally, but all citizens enjoy the benefits of species preservation.¹

¹ The link between these regulations, especially those imposed by the Endangered Species Act (ESA), and housing is discussed in Zabel and Paterson (2006). See Greenstone and Gayer (2007) for a discussion of measurement and inference issues.
Prior work has analyzed the effects of regulations limiting the supply of land available for housing in a very circumscribed fashion. Until quite recently, for example, the costs of preserving land from development under the U.S. Endangered Species Act were estimated simply as the changes in the capitalized rental values of the land whose usage is affected by the regulation. (See Economic & Planning Services, 2002.) This is appropriate only under the assumption of a fully “open” local economy in which mobility is costless across regions and local housing markets. In this special case, all economic costs are reflected in the reduction in aggregate rents generated on those lands which are affected directly by the regulations. Quigley and Swoboda (2007) analyzed the impacts of ESA density restrictions in an urban economy, comparing the impacts upon the owners of regulated and unregulated land and upon consumers in the region. In this framework, the intensity of land use throughout the entire region is modified in response to regulations imposed in one part of the region. These prior results are, however, subject to a rather important limitation. The assumption of long-run equilibrium means that the density of housing and other salient features of the existing capital stock throughout the region can be modified costlessly in response to regulation affecting the use of land in one part of the region. The model is static, and capital is malleable.

In contrast, Turnbull (2005) examines the impact of prohibiting development in a true dynamic framework. He assumes landowners have choices over the timing of development and the capital intensity of development. His model of regulation is stochastic; landowners do not know which lands will be regulated, or when. This threat of

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2 In a small open economy, the well-being of local residents is exogenous, so a reduction in permitted densities will cause consumers to be reallocated among a large number of regions, having negligible impact elsewhere. Thus, changes in the welfare of local landowners caused by the policy can be measured quite simply – by the reduction in aggregate rents accruing to the landowners at the time the policy is introduced.
regulation is thus an additional cost of waiting to develop, and this pushes landowners to develop their lands sooner than otherwise. The solution to the Turnbull model of development depends crucially, however, upon assumptions about landowners’ expectations for the future course of regulation. In addition, this model is not readily adaptable to address the overall impacts of regulation on consumers and the owners of unregulated land as well as regulated land.

We adopt instead a model with durable capital and myopic land owners, an extension of a closed city model with malleable capital. Thus, the model we analyze and the conclusions we draw do not depend on specific assumptions about the formation or revision of landowners expectations. This is both an advantage and a disadvantage. It is a generalization of previous work (most specifically Anas, 1978), and thus it permits a comparison of the importance of durable capital in drawing welfare implications about regulation. Our work is silent, however, on the role of changed expectations on the behavior of landowners and their investment decisions. Thus, our perspective is more appropriate for the analysis of one-off regulations prohibiting development (say, in response to a judicial determination of the critical habitat necessary for the preservation of a species) rather than for a program of regulation introduced over time in an urban area.

The basic economic model is sketched out in Section II. We illustrate the impacts of regulation under three distinct sets of assumptions: when residents can relocate costlessly to other regions, when capital is malleable, and when capital is durable. When consumers can costlessly relocate to other regions, there are no spillover effects from regulation, and all of the costs of regulation are borne by the owners of regulated land. In
the other cases, displaced residents alter the demand for development on neighboring land and lead to spillover effects from the regulation. We analyze the impact of land use regulation in three components: the direct impacts on the owners of regulated lands, the impacts on the owners of unregulated lands, and the impacts of regulation on consumer welfare.

Our results suggest that significant economic effects of density restrictions typically occur outside of the area designated by the regulation. Incomes are redistributed across landlords, and the well-being of housing consumers is reduced through these linkages. In Section III we provide a comparison of the welfare effects of density regulations under different assumptions of consumer mobility and capital durability. Simulations with plausible economic parameters demonstrate that the economic impacts of density restrictions are larger than in the simpler and more stylized representations which have been used to analyze policy choices. The results suggest that simple models of regulatory impact greatly underestimate the social cost of the regulations. These models underestimate the costs to consumers and the substantial redistribution of wealth attributable to these rules.

Our results also reiterate the importance of measuring the spillover effects from land use regulation. When policy makers protect some lands from development, the displaced residents will have a non-marginal impact on demand for development in other parts of the region. In the case of malleable capital, when producers have the largest ability to respond to the regulation, the area of new development may often be smaller than the regulated area, leading to a reduction in the aggregate land used for development. However, in the case of durable capital, when owners of previously
developed lands are constrained in their ability to respond to the changing demand for housing, regulation may often lead to more total development in the region.

II. A Simple Model with Durable Capital

Consider a “standard” Muth-Mills model of an urban area composed of identical households who work in the central business district (CBD) and who commute to their residences, arrayed in a circle around the CBD which extends to the agricultural hinterland. (See Brueckner, 1987, for the canonical treatment.) Land is used more intensively close to the CBD, and the capital intensity of housing output declines with distance from the center. The price of housing declines along any radius from the CBD, just enough so that households who commute longer distances are compensated with lower rents and achieve a common level of well-being.

Land rents, g services, and the owners of unregulated land will be better off from the increases in land rents that result. Equation (6) indicates the change in rents across newly developed lands, where the benefits to landlords of previously developed land are about 2.7 times as large, as well.

Figure 2 compares the economic cost of the regulation when the amount of regulated land is increased at the same distance from the city center. (In these simulations the distance to the regulated land is kept at 32 miles, the depth is kept at 2.75 miles while the radians of regulated ranges from 0 to 2π.) Figure 2A presents the net economic costs of the land-use prohibition. The costs are much larger in a closed city model and they are very much larger when capital is durable. When 3π/2 radians are regulated (11.4 percent of the metropolitan area, instead of 3.9 percent), the economic costs when capital is
durable are $13.1 million per year; they are $8.8 million per year when capital is malleable. The regulations impose much higher costs on consumers when more land is regulated, and they greatly increase the rents to land owners. When \(3\pi/2\) radians of land are regulated, the costs to renters are $43.2 million per year if capital is malleable and $122.1 million per year when capital is durable. With this larger regulated area, aggregate rents to the owners of previously developed lands are much higher, $43 million when capital is malleable, and $115 million when capital is durable.

The difference in total impact between the lowest and highest costs associated with the regulation can be quite substantial. In fact, in these circumstances, the economic costs in a closed city with durable capital are roughly twice as large as the costs in an open city. This is seen more dramatically in Figure 2B. The figure shows clearly that the marginal cost of regulated land is increasing as more land is regulated. This is an important distinction between the models of regulatory impact. The inappropriate use of a partial equilibrium model will imply that the marginal costs of more extensive regulation are constant while a general equilibrium analysis correctly shows that marginal costs increase with the extent of the regulation.

[FIGURE 2 about here.]

Table 2 displays results of regulating lands in the interior of the developed region, in this case regulating \(\pi/2\) radians of land with a depth of 2.75 miles at a distance of only 24 miles from the region’s center. In the absence of regulation, these lands would be developed much more intensely than land closer to the urban-rural border. In fact, the total impact of the regulation is between six and eight times larger than that reported in
Table 1, even though less land is regulated.\textsuperscript{3} The larger total impact in Table 2 as compared to Table 1 is due to the impact upon regulated lands ($16.64$ million vs. $2.07$ million). As compared to the costs computed from an open-city model, those computed from a closed-city model with malleable capital are larger by 8-9 percent (to a total of about $18$ million). With durable capital, the economic costs of the same regulation increase by an additional 17 percent.

[TABLE 2 about here.]

Figure 3 shows the impact of regulating land more distant from the urban-rural boundary. In this figure, the radians of regulated land are constant at $\pi/2$ and the depth of regulated land is constant at 2.75 miles, but the distance of the regulated land from the city center varies from 22 to 32 miles. When lands located closer to the center of the city are regulated, the total impact is larger even though the total regulated area decreases. In Figure 3A, the differences among the three models are less distinct, although the durable capital model still indicates that costs are more than twenty percent higher than under the partial equilibrium framework. The location of the regulated lands within the city is crucial in determining the aggregate effects of the regulation, whether the city is open or closed, or whether capital is malleable or durable. Figure 3B reports the intensity of the impact of regulating land at different locations within the region. It again shows that while there are differences among the models, the location of the regulated lands is crucial.

However, the economic effect of the regulation becomes substantially larger when capital is more durable. Durable capital generally results in twice the amount of new

\textsuperscript{3} $\pi/2$ radians and a depth of 2.75 miles represents 110 square miles at a distance of 24 miles from the city center and 144 miles at a distance of 32 miles.
development as malleable capital. Indeed, when the regulated lands are located approximately halfway between the city center and the urban-rural boundary, more land is newly developed than is preserved from development by the regulation. These results suggest that regulators should be cognizant of the effect of these types of regulation on aggregate land use – including land used for non-urban purposes.

[FIGURE 3 about here.]

Table 3 compares the quantity of land regulated with the quantity of land newly developed as a consequence of the regulation. To what degree does restricting development in one area simply push development somewhere else? This effect varies considerably depending on the durability of capital. When capital is malleable, the area of new land development ranges from between 12 and almost 50 percent of the regulated area. However, with durable capital the area of newly developed land is often two-to-three times as large. In some of the simulations the area of new development is actually larger than the regulated area, meaning that open-space preservation may lead to overall increases in the total area of development and less open space.

[TABLE 3 about here.]

III. Conclusion

Recently, a great deal of attention has been paid to the efficiency of land-use regulation and to the distributional implications of land-use prohibitions. For example, Glaeser, Gyourko, and Saks (2005) compared construction costs and selling prices for housing to measure the impact of density rules on the New York housing market. Malpezzi and Green (1996) used metropolitan measures of regulatory stringency to document the link between regulation and high rents paid by poor households. Quigley
and Raphael (2005) showed that the rents and prices of owner-occupied housing are much higher in jurisdictions in California which restrict housing development.

The simulation results presented here document the importance of local land-use restrictions in affecting house prices and rents on lands far removed from the site of the regulation. We compare the impacts of land use regulation that prohibits residential construction under a variety of assumptions about the ability of consumers and producers to react to the regulation. In the open city, displaced residents move to another region without loss of welfare. As a result, the only welfare impacts from the regulation are losses in land rents to the owners of regulated lands. Costless mobility from one region to another certainly represents an extreme assumption; whenever this assumption is violated, this approach will underestimate the total economic impact of the regulation, and it will ignore potentially large wealth transfers from residents to landowners.

In contrast, the closed city with durable capital lies at the other extreme. The economic impacts are highest under these circumstances because residents are unable to leave the region, and landowners cannot change the capital intensity on previously developed lands. Of course, neither of these two extremes is likely to be correct, and the truth lies somewhere between. Some displaced residents will likely live in other parts of the region while others will move elsewhere. Although neither of the models conform strictly to reality, this comparison clearly indicates the important influence of capital durability on the welfare of urban renters. These results also suggest that empirical research should explore more carefully the distinction between “open” and “closed” regions and the importance of the durability of real capital.
Finally, the large transfers from renters to land owners reported in these simulations may be suggestive of the political motive for restrictive regulation by local home owners. These restrictions on housing supply may be more palatable when they are presented in terms of conservation or the protection of species and the environment. Future research should explore how the impacts of these regulations vary across owner-occupied communities.

Appendix: Solving the Model

This appendix presents the basic model which underlies the welfare comparisons in the text. It extends and generalizes the model presented by Quigley and Swoboda (2007) for a special case of land use regulation.

Consider a geographic region with N identical consumers of income $y$, whose well-being depends on their consumption of housing, $q$, at price, $p$, and a numeraire good, $c$. At any location, $x$, measured as the distance to the central place of employment, residents must pay commuting costs $t(x)$. For convenience, we assume transportation costs are linear, $tx$.

Each consumer acts to maximize a well-behaved utility function

(A1) \[ U(c, q) = U(y - p(x)q(x) - tx, q(x)) \]

Consumers choose a location and quantity of housing to consume at price $p(x)$. These two choices determine the total commute costs, and also the residual income to be spent on the numeraire good. In equilibrium, the marginal rate of substitution between housing and the numeraire good must equal the ratio of their prices,

(A2) \[ \frac{U_2(y - p(x)q(x) - tx, q(x))}{U_1(y - p(x)q(x) - tx, q(x))} = p(x), \]
where subscripts refer to partial derivatives. Since all consumers are assumed to be identical, they enjoy a common level of utility, $\bar{u}$.

\[ U\left(y - p(x)q(x) - tx, q(x)\right) = \bar{u} \]

Consumers enjoy the same utility level regardless of where they locate within the region. Consequently, the price and quantity of housing consumed must vary systematically by location. The schedules of prices and quantities at all locations are determined by the solution to equations (A2) and (A3).

Now consider production and the supply of housing at all locations. We assume that developers are price-takers in the markets for land and capital, and that the cost of capital is constant throughout the region; the price of land varies endogenously. Let $K(x)$ represent the amount of capital and $L(x)$ represent the amount of land used in the production of housing at location $x$. Assume a housing production function, $H(K,L)$, characterized by constant returns to scale and concavity in input substitution. With a production technology exhibiting constant returns to scale, each producer chooses only the capital intensity, $s(x) = \frac{K(x)}{L(x)}$.

\[ H(K,L) = L \cdot H(K/L,1) = L \cdot h(s(x)) \]

Profit $\pi$ at any location can be written as

\[ \pi = p(x)Lh(s[x]) - is(x)L - r(x)L = L[p(x)h(s[x]) - is(x) - r(x)] \]

where $i$ is the price of capital and $r(x)$ the price of land at location $x$. In equilibrium, the marginal revenue product is equal to the marginal cost of each input, and competitive producers will earn zero profits. Equation (A6) determines the capital-to-land intensity for profit maximizing producers while equation (A7) represents the zero-profit condition for the competitive producers. These two equations fully characterize the production side.
of the model. The capital intensity of housing and the price of land vary systematically by location within the region.

\[(A6)\quad p(x)h'(s[x]) = i\]

\[(A7)\quad p(x)h(s[x]) - ts(x) = r(x)\]

The region must also achieve an economic equilibrium in two other senses. First, land must be successfully bid away from its alternative use. Let \(r_a\) represent the opportunity cost of land, and \(\pi\) be the distance to the border of the economically productive region. Then the rent for land devoted to housing at the border must equal the rent in its highest alternative use,

\[(A8)\quad r(\bar{x}, \bar{u}) = r_a.\]

The equation specifies that all land devoted to housing is successfully bid away from the alternate use.

Secondly, the supply of housing must equal the demand for housing within the region as a whole. Without loss of generality, assume that each household contains one individual, and recall that \(h(s(x, \bar{u}))\) is the quantity of housing produced at location \(x\), while \(q(x, \bar{u})\) is the quantity of housing demanded by the representative consumer at any location. Then, \(2\pi x dx \cdot h(s(x))/q(x)\) is the density of households at distance \(x\), and integration over the entire region, a circle of radius \(\bar{x}\), yields the population of the region, \(N\),

\[(A9)\quad \int_0^{\bar{x}} 2\pi x \frac{h(s(x, \bar{u}))}{q(x, \bar{u})} dx = N.\]
The system of equations in (A8) and (A9) can be solved by rearranging (A8) to solve for utility level as a function of the equilibrium distance to the urban-rural boundary and the model parameters, $\Gamma$,

\[(A10) \quad u(\bar{x}; \Gamma) = \bar{u}.\]

Equation (A10) can then be substituted into (A9) and solved for the equilibrium distance to the urban-rural boundary.

The economy is fully characterized by six equations, two equations representing consumer choice, subject to the constraint that all consumers must have the same utility, two equations representing housing production, subject to the constraint that all producers earn identical normal profits. The equilibrium values for $\bar{x}$ and $\bar{u}$ yield the spatial pattern of housing prices, land rents, capital intensity of housing, and housing density. The $N$ residents of the region all obtain constant utility of $\bar{u}$. Housing prices decline with distance from the center. Land prices decline more steeply than housing prices. Population density decreases with distance from the center.

For the functional forms assumed in the text, Cobb-Douglas preferences and production functions, it is straightforward (but somewhat tedious) to derive the closed form relationships to be substituted into equations (A1) through (A10).
References


### Table 1: Annual impact of prohibiting development near the urban-rural boundary*

(Thousands of dollars)

<table>
<thead>
<tr>
<th>costs imposed on</th>
<th>Open City</th>
<th>Closed City</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>malleable</td>
<td>durable</td>
</tr>
<tr>
<td>owners of regulated land</td>
<td>-$2,065</td>
<td>-$2,065</td>
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<tr>
<td>owners of newly-developed land</td>
<td>0</td>
<td>+6</td>
</tr>
<tr>
<td>owners of previously-developed land</td>
<td>0</td>
<td>+14,394</td>
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<td>resident renters</td>
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<tr>
<td><strong>Total</strong></td>
<td>-$2,065</td>
<td>-$2,838</td>
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*prohibition of building on $\pi/2$ radians of land with a depth of 2.75 miles located 32 miles from metropolitan center: ~4% of metropolitan area.

### Table 2: Annual economic impacts of prohibiting development on interior lands *

(Thousands of dollars)

<table>
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<tr>
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<tr>
<td>owners of regulated land</td>
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<tr>
<td>owners of newly-developed land</td>
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<tr>
<td><strong>Total</strong></td>
<td>-$16,637</td>
<td>-$18,059</td>
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</table>

*prohibition of building on $\pi/2$ radians of land with a depth of 2.75 miles located 24 miles from metropolitan center, ~2% of the metropolitan area.
Table 3: Comparing the Quantity of New Land Development*

<table>
<thead>
<tr>
<th>Distance to Regulated Lands (miles)</th>
<th>Extent of Prohibited Development (mi²)</th>
<th>Extent of New Development (mi²)</th>
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<th>Closed City</th>
</tr>
</thead>
<tbody>
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<td>40</td>
<td>108</td>
</tr>
</tbody>
</table>

*prohibition of building on π/2 radians of land with a depth of 2.75 miles located at varying distances from the metropolitan center.
Figures

Figure 1: Geography of Regulated Land

Regulated Land

Radians of Regulated Land

City Center

Distance to Regulated Land

Depth of Regulated Land
Figure 2: Annual Economic Cost of Prohibiting Housing Development When the Extent of the Prohibition is Increased

Figure 2.A: Total Costs

Figure 2.B: Cost per unit of Regulated Land
Regulated land is computed by varying the radians covered by the prohibition on building, at a distance of 32 miles to the CBD and a depth of 2.75 miles.

Figure 3: Annual Economic Cost of Prohibiting Housing Development at Various Distances from the City Center

Figure 3.A: Total Costs
Regulated land is computed as $\pi/2$ radians with a depth of 2.75 miles at various distances to the CBD.