When Does Land Use Regulation Lower the Average Price of Housing in Cities?

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Abstract

Previous theoretical analysis using classical urban models suggests that planning restrictions on structure density raise average house price in cities. This paper demonstrates that these past results are an artifact of special assumptions about planning. When realistic regulations are applied to either classical or neoclassical models, the average housing price falls compared to laissez faire in the absence of amenity benefits. Therefore, the standard empirical finding that housing prices rise with regulation implies that planning raises urban amenity. This illustrates the importance of using realistic models to analyze the data generating process when testing empirical implications of urban policies.

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Introduction

Land use regulation that lowers residential density has two obvious effects on urban housing markets when compared to laissez faire development. The first is a supply effect. Regulation lowers structure density. Holding population constant, this increases the city radius and shifts the bid rent curve for housing upward. The result is higher housing price at any given radius. Second is an amenity effect which also raises housing price if lower density and open space raises willingness to pay for housing in the city. The Rosen-Robuck model literature documents the amenity effect on housing prices.[1] Given that laissez fair market development ignores negative externalities associated with density, planning may be a rational response to market failure.[2]

For policy purposes, it is necessary to determine the size of these supply and amenity effects in order to determine what, if any, types of planning restrictions can provide welfare enhancing restrictions on laissez faire development. The obvious difficulty in empirical testing of the supply and amenity effects of planning is that both effects appear to shift housing prices in the same direction. A finding that removing planning restrictions lowers local housing price is not a dispositive test of either supply or amenity effects because it is consistent with both. Raising density lowers price by increasing supply but the higher density could lower amenity and that would also lower price. Therefore the empirical finding that housing prices vary directly with planning regulation is not dispositive regarding the importance of the supply versus amenity effects.[3] This concern about separating supply and amenity effects of land use regulation is not

[1] Berliant and Mori (2017) note research showing a direct effect of amenity on city size.

[2] This contrasts with the treatment of planning or topography in Saiz (2010) in which amenity and productivity are treated as equivalent shocks that are not a function of laissez faire density. Consequently housing price is not modeled as a cause of efficient regulation and the amenity effect of density is ignored.

[3] This paper ignores the empirical difficulties associated with measuring effects of regulation on the user cost of housing. A list of empirical difficulties includes the fact that asset prices are observed for some units and rental prices for others. In some large cities half of all units are rental and the spatial distribution of unit types is not uniform. Neighborhood amenities are jointly provided with housing units. The ideal measure is the price of

new, see, for example, Ihlanfeldt (2007). A further challenge to identifying the relation between price and planning is that higher prices incentivize the higher laissez faire density that provides a rational for more planning restrictions. Therefore, if there are negative density externalities, a full model would consider the possibility that high prices cause greater regulation designed to limit negative density externalities associated with laissez faire production. That is, in an optimal city, higher prices cause more restrictive density regulations. For a theoretical demonstration of this result, see Lin (2024).

Two general empirical approaches have been used to determine the effects of planning restrictions on the cost of housing. The first can be termed "micro testing." This literature attempts to identify the very local effects of planning regulations on nearby housing prices. The second can be called "macro testing" because it relates measures of overall land use and building restrictions in a city to the average price of housing in that city. As noted above, both patterns of testing find a positive association between restrictions on laissez faire development and housing price. Given the prior theoretical expectation that both supply and amenity effects are positive, this testing is not dispositive regarding the importance of either effect.

Additional micro testing has uncovered negative externalities associated with lack of sunshine and unhealthy air associated with building density.[4] Pricing these negative effects so that they can be used to judge optimal density restrictions has been challenging. In a recent breakthrough, Lin (2024) has designed and implemented a dispositive micro test which separates the supply and amenity effects of density. His measure of the negative amenity externality effects associated with density is so large that it can justify substantial restrictions on laissez faire building density. This research illustrates the importance of designing dispositive tests capable of

interior space but housing prices are observed for units. Therefore, smaller units are over-counted in measuring space cost. The diversity in housing stock itself makes characterizing cost of a standard unit challenging. Rodriguez-Pose and Storper (2020) note that characterizing the city limit in empirical research is problematic. By relying on theory, this paper is able to avoid these empirical problems of constructing city average housing price indexes.

[4] For example, specific examples negative amenity effects of added density are identified by Fleming, et al (2018), and Davidoff, Pavlov, and Somerville (2022). Buchler and Lutz (2021) find that removing binding regulations in a small area results in additional supply but no change in prices. Freemark (2020) finds that upzoning increased asset prices in Chicago as land values rose after deregulation. An extensive discussion of micro testing supply issues is found in Baum-Snow (2019) and Baum-Snow and Han (2024). Brueckner, et al (2017), and Brueckner, and Singh (2020) develop the theory of micro supply effects in the absence of amenity effects.

distinguishing between supply and amenity effects of regulations limiting development density. It also shows that the negative amenity effects of density may be substantial.

This recent finding regarding large positive micro amenity effects of localized zoning decisions is very important but it does not imply that the aggregate effects of planning restrictions, i.e. the macro effects of zoning on entire cities, are welfare enhancing. There is abundant empirical evidence in the macro testing literature, confirmed recently by Gyourko and Krimmel (2021), using new regulatory measures from Gyourko, Hartley, and Krimmel (2021), that there is a positive empirical relation between intercity differences in planning regulation and the average asset price of city housing. Recently, Molloy, Nathanson, and Paciorek (2022) have reported that the relation between rent and regulation is substantially smaller than the asset price relation but it is still positive.

This empirical result is consistent with planning having a positive amenity effect. Previous research has also held that the supply effect of planning on average housing price is also positive. Thus the macro empirical finding of a direct relation between planning and average house price does not appear to be dispositive because it is consistent with both the amenity and supply effects. However, the models in Green, Malpezzi, and Mayo (2005) and Saiz (2010) that have been used to support the theoretical expectation that planning restrictions raise average city housing price have been based on a highly stylized characterization of planning. Specifically the theory has assumed that planning is equivalent to cutting a uniform slice out of a circular land market which has no amenity effect and renders land unavailable for housing or transportation. Given this characterization of the city as a pie with a slice whose size is an increasing function of regulation missing, it can be shown that the average of price of city housing will vary directly with regulation. If this theoretical result is accepted, then both the amenity and supply hypotheses regarding the effects planning on average housing price are identical and empirical finding of a positive relation is not dispositive between the two hypotheses.

The contribution of this paper is to overturn the result in previous theoretical models supporting the macro testing literature that the supply effect of common density or floor area ratio (FAR) regulations imposed in cities raises the average price of housing. This paper demonstrates that the pure supply effect of a realistic theoretical model of planning regulations should lower the average price of housing compared to laissez faire. This new finding means that macro testing of

the relation between levels of density regulation and the average price of housing in cities is dispositive between the supply and amenity effects. Specifically the positive relation between planning and average housing price in empirical macro testing indicates that there are substantial amenity benefits of planning because the pure supply effect should lower average housing price.

The theoretical argument made in this paper will appear counterintuitive to those familiar with the previous literature because the laissez faire housing market produces the lowest supply price of housing at each distance from the center, i.e. it produces the lowest housing price gradient. It is certainly true that, compared to laissez faire, density regulation raises the housing price profile of the city so that price at any distance from the center increases. However, planning also changes the spatial distribution of housing density. In particular, it lowers density in the parts of the city where laissez fair density is greatest and housing price is highest. The assumption that the average city housing price depends only on the height of the housing price profile can be thought of as an application of the fallacy of composition or alternatively of Simpson's paradox.[5] This paper demonstrates that, if there is no amenity effect of planning, the pure housing supply effect of standard floor area ratio (FAR) planning restrictions can raise or lower the average housing price compared to laisez faire development depending on the way in which regulation modifies the spatial distribution of housing. Furthermore, a realistic characterization of the effects of regulation on the spatial distribution of housing demonstrates that the supply effect causes housing prices to fall with regulation if there is no amenity effect.

The fallacy of composition argument made here is easily illustrated by a simple example. Consider a rather large puddle of water whose depth varies considerably. Now submerge a brick at the deepest point of the puddle. The height of the water rises at each location and puddle circumference expands. However, the average depth of water in the puddle will likely fall as the fraction of water at the deepest point falls due to displacement by the brick and expansion takes place at the shallowest points of the puddle. Alternatively, the argument can be viewed as an illustration of Simpson's paradox in which average housing price at each distance from the city

[5] Simpson's paradox states that the difference in two series of averages is not the same as the overall differences in averages because it ignores the distribution of observations generating the averages. The paradox is easily illustrated. One baseball player can have a higher batting average in every year than another player but still have a lower lifetime batting average because the distribution of plate appearances across years is not identical.

center rises but average housing price in the entire city falls as the fraction of housing near the center falls.[6]

For those who consider these statements about paradoxes to be counterintuitive, a simple thought experiment shows that they are actually intuitive. Central Park in New York is a major example of land use restriction in the city. Imagine that this restriction was lifted. High density housing would be constructed on the park land. It would be the highest cost housing in the city. Ignoring amenity effects, this new housing would displace more remote housing in the city and the average price of city housing would rise as a result of relaxing the planning restrictions, i.e. planning restrictions and housing price would vary inversely.

The remainder of this paper will present a theoretical analysis of the difference in the average price of housing in cities between laissez faire and development under density restrictions. The analysis will assume that planning has no amenity effect so that the pure supply effect on average price is clear. Because the previous literature has tended to rely on highly stylized models of regulation using classical models of the urban land market, these approaches are considered first. Then the analysis is extended highly stylized models of a neoclassical urban housing market. The theoretical effects of these stylized models of regulation, on a neoclassical housing market are considered. In all cases, the data generating process producing the average city housing price is modeled explicitly. The results demonstrate that the supply effect of regulation on the average price of city housing depends on the manner in which the regulation is implemented.

Finally, theoretical results are derived consistent with standard neoclassical models in using actual patterns of density regulation taken from the literature. These results demonstrate that a realistic characterization of density regulation produces a supply effect that lowers the average price of housing in regulated cities below that expected under laissez faire. Thus, the answer to the question posed in the title of this paper is that, if land use regulation than has no amenity effect, i.e. only a pure supply effect, then regulation would lower the average price of city housing. Therefore, the positive relation between indexes of regulation and average price found in the empirical literature is dispositive between the supply and amenity effects. It indicates that

[6] Alternatively one could regard the finding, demonstrated in this paper, that the direction of change in a city housing price pros a file or gradient does not imply that the average price of housing changes in the same direction as a new paradox.

regulation has substantial amenity effects that overcome the negative supply effects. This conclusion contrasts sharply with previous literature.[7]

II. Stylized planning models and housing price in a classical city

This section considers three alternative stylized but simplistic theoretical characterizations of planning regulation. First, and by far most common in previous literature, is the proportional open space assumption in which a fraction, Λ, of land at each distance from the city is removed from development due to planning. This fraction can also be related to topography rather than regulation. It is assumed that changing open space has no effect on amenity or transportation. Second, is a proportional density restriction applied to the entire city that limits the ratio of interior space to land to a fraction of laissez faire density. Third, is a planned central open space such as the classic plaza, central park, or mall found at the center of many cities. This possibility has not been considered previously. In reality, any given city may have a mix of these planning regulations implemented in a patchwork pattern across space. Furthermore, actual regulations may be more or less binding and granting of exceptions can be generous or limited.

The primary reason for considering a classical land market model in this section is that previous literature has made this assumption, i.e. that the supply of interior housing space is based on a Leontief production function and each household consumes one unit of housing.[8] Furthermore, the mathematical analysis is quite straightforward.

In a classical city, households consume a standard quantity of housing, h, and the housing production function is Leontief, so that:

$$H = Min\ [\alpha l, \beta s] \qquad (II\text{-}1)$$

[7] Quigley and Rosenthal (2005) reviewed 40 studies and concluded that the empirical evidence on house price effects of land use regulation was mixed. Subsequent research using new indexes of regulation indicates a positive relation between these measures and average housing price. A number of papers, including Hsieh and Moretti (2019), Howard and Lieberson (2021) and Duranton and Puga (2023), have blamed planning for raising housing prices without producing compensating benefits and seriously distorting allocation of labor across cities. Rodriguez-Pose and Storper (2020) argue that distortions in the spatial allocation of labor due to regulation are not significant.

[8] See, for example Green, Malpezzi, and Mayo (2005), Saiz (2010), Albouy, et al (2019) and Duranton and Puga (2023).

where H is the quantity of housing space, l is land, s is structure inputs, and α and β are parameters reflecting output per unit input. Producers of housing will set $\alpha l = \beta s$ so that housing output is a simple multiple of land, $H = \alpha l$. Classical households consume a fixed amount of housing, h, which is normalized to unity to economize on notation. The housing producer's cost function at any location is:

$$C = rl + is \qquad (II\text{-}2)$$

where r is the rental price of land at that location and i is the rental price of structure inputs which is invariant. Competition forces developers to set price equal to average cost so that:

$$C/H = rl/H + is/H = rl/\alpha l + is/\beta s = r/a + i/\beta = p \qquad (II\text{-}3)$$

with p equal to the rental price per unit of housing and p_o the price at the city center where $k = 0$. H is both the number of units and the amount of space supplied because h is normalized to unity. If the city limit is at distance k^* from its center, p^* is housing price at that limit, γ is the cost of converting rural to urban land, and the opportunity cost of raw land, commonly called the rental price of agricultural land, is r_A, then:

$$r_A + \gamma = r^* = a[p^* - i/\beta] = a[p_o - tk^* - i/\beta] \quad or$$

$$k^* = (p_o - p^*)/t \quad and \quad p^* = (r_A + \gamma)/\alpha + i/\beta \qquad (II\text{-}4)$$

In this classical model, housing supply, both space and units, is proportional to land in the city used for housing.

The parameter γ in *(II-4)* deserves special attention. This is the cost of converting agricultural land into finished land suitable for residential development. There is a significant empirical problem in determining both the size and effect of regulations on the supply price of housing near the city perimeter. This arises because of the massive infrastructure costs associated with converting an agricultural region into buildable urban land that are not faced by builders in a developed urban area. Some of these costs are experienced by developers including: planning, grading, drainage, local streets, utilities, etc. Costs for congestible facilities provided by local governments include, fire, police, parks, playgrounds, schools, etc. In some cases, these costs of local public goods are imposed on new construction in the form of impact fees that should not be confused with the planning regulations considered here. Brueckner (1987) has argued that these

regulatory fees are retained by local government and presumably result in lower property taxes. Therefore, the practice of requiring new construction at the city edge to pay for infrastructure with impact fees rather than higher property tax has no net effect on development of the city. These costs, all included in γ, would need to be paid by developers or homeowners under laissez faire as higher property taxes. In addition, Capozza and Helsley (1990) note that development is a non-reversible real option that has a significant value depending on the stochastic pattern of housing price change. Zhao (2022) has been recently embedded in these effects in a fully dynamic model which includes planning regulation.

In the following counterfactual exercises, the average price of housing space in a laissez faire city is compared to that in various planned cities in which different types of stylized land use regulations are imposed. Total housing supply in the city is held constant in each of these comparative exercises. For notational convenience, small letters, $p(k)$, p^*, p_o, p_{Avg}, k, k^*, and $r(k)$, are used to represent the price per unit interior space at any distance, price at the city edge, price at the city center, average price (quotient of total rent and total space), distance from the city center, and distance at the edge of the city under laissez faire. Capital letters reflect values of these variables under alternative sets of planning restrictions. Density of housing units under laissez faire or regulation, which is always constant and equal to l/α, is given by D.

The average price of housing space, computed as the quotient of total rental revenue and total interior space, is solved for the three stylized representations of land use regulation holding aggregate city housing supply constant.[9]

Case 1: Removing a constant fraction of land at each radius

This stylized land use restriction dominates the literature. Assume that the city be located on a featureless plane and that regulators only allow a fraction, $0 < \Lambda < 1$, of the land at each distance from the center for housing development. Following the assumptions in the literature, this policy creates no benefits that influence willingness to pay for housing in the city and the excluded land is not used for any productive purpose such as transportation. This regulation does not change p^*.

[9] In a classical model, housing supply and population are equal because there is one household for each homogeneous housing unit. Use value of housing is computed as opposed to option value.

The average housing price in a two-dimensional laissez faire city, where $\Lambda = 1$, is given by: $p_{Avg} = p_o - tk^*/3 = p^* + (2/3)tk^*$.[10] The average price of housing in the city subject to a land use restricting development to a share $0 < \Lambda < 1$ of all possible land exceeds that under laissez faire by an amount equal to:

$$P_{Avg} - p_{Avg} = (2/3)tk^* [(1/\Lambda)^{0.5} - 1] = (2/3)(p_o - p^*)[(1/\Lambda)^{0.5} - 1] > 0 \qquad (II\text{-}5)$$

It is not surprising that for large cities with large radius k^* and/or higher t resulting in a large difference $(p_o - p^*)$, the removal of a uniform fraction of land from development raises average housing price compared to laissez faire substantially. This highly stylized representation of the effects of planning is commonly used, see Saiz (2010).[11] It has led to the conclusion that the supply effect of planning regulation raises the average price of housing in cities.

Case 2: Reducing housing density uniformly at all locations

Laissez faire density is $D = 1/\alpha$ in equation *(II-1)* and regulation lowers density by a uniform fraction, ψ, $0 < \psi < 1$. Regulation has no effect on p^*. For a two-dimensional city, as noted above, laissez faire average price is $p_{Avg} = p_o - (2/3)tk^*$ and the difference in average price between the uniform density regulated city and laissez faire is:

$$P_{Avg} - p_{Avg} = (2/3)(tk^*)[(1/\psi)^{0.5} - 1] = (2/3)(p_o - p^*)[(1/\psi)^{0.5} - 1] > 0 \qquad (II\text{-}6)$$

The results for the effect of proportional land restriction and density regulation are analogous. For density regulation, the margin between the regulated and laissez faire price is smaller for three reasons. First for given housing supply, city radius is smaller. Second $k^*/3 < k^*/2$ even ignoring the shorter radius. Third $(1/\psi)^{0.5} < (1/\psi) \mid 0 < \psi < 1$. However, these case 2 results are quite similar to case 1 and agree well with general intuition. Accordingly, the fact that the literature has concreted on case 1 does not appear to be not particularly consequential because results of case 2

[10]Similar results are easily obtained for a one-dimensional city.

[11] The assumption that planning excludes a fixed proportion of land has also been used to argue that planning lowers the elasticity of housing supply. However, given that housing supply is proportional to city land area, it is easy to show that this result is incorrect because housing supply elasticity is not a function of Λ. Aggregate housing supply in a classical two-dimensional model is given by $H = \int_o^{k^*} (\Lambda 2\pi\alpha)\, k\, dk = (\Lambda\pi\alpha)\, k^{*2}$ where k^* is the city limit that is a function of housing price. Taking logs of this expression and differentiating it is easily seen that $dlog\ H/log\ dk^* = dlog\ H/log\ dp_o = 2p_o/(p_o - p^*)$ and housing supply elasticity in a given city is not a function of the level of Λ in that city. As $p^* \rightarrow 0$, housing supply elasticity in a classical model is constant and equal to *2* regardless of the level of Λ. This point appears to the confused in the housing supply elasticity literature.

are similar. Planning regulation has a positive supply effect on average housing price even when it has no amenity effect.

Case 3: Inserting open space at the city center: mall, plaza, or central park planning

In this alternative stylized case, planners insert open space at the city center. Curiously, this type of planning innovation has not been considered in the literature although it is common in practice. Again, it is assumed that there is no amenity benefit to residents associated with this open land. The price at the city limit is constant at the value of p^* determined by *(II-4)*. The park or mall extends from $k = 0$ to $k = \mu k^*$, $0 < \mu < 1$. The average housing price for the laissez faire city is the same as for cases 1 and 2 above.

The contrast in results between case 3 and either cases 1 or 2 is substantial. The difference arises because city radius only rises to $K^* = (1 + u^2)^{0.5} k^*$ in order to hold city housing supply constant. Given that $(1 + u^2)^{0.5} < (1 + u)$, $K^* < k^*(1+ u)$ and it follows that the radius of the city net of the mall is smaller than the radius of the laissez faire city. Consequentially, the price of housing at the edge of the mall is less than laissez faire price at the city center, $P(\mu k^*) = p^* + t(K^* - \mu k^*) < p_o = p^* + tk^*$. Most important, the effect of planning on the average housing price under regulation with a mall is below that under laissez faire!

$$P_{Avg} - p_{Avg} = tk^* [(1+\mu^2)^{0.5} - (1+\mu)] < 0 \qquad (II - 7)$$

For example if $\mu = 0.1$, $P_{Avg} - p_{Avg} = tk^*(-0.095)$ which is a substantial fall in average price associated with the mall planning strategy. Indeed the fall in housing price is almost proportional to the size of the mall. The sharp contrast in the sign of the supply effect of land use planning on the average price of housing space between the stylized mall specification and the previous two cases suggests that simple stylized assumptions can mislead.[12] The fallacy of composition applies to the mall but not to cases 1 and 2, because this open space effectively shifts the spatial distribution

[12] There is a simple intuitive argument for the different results obtained for case 3 versus cases 1 or 2. In cases 1 and 2, the spatial density of function housing at any distance, k, is either constant or proportionally lowered under planning. Therefore the effect of planning on housing price is due entirely to the $P(k)$ function which is minimized under laissez faire. In case 3, both the $P(k)$ and housing density functions shift and the net effect lowers average housing price because the change in the density function dominates.

of housing density across the city compared to laissez faire as suggested by the brick in the puddle example in the introduction.

This concludes the analysis of the effects of the three alternative stylized theoretical characterizations of the supply effects of planning regulation using a classical land market model. Clearly, in any actual city, planning will include some complex combination of these land use strategies. Because the effects of the stylized characterizations on the difference in average house price between the planned and laissez faire city do not even agree in terms of sign, this suggests that generating theoretical implications of the supply effect in any real world observed planning strategy requires a more realistic specification of the regulatory environment.

III. Stylized planning specifications and housing price in a neoclassical city

This section considers the effects of the three alternative highly stylized representations of planning regulations on the supply price of housing in a neoclassical city in which the density of housing varies directly with the price of housing services. Because density varies with location in the neoclassical model, opportunities for specifying planning regulations based on density, or floor area ratio (FAR) are enhanced. The effects on average housing price of the three stylized specifications of planning regulation holding city housing supply constant are generated as they were for the classical market in the previous section. The assumption that planning policy can be represented by a simple planning parameter in each case is be maintained here.

The neoclassical urban housing model used for comparative analysis here assumes that housing is produced using structure and land inputs according to a neoclassical production function. The specification adopted here is based on Bertaud and Brueckner (2005) and follows logically from Muth (1975). The two functions which are structural equations derived from the model and used here to compute the effects of density regulation on average housing price are the housing price function $p(k)$, and the housing density function $H(k)$. Muth (1961) is generally credited with the first formal derivation of these price and density functions from housing production, housing demand and transportation cost functions.

A substantial empirical literature, discussed in Larson, et. al (2022), has used a negative exponential functional form to estimate the housing price and density gradients of cities in a variety of countries at different time periods. Recently Liotta, Viguie, and Lepette (2022) have provided

substantial support for application of this model to cities around the world. The specific negative exponential form for the price and density functions has recently been tested by Qiang, Zu, and Zhang (2020) who find it is most often superior to alternative, but similar, non-linear functional forms.

A fraction of households at each radius within the city commute to the city and choose location subject to an iso-utility condition such that housing prices in a laissez faire city follow a negative exponential distribution to compensate for the commuting cost which increases with k:

$$p(k) = p_o\, e^{-\theta k} \qquad \textit{(IV-1)}$$

In this case the slope of the housing price gradient is calibrated to $\theta = 0.02$. This results in a housing density gradient of:

$$H(k) = H_o\, e^{-\sigma k} \qquad \textit{(IV-2)}$$

The housing density gradient has a slope of $\sigma = 0.06$ with h_o noted as housing density at the city center. The relation between θ and σ is based on both the empirical literature on density gradients reviewed above. Consistent with previous notation, p^* is the minimum price at which owners of agricultural land at the city boundary are willing to convert it into housing based on the value of farm land, r_A, the conversion cost γ, and the price of structural inputs, i. The density at which this conversion takes place under laissez faire is noted as h^*. In order to economize on notation, the values of p^* and h^* are normalized to unity. Finally the radius of the laissez faire city, k^*, is set equal to 50.

Case 1: Removing a constant fraction of land at each radius

As with the classical model, it is assumed that planners reserve a fraction $0 < \Lambda < 1$ of the land at each radius for open space. The total amount of housing in a laissez faire city is given by:

$$h_T = \int_0^{k*} 2\pi h_O k e^{-\sigma k} dk \;=\; 2\pi\, h_O\{1 - (\sigma k^* - 1)e^{-\sigma k*}\}/\sigma^2\} \qquad \textit{(III - 3)}$$

Total housing rent, p_T, generated by the city is:

$$p_T = \int_0^{k*} 2\pi h_O\, p_O k e^{-(\sigma+\theta)k} dk = 2\pi h_O p_O\{1 - [(\sigma+\theta)k^* - 1]e^{-(\sigma+\theta)k*}\}/(\sigma+\theta)^2\}) \qquad \textit{(III - 4)}$$

The average rental price under laissez faire, p_{Avg}, is the quotient of *(III - 4)* and *(III - 3)*. Given the model calibration, the average rental price of housing space is $p_{Avg} = 1.78$.

In the regulated city, total housing supply, noted by H_T, is given by:

$$H_T = \int_0^{K*} 2\pi \Lambda h_O K e^{-\sigma k} dK = 2\pi \Lambda h_O \{1 - e^{-\sigma K*}(\sigma K^* - 1)\}/\sigma^2\} \qquad (IV\text{-}5)$$

Given $0 < \Lambda < 1$, and the housing supply constraint which requires that $H_T = h_T$, it follows that the radius of the planned city exceeds laissez faire, $K^* > k^*$. Aggregate housing supply under the regulation is equated to that under laissez faire which determines K^*. The calibrations adopted in this model for σ, and θ, are identical to laissez faire and $\Lambda = 0.8$ to characterize the regulatory environment. The normalization of $P^* = p^*$, and $H^* = h^*$ follows from the laissez faire case just presented. Consequently, it is straightforward to solve for the relation between the housing market under regulation versus laissez faire. In this case, $K^* = 1.08k^*$, $P_o = 1.09p_o$ and $P_{Avg} = 1.03p_{Avg}$. Note that a relatively large *20%* reduction in land available for housing resulted in only a *8%* larger city radius, a 9% increase in price at the city center and the rise in average price was a modest *3%* due to increase in the city radius changing the average location of housing units. These results are qualitatively consistent with the classical model but the difference between the planned and laissez fair cities is far less dramatic than in the classical land market model. Regulation that reduced Λ by *20%* has only raised average housing price *3%* so that the elasticity of price with respect to Λ is only *0.15*.

Case 2: Reducing housing density at all locations

This policy involves reducing density below laissez faire by a fraction $0 < \psi < 1$. The two-dimensional neoclassical city with proportional density regulation is essentially identical with the case 1 for land use sequestering except that ψ is substituted for Λ in equations *(III - 4)* and *(III - 5)*.

Case 3: Inserting open space at the city center: mall, plaza, or central park planning

Characteristics of the city under laissez faire are identical for all three cases. The same reference parameter values will be used. As in the classical case, the radius of the open mall, plaza, or park at the city center will be μk^*, i.e. proportional to the laissez faire city radius.

The key to determining housing price under regulation is to find an expression for the K^* that holds housing supply constant given μ and k^*. Total housing supply in the planned city is:

$$H_T = \int_{\mu k*}^{K*} 2\pi H_O K e^{-\sigma K} dK = 2\pi H_0\{e^{-\sigma\mu k*}(\sigma\mu k^* - 1) - e^{-\sigma K*}(\sigma K^* - 1)\}/\sigma^2\} \qquad (III - 8)$$

Given that density at the city edge has been normalized to unity, $H_0 = H(K^*)e^{\sigma K^*}$. This allows straightforward solution for the value of K^* consistent with $H_T = h_T$ to achieve the same aggregate city housing supply. Then, given the model calibration adopted here, the laissez faire city can be compared to the city with a mall. In this case the comparison is illustrated by setting $\mu = 0.1$. The radius under planning is slightly larger, $K^* = 1.02k^*$ but significantly less than the radius of the laissez faire city with the mall added, $K^* < (1+\mu)k^* = 1.1k^*$. Housing price at the edge of the mall is lower than at the center of the laissez faire city, $p_o = 1.08P_{uk*}$. Most important, average price under laissez faire is higher than the average price in the planned city, $p_{Avg} = 1.16P_{Avg}$. This is consistent with the results found for the classical land market model where mall zoning also lowered the average housing price. Total land area in the planned city expands by an amount equal to four times the area of the mall to keep housing supply constant. Due to the geometry of the city, the land used for housing can expand substantially while the radius of the area occupied by housing falls. This generates the substantial fall in average cost per unit housing space in the regulated city compared to laissez faire again illustrating the potential for error when a shift in the housing price profile is confused with a change in the average price of housing. When regulation shifts the shape of the housing density function, the data generating process for average housing price becomes more complex, producing a Simpson's paradox situation in which the effects of spatial composition must be computed carefully.

The effects of the three different stylized representations of land use restrictions on average housing price for the neoclassical housing market are consistent with classical models. In the first two instances, removal of a uniform slice of land, and lowering of developmental density at all locations, both raise the average price of housing space above laissez faire. However the increase in average price is small compared to the size of the land use restriction. In contrast, imposing a center city mall or plaza space requirement in a neoclassical city lowers average price substantially below that for laissez faire.

Clearly the effect of land use planning regulations on average price of housing space varies with the form of the stylized representation of the regulation under the assumption that there is a supply effect only and amenity is invariant. Furthermore, the differences in the effects under the classical an neoclassical models are substantial. This suggests using a neoclassical model to investigate effect of a more realistic representation of the form of land use planning in cities than any of the three stylized cases considered thus far.

IV. Specification of realistic planning regulation in a neoclassical city

The goal of this section is to determine the supply effect of land use restrictions on average housing price ignoring amenity effects using a specification of regulations that is much closer to reality than any of the three stylized cases considered in previous sections. The specification combines aspects of the first three stylized representations which are all different ways of limiting the density of private housing production under laissez faire. Planning regulations can lower density in many ways. They can provide open space, either wedges of land throughout the city in the form of parks or a central mall. However, most planning primarily restricts laissez faire development through floor area ratio (FAR) density limits, and setback requirements which are often related to density. In some cities, FAR limits are an increasing function of space allocated to streets. This practice may be related to concerns over light and air circulation.

In the specific hybrid specification adopted here, planners set a maximum density of development that applies in all areas of the city but is only binding where laissez faire density would be greatest. This specific specification is virtually identical to that in the Bertaud and Brueckner (2005) simulation model of the effect of building height limits. Brueckner and Singh (2020) have implemented tests to determine if current zoning regulations are binding and find strong evidence for Washington, D.C. and New York, intermediate for Boston, and weak results for Chicago and San Francisco. The results suggest, consistent with findings regarding density externalities in the micro literature reviewed earlier, that density limits are most likely to be binding in the central portions of large cities.

The specific planning limitations considered here are for a two-dimensional neoclassical urban housing market whose laissez faire characteristics are identical to the previous section. The city is calibrated to have a radius of 50 kilometers under laissez faire and the density at a distance

of 20 kilometers is adopted to be the maximum allowed by planners. Under laissez faire, this density is exceeded within the first 20 kilometers of the city. The exact form of this density limit, whether due to imposition of parks, and malls, or simply height restrictions, could be flexible and might vary with location within the city. The overall effect of the hybrid land use restrictions is to substantially reduce density in central areas of the city. There are reasons to believe that this type of planning has substantial amenity benefits identified by Flemming, et al (2018), Carozzi and Roth (2023), Davidoff, Pavlov, and Somerville (2022), and Lin (2024). While such potential gains may motivate planners, the assumption here is that there are no amenity effects associated with these hybrid land use restrictions.

Computation of the characteristics of the city under hybrid planning first involves restricting density on the first 20 kilometers of the city to that found under laissez faire at 20 kilometers. Accordingly, housing supply in this part of the city is a trivial computation of the product of regulated density and land area. Then the remainder of the city develops under the constraint that $P^* = p^*$ and total housing supply is identical, $H_T = h_T$. In this case the additional housing supply must compensate for the lower density where regulations are binding. Characteristics of the planned city can then be performed yielding the following relations between the planned and laissez faire city.[13] The regulated city has larger radius, $K^* = (1.06)k^*$ but substantially smaller average housing space cost, $P_{Avg} = (0.78)\, p_{Avg}$. These results are similar to the stylized case in which a central mall was inserted. The key intuition regarding the result is that the density of very high priced central housing is reduced and the distribution of housing supply is shifted out. Land use regulation may raise price at any given location but it also alters the spatial distribution of housing toward lower priced locations. This relocation effect results in a Simpson's paradox effect that has been ignored in the previous literature.

VI. Conclusions and implications

Past theoretical research on the macro effects of land use planning on average city housing prices has concentrated on classical housing market models in which highly stylized representations of regulation are considered. Under the assumption that planning has no amenity effects, these theoretical results suggest that planning has a supply effect that raises housing prices

[13] The precise value of K^* at which $H_T = h_T$ is determined by iterative computations of H_T as a function of K^* by increasing housing price at $K > 20$ until the housing supply equality is achieved.

and lowers welfare. This paper extends the literature by considering both classical and neoclassical urban housing markets and allowing three alternative stylized representations of land use restrictions. These alternatives produce a variety of implications. Most importantly, they demonstrate that the supply effect of regulation can either raise, or lower average housing price compared to laissez faire assuming no amenity effects. A first conclusion is that simple stylized assumptions of planning policy using ether classical or neoclassical housing market models produces theoretical results that are not consistent.

Next a hybrid neoclassical urban model in which planners limit maximum density is considered. Regulation is based on the micro literature which suggests that there are substantial externalities associated with high density as well as the observation that binding regulation is concentrated in high density areas. Possible amenity effects on the average price of housing are ignored. This hybrid model implies that the pure supply effect of land use restrictions lowers average housing prices compared to laissez faire assuming no amenity effects. The major implication of this result is that macro tests of the relation between regulation and average housing price are dispositive because the pure supply effect lowers and the amenity effect raises average housing price. Accordingly, the answer to the question in the title of this paper is that typical FAR regulation lowers the average price of housing in cities if it generates no compensating benefits. The finding that regulation raises average housing price indicates that there is a substantial positive amenity effect that dominate the negative supply effect.

This interpretation of the results of macro testing of planning regulation brings them into conformity with recent theoretical and empirical micro findings that there are substantial density externalities that can justify limits on laissez faire supply. It also raises the possibility that high housing prices cause very dense housing supply under laissez faire that prompts regulation. Thus, the regulatory cure is easily empirically confused with the high density disease.

The discussion of macro effects of planning regulations here is concerned with general patterns of development restrictions limiting density. These regulations are found in most cities although the extent to which they are flexible varies significantly. This does not mean that all planning restrictions have compensating amenity benefits. In particular, planning reviews that substantially delay development may be problematic. Accordingly, a finding that, on average, there is a positive relation between measures of overall planning regulation and average housing

price, does not mean that all regulations are welfare enhancing. Further research, particularly micro studies of individual regulations, may be necessary to identify the regulations that are not welfare enhancing.

Finally the discussion here follows the general literature on planning and housing price by ignoring two other classic arguments for use of planning regulations to deal with market failures associated with laissez faire development. The first is the problem of separating housing and activities that cause negative externalities first presented in an urban model by Stull (1974). The second is Sullivan's (1984) argument that the CBD may be too large under laissez faire due to infra-marginal effects of firm expansion on the cost of labor in the city. The macro empirical literature results may be influenced by the use of regulation to deal with either or both of these effects.

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