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The Investment Incentive Effects of Land Use Regulations

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Abstract

This paper provides an overview and synthesis of the results from recent studies of how different types of land use regulations affect land development incentives. The presentation is nontechnical and focuses on uncovering general principles for the dynamic effects of such policies. It explains why the risk of regulation leads to faster development of unregulated land and how the effect on structural densities reflects the underlying pattern of growth in the demand for land by competing uses. It also discusses how the general pattern of timing and density responses for regulated property reflect the same growth patterns in demand.

Key Words: land development, land use regulation, regulatory risk, takings

1. Introduction

Recent research on land use restrictions emphasizes the role of regulation adopted over time in the urban development process. The intertemporal perspective of this work reveals how regulation alters the pace and pattern of land development across the urban area, with varying effects on both regulated and unregulated property reflecting the pattern of growth or decline in the underlying demands for land by competing land uses. The results are novel in that they fundamentally differ from the implications of static analyses, yet this survey reveals that they are surprisingly robust across the different types of land use regulations studied. This paper summarizes and discusses the results of a series of recent papers studying development prohibition, development moratoria, restrictions on allowed use, and development fees.[1] It provides a self-contained discussion of key results and relationships that is geared to the nontechnical specialist, especially to individuals with a policy perspective.

One goal of this survey is to stimulate further research on the issues surrounding the design and evaluation of regulation in a dynamic context, including new effort to derive robust dynamic efficiency rules. Another goal is to stimulate interest in making the dynamic land development literature more accessible to an audience that needs to incorporate dynamic insights into their world-view: economists and planners with policy interests and those who teach them.

The underlying theme of this paper is that policy design and evaluation requires a firm grounding in how urban capital and real estate markets respond to different types of land use and tax policies. The longevity of capital improvements to land and the relatively high costs required to modify structures and infrastructure once put into place means that market participants choose from alternative projects whose net returns extend into the indefinite future. The key to understanding capital and real property markets is to recognize their inherently dynamic nature. Because urban real estate plays a central role in urban economies, it is perhaps not surprising that dynamic or intertemporal analysis has become a widely used tool in modern urban economics.[2] But the dynamic perspective needs to attain greater prominence in the modern planning and policy tool kit as well. Therefore, one task for this paper is to illustrate how the dynamic or intertemporal view of the urban development process leads to insights that are not evident in the traditional static approach.

This discussion addresses two related issues in land use regulations. The first issue concerns what we know about how the threat of regulation affects the pace and pattern of urban development when urban development is irreversible. The second issue concerns how constitutional and legal constraints on policy makers can alter the intended effects of land use controls. The starting point of this line of literature recognizes that the market response to regulation as actually implemented may differ considerably from the ultimate policy goal.

Nonetheless, there is one lesson that keeps popping up in the recent literature that can be troubling when designing land use policies. Specifically, introducing dynamic considerations moves such policy design into the world of (at best) second best, since a single policy rule is not likely to be efficient across space and time. The adverse possession literature provides an explicit example. Baker et al. (2001) derive the efficient period for adverse possession, that is, the efficient rule defining how long it should take for an individual to acquire property by squatting or adverse possession. That paper shows that land on the fringe of a growing urban area will have a different efficient time period for adverse possession than will land deep in the agricultural hinterland. And even more troubling for advocates of efficient policy design, Miceli et al. (2003) use a monocentric model of a growing urban area to show that the optimal adverse possession rule varies with distance from the central business district. Given the practical restriction that property rights be defined uniformly within jurisdictions, these papers illustrate that it is likely that the first-best adverse possession rule simply cannot be implemented.

Although the issue of second-best welfare analysis has not been fully addressed yet in the dynamic land regulation literature, the results of the two adverse possession studies are suggestive. It appears reasonable to expect that a similar type of spatial variation will permeate the design of dynamically efficient land use policy. The dynamic perspective will likely consign land use regulation to the world of second best when it is not feasible to sculpt regulations to individual parcels of land in the same jurisdiction.

This paper focuses on recent work with a common theme: how does viewing land development as a dynamic process lead to different regulatory consequences? There is an established literature concerned with tax effects on land development, some of which uses the same general framework underlying the regulation models explained here.[3] Aside from acknowledging this cross-pollination up front, though, this paper focuses more narrowly on dynamic issues surrounding land use regulation.

This discussion is concerned with the effects of regulation on investment incentives in a dynamic context. The line between the concepts of eminent domain and regulation is somewhat blurred, however, so some comments on eminent domain are in order at this point. When exercising eminent domain, governments take the entire value of an asset out of the hands of its owner. While the owner does not lose title to his asset under regulation, regulation is similar to a "partial taking" in that it eliminates some, but not all, asset value from the owner's control. Yet, eminent domain and regulation are worlds apart in terms of constitutional protection. While the Fifth Amendment of the US Constitution obligates governments to compensate owners for the value of real estate taken by eminent domain, it does not impose a similar duty on governments that effectively take only part of asset values by regulation.

Given the similarities between eminent domain and regulation, it is not surprising that some of the eminent domain literature is properly viewed as antecedent to the regulation issues examined here. While Blume et al. (1984), Fischel and Shapiro (1988), and Miceli (1991) do not adopt an explicitly dynamic perspective, they do concentrate on how the threat of eminent domain distorts investment incentives. Their focus is on how structural density decisions are distorted by compensation rules given that investors cannot know future government eminent domain decisions with certainty. Innes (1997) sets aside structural density concerns to focus on the investment timing question. Like the previous papers, Innes pays close attention to the normative consequences of compensation rules. The positive analysis, however, is interesting in light of the regulation results examined below. In particular, Innes finds that full compensation to owners renders the market impervious to the threat of taking by eminent domain.[4]

The dynamic land use regulation literature considers neither compensation (since none is constitutionally required) nor the risk of losing property through eminent domain (Geltner et al. 1996; Riddiough, 1997; Titman, 1985; Turnbull, 1991, 2002, 2004a). Instead, these papers study how the risk of different types of land use regulation can affect planned investment timing when the government is free to exercise regulatory takings. Titman (1985) and Turnbull (1991) consider density restrictions that are certain, but imposed in an explicitly dynamic setting. Both find deviations from the static certainty perspective. Other papers follow the lead of the eminent domain literature mentioned earlier, envisioning regulation as a stochastic process. Riddiough (1997) applies a financial options simulation model to calculate how threatening to prohibit or delay development alters asset values and investment timing incentives. Turnbull (2002, 2004a) introduce the interplay among capital density and investment timing incentives, focusing on density restrictions like zoning and development moratoria.

The discussion is organized as follows. Section 2 offers a rationale for dynamic analysis in land use issues, and lays out a simplified version of a standard framework used to explain many of the subsequent results. Section 3 discusses the relationship between regulation and property rights in the US. Section 4 examines the effects of development prohibitions while Section 5 looks at development moratoria. Section 6 discusses the effects of restrictions on allowed density, like zoning, when such restrictions are known with certainty, but the demand for land may be certain or uncertain. Section 7 turns to the issue of uncertain restrictions on allowed density.

Section 8 relates the effects of regulatory risk discussed in the previous sections to the issue of ownership risk in general. Since development fees are increasingly popular tools that are often justified as a way to promote efficient development, they are addressed in this paper in Section 9. A summary and conclusions appear in Section 10.

2. A simple model of land development

The increasing role of dynamic analysis in urban economics is motivated in part by the fact that urban growth and economic development are inherently dynamic processes. Urban areas exhibit continuous change: population or employment are growing (or declining), interior sites are being abandoned or redeveloped for different uses, existing structures and infrastructure are constantly aging, and the fringe of the urban area is expanding. The static view of the urban economy explains these changes as disequilibrium adjustment to shifting demands and supplies. In contrast, the dynamic view envisions the constantly changing urban area as the equilibrium outcome, a time path of population or employment and land use patterns. Although static analysis does lead to insights that serve as an important starting point, deeper understanding of the process of urban growth or decline requires the dynamic or intertemporal perspective.

The economic arguments traditionally used to justify land use controls and regulations are static in nature; they do not incorporate the intertemporal adjustments that market participants make in response to policy proposals. Recent research in this area exploits the dynamic perspective emphasizing what, where, and particularly when land development occurs. This research provides a basis for beginning to understand the rationale for and effects of land use regulation in a continually changing metropolitan economy.

A useful consequence of viewing economic growth as a continuing dynamic process is that it draws attention to political forces underlying the demand for land use regulation quite apart from mitigating market failure. Successful urban development itself creates interest group pressure for curtailing further growth. As the metropolitan economy grows over time, the population grows, largely through in-migration to the metropolitan area, which creates incentives for residents of jurisdictions to use the regulatory power of their governments to gain at the expense of others by "closing the door" behind themselves after they have settled an area. Thriving urban areas are growing urban areas. The relatively greater opportunities and higher standards of living pull in population from elsewhere. There is nonetheless an incentive by those who have already reside in the thriving urban area to thwart this population growth to maintain the higher standard of living that is the source of attraction for immigration into the metropolitan area. Individuals find it appealing to use their first-mover advantage, relying on the machinery of their local governments to preserve the ambiance of their residential enclaves with surrounding green spaces or prevent aesthetically unappealing commercial development—in a way that shifts the cost of such regulation onto other parties. As explained below, some of the concerns of existing residents truly reflect market failures. Other arguments for growth control policies, however, fall into the realm of rent-seeking, using the public sector to garner benefits while the cost is borne by others.

One factor that is typically under-appreciated by policy makers is the future signalling effect of current policy decisions; a policy enacted today for a particular situation affects investors' expectations of future policies. Even though the current policy, say a prohibition of development for a particular parcel of land, may be in response to a very specific problem, the fact that the policy maker has obtained the power to enact such a prohibition makes it impossible for the policy maker to credibly commit to not imposing a similar prohibition on some other property in the future—even if the policy maker truly believes (at the time) that such a policy will never be enacted again. As a result, active involvement in the development process injects another source of uncertainty into the mix already facing private investors: regulatory risk. This regulatory risk is the point of departure for some of the land policy research discussed below.

It is convenient at this point to present a simple model that will be useful for illustrating how regulation affects investment incentives. This is a partial equilibrium framework that focuses on the decisions to develop a particular parcel of land. Development, once undertaken, is irreversible. Of course, different tracts of land are going to have different development options because they have different locations within the same urban land market (Fujita, 1982; Wheaton, 1982; Turnbull, 1988a, b). Nonetheless, the model used throughout most of this paper has the virtue of simplicity without losing its ability to explain the basic economic relationships that drive the conclusions in the more general models.

The notation is defined as follows:

S = structural density on the unit of land once developed (buildings and improvements per unit of land);
$R(S, t)$ = land rent during time period t for the plot of land developed with structural density S;
$C(S)$ = cost of developing the land with structural density S;
T = time period during which the plot of land is developed;
w = land rent during period t for the plot of land when undeveloped; and
r = discount rate.

The land rent function $R(S, t)$ represents the upper envelope of bid rents of potentially competing land users at t. The rent for developed land is assumed to be increasing concave in structural density ($R_S > 0$, $R_{SS} < 0$). The net rent to developed land is assumed to be increasing over time ($R_t > 0$), reflecting an underlying trend growth in the export sector of the urban area economy relative to the nonurban sector. Also, the cost of developing the land rises with greater structural density ($C' > 0$, $C'' \geq 0$).

The present value of returns to the unit plot of land (at a particular location in the urban area) is the sum of land rent while in the undeveloped state and the land rent once developed with structural density S, less the cost of developing the parcel, or

$$V(S,T) = \int_0^T we^{-rt}dt + \int_T^\infty R(S,t)e^{-rt}dt - C(S)e^{-rT} \qquad (1)$$

The investor maximizes V with respect to S and T, which yields the structural density condition

$$\int_T^{\infty} R_S(S,t)e^{r(T-t)}dt = C'(S) \tag{2}$$

and the timing condition

$$rC(S) + w = R(S,T) \tag{3}$$

The density condition requires that the present value of incremental rent from greater density equals the additional development cost. The timing condition requires that the developer wait until the annualized cost of development, rC, plus the opportunity cost of the land, w, equals the land rent from developing the land, R.

It is useful to note at this point that the above formulation includes Anderson's (1986) model in which structural density is implicit. The connection between the Fujita-Wheaton-Turnbull (FWT) type models with explicit structural density and Anderson's framework can be seen by solving the optimal density condition (2) for density as an implicit function of development time, $S(T)$, then substituting into the objective function (1) to obtain $\tilde{V}(T) = V(S(T), T)$. Denote $f(T, t) = R(S(T), t)$ and $\tilde{C}(T) = C(S(T))$ to obtain an analog to Anderson's objective function:

$$\tilde{V}(T) = \int_0^T we^{-rt}dt + \int_T^{\infty} f(T,t)e^{-rt}dt - \tilde{C}(T)e^{-rT} \tag{4}$$

from which the optimal development timing follows

$$r\tilde{C}(T) + w = f(T,T) \tag{5}$$

which is readily recognized as parallel to (3).[5]

Although we could proceed directly from the optimality conditions (2) and (3) or (5), it turns out that using a hybrid of both FWT's and Anderson's approaches is a more convenient way to illustrate the investor's optimal timing-density choice that will allow us to more readily address the land regulation issues considered later.

For the single tract of land under examination, when the competing demands for alternative uses are changing over time such that the current best use has a lower structural density than a future best use, then $R_{St} > 0$ in terms of the model above and the "demanded density" is said to be rising over time (Wheaton, 1982; Turnbull, 1988b). This is pictured as the *dd* curve in the lower panel of Figure 1. As the development time is postponed, the best use for that time entails greater structural density, hence the curve depicting development time and the best use at that time is upward sloped. On the other hand, when the underlying demand conditions yield a current best use that has a higher structural density than a future best use, then $R_{St} < 0$ in the above model and the demanded density is said to be falling over time. This case is pictured as the *dd* curve in

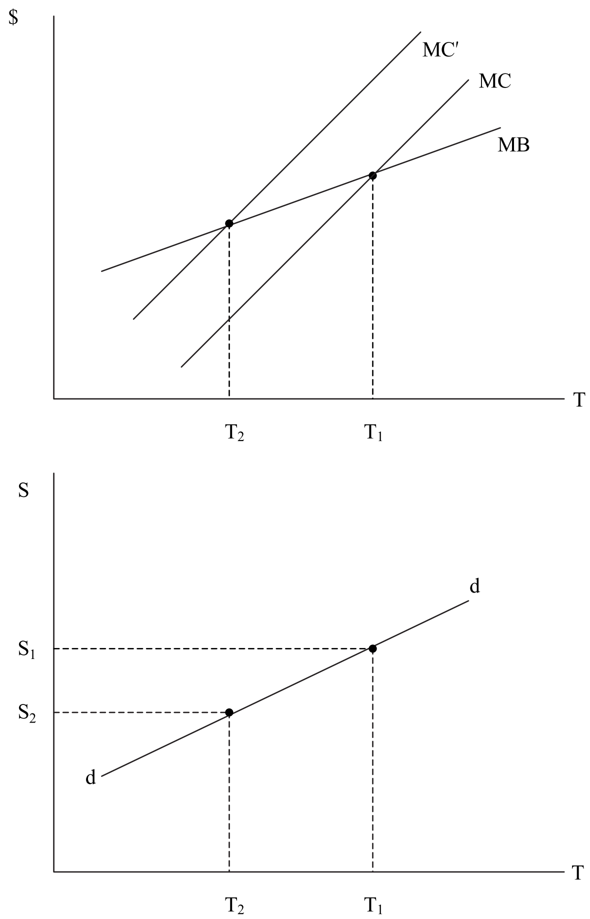

Figure 1. Effect of development prohibition threat on planned timing and density when demanded density is rising over time.

the lower panel of Figure 2. Projects developed later entail a lower structural density in this case.[6]

Regardless of the underlying source of the slope of the *dd* curve, the resultant relationship between development timing and the best type of project to pursue does not answer the question of the best time to develop the land. The upper panels in Figures 1 and 2 portray the timing condition (5). For an undeveloped parcel of land, the decision of when to develop is essentially one of deciding how long to wait before investing in the capital improvements that will make the real estate most marketable. By postponing the development process, the investor saves the (annualized) cost of capital for the structures and other improvements that would be put into place when the land is developed. In addition, the land might earn income as agricultural, forestry, or recreational property,

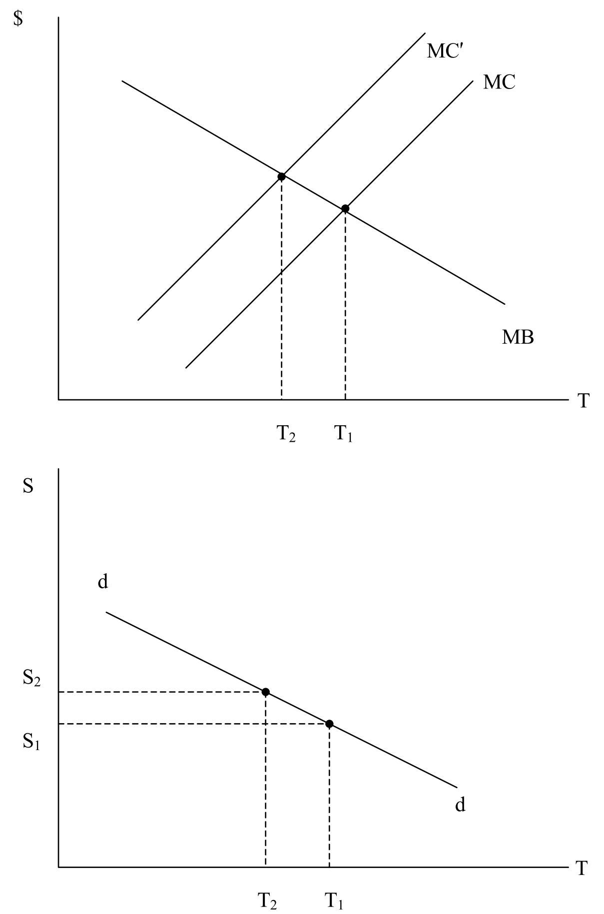

Figure 2. Effect of development prohibition threat on planned timing and density when demanded density is falling over time.

but can be fallow just as well. This cost savings (plus any agricultural earnings) is the marginal benefit of waiting, the left hand side term of (5), which is depicted by the *MB* curve in the figures.[7] At the same time, any postponement of the development time beyond a given year means that the investor forgoes what the land would have earned as developed property during the year. These forgone earnings represent the marginal cost of waiting, the right hand side of (5), which is reflected in the *MC* curve in Figures 1 and 2. Since the demand for urban land is growing over time, this (annualized) return is rising over time and the *MC* curves are upward sloped in general.

The most profitable time to develop is when the marginal benefit and marginal cost of waiting are equal; the investor's planned development time is T_1 in Figures 1 and 2. Reading from the bottom panels, the planned structural density is S_1.

3. Regulation and property rights

The problem confronting land owners and developers is that, regardless of its justification from the perspective of broader community welfare, land use regulations restrict the exercise of private property rights. The benefits of such regulation accrue to residents of the jurisdiction. The costs of regulation, on the other hand, fall on the property owner in the form of diminished value. Of course, in some cases this can be justified as elimating a property value premium that arose only because the property owner was free to impose costs on others. Nonetheless, the consequence of the regulation is typically evident in the form of diminished property value.

3.1. Land use regulation and takings

When a particular land use regulation substantially reduces the value of the affected property, even though the owner retains title to the asset, the regulation is equivalent to a discriminatory tax or exaction. Discriminatory taxes, however, violate the principle of horizontal equity in taxation. Thus, even narrowly applied land use regulations for specific goals can lead to capricious reallocations of wealth among individuals and need to be implemented with due attention to this feature. For two families of equal economic circumstances at the outset, the one with the greater share of its wealth in undeveloped land is taxed more heavily by land use regulation than is the other; wealth is reallocated from the landowning family to the residents of the jurisdiction who benefit directly from the new land use regulation.

Another aspect of land use regulation also takes a prominent position in the recent literature. Because land use regulation alters investment incentives for both regulated and for *unregulated* property, the unintended consequence of a regulation that is intended to improve social well-being may be to reduce it.

The importance of the tie between regulation and property values has been recognized for a long time but has taken on a larger role in recent policy debates over the tension between regulation and property rights. The Fifth Amendment of the U.S. Constitution prohibits the taking of property by a government without just compensation to the owners, but it does not cast a clear and absolute prohibition on regulation that reduces property values. The Supreme Court recognizes that governments must sometimes restrict the property rights of one group of individuals in order to protect the property rights of others or for enhancing the general welfare. In the landmark case *Pennsylvania Coal v. Mahon*, however, Justice Holmes also argued that there is a point after which the property owner must be compensated for the loss of value arising from the regulation. One problem with this decision is that it establishes neither a numerical standard nor an easily interpreted conceptual measure for the loss that property owners must bear before the burden constitutes a taking and requires compensation.

Recent important Supreme Court cases have honed economists' interest in regulatory real estate takings. In *Nollan v. California Coastal Commission* and *Dolan v. City of Tigard*, the local governments required that the property owners "contribute" some of their land to an alternative specified use in order to obtain permission to build on their remaining land. Both decisions refine the police power criteria for regulation. In *Dolan* the Court decided that the cost borne by the owners passed the takings threshold in that it placed an excessive burden on the property owners that exceeded the cost to correct the identified nuisance arising from changes in the drainage pattern. In *Nollan* the cost borne by the owners passed the takings threshold in that the regulatory remedy and the identified nuisance lacked substantial nexus. Relatedly, in *Lucas v. South Carolina Coastal Council* the U.S. Supreme Court sent the case back to the lower court, effectively inviting the Coastal Council to justify the regulation as police power in light of the dimunition of value suffered by the property owner. The parties to that suit settled, eliminating an opportunity for the Court to further clarify the point. Nonetheless, the Supreme Court used all three of these cases as opportunities to suggest a broader view of police power than the narrowly construed notion of regulating nuisances.

It is still uncertain where the dividing line lies between a constitutional exercise of police power and an unconstitutional taking. After all, many land use regulations are rationalized as attempts to govern nuisances and correct externalities that give rise to market failure, which justifies them as police power rather than takings in light of the Court's comments in *Nollan*, *Dolan*, and *Lucas*. The threat of uncompensated or under-compensated lost property value remains a relevant concern for U.S. investors in developable urban land. Investors recognize these risks, so the threat of land use regulation affects the market pace and pattern of land development. The question is: precisely how are investment incentives altered?

Before turning to that question, it is interesting to note at this point that even if local governments are strictly enjoined from engaging in regulatory taking, owners still can expect to confront uncertainty about land use regulations. For example, suppose that, in order to avoid being labeled an unconstitutional taking, a particular land use regulation must be justifiable as legitimate police power. Following the definition above, for a regulation to be considered an exercise of police power requires that it be imposed to counter a specific market failure that harms the welfare of individuals in the community. The existence of likely market failures, however, will only become evident with the passage of time. Thus, we have the situation envisioned in the earlier eminent domain literature: investors can never be certain when their land will be taken because the value of alternative social uses is often revealed only after the passage of time (Miceli, 1991; Innes, 1997). A similar view pertains to the regulatory environment envisioned here. As a consequence, the owner of a currently unregulated parcel of land cannot be sure if or when a legitimate excuse will arise in the future, which would mean that the local government could then impose the regulation without violating the prohibition on uncompensated taking. Thus, the requirement that all local land use regulations be justified as police power does not resolve investors' uncertainty over the future status of currently unregulated property.

3.2. Threat of regulation

The impact of land use regulations goes beyond the effect on asset value. The *threat* of regulation, whether or not the taking actually occurs, introduces uncertainty into property rights, and as a consequence, alters investment incentives. As a broad principle, uncertainty in property rights—regardless of its source—affects economic development in general and the process of urbanization in particular (e.g., Alchian and Demsetz, 1973; Besley, 1995; Demsetz, 1967; Feder et al. 1988; North and Thomas, 1973; Rosenberg and Birdzell, 1986; Torstensson, 1994; Miceli et al. 2000, 2003; and Bohn and Deacon, 2000). Poorly defined or uncertain property rights affect the overall level of investment through several channels. Alchian and Demsetz (1973) and Demsetz (1967) argue that the threat of expropriation tends to reduce investment, thereby slowing the pace of economic growth. This is because investors are reluctant to put their capital into projects whose returns might be appropriated in the indefinite future; as a result investors have shorter time horizons, favoring projects with rapid payouts over longer term commitments. Feder et al. (1988) emphasize that poorly defined or uncertain property rights make it difficult to use real estate as collateral, increasing the difficulty of obtaining debt financing to pursue the long term capital commitments needed for structures and other improvements to property. This reduction in liquidity hampers capital accumulation in the economy, thereby slowing economic growth.

The property rights uncertainty that is introduced through land use regulation by local and regional governments, however, has its primary effects on investment through different channels than envisioned by Alchian and Demsetz (1973) or Feder et al. (1988). Since land use regulations typically restrict the quantity and type of capital improvements that can be applied to specific parcels of land, they are clearly not the same as outright expropriation of private land and capital by governments. Land use regulations also need not affect the liquidity of the real estate in question, although they can reduce the market value of the regulated (and, as argued here, even the unregulated) real estate. Nonetheless, the economic consequences of land use regulation has two levels. At one level, the regulation places direct restrictions on investment decisions, limiting the range of options open to property owners and thereby narrowing property rights. At a deeper level, though, even when not imposed, the threat of regulation itself alters private property rights by restricting landowners' perceived options. That is, the mere threat of regulation affects investment incentives. This is the main focus of recent land use regulation research: precisely how this perceived threat affects development incentives.

Riddiough (1997) and Turnbull (2002, 2004a) examine how the modified private property rights under threatened regulation affect the timing and density of development in an urban land market. The consequences of distorting urban land development incentives should not be taken lightly. Given the large commitment of resources that such development requires and the irreversibility of such investment, inefficient resource allocation decisions at the initial development stage can have long lasting effects. The imprint of past decisions are observed on the face of today's urban areas; investment distortions, from whatever source, can be significant because their consequences extend long into the future.

Turning briefly to the underlying methodology issue, the dynamic approach to modeling land development is essential to these papers for several reasons. First, it turns out that static model predictions generally do not extend to the dynamic case when development is irreversible, whether regulation is certain or uncertain. This has been illustrated by Titman (1985), Geltner et al. (1996), and Turnbull (1991), who present dynamic analyses of land markets in which land use regulations are imposed in a way that all investors know with certainty their form and function.

The discussion below does briefly address these papers, given their role as a starting point for motivating the subsequent focus on the uncertain nature of land use regulation—at least from the investors' perspective. This view emphasizes that the threat of regulation is an important factor. The threat creates incentives for investors to attempt to reduce the risk of exposing their land and capital investments to regulation, leading to distortions in the pace and pattern of planned investment. The research discussed in the following sections also shows that these distortions generally differ from the effects of regulation under certainty.

4. Prohibiting development

This section considers the case where a regulatory taking is in the form of development prohibition, drawing primarily from relevant parts of Turnbull (2002). The regulatory restrictions in the cases *Nollan v. California Coastal Commission*, *Dolan v. City of Tigard*, and *Lucas v. South Carolina Coastal Council*, mentioned above, are examples of the type of development prohibition examined here. In a different vein, Environmental Protection Agency (EPA) policies regarding the development of wetlands and watershed land fall within this case as well. While the EPA prohibits developing wetlands, permission or waivers can be obtained. Whether or not an owner can obtain a waiver, however, is not something that is known with certainty until after the application is made. And the application is not going to be made until the demand for a particular type of developed land has sufficiently matured in the market to make such development feasible. Thus, prior to initiating the development process, it remains uncertain whether or not the development will be prohibited; the regulation in effect remains only a threat of prohibition until actually implemented.

Similarly, the endangered species act (ESA) provides another example of this type of regulation. An owner of undeveloped land may have evidence that the property is the habitat of a protected species. The absence of such evidence, however, does not establish that the property is *not* a habitat of some protected species. In this case maybe a more stringent search would reveal such evidence. Perhaps the fortuitous discovery of a novel butterfly by a naturalist trespasser on the property will provide the evidence needed in invoke the ESA development restrictions. Or, it may be that a species known to be living on the land in question that is currently not protected may be designated as protected at some future date. In any event, ESA creates a degree of uncertainty over possible development restrictions that might arise in the indefinite future.

In order to assess the impact of the threat of development prohibition on the property, first note that the developer retains unfettered ownership until (and if) the government imposes the regulatory restriction at a particular point in time. Whether or not such a restriction will be imposed on the property by the regulatory body is only probable, though, and the point in time at which it might be imposed (if ever) is not known with certainty by the investor. Recall that this view of land use regulation as stochastic or uncertain recognizes the constraints imposed upon state and local governments in the U.S., since they cannot impose restrictions on a particular parcel of land until they can assert with some degree of confidence (in the face of an otherwise likely legal challenge) that such regulation can be justified as contributing to the common welfare.

In all cases considered here, the government does not take outright possession of the land. The government does, however, reduce land value by restricting the range of allowed development. Of course, this type of restriction is only meaningful for undeveloped land. Once a particular tract of land is developed, the irreversibility of land improvements erases any remaining threat of this kind of regulation for the tract.

The regulatory environment envisioned here can be represented by a stochastic survival model, with $p(t)$ the probability of the regulation not having been imposed by time t, where the probability of vacant land continuing to avoid regulation decreases over time, or $\dot{p} < 0$. The expected present value of returns to the unit plot of land is now

$$V(S,T) = \frac{w}{r} + p(T)\int_T^{\infty} [R(S,t) - w]e^{-rt}dt - p(T)C(S)e^{-rT} \tag{6}$$

The landowner is assured the present value of nonurban rents, w/r, the first right hand side term above, regardless of whether or not the development is ever prohibited on this plot of land. The only question is whether or not the owner is going to be allowed to garner the excess of rents from the developed land over and above the nonurban rents (the last two terms on the right hand side above). For the planned development time T, the expected return to development must be weighted by the probability that such development will still be allowed at that time, $p(T)$. The net return above the flow of urban rents is therefore uncertain, depending upon the regulatory decisions made between the initial time and the planned development time.

The investor's optimal structural density condition remains unchanged, as (2) above. The development timing condition, however, is modified by the regulatory risk. Differentiating V with respect to T for the first order condition and rearranging yields the new timing condition

$$rC(S) + w = R(S,T) - \dot{p}(T)\int_T^{\infty} [R(S,t) - w - rC(S)]e^{-r(T-t)}dt \tag{7}$$

When expressed in this way, we can see the structure of the problem confronting the investor and how a development prohibition policy affects development incentives. Consider a particular tract of undeveloped land. Given that development is not currently prohibited, an investor can either build on the land now or can choose to wait. If the decision is to wait, however, the investor is then also opening himself to the risk that the development prohibition will be imposed at some point in the future before the land is developed. In any case, when making the decision to develop the land today (for the current best use) or wait until later (for the future best use), potential investors weigh the returns to the current and future best uses. But, investors also weigh the threat of the development prohibition being imposed before the land is developed if they choose to wait in order to develop the land for the future best use. The regulatory threat increases the riskiness of the investment returns from waiting to build on the land. From today's perspective, this risk is an additional cost of waiting, $-\dot{p}(T)\int_T^\infty [R(S,t) - w - rC(S)] e^{r(T-t)}dt > 0$ (since the probability of the parcel of land staying unregulated decreases over time, or $\dot{p} < 0$). This regulatory risk cost shifts the expected marginal cost of waiting upward to MC' in the top panel of Figure 1. The additional risk introduced by the threatened regulation will tip the comparison of the development options in favor of an earlier development time than would otherwise be the case; the planned waiting time for the parcel pictured in Figure 1 is shortened from T_1 to T_2. The threat of the regulation, rather than the regulation itself, creates an incentive to hasten the pace of development.

The effects on the structural density of the development follow from the effect on timing and can be seen using the lower panels of Figures 1 and 2. Figure 1 pictures the case where the current best use has a lower structural density than a future best use. For parcels of land for which this holds, the lower panel shows that the shorter planned waiting time reduces the planned structural density, from S_1 to S_2. Figure 2 pictures the case where the current best use has a higher structural density than a future best use. In this case, the lower panel in the diagram shows that the shorter waiting time increases the planned structural density. The effect of the regulatory risk on structural density therefore systematically depends upon whether the demanded density is rising or falling over time.

To summarize for unregulated property, the threat of a development prohibition shortens the waiting time for land development, increasing the pace of development for unregulated property. The threat of development prohibition decreases the density of development at locations where the demanded density is rising over time, that is, at those locations in the urban area where the current best use entails a lower structural density than does the future best use. On the other hand, the threat of development prohibition increases the density of development at locations where the demanded density is falling over time, that is, at locations where the current best use entails a higher structural density than does the future best use.

For property that actually becomes subject to the regulation before it is developed, of course, development is prohibited and therefore does not take place, regardless of the owner's initial plans.

Note that the discussion to this point also illustrates how the threatened policy elicits an opposite effect than intended. For example, when greenspace or watershed restrictions are imposed in one region in a spatial land market, any belief by landowners that the policy could be expanded to a wider region will increase the pace and density of surrounding development if policy-makers cannot credibly commit to restricting the development policy to the narrower targeted region. As stated earlier, the problem from the policy-makers' perspective is how to credibly commit to potential investors to never imposing a similar regulation outside the original targeted region. This difficulty is especially acute for local and regional land use planning authorities, given that the political pressure by local residents to do so will likely increase in the future as urban growth continues.

5. Regulating development timing

Instead of an outright prohibition on developing a specific parcel of land, the local government can impose a moratorium, postponing development of any sort until a specified date. There are basically two broadly defined situations in which development moratoria are threatened. One example is provided by the Portland, Oregon, Metropolitan Council (Metro). The Metro is a regional authority charged with the responsibility of delineating the urban service boundary (growth boundary) for the Portland metropolitan area, and acting as a venue for local governments to coordinate their own zoning and land use regulations. The Metro Council long range planning envisions an urban land preserve in the interior of the metropolitan area, a large tract of land that is to be left undeveloped until 2020, after which private owners will be free to develop their land for urban uses.[8] Similar examples appear repeatedly throughout the US. For example, the City of Atlanta imposed local development moratoria in parts of the city where the aging sewer system has failed to meet federal standards. As in the Portland urban preserve example, Atlanta's development restriction is not permanent; the Atlanta moratoria will be lifted once the requisite repairs are in place for each affected area.

Another example of local development moratoria passing constitutional muster is addressed in the 2002 Supreme Court decision, *Tahoe-Sierra Preservation Council v. Tahoe Regional Planning Agency*. The Court decided that what had turned into a six year moratorium on land development was not an unconstitutional regulatory taking as the plaintiff's claimed, but was instead an example of police power allowing the planning agency to ponder alternative development policies. Such moratoria are not unusual, as the Court notes that "the consensus in the planning community appears to be that moratoria, or 'interim development controls' as they are often called, are an essential tool of successful development." In any event, the Supreme Court avoided setting a bright-line rule for how long a "temporary" moratorium must extend in order for it to fall into the category of a taking in the form of an effective lease-hold requiring compensation for affected owners. The regulatory threat concept is also relevant for this case. While the Court pointed out that property owners should have "known" years earlier that some sort of regulation was "in the works"—the moratorium that finally occurred years later in 1981—the precise date of the regulation was nonetheless uncertain to investors during the time leading up to its actual imposition.

These examples illustrate that development moratoria are feasible policies for local governments. The question is how the threat of such a moratorium alters development incentives. The general principles for this case are best seen by modifying the setting envisioned in the previous section, following the relevant analysis in Turnbull (2004a).

This paper incorporates a model of credible government behavior, unlike the earlier views of regulation as an exogenous stochastic process (Riddiough, 1997). To begin, recall that a greenspace externality is an external benefit from undeveloped land that disappears once the land is developed. Investors do not know with certainty at the outset whether or not a particular parcel of vacant land is a source of a greenspace externality. Evidence of the externality, or even if it is ever going to be present, only becomes evident over time. If the government's goal is ex post efficiency, the government will pursue the corrective regulation when evidence of the externality arises—the government follows the Pareto rule identified in the eminent domain literature (Fischel and Shapiro, 1988). If the moratorium is permanent, then this case reverts to the previous situation in which further development is prohibited outright, which is the case examined in the preceding section. If the moratorium is not permanent, though, the developer will be allowed to proceed after the designated interval of time has passed.

It is obvious that regulatory risk arises when there is no constitutional restraint on local government regulatory behavior. But the strict no taking constraint also introduces regulatory uncertainty because the government can impose the efficient development moratorium on a specific parcel of land only after the externality is known to exist for that parcel. This gives the rationale for the government's behavior as ex post efficient or following the Pareto rule.[9] Even if the government were inclined to exercise the moratorium capriciously, it cannot do so because of the no taking constraint. As a result, because the existence of an externality for the land parcel is uncertain at any point in time, the regulation must be uncertain as well.

Consider the private investor's behavior under such a policy. The planning authority imposes a development holiday on the land only when (and if) it is revealed to be the source of a greenspace externality. This policy, although efficient after the fact for regulated land, creates a risk of regulation for a broad swath of landowners in the locale, whether or not ultimately falling under the development moratorium. It turns out that the structure of this problem requires a dynamic programming framework to capture the effect of the policy threat on investor incentives. Rather than work through the details, this discussion employs graphs similar to those above to illustrate the forces at work.

Since there is no risk of a development moratorium once the land has been developed, we only need to focus on how the moratorium threat affects investment decisions before actual development takes place. From a potential investor's perspective, at any point in time only one of two regulatory events can occur given that the moratorium has not yet been imposed. Either the development moratorium is imposed at that time or it is not. We start with the first case.

If the moratorium is imposed, the investor's best strategy is straightforward: develop the land as soon as it is allowed, say at time T_m. And, when finally developing the land, develop it in the configuration or use that the market demands at the allowed development time, which is S_m in Figures 3 and 4. This simple investment timing rule makes sense. After all, when the development moratorium is imposed, it is intended to postpone the developer's decision. The investment density rule also makes sense when the moratorium is in effect; the most profitable development pattern in earlier years when the unrestricted developer would have pursued the project will likely not be the most profitable project in later years when the market for alternative land use configurations has matured. Therefore, when actually imposed, the moratorium affects the ultimate use to which the regulated land is put. We can easily see this using the bottom panels of Figures 3 and 4. When the future best use entails a higher structural density than the current best use (that is, when demanded density is increasing over time), forcing the regulated property to postpone development from the planned time T_1 to T_m leads to the property

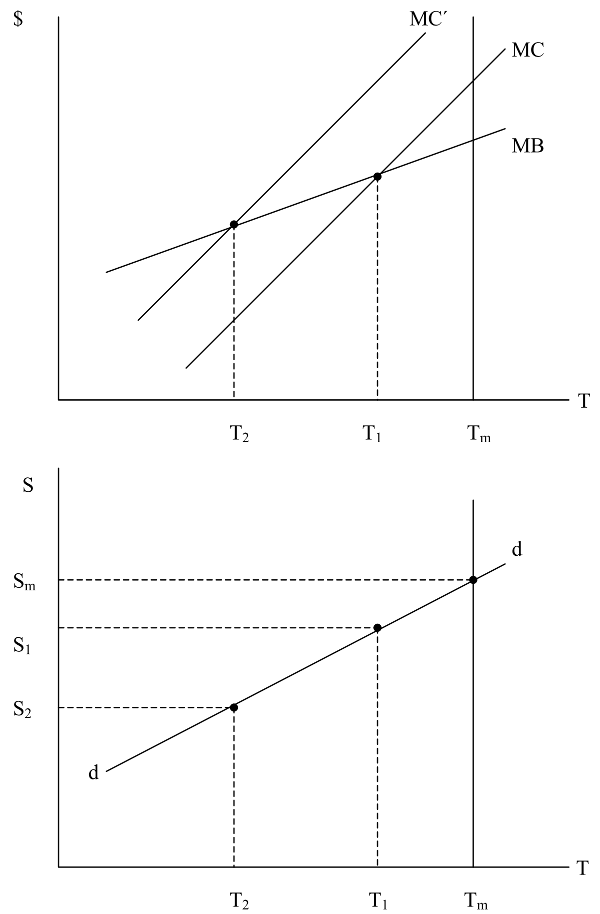

Figure 3. Effect of development moratorium threat on planned timing and density when demanded density is rising over time.

being developed for a use with greater structural density than it otherwise would have without the moratorium: $S_m > S_1$ in Figure 3. On the other hand, when the future best use entails a lower structural density than the current best use (that is, when demanded density is decreasing over time), the development moratorium leads to a lower structural density than otherwise would have been the case for the regulated tract of land: $S_m < S_1$ as depicted in Figure 4.

While the preceding deals with what happens when the moratorium is actually imposed, there is also the second possible regulatory outcome at any point in time, that the moratorium is *not* imposed. In this case the developer's best strategy is to wait until what would be the planned development time without regulatory restriction, T_2 in Figures 3 and 4. This planned development time, however, is still affected by the future threat of the moratorium being imposed. The longer the land remains undeveloped, the longer it

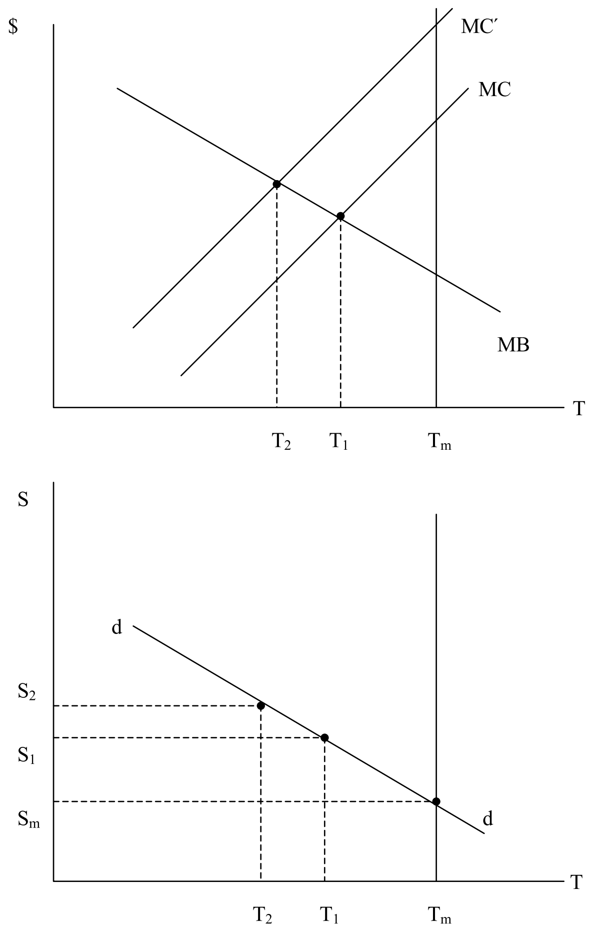

Figure 4. The effect of development moratorium threat on planned timing and density when demanded density is falling over time.

remains exposed to the potential regulation, which increases the probability that it will be regulated before development. But once developed, the threat of the governmentally imposed postponement disappears. Thus, investors face an additional holding cost when waiting for the land market to mature for their most desired project. This additional holding or waiting cost shifts the marginal cost of waiting upward to MC' in the top panel of Figures 3 and 4, which in turn provides and incentive to develop the land sooner than without the threat; planned waiting time is shorter (T_2) than without the regulatory threat (T_1). Put somewhat differently, the risk of being forced to postpone development eliminates some feasible alternative projects from consideration, thereby reducing the option value of vacant land as a source of potential development projects (Riddiough, 1997). The reduction in the vacant land value makes earlier development desirable.

This acceleration of the planned development time also affects the way in which unregulated land is ultimately developed, as can be seen from the bottom panels of the figures. When the future best use entails a higher structural density than the current best use, the shorter planned waiting time to development prompts investors to prepare the property for a use with lower structural density than they would have without the threatened moratorium ($S_2 < S_1$ in Figure 3). On the other hand, when the future best use entails a lower structural density than the current best use, the threatened development moratorium leads to a higher structural density than otherwise would have been the case for that particular tract of land ($S_2 > S_1$ in Figure 4).

Pulling these results together, the threat of a development moratorium speeds the planned development time and either increases or decreases the planned development density as demanded density is falling or rising over time. Land that escapes regulation is therefore developed more quickly than without the regulatory threat, with the appropriate change in density following the demanded density pattern. Of course, some of the land awaiting development will inevitably get caught by the regulation. This land will be developed at a later date than it would if it had instead escaped the moratorium, but now the structural density is greater or less than for unregulated land as the demanded density is rising or falling over time, respectively. Nonetheless, the moratorium does not force all developers in the market to pursue their projects at the earliest feasible date; rather they must balance the risk of the moratorium against the gains from postponing the development time as the market for the planned project matures to its most profitable state.

To summarize, the threat of a development moratorium gives investors an incentive to prefer projects with shorter waiting times than they would otherwise prefer without the threat. Investors' incentives favor projects with a lower structural density than without the threat at locations in the urban area at which the current best use structural density is lower than the structural density of the future best use (i.e., the demanded density is rising over time). The threat of a moratorium prompts investors to favor projects with a higher structural density than without the threat at locations where the current best use structural density is higher than the future best use structural density (i.e., the demanded density is falling over time).

Of course, different types of property in the urban area will differ by their likelihood of being identified with the externality, hence being an intended target of the regulation. High risk land will have a greater upward shift in the *MC* curve and therefore a more rapid planned development pace than otherwise identical low risk land, where the relative risk reflects the market's estimate of the likelihood that the specific parcel of land will be subject to the regulation at some time in the foreseeable future. In addition, the planned capital density for high risk land will be greater than that for low risk land at those locations where the demanded density is falling over time. Similarly, the planned capital density for high risk land will be less than that for low risk land at those locations where the demanded density is rising over time.

So, how does lengthening the development moratorium (when it is imposed) affect investors' incentives? In terms of Figures 3 and 4, shifting the allowed development time T_m to the right increases the upward shift in the *MC* curve in the upper panels, as it increases the expected cost (in the form of lost profits) of the probable moratorium.

Clearly, the greater this shift in MC, the greater the difference between the planned development time under the regulatory threat, T_2, and that without such a threat, T_1. Also, the greater the reduction from T_1 to T_2, the lower (higher) is S_2 relative to S_1 in Figures 3 and 4, respectively. Thus, lengthening the moratorium decreases the planned structural density for land at locations where the demanded density is rising over time; lengthening the moratorium increases the structural density at locations where the demanded density is falling over time.

The results have important implications for the unintended distorting effects of the regulatory threat in the broader land market as well. Generally, the greater the possible externality associated with the undeveloped land, the longer the duration of the efficient development holiday. Therefore, the preceding paragraph implies that land that might generate a larger greenspace externality will have a more rapid planned development pace than land that might generate a smaller greenspace externality. The divergence between investors' strategies and efficient outcomes for unregulated land is greater the greater the possible size of the greenspace externality elsewhere in the market. Simply put, a greater potential externality drives a larger wedge between private investors' development timing and the economically efficient timing.

6. Restricting uses when regulation is certain

The series of papers by Titman (1985) and Turnbull (1991, 2002) study how restrictions on development density affect investment incentives and urban development. This section discusses the effects of zoning or other land use regulations in the form of maximum density restrictions. The discussion of this type of regulation is by necessity more complicated than the development prohibitions or moratoria discussed in previous sections. A wide range of zoning restrictions (by allowed use type, etc.) can be included in this density restriction characterization, given that different uses generally entail different land-structure configurations, hence structural densities.

6.1. Density restrictions under certainty

When the structural density is regulated, say as a maximum allowed density M, the investor's problem is modified to

$$\max_{S,T} V(S,T) = \int_0^T we^{-rt}dt + \int_T^\infty R(S,t)e^{-rt}dt - C(S)e^{-rT} \quad \text{s.t.} \quad S \le M \tag{8}$$

A binding structural density constraint means that the investor sets $S = M$, and the density condition (2) becomes irrelevant. The timing condition is also much simplified: the investor should develop during the period for which the allowed structural density M is the "current" best use. As a consequence, this type of binding restriction speeds development where the demanded density is falling over time and slows development where the demanded density is rising over time (Turnbull, 1991).

This timing relationship makes sense. As illustrated in the bottom panels of Figures 5 and 6, when the maximum allowed structural density, M, is less than what the investor's most profitable development scheme would call for (e.g., S_1), then the land use restriction is binding on the development. Investors have an incentive to adopt the allowed use, which is the best use for an earlier development time than that most preferred when the demanded density is rising over time; $T_m < T_1$ in Figure 5. When the demanded density is falling over time, on the other hand, the allowed use is the best use for a later development time than that most preferred without the regulation; $T_m > T_1$ in Figure 6. Once again the determining factor for how the regulation affects development patterns rests with the underlying pattern of growth in the demands for alternative land uses over time.

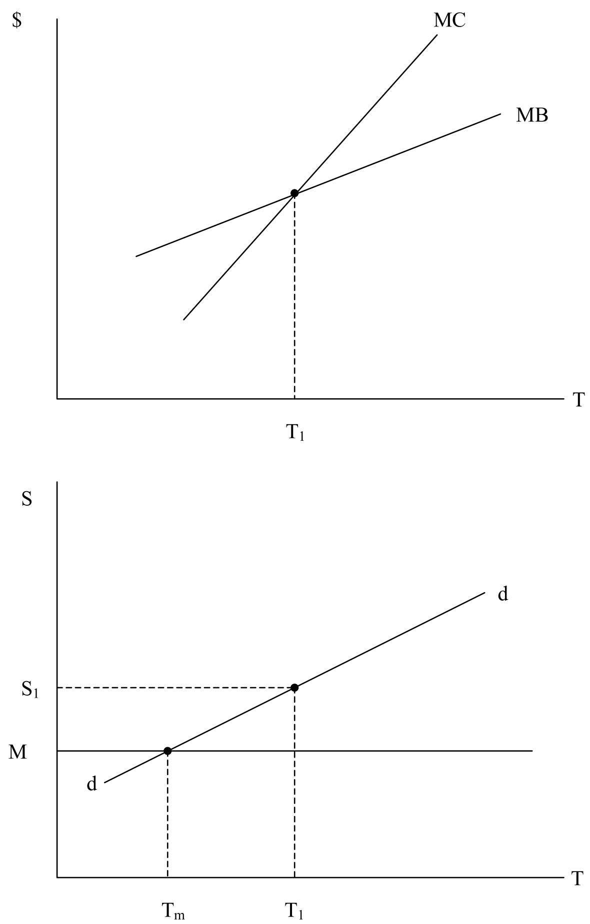

Figure 5. Effect of known density restriction on timing and density when demanded density is rising over time.

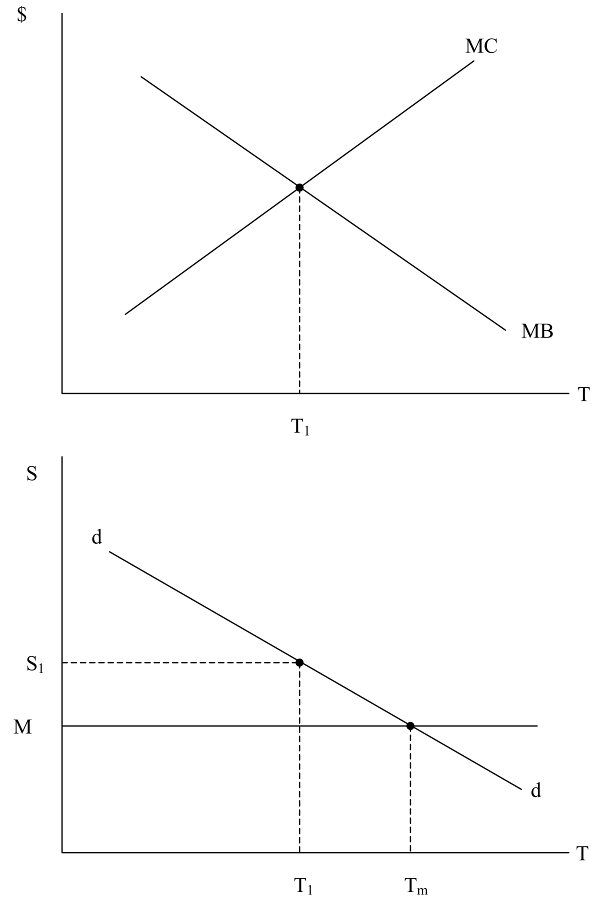

Figure 6. Effect of known density restriction on timing and density when demanded density is falling over time.

6.2. Density restrictions under demand uncertainty

Now consider a different setting. Suppose that the land use regulation is imposed with certainty as in the preceding example. Now, however, the land market is uncertain. Specifically, assume that the demand for developed real estate (e.g., building units) is stochastic so that the future price of building units is uncertain. Titman (1985) offers a model of how the introduction of nonstochastic development restrictions affects land value when future returns to development are uncertain. The framework is a simple option pricing model extending over two periods. The discussion here differs from Titman's original construction in order to emphasize the underlying valuation concept.

The general setting is as follows. There are two periods. In the absence of regulation, in the current period an investor is free to construct structures, with the number of building units per unit of land S, at the cost $C(S)$ as above. Building units can be sold outright in the initial period for the market price P_0. With the riskless interest rate r and no depreciation, rented units earn rP_0 during the period. The market price of a building unit in the second period is uncertain. It will either rise to P_1 or fall to P_2 (i.e., $P_2 < P_0 < P_1$). Any land left vacant in the first period can be developed in the second period; the profit to the owner of vacant land in the second period is either $\pi(S_1)$ or $\pi(S_2)$, where S_i is the profit-maximizing structural density when the price for a building unit is P_i. It follows that $\pi(S_1) > \pi(S_2)$.

When cast this way, vacant land in the first period represents an option on future buildings. The portfolio comprising one building unit coupled with selling short h units of vacant land (options on future buildings) has the initial value $P_0 - hV$ and evolves following according to one of the two indicated outcomes:

$$P_0 - hV \rightarrow \left\{ \begin{matrix} rP_0 + P_1 - h\pi(S_1) \\ rP_0 + P_2 - h\pi(S_2) \end{matrix} \right\} \tag{9}$$

Of course, which outcome will ultimately obtain is unknown at the outset. Setting the two second period portfolio values equal to one another and solving for the riskless hedge ratio yields

$$h^* = \frac{P_1 - P_2}{\pi(S_1) - \pi(S_2)} \tag{10}$$

Since h^* yields a riskless portfolio, the initial portfolio must earn the riskless rate of return in equilibrium, so that

$$(P_0 - h^*V)(1 + r) = rP_0 + P_1 - h^*\pi(S_1) \tag{11}$$

and value of vacant land at the outset is

$$V = \left(\frac{P_0 - P_2}{P_1 - P_2}\right)\left(\frac{\pi(S_1)}{1 + r}\right) + \left(\frac{P_1 - P_0}{P_1 - P_2}\right)\left(\frac{\pi(S_2)}{1 + r}\right) \tag{12}$$

In equilibrium, land is developed in period one up to the point where $\pi(S_0) = V$. This implies that factors increasing V slow the pace of development (in the sense that less land is developed in the initial period and more held to exploit future development options) while factors decreasing V speed the pace of development.[10]

The effect of a land use restrictions is easily seen from (12). Suppose we now place a binding constraint either on the maximum ($M < S_1$) or minimum allowed structural density ($m > S_1$). Either case reduces second period development profit (land rent) in the higher or low price states: $\pi(M) < \pi(S_1)$ or $\pi(m) < \pi(S_2)$. By (12), each of these restrictions reduces the value of vacant land, V, and speeds the development pace. Intuitively, the land use regulation reduces the range of allowable options for development, reducing the option value of vacant land, and lowering the hurdle for current period investment decisions to proceed.

This conclusion contrasts with the results for such regulation under complete certainty. Recall from Figures 5 and 6 that regulating allowed structural density either speeds or slows development when demand is certain, depending upon how the demanded density is changing over time. On the other hand, the previous sections show that development proceeds at a more rapid pace in response to a threatened development moratorium or prohibition, outcomes that look similar to that found here with the option value model. So, what explains the difference in regulatory effects on the pace of development? It turns out that there are different forces at work. In part, the conclusions in the certainty model hinge upon the assumption that investors know both the regulatory regime and market outcomes with certainty; all land in the market is already zoned according to allowable final use and there will be no changes or variances in the future.

Although providing a good starting point for the ensuing line of research, this characterization of zoning is, of course, not an accurate depiction of how land use regulation is devised and put into play over time. A more realistic picture recognizes that zoning and other types of allowed density restrictions can be the source rather than resolution of uncertainty facing investors (Ellson and McDermott, 1987). Zoning plans change over time in response to local political pressures by residents and developers as well as the observed evolving patterns of land use in the urban area. Even when the zoning pattern is set, it is possible to obtain variances. Future changes and variances are, of course, by their nature uncertain. These observations motivate the question addressed in the next section, how uncertainty over future density regulation affects the urban land development process.

7. Uncertain density restrictions

Turnbull (2002) combines the probabilistic structure of the regulation envisioned in the previous section with the type of density restrictions envisioned in the certainty model of zoning or land use controls in order to evaluate the net effect of the policy on investment patterns. This discussion focuses on allowed use regulations that effectively place an upper bound on the allowed structural density, regulations that rule out high density development—unless, of course, a zoning variance is obtained, which is uncertain until applied for.

To keep the description as straightforward as possible, the regulatory environment is envisioned as one beginning with no density restriction. Over time, a binding density restriction might or might not be imposed. Of course, imposing a non-binding density restriction is equivalent to no restriction. If the most profitable use for the land would be single family detached houses and the zoning restriction prohibits nonresidential uses for which multi-story office buildings or large commercial structures would be appropriate, then the restriction is not binding on developers' decisions. It seems reasonable to infer that the uncertain density restriction model also pertains to the situation in which the maximum allowed density is imposed at the outset, but whether or not a variance will be allowed will not be known until applied for at a later date. However envisioned, the basic model described here remains the same.

A complete treatment of this case requires solving a dynamic programming problem. This discussion, however, remains informal in order to tease out the intuition underlying several of the key results. Looking at the effects of development timing first, given the results discussed in previous sections, it is not surprising that the threat of restrictions on allowed use creates a regulatory risk that can be interpreted as an additional holding cost for undeveloped land. Graphically, the waiting cost shifts upward to MC' in Figures 7 and 8. Once again, the regulatory threat hastens the overall pace of development for unregulated land as the planned development waiting time decreases from T_1 to T_2. In this case, though, determining effects on the structural density of unregulated land and the effects on the timing of the development of regulated land requires a slightly different approach than followed for the prohibition and moratorium regulations discussed earlier.

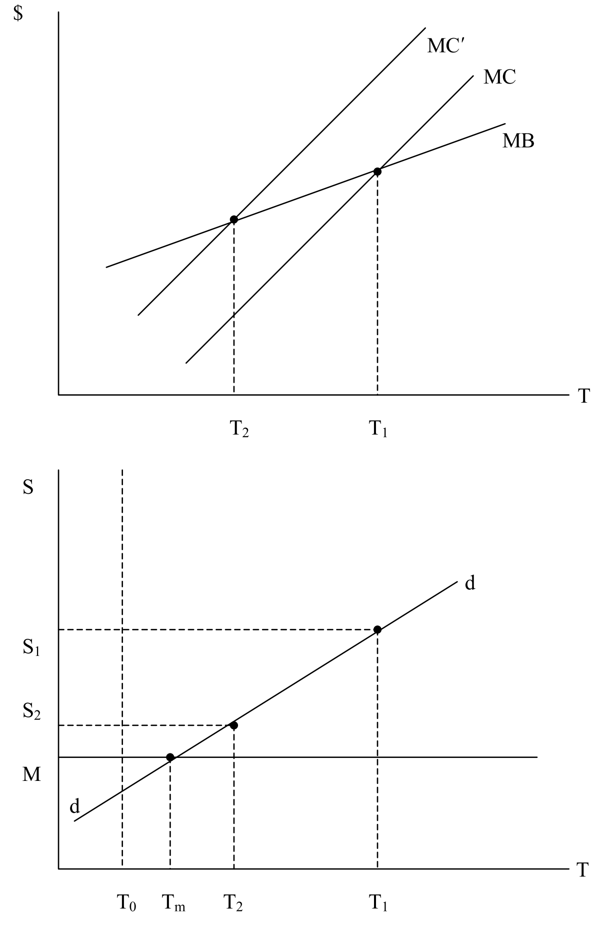

Figure 7. Effect of density restriction threat on planned development timing and density when demanded density is rising over time.

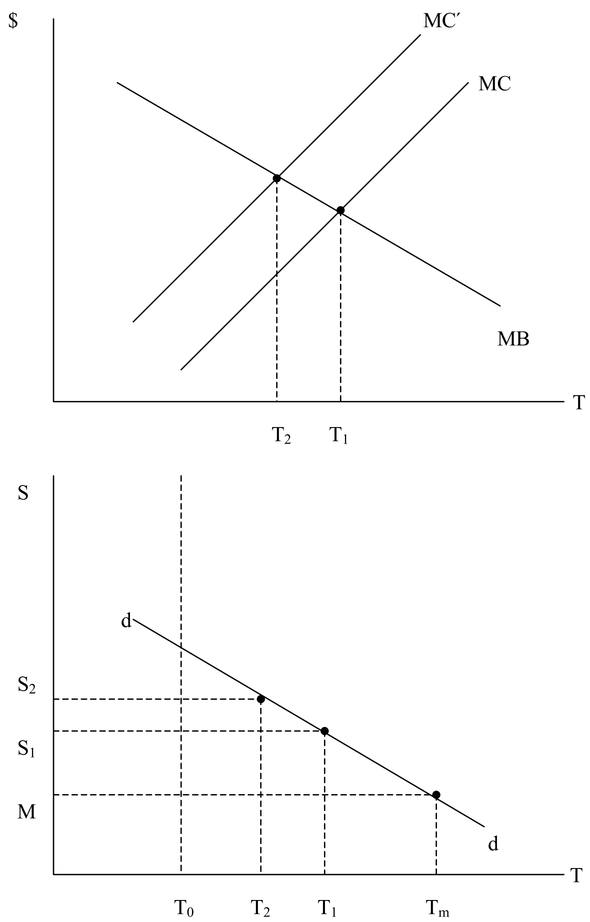

Figure 8. Case one: Effect of density restriction threat on planned development timing and density when demanded density is falling over time.

Market participants take into account the possibility that the binding land use restriction might be imposed at some time prior to the planned development time. Consider a time period before the planned development time for the tract of land, say T_0, when the development restriction has not (yet) been imposed. There are only two possibilities: either the restriction will not be imposed at that time, possibly to be imposed at some unspecified future date, or it will be imposed at that time. Consider each possibility in turn.

First, there is the possibility that the regulation is not imposed at the point in time envisioned. In this case, the investment strategy is simple: if the current time is the previously planned development time (T_2), then the market for the most profitable use is ripe and the investor goes forward with the planned project. On the other hand, if the current time T_0 is before the planned development time, the investor's incentive is to await T_2 and develop at that time. In either case, the investor undertakes the project at the planned density (S_2 in Figures 7 and 8).

Now consider the second possibility, that a binding land use restriction is imposed at the current time T_0. Since the maximum density restriction, M, is binding, it is lower than the originally planned density, S_2, as drawn in Figures 7–9. The investor's strategy is to revise the planned project to coincide with what is now allowed, and then await the maturing of the allowed project in the market. There are two subcases to examine. For one, it is possible that the market is already fully matured for the allowed project when the regulation is imposed. Since the more profitable project for which the investor was waiting to mature when the land use restriction was imposed is no longer an option, the investor now has an incentive to immediately develop the land for the allowed use. It turns out that is will only occur when the demanded density is rising over time for the

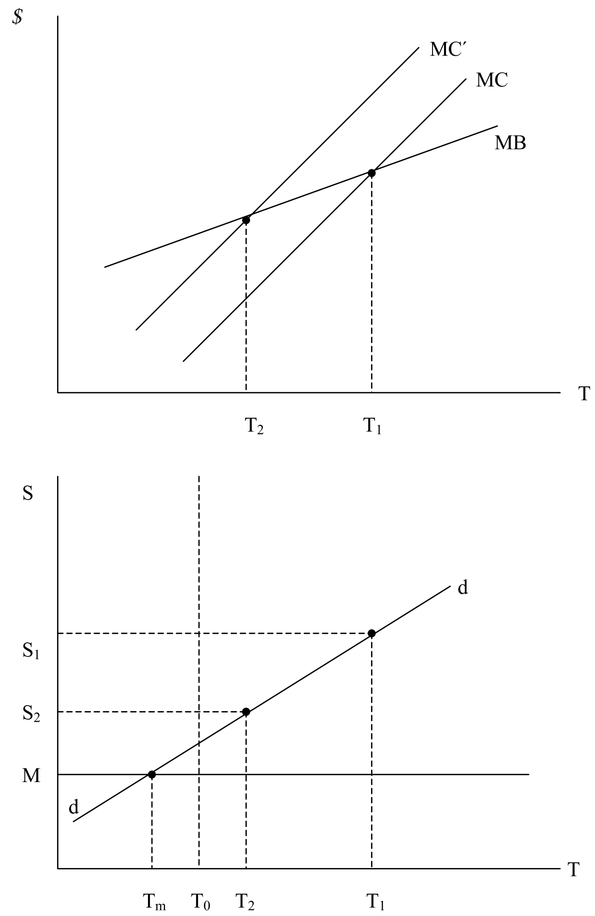

Figure 9. Case two: Effect of density restriction threat on planned development timing and density when the market for the allowed density has fully matured.

land parcel in question. To see why, suppose that the allowed use restriction is imposed at time period T_0 in Figure 9. With the maximum allowed density M, clearly the best time to develop is as close to T_M as possible; but seeing as the regulation is being imposed at the current time T_0, the best time to develop the land with structural density T_M is already past, so the best option left is to develop the land immediately at the current time T_0.

For the other possibility, though, if the land use restriction is imposed before the allowed use has fully matured in the market, then investors have an incentive to wait until the market matures for the allowed use. It turns out that this will always occur when the demanded density is falling over time for the land parcel in question (as in Figure 8) and may occur when the demanded density is rising over time (as in Figure 7). In Figures 7 and 8, for example, the maximum allowed density is M; the optimal time to develop land for that use is the time at which M represents the best use, T_M.

Sorting out the effect of the threatened maximum allowed density restriction on development outcomes depends upon whether the plot of regulated land would be developed earlier or later when compared to the most profitable time to develop when left unregulated (but still threatened with regulation). If the best time to build the allowed land use is later than the best time to build for the most profitable land use (that is, $T_M > T_2$ as in Figure 8), then there is never an incentive to develop the regulated land prior to the original planned development time ($T_M > T_1$). On the other hand, it is possible that the best time to build for the allowed land use is actually before the best time to build for the most profitable land use, that is, $T_M < T_2$ as pictured in Figures 7 and 9. In this situation, actually imposing the land use regulation hastens the development time, and the land will be developed before the originally planned development time (that is, $T_M < T_2 < T_1$). What is interesting in this latter case is that imposing the land use restriction speeds the pace of development of regulated property relative to property that remains unregulated ($T_M < T_2$). Therefore, whether or not imposing the land use restriction slows or speeds development of regulated land relative to unregulated land is determined in part by how the demanded density is rising or falling over time.

In summary, the threat of binding land use regulation tends to speed the pace of development for unregulated property. The effects on structural density depend upon how the underlying demands for land expressed by different land uses are changing over time. The imposition of the allowed use regulation has a more complicated effect on timing decisions than observed for the previous types of regulations, but the outcomes once again systematically depend upon how the demanded density is changing over time.

8. Regulatory risk versus ownership risk

The above analysis of threatened development prohibition, moratoria, and density restrictions reveal a basic principle: all create an additional risk cost associated with holding undeveloped land, thereby creating greater incentive for investors to develop property more quickly. This prompts a relevant question in light of the broader literature on property rights and urban development. For example, Miceli et al. (2000, 2003) examine how ownership risk arising from private sources, like boundary encroachment, squatting, title system errors, or the other complications, affects development. Is the effect of public sector regulation risk comparable to that from these private sources of property rights risk?

Not surprisingly, the stochastic structure implied by ownership risk arising from private sources differs from that arising from the public regulations examined above. Suppose that at any given point in time, the current possessor (since "owner" is an ambiguous label in this model) runs the risk of losing title to the property from one of these private sources of risk. Also assume that the only property rights conflict that might arise is associated with the land itself. In this case, the current possessor can expect to be reimbursed for any improvements that were made to the land in good faith if he loses title to the land. Let $p(t)$ be the survival probability, the probability of retaining title at time t given that the current possessor retains title up to that time. The expected present value of returns to the land is[11]

$$V(S,T) = \int_0^T p(t) w e^{-rt} dt + \int_T^\infty p(t)[R(S,t) - rC(S)] e^{-rt} dt \tag{13}$$

The first right hand side term is the expected rents from the undeveloped land; the rent at each time period is weighted by the probability that the current possessor will actually maintain title to the land long enough to enjoy those rents. The second term is the expected net return from the developed land; the rent (less rental cost of structural improvements) is again weighted by the probability $p(t)$.

The investor's optimal structural density and timing satisfy the following conditions

$$\int_T^\infty p(T) R_S(S,t) e^{-rt} dt = C'(S) \int_T^\infty r p(t) e^{-rt} dt \tag{14}$$

Consider how the current best use structural density at a given development time T is altered by this type of private ownership risk. Since the probability p inside the left hand side integral is decreasing over time, when $R_{St} > 0$ the presence of this probability reduces the value of the integral for given values of S and T. Therefore, it is not surprising that the presences of this probability tends to reduce the current best use density at a given development time: the density-timing curve dd in the lower panel of Figure 10 shifts downward to $d'd'$ with the introduction of ownership risk. This new density-timing relationship $\tilde{S}(T)$ yields the timing condition under ownership risk as

$$rC\big(\tilde{S}(T)\big) + w = R\big(\tilde{S}(T), T\big) \tag{15}$$

The lower density at each potential development time T lowers the development cost on the left hand side, thereby lowering the marginal benefit of waiting to MB' in the figure. This lower planned density effect also decreases the right hand side of the above condition, the marginal cost of waiting, shifting it down to MC'. Although not obvious from the diagram, the reduction in the MC turns out to be less than the corresponding reduction in MB, and the planned waiting time falls from T_1 to T_2. The quicker

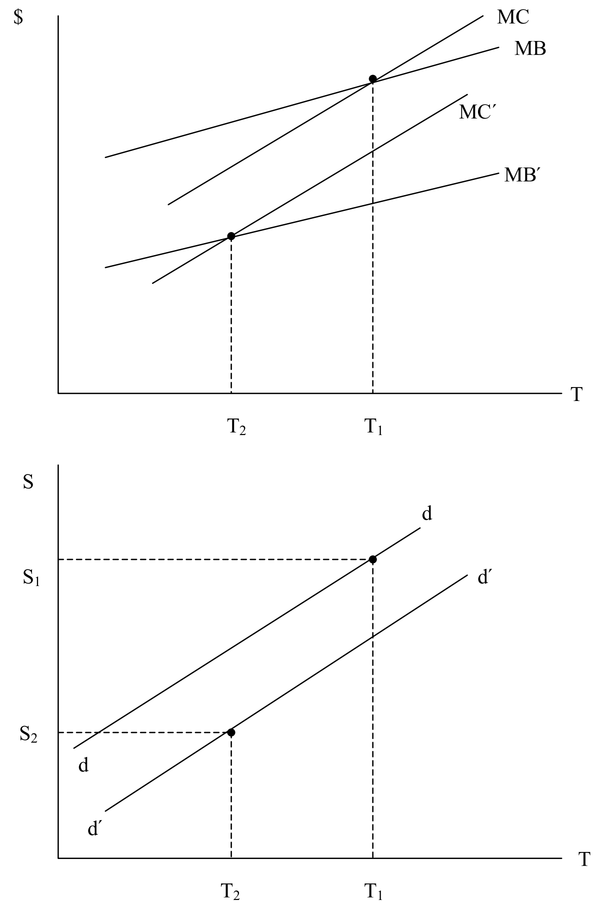

Figure 10. Effect of private source ownership risk on development timing and density when demanded density is rising over time.

development time leads to a lower structural density in the lower panel of the diagram ($S_2 < S_1$) both because the best use density is lower from the risk of losing capital earnings in the future and because the optimal time to develop is sooner under risk to ownership.

The implications of ownership risk for the case where demanded density is falling over time are illustrated in Figure 11. Once again, the presence of such risk changes the *dd* curve, but this time the probability inside the integral in the density condition (14) leads to a higher structural density at each given development time $T : \tilde{S}(T) > S(T)$. This is reflected in the upward shift in the *dd* curve to $d'd'$ in the lower panel. The greater current best use density yields a timing condition like (15). In this case, though, the higher $\tilde{S}(T)$ at each T increases both sides of (15); the marginal benefit of waiting shifts upwards to MB' while the marginal cost shifts upwards by a relatively greater

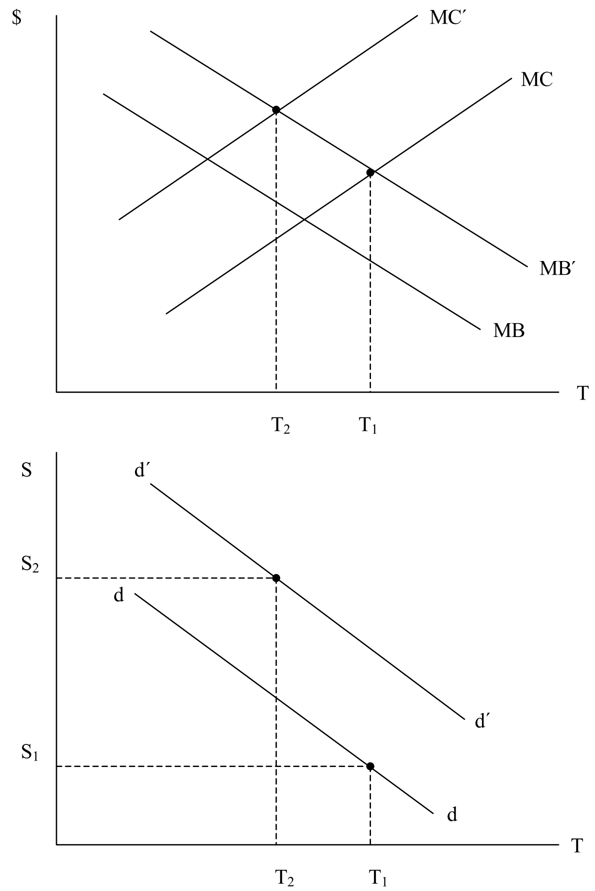

Figure 11. Effect of private source ownership risk on development timing and density when demanded density is falling over time.

amount to MC'. The optimal development time for the investor changes from T_1 to T_2, and the ensuing change in development density rises in this case from S_1 to S_2.

Thus, even though the structure of risk to ownership is different when arising from private sources than when arising from threatened government regulation, we see in both cases that investors have an incentive to accelerate their development plans whenever possible. And the effects on structural density also depend upon how the underlying demands for land are changing over time. When put side-by-side, private ownership risk has effects on planned timing similar to that of threatened regulation.

Nonetheless, there is an important difference between private and regulatory sources of risk to property rights. The difference arises in the part of the market that actually ends up subject to the land use regulation. With private source risk, of course, there is no distinction between affected and unaffected property. In contrast, with regulatory risk, we see a profound difference between how unregulated and regulated property is affected. For example, the discussion in the preceding section illustrates that the threat of an upper bound on structural density generally hastens the development of regulated land where the demanded density is rising over time while slowing the development of regulated land where the demanded density is falling over time. As a consequence this particular regulatory regime threat can lead to faster or slower development of regulated land *on average* across the land market, depending upon patterns of growth in the underlying land demands at each of the affected locations. Private source ownership risk, on the other hand, unambiguously leads to faster development on average across the land market.

9. Development fees

Development fees can increase efficiency when public services or infrastructure are subject to decreasing returns to scale or congestion or when vacant land is the source of greenspace externalities (Brueckner, 1997). In practice, though, local governments view development fees as just another source of revenue. In Georgia, for example, local governments have been able to exploit fungibility and broad interpretations of the state enabling legislation in order to use revenues raised from development fees to repair long neglected infrastructure and even to support new services in older developed neighborhoods. None of these uses bear much resemblance to the corrective tax envisioned by economists.[12] Regardless of the motivation, whether applied as corrective Pigovian taxes to control development or used simply as another revenue source, development fees remain popular among local governments in many states.

Looking at their impact, development fees represent an additional cost of development to investors and will in general slow the development pace throughout the jurisdiction—provided that the fees are both imposed with certainty and are invariant with respect to planned development density. There are, however, two dynamic aspects of development fees considered here.

To do so, let the development fee $D(S)$ be due at the time of development, where $D' > 0$ when the fee rises with structural density and $D' = 0$ when it is levied as a lump-sum tax. The present value of returns to a unit of land is (1) less the tax,

$$V(S,T)\int_0^T we^{-rt}dt + \int_T^\infty R(S,t)e^{-rt}dt - [C(S)+D(S)]e^{-rT} \tag{16}$$

The investor's structural density condition is

$$\int_T^\infty R_S(S,t)e^{r(T-t)}dt = C'(S) + D'(S) \tag{17}$$

Given the density that satisfies this relationship, $S(T)$, the timing condition becomes

$$rC(S(T)) + rD(S(T)) + w = R(S(T),T) \tag{18}$$

The fee will still affect the density of development in the affected region even if the fee does not vary with planned density. This corresponds to McFarlane's (1999) case where the development fee is assessed per unit of land. To see the result, use the fact that in this case $D' = 0$ and the density condition (17) reverts back to the condition with no taxes or regulatory threat (2) and the density-timing curves in the bottom panels of Figures 12 and 13 remain *dd*. The only change is that the timing condition is now modified only by the addition of the annualized development fee, *rD*, to the left hand side; this development fee increases the marginal benefit of waiting to MB', thereby slowing the development pace (T_1 to T_2). McFarlane's (1999) model is restricted to the case where demanded density is rising over time, the situation depicted in Figure 12. As is clear from the diagram, this type of development fee not only postpones planned

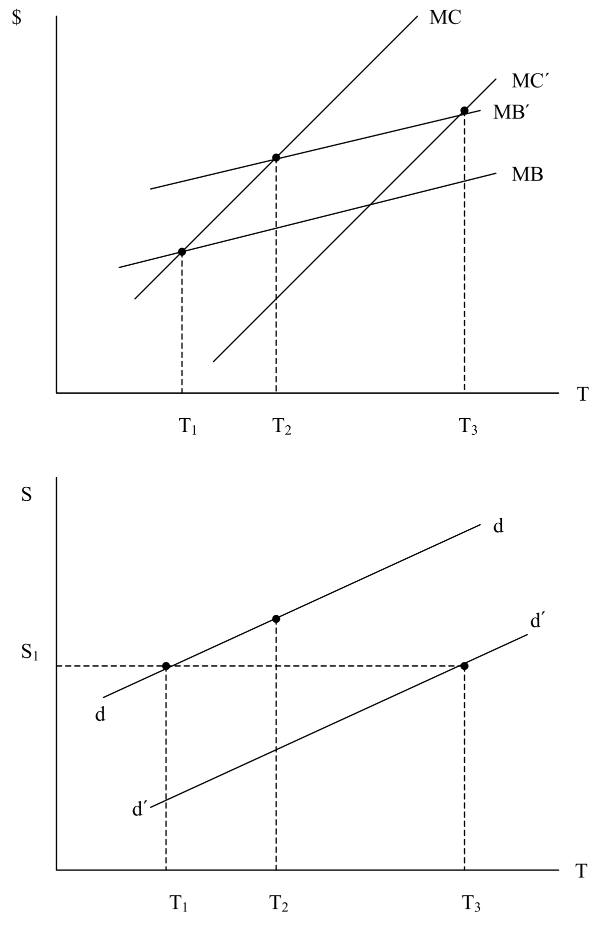

Figure 12. Effect of development fee on timing and density when demanded density is rising over time: Example of a neutral effect on density.

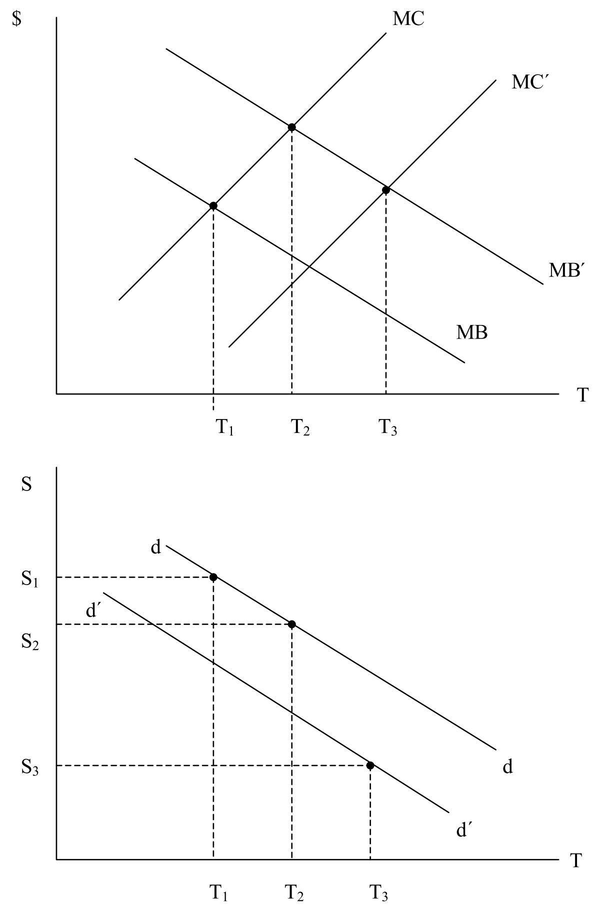

Figure 13. Effect of development fee on timing and density when demanded density is falling over time.

development, it also increases the structural density from S_1 to S_2 in the figure. The framework used here, however, is more general than McFarlane's in that it also allows for decreasing demanded density over time. In this case the development fee levied per unit of land lowers the structural density at such locations, from S_1 to S_2 in Figure 13.

It is interesting to also note that this development fee does not match slowing development with the solution to a specific identified market failure attributable to decreasing returns to scale or congestion externalities that are tied to population rather than the quantity of land developed. While imposing the development fee slows the development pace, the policy has varying effects on population, since that effect in part depends upon how density changes. Nonetheless, such a fee increases the cost of development when undertaken, slowing the pace of development in the affected region. But, even aside from the second-best normative concerns raised earlier, there is no reason to expect a general slowing of development to necessarily enhance the well-being of residents in the locale.

When the fee varies with planned structural density ($D' > 0$) there is an additional direct affect on investors' plans for how to develop the property. In this situation the development fee becomes a tax on buildings. Static analysis shows that such taxes generally tend to reduce development density and increase the total area of land that is developed to accommodate a given population (Brueckner, 1986). In a growing economy, though, this type of a development fee will also affect the pace of development (Turnbull, 1988a, 2004b). The question is, how?

When the development fee varies with structural density then the tax has an additional effect similar to higher marginal development costs. Increasing the marginal development cost can have a surprisingly wide range of effects in dynamic models (Turnbull, 1988a). Looking at (17), for example, the greater marginal cost of density decreases the best use density for each time period, which is reflected in the downward shift of dd to $d'd'$ in Figures 12 and 13. Substituting the lower density at each T into the timing condition lowers the development cost term, but if the presence of the development fee $D(\tilde{S}(T))$ increases the left hand side of the above condition, the MB shifts upwards. The lower best use density associated with each T decreases the right hand side in the timing condition, shifting the MC downwards in the figures. When the demanded density is falling, the development fee unambiguously decreases the density from S_1 to S_3 (Figure 13), a result consistent with the static analysis. When the demanded density is rising, however, the fee lowers the density for any given development time (the downward shift in $d'd'$) while the slower development pace tends to increase density (the movement along $d'd'$), leaving the net effect of the development fee ambiguous. A larger (smaller) shift in dd than pictured in Figure 12 will lower (raise) the structural density. While increasing structural density is not what one would expect to find in light of the established static results, it is nonetheless possible under reasonable conditions in the dynamic context.

This also explains the otherwise surprising neutrality result reported in McFarlane (1999). That study finds that this type of development fee slows the development pace but has no effect on planned structural density when technology is Cobb-Douglas. Figure 12 reveals why this is a special case of rising demanded density, which is implicitly assumed inMcFarlane's Cobb-Douglas model. The lower panel of the diagram presents an example of where the downward shift in the $d'd'$ curve (from the lower best use structural density due to the tax on structures) just offsets the rightward movement along the $d'd'$ curve from the delayed optimal planned development time (which follows from the top panel). As a result, planned development is delayed by the fee while there is no net change in planned density.

10. Conclusion

This paper explains the thrust of recent research on how land use regulations affect the pace and pattern of urban development. The purpose was not to break new ground, but rather to take a broader view to provide a nontechnical survey and to help uncover any discernible general principles or patterns across the different studies. Pulling the results together, several broad patterns emerge.

The challenges to property rights arising from the threat of land regulation affects investment incentives differently than property rights uncertainty engendered by unclear legal standards, capricious enforcement, or public sector corruption. While poorly defined or defended property rights in general lead to a slower pace of development in an economy, the threat of land use regulation generally creates incentives for more rapid development than would otherwise be observed in the market. The discussion here provided an informal explanation for the observed difference and how the specific nature of the threat to property rights matters when considering the way it alters investment incentives.

The effect of threatened regulation on the planned structural density varies across the urban area and systematically depends upon the growth pattern in the underlying land demands by competing land uses. In general, though, regulation risk decreases the planned structural density at locations where the demanded density is rising over time, that is, at sites where the current best use has a lower structural density than the future best use. Similarly, regulation risk increases the planned structural density at locations where the demanded density is falling over time, or where the current best use has a higher structural density than the future best use.

These papers provide positive analysis of the regulation-development nexus. The results give a starting point for formal dynamic welfare analysis, weighing the direct effects of policy on regulated land against the intertemporal distortions for unregulated land. Since unregulated land subject to regulatory risk is generally developed more quickly than is socially efficient, this effect must be taken into account and weighed against the efficiency gain accomplished by resolving the externality incentives effects for regulated land. This regulatory compromise is in addition to the second-best effects identified at the outset. The conclusions that will be derived from research focused on these and other normative issues are not obvious at this point, but existing studies suggest that the normative efficiency rules arising from the popular static perspective will not generalize to the dynamic environment (Turnbull, 2004b). More work must be done in this direction, however, before we can hope to see general principles emerge for weighing the relative dynamic efficiency of different regulatory regimes.

There are other important aspects of land use regulation that need to be considered. In the positive vein, the partial equilibrium results need to be aggregated to the urban area. The complications here are daunting. Zoning and related types of planning and regulation are often local government functions. Thus, aggregating to the urban area means that, not only must the intertemporal aggregation across time be tied together through the capital and property markets, but the property markets must also be aggregated over multiple jurisdictions, each pursuing their own policies.

As stated at the outset, one goal of this paper was to stimulate further thought and research on these and related issues concerning land use policies as viewed within a dynamic context. The other goal, perhaps more important for this particular effort, was to offer a self contained survey that appeals to a broader audience. Although much simplified, the graphical device used throughout most of this paper provides a useful framework with pedagogical as well as analytical value.

Notes

1. Riddiough (1997) and Turnbull (2002) examine development prohibition, Turnbull (2004a) development moratoria; and Ellson and McDermott (1987), Geltner et al. (1996), Titman (1985), Turnbull (1991, 2002) study restrictions on allowed use.
2. See Brueckner (2000) for an overview of dynamic land market models with durable capital or costly redevelopment.
3. See, for example, Anderson (1986), Arnott and Lewis (1979), Bentick (1979), Kanemoto (1985), Mills (1981, 1982), Sinn (1986), Tideman (1982), and Turnbull (1988b).
4. The normative consequences are more troublesome, though; the efficient development pace is slower than the market determined pace, so full compensation is not dynamically efficient.
5. In contrast, models in which the urban rent function, $f(t)$, is not explicitly a function of development time represent special cases of the FWT or Anderson versions of the model corresponding to $R_{St} = 0$ in the FWT approach. Turnbull (1988b), however, shows that $R_{St} = 0$ can hold for a set of locations with measure zero within a growing monocentric urban area comprising homogeneous residents. This conclusion is relevant for dynamic investment timing models using continuous time option pricing formulae. See, for example, the models used in Geltner et al. (1996) and Riddiough (1997).
6. See Fujita (1982), Turnbull (1988b), and Wheaton (1982) for analysis of the factors determining increasing or decreasing demanded density at different locations in the same urban area.
7. Differentiating the *MB* yields $MB' = C'S'(T)$, which takes the sign of S', that is, the slope of the *dd* curve. The *MB* is upward (downward) sloped when the demanded density is rising (falling) over time, as drawn.
8. The urban preserve concept can be intepreted as an officially sanctioned leapfrog development pattern. As such, the urban preserve policy might be evidence that growth control advocates are beginning to recognize that leapfrog development is not *prima facie* evidence of inefficient private markets.
9. The assertion here is that the distinction between police power and regulatory taking prompts local governments to follow the Pareto rule when exercising land use controls. This ex post efficiency will not hold to the extent that the standard of proof for police power is low (as in *Tahoe-Sierra*, as an example). In any case, this distinction affects the normative interpretation of the results but not the positive effects that are the primary concern here.
10. The concept of rising or falling demanded density over time is not meaningful in this model. Since $dS_i/dP_i > 0$, the structural density in the second period is greater for P_1 than for P_2; in terms of the earlier models, this framework assumes that the demanded density either rises (if P_1 realized) or falls (if P_2 realized). Further, the *expected* structural density will either rise or fall over time, depending upon the underlying probabilities of each outcome.
11. The presence of a statute of limitations can extinguish many prior competing claims so that $\dot{p} = 0$ after that point (Miceli et al., 2003).
12. The courts in many states apply a three part test for development fees: the fee must be rationalized by some additional costs or damages associated with the new development, the funds raised by the fee must be segregated from general revenue funds, and there must be a reasonable possibility that the new residents or land users will benefit from the expenditures supported by the fee. In application, these criteria do not identify the fee as a Pigovian corrective tax. They do not require matching the fee with marginal externality costs and in general they bear at best a strained resemblance to the efficiency rationale articulated by Brueckner (1997).

References

Alchian, A., and H. Demsetz. (1973). "The Property Rights Paradigm," *Journal of Economic History* 33, 16–27.

Anderson, J. E. (1986). "Property Taxes and the Timing of Urban Land Development," *Regional Science and Urban Economics* 16, 483–492.

Arnott, R. J., and F. D. Lewis. (1979). "The Transition of Land to Urban Use," *Journal of Political Economy*, 87, 161–169.

Baker, M., T. J. Miceli, C. F. Sirmans, and G. K. Turnbull. (2001). “Property Rights by Squatting: Land Ownership Risk and Adverse Possession Statutes,” *Land Economics* 77, 360–370.

Bentick, B. L. (1979). “The Impact of Land Taxation and Valuation Policies on Timing and Efficiency of Land Use,” *Journal of Political Economy* 87, 858–868.

Besley, T. (1995). “Property Rights and Investment Incentives: Theory and Evidence from Ghana,” *Journal of Political Economy* 103, 903–937.

Blume, L., D. Rubinfeld, and P. Shapiro. (1984). “The Taking of Land: When Should Compensation Be Paid?” *Quarterly Journal of Economics* 99, 71–92.

Bohn, H., and R. J. Deacon. (2000). “Ownership Risk, Investment, and the Use of Natural Resources,” *American Economic Review* 90, 526–549.

Brueckner, J. K. (1986). “A Modern Analysis of the Effects of Site Value Taxation,” *National Tax Journal* 39, 49–58.

Brueckner, J. K. (1997). “Infrastructure Financing and Urban Development: The Economics of Impact Fees,” *Journal of Public Economics* 66, 383–407.

Brueckner, J. K. (2000). “Urban Growth Models with Durable Housing: An Overview.” In J.-M. Huriot and J.-F. Thisse (eds.), *Economics of Cities*, Cambridge, UK: Cambridge University Press.

Demsetz, H. (1967). “Toward a Theory of Property Rights,” *American Economic Review, Papers and Proceedings* 57, 347–359.

Dolan v. City of Tigard, 194 U.S. 4826 (1994).

Ellson, R., and J. McDermott. (1987). “Zoning Uncertainty and the Urban Land Development Firm,” *Journal of Urban Economics* 22, 209–222.

Feder, G., T. Onchan, Y. Charbain-Wong, and C. Hongladarom. (1988). *Land Policies and Farm Productivity in Thailand*, Baltimore: Johns Hopkins University Press.

Fischel, W., and P. Shapiro. (1988). “Takings, Insurance, and Michelman: Comments on Economic Foundations of ‘Just Compensation’ Law,” *Journal of Legal Studies* 17, 269–293.

Fujita, M. (1982). “Spatial Patterns of Residential Development,” *Journal of Urban Economics* 12, 22–52.

Geltner, D., T. Riddiough, and S. Stojanovic. (1996). “Insights on the Effect of Land Use Choice: The Perpetual Option on the Best of Two Underlying Assets,” *Journal of Urban Economics* 39, 21–50.

Innes, R. (1997). “Takings, Compensation, and Equal Treatment for Owners of Developed and Undeveloped Property,” *Journal of Law and Economics* 40, 403–432.

Kanemoto, Y. (1985). “Housing as an Asset and the Effects of Property Taxation on the Residential Development Process,” *Journal of Urban Economics* 17, 145–166.

Lucas v. South Carolina Coastal Council, 505 U.S. 1003 (1992), *rem’g*, 404 S.E. 2d 895 (S.C. 1991).

McFarlane, A. (1999). “Taxes, Fees, and Urban Development,” *Journal of Urban Economics* 46, 416–436.

Miceli, T. (1991). “Compensation for the Taking of Land Under Eminent Domain,” *Journal of Institutional and Theoretical Economics* 147, 354–365.

Miceli, T. J., C. F. Sirmans, and G. K. Turnbull. (2000). “The Dynamic Effects of Land Title Systems,” *Journal of Urban Economics* 47, 370–389.

Miceli, T. J., C. F. Sirmans, and G. K. Turnbull. (2003). “Land Ownership Risk and Urban Development,” *Journal of Regional Science* 43, 54–73.

Mills, D. E. (1981). “The Non-Neutrality of Land Value Taxation,” *National Tax Journal* 34, 125–129.

Mills, D. E. (1982). “Reply to Tideman,” *National Tax Journal* 35, 115.

Nollan v. California Coastal Commission, 483 U.S. 825 (1987).

North, D., and R. Thomas. (1973). *The Rise of the Western World: A New Economic History*, Cambridge, UK: Cambridge University Press.

Pennsylvania Coal v. Mahon, 260 U.S. 393, 413 (1922).

Riddiough, T. J. (1997). “The Economic Consequences of Regulatory Taking Risk on Land Value and Development Activity,” *Journal of Urban Economics* 41, 56–77.

Rosenberg, N., and L. E. Birdzell. (1986). *How the West Grew Rich: The Economic Transformation of the Industrial World*, New York, NY: Basic Books.

Sinn, H. (1986). “Vacant Land and the Role of Government Intervention,” *Regional Science and Urban Economics* 16, 353–385.

Tahoe-Sierra Preservation Council v. Tahoe Regional Planning Agency, 535 U.S. _ (2002).
Tideman, T. N. (1982). "A Tax on Land is Neutral," *National Tax Journal* 35, 109–111.
Titman, S. (1985). "Urban Land Prices under Uncertainty,"*American Economic Review* 75, 505–551.
Torstensson, J. (1994). "Property Rights and Economic Growth," *Kyklos* 47, 231–247.
Turnbull, G. K. (1988a). "Residential Development in an Open City," *Regional Science and Urban Economics* 18, 307–320.
Turnbull, G. K. (1988b). "The Effects of Local Taxes and Public Services on Residential Development Patterns," *Journal of Regional Science* 28, 541–562.
Turnbull, G. K. (1991). "A Comparative Dynamic Analysis of Zoning in a Growing City," *Journal of Urban Economics* 29, 235–248.
Turnbull, G. K. (2002). "Land Development under the Threat of Taking," *Southern Economic Journal* 69, 468–501.
Turnbull, G. K. (2004a). "Development Moratoria," *Journal of Housing Economics* 13, 155–169.
Turnbull, G. K. (2004b). "Urban Growth Controls: Transitional Dynamics of Development Fees and Growth Boundaries," *Journal of Urban Economics* 55, 215–237.
Wheaton, W. C. (1982). "Urban Residential Growth under Perfect Foresight," *Journal of Urban Economics* 12, 1–21.