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Minimum parking requirements and housing affordability

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Abstract: A growing consensus argues that minimum parking requirements (MPRs) make housing more expensive. This paper examines two claims from this discussion: (1) that MPRs discourage the construction of small units; (2) that the costs of building required parking are "passed on" to buyers and renters in the form of higher prices and rents. However, the mechanisms behind these two effects have never been made explicit in the literature. This paper proposes, for each claim, a plausible mechanism relying on the specific choices of housing suppliers and consumers. We propose that MPRs discourage small units because they eliminate the most profitable floorspace/parking bundle to supply to relatively lower-income households. We propose that parking costs may be passed on by reducing the supply of housing on offer at a given price.

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1 Introduction

Cities in the United States face an affordable housing crisis. In 2015, 11.1 million households paid more than 50 percent of income in rent—up 3.8 million since 2001 (Joint Center for Housing Studies 2017). One proposed way to make housing more affordable is to relax minimum parking requirements (MPRs) which are local regulations stipulating that developers build parking spaces in proportion to the number of housing units they build—most typically to be bundled with the rent or sale of the units. This is a proposal with growing influence: housing costs have motivated legislation to weaken MPRs in Mexico City (Institute for Transportation and Development Policy 2018) and a number of American cities as well (Infranca 2014).

The scholarly literature on the topic makes several claims regarding the effect of MPRs on housing prices and rents, which we can usefully group as follows:

1. Bundled parking adds to the price of units after controlling for the units' other attributes. Manville (2013) finds that an "apartment with bundled parking is associated with $200" more in asking rent, and bundled parking with a condo is associated with a $43,000 increase in asking price." Using data from the National Housing Survey, Gabbe and Pierce (2017) notes that "the cost of garage parking to renter households is approximately $1700 per year." Likewise, Jia and Wachs (1996) observe that, in San Francisco, houses without bundled parking sold for $40,000 less than those that have it.

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2. MPRs discourage developers from building relatively small units (Bertha 1964; Gabbe 2015; Morlan 2017).
3. The cost of required parking will be "passed on to renters" (Been et al. 2012; Gabbe and Pierce 2017; Weinberger et al. 2010). Looking at twelve major American cities, Shoup (2014) estimates it costs an average of $34,000 to build an underground parking space and $24,000 to build one in a parking structure.

The logic behind claim (1) is straightforward: bundled parking is an amenity, and consumers will pay more for a unit that has it—just as they will pay more for a unit with granite countertops or a gym. But the literature has never been explicit about what causes the other two effects. Regarding (2), one might ask "Why do MPRs specifically discourage *small* units?" After all, the cost of adding a parking space to a small unit or a luxury condo are probably the same, and—per the evidence listed in (1)—parking raises the unit's value, which should help offset these costs. Regarding (3), one might ask "*How* exactly are the costs of parking passed on?" Costs do not obey a conservation law, like mass or energy; it is not strictly necessary that their rise push up the price of finished units. The costs of oil drilling vary widely from place to place, but oil companies all sell at about the same price.

This paper advances ways that (2) and (3) might arise from specific, plausible actions of housing consumers and suppliers. The aim is to enrich policy discussions with an understanding of the specific mechanisms we propose, and to stimulate further thought about other possible mechanisms. The claim that MPRs are an obstacle to housing affordability is more credible if backed by clear channels of causation.

There are two main sections to the paper. Each proposes a theory explaining one of the two claims and then works through an economic model designed to illustrate the theory. Section 2 argues that MPRs can discourage small units by prohibiting a developer from building the types of homes that are most profitable to supply to relatively lower-income market segments, which homes are also smaller. Section 3 argues that the costs of MPRs are passed on to consumers via market-wide effects: they reduce the supply of housing on offer at a given price, leading the market to clear at a higher equilibrium price. Section 4 concludes and offers ideas for further research.

Before beginning, it will help to note several points. First, for simplicity, we refer to "rents" and "renters" as though all housing were rented out, but for the sake of interpretation the reader should assume that any effect that inflates rents will also inflate buy prices—the exact ratio between the two depending on factors beyond the scope of parking. Second, the paper assumes throughout that parking is bundled with its associated housing unit—even though it may in fact be legal for a developer to rent or sell mandated parking spots to people not living in the associated housing. This assumption can be justified by the facts that bundling is very common (Manville 2017), that developers have sometimes resisted efforts at forced unbundling (Weinberger et al. 2010, p. 8) and that many homes come with bundled spots even when their residents do not own vehicles (Gabbe and Pierce 2017). One explanation for the ubiquity of bundling is that there exist significant transaction costs to selling or leasing spaces in many residential developments to non-residents. Levinson and Odlyzko (2008) note that bundling is common to transportation services due to transaction costs—both financial and mental. Recently, several technology firms (e.g., SpotHero, Pavemint) have sprung up to ease transacting for the rights to parking, which suggests such transactions have natural obstacles to overcome.

2 The discouragement of small units

2.1 Argument

In recent years, some US cities have tried to encourage developers to build smaller, cheaper housing units by tweaking land-use regulations (Infranca 2014). Such units are said to be affordable "by design" (SPUR 2007; White et al. 2016), insofar as what makes them cheap is not rent control but simply that they are less desirable—the same way that a small hotel room is cheaper than a large one.

Roughly speaking, such units come in two varieties: "accessory dwelling units" (ADUs) and "micro-units." ADUs (also called "in-law units" or "granny flats") are small units situated on the same lot as an existing home. Micro-units are unusually small apartments or condominiums.

There is a consensus that MPRs represent a major obstacle to the development of small units. As regards ADUs, the nature of the obstacle is geometric: it might be untenable to add parking to an already-developed parcel without reconfiguring the property (Brown et al. 2017; Chapple et al. 2012). But scholars and developers also argue that MPRs discourage small units on cleared lots. In a study of Oakland, California before and after an MPR was implemented in 1961, Bertha (1964) found that the MPR encouraged developers to build larger units with more amenities and higher rents than they had before the ordinance. Gabbe (2015) lists MPRs as one of the main barriers to micro-unit construction in San Francisco. Hinshaw and Holan (2011, p. 18) (of LMN Architects) call MPRs the "chief culprit" among ordinances discouraging micro-units in Seattle. Developers in San Diego have complained that the city's high MPRs have made micro-unit development infeasible (Morlan 2017; Trageser 2018), and, relatedly, **?** cites MPR being strengthened as a way to end a wave of new Single Room Occupancy (SRO) units in that city.

The argument of this section is that MPRs, when high enough, discourage small units by making it less profitable to build units for lower-income households. We say "lower-income" (and "higher-income") rather than "low-income" (and "high-income") to emphasize that the classification is relative; everyone but one person has less income than someone else. One does not have to be truly "low-income," as the term is used in common parlance, to forgo bundled parking, nor "high-income" to be willing to pay for it.

The reasoning behind the argument runs as follows: Housing units are not generic entities but rather bundles of attributes—of which the two germane to this discussion are size and the amount of parking available. Housing consumers, likewise, are not all the same but rather can be usefully grouped into various market segments, which are each most profitably served by units with certain attributes. Specifically, the most profitable type of unit to build for a lower-income market segment will have less parking. Thus, an MPR—by prohibiting units with little or no parking—reduces the profits earned by building units for such households. Since it is also true that lower-income markets are most profitably served by relatively small units, a binding MPR may wind up discouraging small units.

Importantly, this logic can operate at the level of a small neighborhood or an individual parcel—even if the amount of extra housing provided is not large enough to substantially alter the overall market conditions in a city. This fact matters to practice, because some of the aforementioned regulatory changes designed to produce small units apply to only certain areas of a city—e.g., areas around transit. Parking variances are even granted for individual parcels. Of course, small changes add up; tweaking rules in enough places will change an overall market. But scale is not necessary for our logic, and so for simplicity we present a model that illustrates the argument from the perspective of a lone developer. The model is in the tradition of Muth (1969): a developer designs units for households with preferences defined over parking and floorspace. We consider the developer's most profitable unit design with and without an MPR, then present a numerical example. Franco (2017) propose a similar setup, though with a focus on traffic externalities and a slightly different utility function.

2.2 Model

2.2.1 Unconstrained development

Consider a developer building units characterized by two physical attributes: floorspace, f, and parking area bundled with the unit, s.[1] The developer faces a Floor Area Ratio (FAR) limit rather than a limit on the number of units that can be built on a parcel, and so to maximize profit overall the developer designs units so as to maximize profit per unit area of floorspace. The cost of building a parking spot is c_s, the cost of building a unit area of floorspace is c_f and the rent charged per unit area is r. Thus, profit per unit area of floorspace is

$$\pi = r - c_s s/f - c_f. \tag{1}$$

The developer has three variables to choose: r, s and f. In choosing, she faces a physical constraint: s and f must be positive (she cannot provide negative parking or negative floorspace). And she faces an economic constraint: someone must want to rent the unit. Whether someone does depends on renters' preferences and their alternatives. The developer operates within a marketplace for housing composed of renters who all have utility functions

$$v(z, f, s) = z^\alpha f^\beta (s + s_0)^\gamma \tag{2}$$

with $\alpha, \beta, \gamma \in [0, 1]$ and $\alpha + \beta + \gamma = 1$. The variables s and f are the parking and floorspace of the renter's home, while z is a "numeraire" that stands in for all non-housing spending. s_0 is a positive constant added for realism: without s_0, a mansion and a hovel yield the same utility if both lack parking.

Although all renters have the same utility function, they vary in other ways and can be classified in different groups. A renter of type i has income y_i and "reservation utility" u_i. The reservation utility (a positive number) is the utility that the renter can get from the next-best alternative that is not under the developer's control—such as the unit the renter already lives in.

In order to attract a renter of type i, the developer must ensure the $f/r/s$ combination she offers lets that renter attain at least utility u_i. Renters face the budget constraint

$$z = y - f r, \tag{3}$$

where the product $f r$ is what we will call the "total rent," which is the rent typically advertised. Given this budget constraint, to meet i's reservation utility, it must be the case that

$$u_i \leq (y_i - f r)^\alpha f^\beta (s + s_0)^\gamma. \tag{4}$$

By isolating r in this expression, we find the highest r the developer can charge a renter of type i for a unit with s parking and f floorspace:

$$r \leq \frac{1}{f}\left(y_i - \left[\frac{u_i}{f^\beta (s + s_0)^\gamma} \right]^{1/\alpha} \right). \tag{5}$$

[1] For simplicity, we let s be a continuous variable—even though in real life it is probably the integer number of spots that matters.

To maximize profit, the developer *does* charge as much as possible, so we substitute the right-hand side of (5) for r in (1), yielding

$$\pi = \frac{1}{f}\left(y_i - c_s s - \left[\frac{u_i}{f^\beta (s+s_0)^\gamma}\right]^{1/\alpha}\right) - c_f. \tag{6}$$

From here, the developer finds the values of s and f which maximize π conditional on having an i-type renter. Let the maximum profit possible from serving type i be π_i^*. If π_i^* is negative for every i, then the developer will not build; otherwise she will build the optimal unit for the market segment with the highest π_i^*.

2.2.2 Development with an MPR

So far this analysis has assumed that the developer is free to choose any value of s—to provide as much or as little parking as desired. Suppose now that the city places an MPR over the neighborhood where the developer is building, while holding policy in the rest of the city constant. Assume the neighborhood is small enough to not significantly affect renters' overall options, so that renters' reservations utilities stay the same.

Formally, the MPR is a positive lower-bound, $s_{\min}$, on the choice of s. How will this impact the developer's decision? To check, we look at the first-order condition on s, $\partial\pi/\partial s = 0$, which gives the best-possible value of s for renters of class i (subject to s being positive):

$$s_i^* = \max[\gamma y_i/c_s - (\alpha+\beta)\cdot s_0, 0] \tag{7}$$

From (7), we see that the optimal amount of parking, s_i^*, to provide some renter rises and falls linearly with the renter's income as long as that amount is positive. Thus, the MPR will prohibit the unit designs that are most profitable for renters with incomes below a certain level—specifically, those with incomes

$$y_i < \phi, \tag{8}$$

where

$$\phi := \frac{c}{\gamma}[s_{\min} + (\alpha+\beta)\cdot s_0]. \tag{9}$$

With the MPR, serving one of these types is now less profitable, because the developer has to provide too much parking. Among these markets, the lower the renter's income, the farther from the optimal floorspace/parking bundle the developer must deviate.

If one of these lower-income types were not the most profitable anyway, then the MPR will have no effect: the developer will carry on providing more than $s_{\min}$ parking. But the fact developers complain about MPRs (e.g., Hinshaw and Holan (2011)) and try to get variances to avoid them suggests that they sometimes do find such types to be the most profitable. A good example is student housing.

However, if some type with $y_i < \phi$ would otherwise be most profitable, then the MPR can wind up discouraging small units in several ways. In some cases, by removing the most profitable option, the MPR may make development unprofitable altogether. In others, the developer will switch from serving a population L with $y_L < \phi$ to serving a population H with $y_H > \phi$. If the MPR does make the developer switch in this manner, then the resulting unit will be larger. The proof is in the appendix.

Table 1: Optimal designs

MPR	type	s	f	r	fr	π
none	L	0.0	1.01	2.46	2.47	1.46
none	H	1.03	1.92	2.83	5.43	1.4
$s_{\min} = 0.8$	L	0.8	0.98	2.9	2.85	1.24

2.2.3 Numerical example

Before closing this section, we will work through a numerical example to make the algebra above more concrete. The example is designed to illustrate the result of Bertha (1964): that MPRs can cause developers to switch to building larger units.

Suppose that there are two types of renter in the marketplace for housing: L and H. Type L has income $y_L = 6$ and reservation utility $u_L = 2$. Type H is wealthier and better off, with income $y_H = 12$ and reservation utility $u_H = 3.7$. Let $\alpha = 0.5$, $\beta = 0.35$, $\gamma = 0.15$, $s_0 = 1.5$, $c_s = 0.8$ and $c_f = 1$.

Without an MPR, the developer will calculate the optimal designs for each type of renter, which are listed in the first two rows of Table 1. The developer will then build for type L, as this yields a higher profit ($\pi = 1.46$) than serving type H ($\pi = 1.4$). The resulting unit will have no parking.

Now suppose the city institutes an MPR of $s_{\min} = 0.8$, so that what had been the most profitable unit type (row 1) is now banned. Since the optimal unit for type H renters (row 2) already includes more than the minimum of parking ($s = 1.03$), there is no need to reconfigure that type's unit. For type L renters, by contrast, it is profitable to provide no more than the regulation requires, and the resulting unit is shown in row 3. Comparing rows 2 and 3, we see the MPR has made it more profitable to serve type H renters than type L, so the developer builds the unit in the second row. This unit is almost twice as large as the unit the developer would have designed and has more than twice the total rent. Note that type L is still willing to pay more per unit area (compare the values of r in the second and third rows), but type L's optimal unit is much smaller, and so the cost of parking is spread over less area.

3 "Passing on" costs

3.1 Argument

A refrain common to discussions around MPRs is that the cost of building additional parking is "passed on" to renters and buyers in the form of higher rents or prices.[2] This section explores how this phenomenon might happen, but to do so requires a meaningful definition of what it means for costs to be "passed on." In the numerical model of Sec. 2, the MPR raised the rent only because the developer built a larger unit with more parking. The rent of a unit with any given floorspace/parking combination would have been the same with or without an MPR, since the unit and its rent had to leave renters at least as well off as other alternatives, which were not affected.

A more meaningful definition of "passing on" costs is that the MPR lets a developer charge more for the same unit. But the developer will not be able to do so, and still find willing renters, unless the MPR also constrains the renters' alternatives. The argument of this section is that an MPRs costs can

[2] See for example Lewis (2016), London and Williams-Derry (2013), Thompson (2016) and Schneider (2018, p. 4).

be passed on if they drive some units out of the market at a given rent, thereby reducing the supply of housing on offer. A lower supply causes renters to compete with each other for available units, which lets a developer charge a higher rent and still find tenants. This is an effect of an entirely different scale than that of Sec. 2—one that requires changes to general market conditions.

It is useful to contrast this argument with at least one alternative theory that is also somewhat intuitive: perhaps developers practice some form of "cost-plus" pricing—that is, they look at their costs and then add some "reasonable" amount for profit. In that case the costs of housing under an MPR are passed on directly, because developers base their rents on a higher cost base when there is an MPR. But there is a flaw in this "cost-plus" theory: it is inconsistent with the idea that developers maximize profit. Why do developers with below-average costs charge low rents when they could raise their rents and still steal renters from competitors with higher costs? If the costs of building parking were to fall, why would developers lower their prices?

The distinction between the two views has several policy implications. In the first place, our "supply and demand" argument requires that, to see the cost savings of weakened MPRs show up in rent, a city must allow developers to build additional housing; if zoning prohibits much additional building then the developers' cost savings will not be substantially passed through. By contrast, the "cost-plus" view has it that developers would automatically lower rents if their costs fall—even if no additional housing is built. In the second place, our argument implies that cost savings will require time to be passed through, since it takes time to build new structures. "Cost-plus" savings could seemingly happen instantly.

3.2 Model

Consider a rental market for generic "housing units," which are all interchangeable in the way that barrels of oil are in commodities markets; they do not vary in size as they did above. This is what Arnott (1987) calls the early "Marshallian" treatment of the housing market. Differentiation has been excised because, while realistic, it is not necessary for the logic we are proposing to make sense. These units are supplied competitively by landlord-developers, consistent with evidence in (Glaeser et al. 2005).

We will now contrast two regimes regarding parking. Suppose first that there prevails a regime in which housing units lack bundled parking. In Figure 1, the curves S_h and D_h are, respectively, the supply and demand curves for these housing units without parking. The equilibrium market rent is R_h.

Now suppose, instead, that all the housing was built under an MPR of one space per unit, which comes bundled with housing. If c_s is the amortized cost of building a parking space, then the supply curve is shifted upwards, to S_{h+s}, by the amount c_s. At the old rent R_h, there are now fewer than q_h housing units on offer, because developers at the margin (likely those with relatively high costs or who were developing on sites that were also prime for non-residential uses) have been driven out of the market. Thus, even ignoring any possible impact that the bundled parking has on demand, an individual developer will be able to charge somewhat more than R_h and still find a renter. This situation will persist at any rent level lower than R_{h+s}, and so R_{h+s} is the new equilibrium rent. In summary, some part of the cost of parking has been "passed through" to consumers via the change in competitive conditions, represented by the shift in the supply curve.

Note that this process requires that the market quantity actually is the one set by the intersection of supply and demand—i.e., that developers are free to build whatever units are profitable subject to

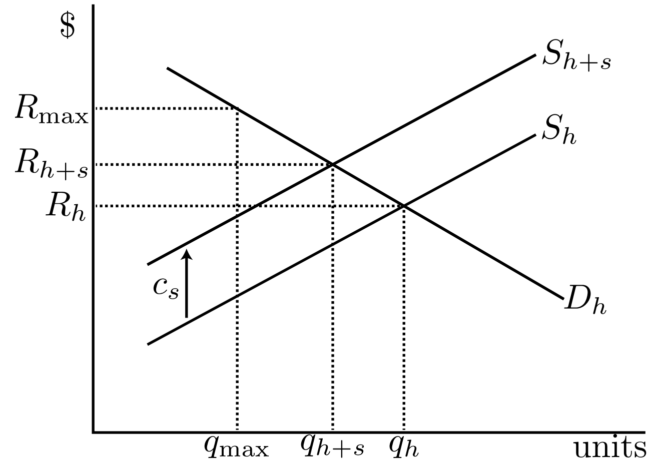

Figure 1: Shift of the supply curve due to an MPR

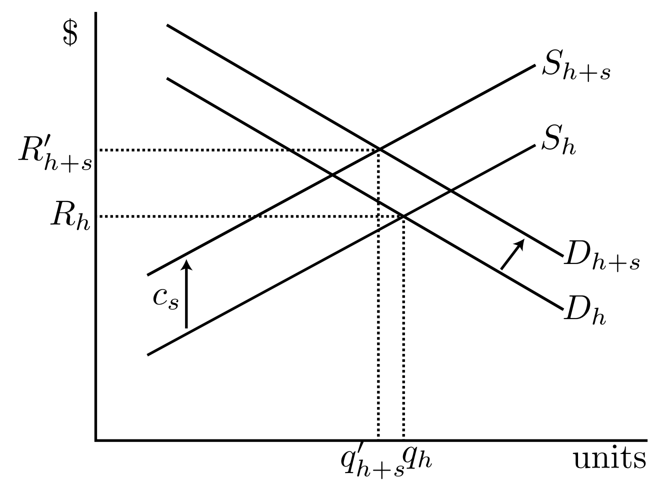

Figure 2: Shift of supply and demand curves caused by MPR

the MPR. But if zoning regulations cap supply at some low-enough level, then different results may be expected. Suppose, for instance, that a city uses zoning regulations to cap housing supply at the level $q_{\max}$ shown in Fig. 1. In this case, the equilibrium rent will be $R_{\max}$ with or without the MPR. The lesson is that weakening MPRs will not *directly* lower rents; housing supply must expand.

All this deduction, of course, ignores any impact the MPR has on demand, but since parking is an amenity, the addition of bundled parking would shift the demand curve upwards as well. Figure 2 illustrates, with the demand curve shifting upward to D_{h+s}. Considering the shifts in both the supply *and* demand curves, the market rent will be R'_{h+s}, which is higher than R_{h+s}. Thus, some part of the inflation we see from an MPR is due to cost pass-through, and some part is just due to the amenity value of parking.

4 Conclusion

This paper has proposed specific mechanisms that plausibly justify two claims in the debate over MPRs: (1) that MPRs discourage small units; (2) that the costs of parking required by MPRs are "passed on" to housing customers. Section 2 showed that MPRs can, at the level of an individual parcel or small neighborhood, make it less profitable to build units for lower-income households by forcing the developer to provide them with more parking than is profitable. Section 3 argued that for costs to be passed on, in the sense that equivalent units cost more, requires a larger-scale change in market conditions: the costs of providing required parking drive some units out of the market at a given rent.

Both models, of course, involve serious simplifications of reality. In the first model, market supply is absent; and the second one ignores that housing units can vary in size. A realistic approach would combine insights from both models. For example, by eliminating the most profitable unit designs, an MPR could make marginal projects infeasible, and thereby reduce the supply of housing. But the goal here has not been so much to provide a full account of what happens in real housing markets as to isolate and clarify how certain phenomena, already noted in the debate, might arise from the specific actions of developers and housing customers.

It is the author's opinion that of the two mechanisms, the discouragement of small units is probably the more important one to policy considerations. Since the model takes place at the level of the individual development, reforming MPRs could have a quick impact on the number of small units available. By contrast, to make housing more plentiful at the market scale would require enough time for substantial new construction. Moreover, the American cities that face affordable housing crises do not only impose MPRs but also purposefully limit the housing supply via zoning (Glaeser and Gyourko 2018; Quigley and Rosenthal 2005).

An important question for further research is to establish more credibly that the effects described do exist and, if so, how strong they are. The only empirical study to isolate the link between MPRs and unit size (Bertha 1964) is over fifty years old. Fortunately, Mexico City and Buffalo, New York (Hess 2017), have recently eliminated MPRs entirely. In due time allowing for development, a before-and-after study of construction and prices in such cities—combined with comparisons to other cities keeping or strengthening their MPRs—could be invaluable.

In closing, it is important to recognize that the mechanisms described above are not the only possible ways that MPRs might interact with housing rents and prices. Detailed study of particular ordinances can probably shed light on other effects. One promising channel is that MPRs sometimes vary with the overall number of units in a project, requiring more parking per dwelling unit in projects with more units. For example, in 2013, Portland, Oregon instituted a regime in which MPRs are waived for buildings with fewer than 30 units. An informal study by local activists (Jordan 2017) shows that the years since have seen a boom in new projects with exactly 30 units but few with more. Whether this policy has led, on net, to more or fewer units is an empirical matter (and depends on what the alternative regime would be), but the plausibility of the noted effect invites further study on small details of particular parking rules.

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Appendix

This appendix proves a claim made at the end of Sec. 2.2.2: that if an MPR of s_{min} leads the developer to switch from serving a population best served by less parking than s_{min} to one best served by more, then the resulting unit will be larger. To prove this, we note that from the first-order conditions of (6), it can be determined that

$$f_i^* = \frac{\beta(y_i + c_s s_0)}{\pi_i^*} \tag{10}$$

for anyone with income $y_i \geq c_s s_o(\beta + \alpha)/\gamma$, and

$$f_i^* = \frac{\beta y_i}{(\beta + \gamma)\pi_i^*} \tag{11}$$

for anyone with income $y_i < c_s s_0(\beta + \alpha)/\gamma$.

Now, it must be that $\pi_L^* > \pi_H^*$ or else the developer would not have served H in the first place. It follows that if $\phi > y_L \geq c_s s_0(\beta + \alpha)/\gamma$, then

$$\frac{f_L^*}{f_H^*} = \frac{\pi_H^* \cdot (y_L + c_s s_0)}{\pi_L^* \cdot (y_H + c_s s_0)} < 1, \tag{12}$$

meaning H's optimal unit is larger than L's.

Similarly, if $y_L < c_s s_0(\beta + \alpha)/\gamma$, then we have

$$\frac{f_L^*}{f_H^*} = \frac{\pi_H^* y_L}{\pi_L^* \cdot (\beta + \alpha)(y_H + c_s s_0)}. \tag{13}$$

Since $y_H > \phi > c_s s_0(\alpha + \beta)/\gamma > y_L$, this ratio is also less than one.