

# Understanding the Effects of Inclusionary Zoning on Housing Markets Using a Stock-Flow model

By

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Submitted to the Department of Urban Studies and Planning in partial fulfillment of the requirements for the degree of

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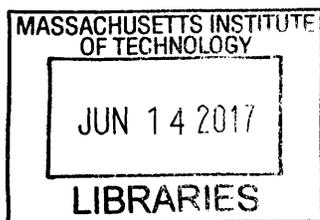
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## **Abstract**

In this thesis I demonstrate how different housing markets would react to an exogenous shock of inclusionary zoning. I develop a stock-flow model of housing based on the model presented in Wheaton (1999). In this model, the degree of durability, elasticity of supply of new construction, and rental elasticity of demand of housing can vary. Various experiments were conducted to understand the dynamic behavior of different (hypothetical) housing markets after the introduction of an inclusionary zoning shock. The above mentioned study is supplemented with an analysis of Boston's inclusionary development program, and its impact on the residual land values. Detailed financial analysis was undertaken for three prototypical projects, to study how residual land values would change for varying levels of inclusionary zoning requirements. The overarching goal of the thesis is to add to the existing literature on the economics of inclusionary zoning, and to produce material of pedagogical value for students of urban planning and real estate, and also relevant policy makers.

Thesis Supervisor: William Wheaton  
Professor, Center for Real Estate, MIT  
Professor Emeritus, Department of Economics, MIT



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And of course, all errors and inconsistencies in this thesis are mine.



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## Chapter 01

# Introduction: Inclusionary Zoning and its (theoretical) Incidence

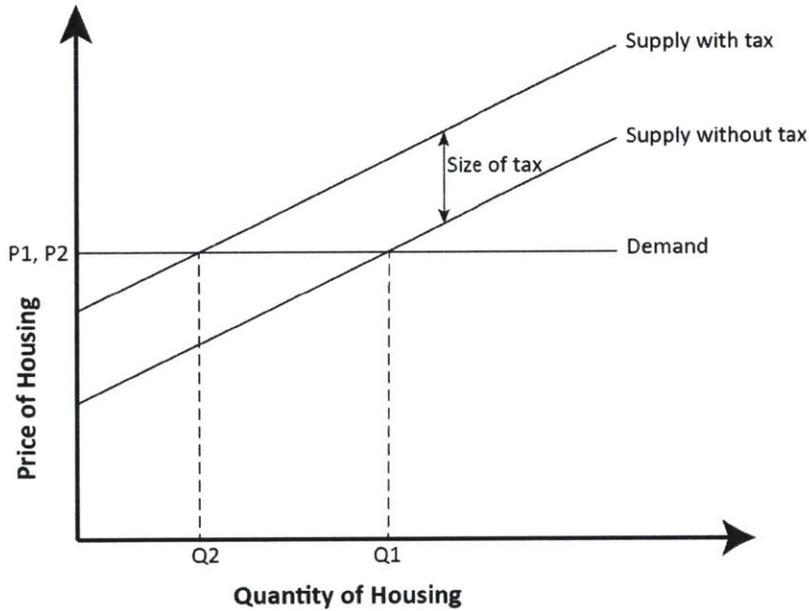
Provision of affordable housing for lower income households is becoming a major challenge in many cities around the world. In United States, many of the areas with worst housing affordability crisis are clustered along the East and the West coast, with California having twenty of the twenty five least affordable metropolitan areas in the country (Powell and Stringham, 2005). Many local governments are adopting inclusionary zoning as one of the policy interventions to increase the supply of affordable housing in urban and suburban areas. Inclusionary zoning refers to a program, regulation or law which requires private developers to allocate a certain percentage of units in their new market rate residential developments as affordable housing for low and/or moderate income households (Calavita and Mallach, 2010).

In his classic article, *Irony of "Inclusionary" Zoning* (1981), Robert Ellickson, posits that inclusionary programs are exclusionary in practice as they are essentially taxes on the construction of new housing, usually increasing housing prices and further limiting housing opportunities for moderate income people. Many law and economics scholars have compared inclusionary zoning to rent control, as price restrictions on a percentage of new housing will have similar market distortions as rent control (Powell and Stringham, 2005). Inclusionary zoning can also be understood as consisting of the following three policies: (1) taxation of new housing for local social programs (affordable housing); (2) provision of housing subsidies to middle (and sometimes low) income families to avail new housing; and (3) spending of revenues generated during step (1) at step (2) without the legislative oversight that constrains government spending programs (Ellickson, 1981).

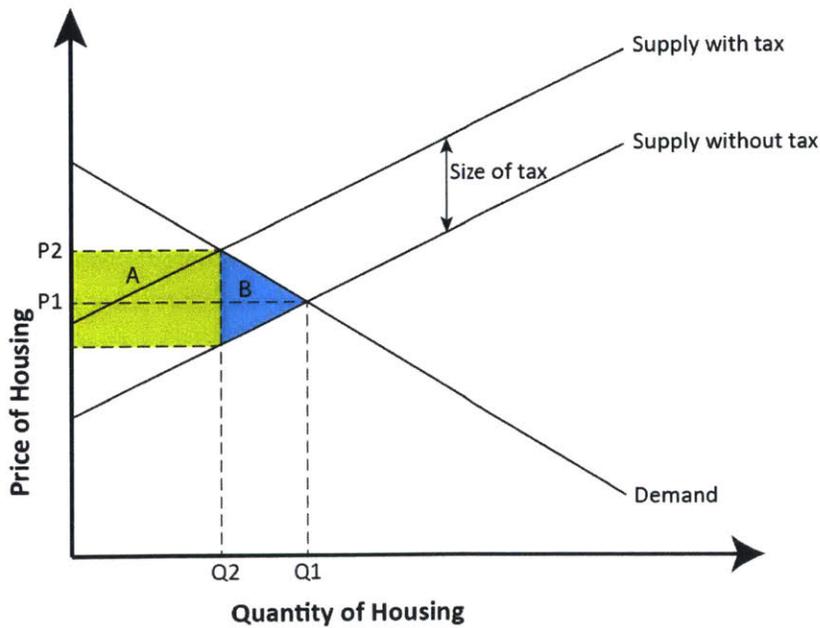
The incidence of inclusionary zoning as a tax on new construction would depend on the relative supply and demand elasticities of housing. Assuming that the tax imposed due to inclusionary zoning is not completely offset by various developer subsidies (as is found in most of the cases), the burden of the tax would result in some combination of reduced developer profits, reduced residual land values, and an increase in the price of housing consumption. Ellickson

(1981) describes the incidence of inclusionary zoning for two hypothetical cities: (1) cities with perfect substitutes, and thus having infinitely elastic demand; and (2) unique cities without perfect substitutes. These two scenarios are explained below along with their respective partial equilibrium supply and demand graphs.

**Figure 1.1. Incidence of Inclusionary Zoning on a City with Perfect Substitutes**

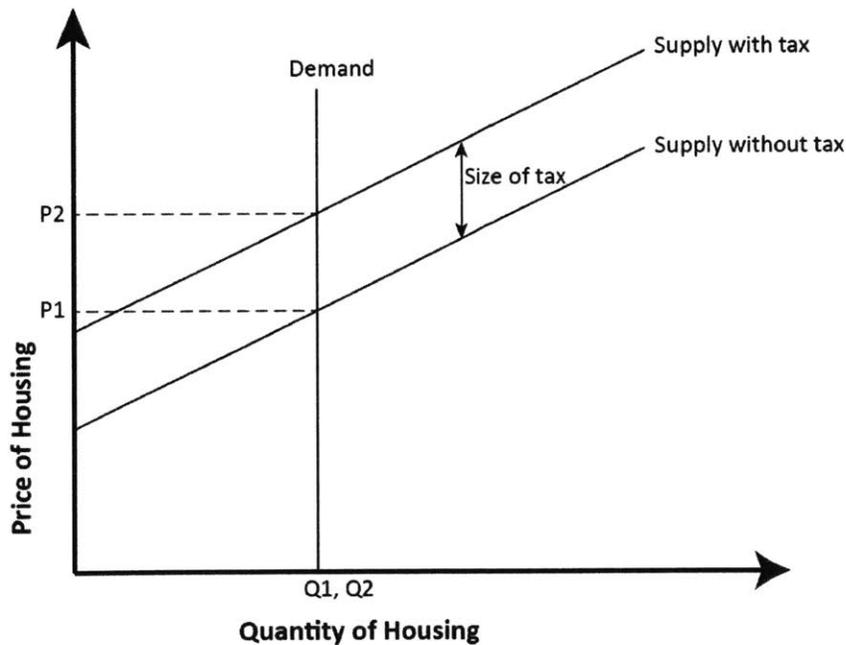


**Figure 1.2. Incidence of Inclusionary Zoning on a Unique City without Perfect Substitutes**



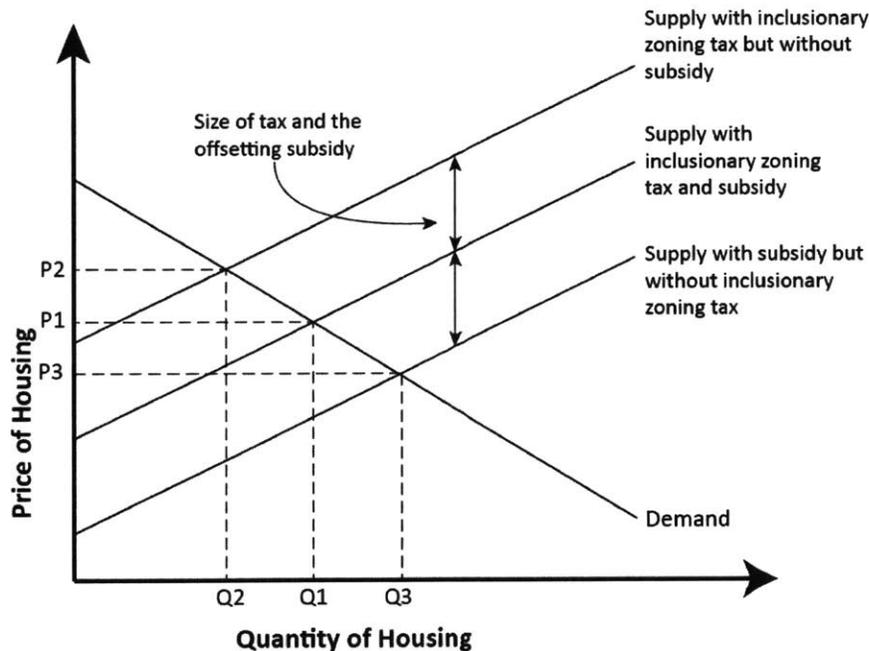
As illustrated in Figure 1.1, imposition of an inclusionary zoning tax on a city with perfect substitutes will not have any effect on the market clearing price ( $P1$  and  $P2$ ), but will reduce the amount of new construction from  $Q1$  to  $Q2$ . Thus, in this scenario developers will be unable to pass on the burden of the tax to the consumers. On the other hand, developers will pass the burden of the tax to the land owners in the form of lower residual land values (ibid.). In the case of a unique city (Figure 1.2), imposition of an inclusionary zoning would result in a higher market clearing price ( $P2$ ), compared to the price before the tax was imposed ( $P1$ ). The amount of new construction would also go down from  $Q1$  to  $Q2$ . In this case the developer will be able to pass some portion of the tax burden to the consumer in the form of higher prices. The portion of the tax that is not passed on to the consumer will be shared between the developer and land owner. The total amount of subsidy generated in this case is highlighted by the rectangle A. Such a tax can distort the efficiency of resource allocation and result in a dead weight loss as highlighted by the triangle B (ibid.). A third scenario is possible in which the developer is able to transfer the entire burden of the tax to the consumer in the form of higher rents. This would happen if the city has a perfectly inelastic demand for residential use (Figure 1.3). In this case the rents would increase after the imposition of the tax, while the supply of new housing would not change.

**Figure 1.3. Incidence of Inclusionary Zoning on a City with perfectly inelastic demand**



The above three scenarios had an underlying assumption that the inclusionary zoning tax is not revenue neutral, which means that the subsidies provided to the developer as a part of inclusionary zoning program do not compensate for the entire burden of the tax. Powell and Stringham (2005) highlight a hypothetical case where the subsidies provided completely offset the burden of the inclusionary zoning tax (Figure 1.4). In this scenario the supply of new housing after the imposition of tax (with subsidy) remains the same as before ( $Q_1$ ), thus resulting in the same market clearing price ( $P_1$ ). Powell and Stringham (2005) argue that the real test of whether such subsidies offset the entire cost of the tax is when developers would choose to participate in the inclusionary zoning program voluntarily. It is important to note that, even in this scenario inclusionary zoning does have a negative effect on the housing affordability. If the government provides subsidies to the developers without imposing any tax on them, then the supply of new housing would increase ( $Q_3$ ), lowering the equilibrium price of housing consumption ( $P_3$ ), thus making housing more affordable to a larger population (ibid.).

**Figure 1.4. Effect of Inclusionary Zoning with accompanying Subsidies**



Although the four scenarios explained above provide a good understanding of the incidence of inclusionary zoning, they do not provide a complete picture. Inclusionary zoning is not only a tax on new construction; it also provides targeted households the opportunity to avail new housing at below market rates. Inclusionary zoning affects the demand for market rate housing by

gradually taking a certain fraction of the population out of the market by providing them subsidized housing. Instead of the partial equilibrium supply and demand diagrams presented above (and also in numerous articles on the economics of inclusionary zoning), the canonical *four quadrant model* (4QD) introduced by DiPasquale and Wheaton (1996) can provide a better qualitative understanding of the impact of inclusionary zoning on the housing markets. In the following section, I will briefly introduce the four quadrant model and use it to explain the impact of an exogenous inclusionary zoning shock for the case of a unique city.

The four quadrant model (figure 1.5) provides an eloquent theory to understand the relationship between the property market for space use and the asset market for space ownership.<sup>1</sup> The model is divided into four quadrants; the northeast and the southeast quadrants represent the property market while the northwest and the southwest quadrants represent the asset market. In the north east quadrant, the two axes represent the stock of space (in this case of housing) and rent, while the curve represents the demand for housing as a function of rent and other exogenous factors, represented in the figure as *Economy*. In equilibrium, the demand for space,  $D$ , is equal to the stock of housing,  $S$ , and helps determine the rent,  $R$ , which clears the market. In the northwest quadrant, the curve emanating from the origin represents the *capitalization rate*,  $i$ , which determines the price of an asset for the corresponding equilibrium rent. In the south west quadrant, the amount of new construction is determined for a given price in the asset market. The curve  $f(C)$  represents the replacement cost of real estate and is assumed to increase with greater building activity,  $C$ . In the southeast quadrant, the curve emanating from the origin represents the depreciation rate of stock,  $\delta$ . At equilibrium, the amount of new construction  $C$ , is equal to the amount of depreciated stock. The four quadrants represent a system of equations (Eq.1 – 4), the solution of which is represented by the rectangle touching each of the curves in the four quadrants. This solution represents the long run equilibrium of model.

$$D(R, Economy) = S \quad \text{Eq.1}$$

$$P = R/i \quad \text{Eq.2}$$

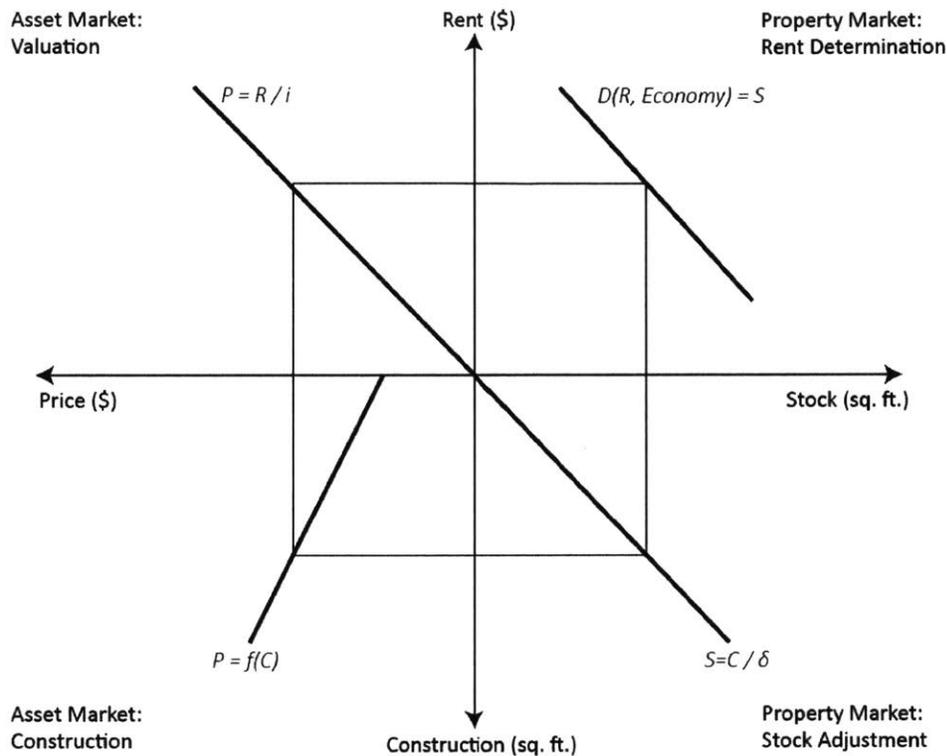
$$P = f(C) \quad \text{Eq.3}$$

$$S = C/\delta \quad \text{Eq.4}$$

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<sup>1</sup> For a complete understanding of the four quadrant model, please refer to DiPasquale and Wheaton (1996).

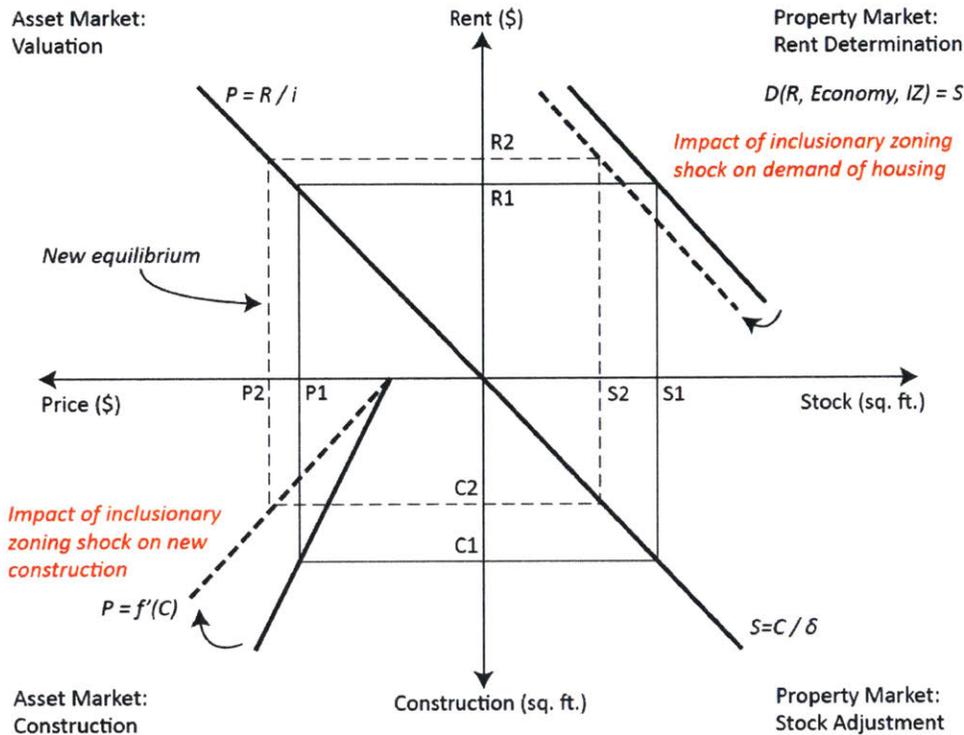
**Figure 1.5. Four Quadrant Model from DiPasquale and Wheaton (1996)**



The impact of inclusionary zoning as an exogenous shock on a unique city is highlighted in Figure 1.6. Imposition of inclusionary zoning impacts the Replacement Cost function (south-west quadrant), and the Demand function (north-east quadrant). As mentioned earlier, inclusionary zoning acts as a tax on new construction, thus reducing the amount of new construction delivered for a given asset price. This is represented as a rotation in the Replacement Cost function in the northwest direction. The other impact of inclusionary zoning is to gradually take a certain fraction of the total population out of the market by providing them subsidized housing. This is represented as a shift in the Demand function in the southwest direction. Another way to conceptually understand the impact of inclusionary zoning on housing markets is that it divides the market for new housing into two, one for price-controlled (or income restricted) units and the other for non-price controlled (market rate) units (Powell and Stringham, 2005), and thus creates two stocks of housing. The new long run equilibrium of market rate housing is represented by the dotted rectangle, whose new position lies northwest of the earlier rectangle representing the previous long run equilibrium. We find that in the new equilibrium, market rate rents are higher

( $R_2 > R_1$ ), while new market rate construction, and stock of housing lower ( $C_2 < C_1$ , and  $S_2 < S_1$  respectively).

**Figure 1.6. Incidence of Inclusionary Zoning on a Unique City**



It is important to note that the four quadrant model described above presents the two long run equilibrium states of the model, and does not explain the dynamic behavior of the model from one equilibrium state to another. To understand this dynamic behavior, in Chapter 04, I will present a stock flow model of housing based on the model presented in Wheaton (1999). In this model, the degree of durability, elasticity of supply of new construction, and elasticity of demand of housing can vary. Various experiments were conducted to understand the dynamic behavior of different housing markets after the introduction of the inclusionary zoning shock. This thesis specifically conducts the following analyses/simulations using the stock-flow model:

1. A comparative statics analysis of housing markets before and after the imposition of inclusionary zoning. Various values of inclusionary zoning requirements were tested in this analysis.
2. A comparative statics analysis of the impact of inclusionary zoning for various plausible values of demand and supply elasticities.

3. Various simulations to understand the dynamic behavior of different (hypothetical) housing markets after an exogenous inclusionary zoning shock.

The above mentioned study is supplemented with an analysis of Boston's inclusionary development policy and its impact on the residual land values. Detailed financial analysis was undertaken for three prototypical projects, to study how residual land values would change for varying levels of inclusionary zoning requirements. The overarching goal of the thesis is to add to the existing literature on the economics of inclusionary zoning, and to produce material of pedagogical value for students of urban planning and real estate, and also relevant policy makers. The remainder of the thesis is organized in the following chapters: Chapter 2 presents a literature review of inclusionary zoning and its origins; Chapter 3 briefly describes Boston's inclusionary development program and presents the results of the residual land value analysis; Chapter 4 presents the stock-flow model along with the results of the various simulations conducted; Chapter 5 concludes with a summary of the findings of this thesis and discusses its limitations and suggestions for future research.

## Chapter 02

# Inclusionary Zoning and its Origins

As mentioned earlier, inclusionary zoning refers to a program, regulation, or law which requires private developers to allocate a certain percentage of units in their new market rate residential developments as affordable housing for low and/or moderate income households (Calavita and Mallach, 2010). Inclusionary zoning is considered to be a mechanism by which increased land values in strong housing markets can be captured and directed towards building affordable housing (Schuetz et al., 2011). Calavita and Mallach (2010) trace the origins of inclusionary zoning back to civil rights movement of the 1960s, and as a response to the extensively practiced exclusionary zoning which perpetuated racial segregation through land use planning. The first inclusionary zoning programs were enacted in Virginia, Maryland, and California in the early 1970s; and by mid 1990s it was widely adopted across other states, and had also become a part of the affordable housing strategies of major cities like New York, Chicago, San Diego, Denver and Washington, DC (Calavita and Mallach, 2010). After originating in the United States, inclusionary zoning has spread across to other parts of the world including Canada, Western Europe, Australia, India and South Africa (ibid.). By 2004 close to 400 local jurisdictions in United States had adopted inclusionary zoning, with majority of the programs enacted in Massachusetts, California, and New Jersey (Bento et. al, 2009).

Calavita and Mallach (2010) posit the following reasons which have led to a world wide spread of inclusionary zoning: (1) increasing decentralization and privatization of affordable housing production; (2) increasing concerns for fostering socially inclusive communities; and (3) rapid increase in the market led residential construction and increasing residential prices from late 1990s to 2007, which provided the opportunity to leverage the private sector to provide affordable housing. In United States, the regulatory framework in which inclusionary housing fits varies widely (ibid.). In some cases it has been characterized as a land use regulation, while in other cases as an exaction or a price regulation similar to rent control (ibid.). Schuetz et al. (2011) point out that the two elements of a state's regulatory environment which are relevant to the adoption of local inclusionary zoning programs are: (1) the degree of authority of local

governments over land use policies; and (2) the presence of (other) statewide affordable housing laws or programs.

Although the use of inclusionary zoning has been growing widely, it still remains a deeply contested practice (Mukhija et al., 2010). Inclusionary zoning's critics perceive it as price-controlled housing and as a disincentive for market-based actors (ibid.), which may increase the price of market rate housing while decreasing its supply (Schuetz et al., 2011). On the other hand the policy is perceived as politically attractive by many as it provides affordable housing without directly raising taxes or using public funds (Bento et al., 2009; Schuetz et al., 2011). Ellickson (1981) questions the long run efficacy of inclusionary zoning policy in providing affordable housing. He argues that inclusionary zoning would tend to deter the trickle-down effect in play in the housing markets, and thus the benefits of inclusionary zoning might only accrue in the short run for moderate income families, as in the long run it would tend to decrease affordable units produced through the filtering process.

Mukhija et al. (2010) in their evaluation of the inclusionary zoning programs in Los Angeles, and Orange Counties find that these programs can be as effective as Low Income Housing Tax Credit (LIHTC) program in providing affordable housing.<sup>2</sup> As per David Rusk (2005), inclusionary zoning with a requirement to set aside 15% of new units as affordable, can provide twice as many affordable units as LIHTC program (in Mukhija et al., 2010). In the Bay Area, for the period between 1980 and 2006, affordable units produced under inclusionary zoning make up 2.3% of new residential units permitted (Schuetz et al., 2011). In the Washington, DC metropolitan area, inclusionary zoning program produced 15,252 units since its inception until 2003, which is approximately 3% of the total residential units permitted between 1980 and 2006 (ibid.). In Massachusetts, between 1990 and 1997, 1000 affordable units were constructed statewide under local inclusionary zoning programs, while around 5000 affordable units were constructed under Chapter 40B (Schuetz et al., 2011). The overall count of the total affordable units produced in United States through inclusionary zoning programs may be around 129,000 to 150,000 units (Calavita and Mallach, 2010).

Inclusionary zoning programs adopted by local governments vary widely across United States. The important characteristics which define most inclusionary zoning programs are: (1)

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<sup>2</sup> Mukhika et al. (2010) point out that the income-targeting of housing developed through LIHTC is likely to be deeper than income-targeting of most affordable housing created through inclusionary zoning.

whether the program is mandatory or optional; (2) percentage of affordable units to be set aside; (3) targeted household income levels; (4) triggers and exemptions; (5) incentives to developers as cost offsets; (6) Alternatives to on-site affordable units' provision; and (7) duration of affordability requirements. Table 2.1, provides a brief summary of how these inclusionary zoning characteristics differ across jurisdictions.

**Table 2.1. Important Characteristics of Inclusionary Zoning (IZ) Programs in United States**

<b>Characteristics</b>	<b>Brief Description</b>
Mandatory vs. Optional	In Bay Area, and Washington, DC Area, IZ programs tend to be mandatory, while in suburban Boston, they are generally optional.
Percentage of affordable units to be set aside	It generally varies between 5% - 30%. IZ ordinances in the Bay area generally require 10% - 15% of the units to be designated as affordable housing, with the highest required share being 25%. Most IZ ordinances in the Boston suburbs also require 10% - 15% of the units as affordable, while there are a few communities which require the set aside percentage to be as high as 25% to even 50%. In the DC area, set aside percentage is generally smaller 5% to 15%.
Targeted household income levels	In Bay Area, targeted income levels are generally a combination of very low, low and moderate income levels. Rental units are more likely to be targeted at low income households, while ownership units are targeted at moderate income households. In Washington DC, area targeted households are with incomes no more than 65% to 70% AMI. Boston suburbs income targets are higher than the bay area.
Triggers and exemptions	In the Bay area, IZ ordinances almost apply to all new residential developments, while in Boston suburbs, it applies to a narrow set of projects. In Washington, DC area, IZ small projects are exempt from IZ
Incentive to developers as cost offsets	Many IZ programs provide incentives to developers as offset measures. These incentives can be in the form of density bonuses, fee reductions, property tax exemptions, or waivers of subdivision requirements.
Alternatives to on-site affordable units provision	Different alternatives may be provided under IZ ordinance like in-lieu fees, provision of units on a nearby site, reserving a portion of land for affordable housing and/or transferable development credits.
Duration of affordability requirements	The period often varies between 10-99 years. Boston suburbs IZ programs require longer duration of affordability requirements than bay area and Washington DC area, with almost one third of the programs required permanent affordability requirements. Bay area IZ ordinances are distributed evenly across 30 years, 40-49 years, 50-59 years and permanently.

Sources: Schuetz et al. (2011); Bento et al. (2009)

## Chapter 03

# Residual Land Value Analysis of Boston's Inclusionary Development Policy

City of Boston adopted its Inclusionary Development Policy (IDP) in February 2000 through an executive order of the mayor.<sup>3</sup> Further revisions to the policy were done in 2003, 2005, 2006, and 2007 respectively. In December 2015, an executive order was signed by Mayor Martin J. Walsh replacing the old set of IDP policies with the new single policy. Since its adoption, IDP has resulted in 2,457 affordable units (complete or in construction), which constitutes approximately 10.5% of all new units built or in construction under IDP. The policy has generated total revenue of 139million USD, while another 50million USD is in the pipeline. A brief summary of the important characteristics of Boston's current IDP are provided in Table 3.1.

**Table 3.1. Important Characteristics of Boston's IDP**

Characteristics	Brief Description
Triggers of IDP	IDP is mandatorily applicable to all new residential developments of 10 or more units, any residential project undertaken by the city of Boston, or on a property owned by the City, or developments that require any relief from provision of the Boston Zoning Code
Percentage of affordable units to be set aside	No less than 13% of the total units have to be income restricted for both rental and condominium projects
Targeted household income levels	For rental projects the income restricted units have to be affordable at household income of 70% Area Median Income (AMI) or less. For condominium projects, at least 50% of the income restricted units have to be affordable at household income of 80% AMI or less, while the remaining units have to be affordable at 80%-100% AMI.
Incentive to developers as cost offsets	No incentives are provided under IDP as cost offsets
Alternatives to on-site affordable units provision	Alternatives include provision of affordable units at a different location, in-lieu fees, and purchase, rehabilitation and restriction of existing units in the vicinity of the project.

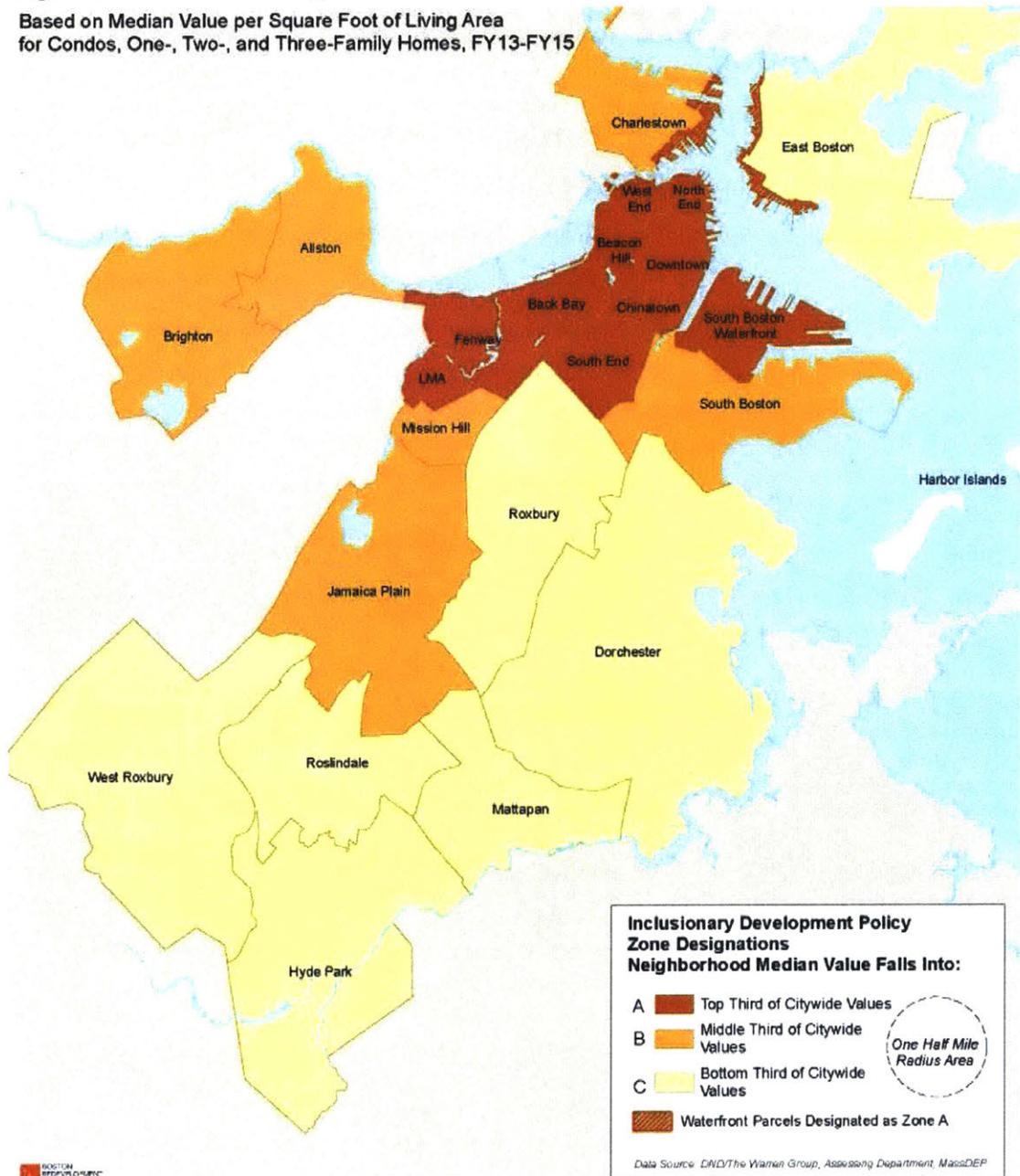
Source: An Order Relative to Inclusionary Development (December 2015)

<sup>3</sup> Please refer to Boston's Planning and Development Agency's website for more information regarding IDP. The IDP policy document and other information regarding the policy can be accessed from the following links: <http://www.bostonplans.org/getattachment/91c30f77-6836-43f9-85b9-f0ad73df9f7c>  
<https://www.bostonplans.org/getattachment/43eefea6-85ae-48ee-965a-6358ea84bc7e>

As per the IDP, all income restricted units have to be comparable in program, size and quality to market rate units. In order to address the issue of different micro-markets within the city of Boston, the city has been divided into three zones, with their respective requirements related to offsite and in-lieu cash contributions (Table 3.2). These zones were based on the median value per square feet of living space in each neighborhood (Figure 3.1).

**Figure 3.1. IDP Zone Designations**

Based on Median Value per Square Foot of Living Area for Condos, One-, Two-, and Three-Family Homes, FY13-FY15



Source: <http://www.bostonplans.org/getattachment/d4e05875-9c82-4d23-adbb-417a12da4ceb>

**Table 3.2. Summary of IDP requirements for the Three Zones**

IDP Option	Zone A	Zone B	Zone C
On-Site	13% of total units	13% of total units	13% of total units
Off Site	18% of total units in vicinity	18% of total units in vicinity	15% of total units in vicinity
In-lieu fees Rental	18% of total at \$380,000	18% of total at \$300,000	15% of total at \$200,000
In-lieu fees Condo	18% of total at 50% of price differential (\$380,000 minimum)	18% of total at 50% of price differential (\$300,000 minimum)	15% of total at 50% of price differential (\$200,000 minimum)

Source: <http://www.bostonplans.org/getattachment/43eefea6-85ae-48ee-965a-6358ea84bc7e>

In order to analyze the impact of the development restrictions (under IDP) on residual land values for new residential constructions in Boston, a detailed financial analysis was undertaken. This analysis was done for three prototypical projects which reflect a range of residential development types in Boston. These prototypes can be characterized as low-rise, mid-rise, and high-rise respectively. In the following section, I will summarize the development program, cost, and revenue assumptions which have informed the financial analysis.

**Table 3.3. Development Program Assumptions**

	Tier A	Tier B	Tier C
Type <sup>1</sup>	Low-Rise	Mid-Rise	High-Rise
Height	50'-70'	70'-160'	>160'
Lot Size (in SF)	10,000	12,500	12,500
Lot Size (in Acres)	0.23	0.29	0.29
Total Units	50	120	240
Residential Density (per Acre)	218.3	419.2	838
Residential Floors	5	12	24
Unit Size <sup>2</sup>	800 NSF	950 NSF	950 NSF
Unit Type	1 BHK	2 BHK	2 BHK
FAR	5.00	11.84	23.69
Ground Coverage	100.0%	98.7%	98.7%
Building Efficiency <sup>3</sup>	80%	77%	77%

1. Tier A prototype is assumed to be a Type V construction, while Tier B and C are assumed to be Type I construction.
2. It was assumed that high rise developments would have larger units. Thus, Tier A prototype was assumed to have 1BHK units (750 NSF), while Tier B and C prototypes were assumed to have 2BHK units (950 NSF).
3. Building efficiencies for residential developments can range between 75% to 80%, with high rise developments being less efficient (Seifel Consulting, 2016, Financial Analysis of San Francisco's Central SoMa Plan).

**Table 3.4. Development Cost and Construction Loan Assumptions**

	Tier A	Tier B	Tier C
Hard Costs <sup>1</sup>	\$275 /GSF	\$325 /GSF	\$350 /GSF
Hard Costs Contingency <sup>2</sup>	5%	5%	5%
Soft Costs <sup>2</sup>	25%	25%	25%
Loan to value Ratio <sup>2</sup>	70%	70%	70%
Construction Period <sup>3</sup>	18 months	24 months	30 months
Interest Rate <sup>2</sup>	5%	5%	5%

1. These hard costs are for only residential construction. Commercial or parking spaces have not been included in the financial analysis. Tier A prototype is a Type V construction while Tier B and Tier C, are Type I construction. In order to account for the variability in the construction costs among developers, sensitivity analysis was done to cover a wide range of possible construction costs for each prototype.
2. These line items were assumed to be same across all three prototypes in order to negate their effects on the final results.
3. Construction period was assumed to increase with the height of the residential construction.

**Table 3.5. Revenue Assumptions**

	Tier A	Tier B	Tier C
Market Rate Rents (Monthly) <sup>1</sup>	\$4.20 /SF	\$4.75 /SF	\$5.50 /SF
Market Rate Vacancy <sup>2</sup>	5.00%	5.00%	5.00%
Income Restricted Vacancy <sup>2</sup>	2.00%	2.00%	2.00%
Operating Expense (/year/unit) <sup>3</sup>	\$5,000	\$6,000	\$9,000
Property Taxes (% of EGI)	10.00%	10.00%	10.00%
Going in Cap Rates <sup>4</sup>	4.50%	4.50%	4.50%
Selling Costs <sup>5</sup>	2.50%	2.50%	2.50%
Cap Rate - ROC spread <sup>4</sup>	1.50%	1.50%	1.50%

1. Market rents were assumed to be higher for higher residential developments. In order to account for varying rents across different micro-markets in Boston, a sensitivity analysis was done to cover a wide range of possible market rate rents for each prototype.
2. Market rate vacancy was assumed to be slightly higher than the vacancy for income restricted units.
3. Operating expense for Tier A and Tier B was assumed to be the same while for Tier C it was assumed to be considerably higher to take into account an increased level of service including 24x7 concierge.
4. Source: CBRE North America Cap Rate Survey (2016); a sensitivity analysis was done to cover a wide range of possible Cap Rate-ROC spreads.
5. Selling costs were assumed to be the same for all three prototypes.

In order to calculate the residual land value (RLV) for each prototype, Return on Cost (ROC) metric was used. The net operating income for each prototype was capitalized on the basis of the ROC metric to give the total investment required for the development project. Residential construction costs and construction financing costs were then deducted from it to arrive at the

RLV. A spread of 150 basis points was assumed between the going-in cap rate and the ROC metric. Other uses like commercial or parking were not considered in the financial analysis in order to isolate the impact of inclusionary zoning requirements on RLV attributable to only residential uses. This RLV model is summarized in the equation below.

$$\frac{\text{Net Operating Income}}{\text{Target Return on Cost}} - \text{Construction Costs} - \text{Construction Financing Costs} = \text{RLV}$$

Four tests were conducted for each prototype to answer the following questions:

1. For the base case scenario, (13% affordable units at 70% AMI, as per the current IDP requirements), what is the RLV?
2. How does the RLV change with different values of on-site affordable unit requirements, while keeping other assumptions constant? The affordable units were assumed to be targeted at 70% AMI for this test.
3. How does the RLV change with different income levels of the targeted households, while keeping other assumptions constant? Percentage of affordable units was assumed to be 13% for this test.
4. For what values of market rate rents and ROC, does the residual land value become negative? For this test, percentage of on-site affordable units was assumed at 13%, and the targeted household income level at 70% AMI. In the following section, I will provide the summary of the results for each prototype.

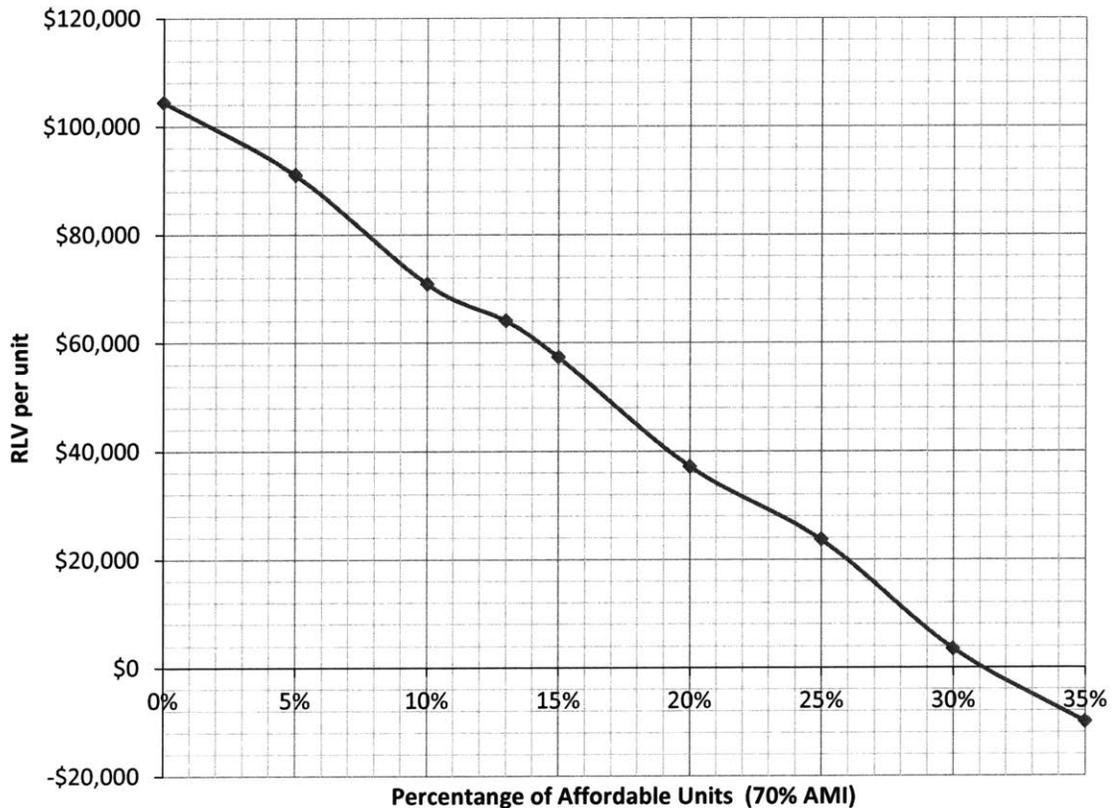
### **Tier A Prototype: RLV Analysis Results**

For the base case, which reflects the current IDP on-site requirements, the RLV for the 10,000 SF parcel comes out to be 3.2 million USD, which translates to 64,000 USD RLV per unit (Table 3.6). An increase in the percentage of on-site affordable units by 5%, reduces the RLV per unit by around 16%, and the RLV becomes zero at around 31% affordable units (Figure 3.2). A deeper targeting of households by 10% AMI (e.g. changing the value of threshold income level from 70% AMI to 60% AMI), reduces the RLV per unit by 5.5% (Figure 3.3). Sensitivity analysis of RLV per unit with respect to market rate rents and ROC metric suggests that low rise developments with the current IDP requirements are possible for a range of different market rate rents, and also different values of ROC metric. RLV per unit is negative for values of market rate rents at \$3.75/SF, and the ROC metric at 6.25%. This suggests that in this case, 2,181 USD subsidy is required per unit along with zero land costs for the project to be feasible.

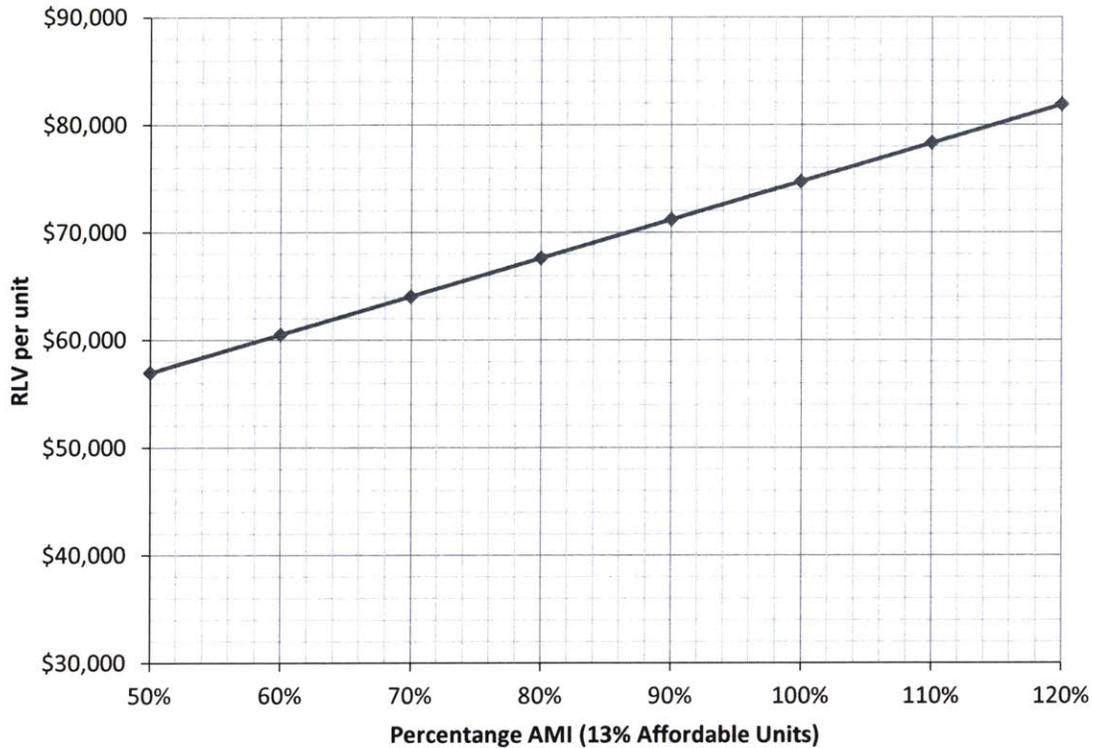
**Table 3.6. Tier A: Base case RLV (13% affordable units at 70% AMI)**

	\$/Unit	Total
Residual Land Value (back calculated as per Target ROC)	\$64,054	\$3,202,721
Total Construction Costs	\$360,938	\$18,046,875
Construction Financing Costs	<u>\$23,548</u>	<u>\$1,177,418</u>
Total Investment through Stabilization	\$448,540	\$22,427,014
Land Value as Percentage of Total Costs		14.28%
<b>Residential Income at Stabilization</b>		
Potential Rental Income	\$37,270	\$1,863,504
Vacancy	\$1,810	\$90,492
Effective Rental Income	\$35,460	\$1,773,012
Operating Expenses	( <u>\$8,546</u> )	( <u>\$427,301</u> )
Net Operating Income (NOI)	\$26,914	\$1,345,710
Target ROC		6.00%
Achieved Unlevered IRR at Target ROC		25.45%
MV of Income Restricted units at Stabilization	176,482	
MV of Market Rate units at Stabilization	638,595	
Diff. between Market Rate and IR units	462,113	

**Figure 3.2. Tier A: RLV w.r.t. Percentage of on-site Affordable Units**



**Figure 3.3. Tier A: RLV w.r.t. Target Household Income Levels (% AMI)**



**Table 3.7. Tier A: RLV w.r.t. Market rate rents and ROC**

	\$3.75	\$4.00	\$4.25	\$4.50	\$4.75
5.50%	\$46,737	\$77,797	\$108,936	\$140,007	\$171,133
5.75%	\$29,002	\$58,747	\$88,498	\$118,268	\$147,994
6.00%	\$12,758	\$41,260	\$69,754	\$98,297	\$126,782
6.25%	(\$2,181)	\$25,156	\$52,547	\$79,919	\$107,307

Note: For this test, percentage of affordable units is at 13%, targeted household income is at 70% AMI. The first row represents the different values of market rate rents assumed, while the first column represents the different values of ROC metric assumed.

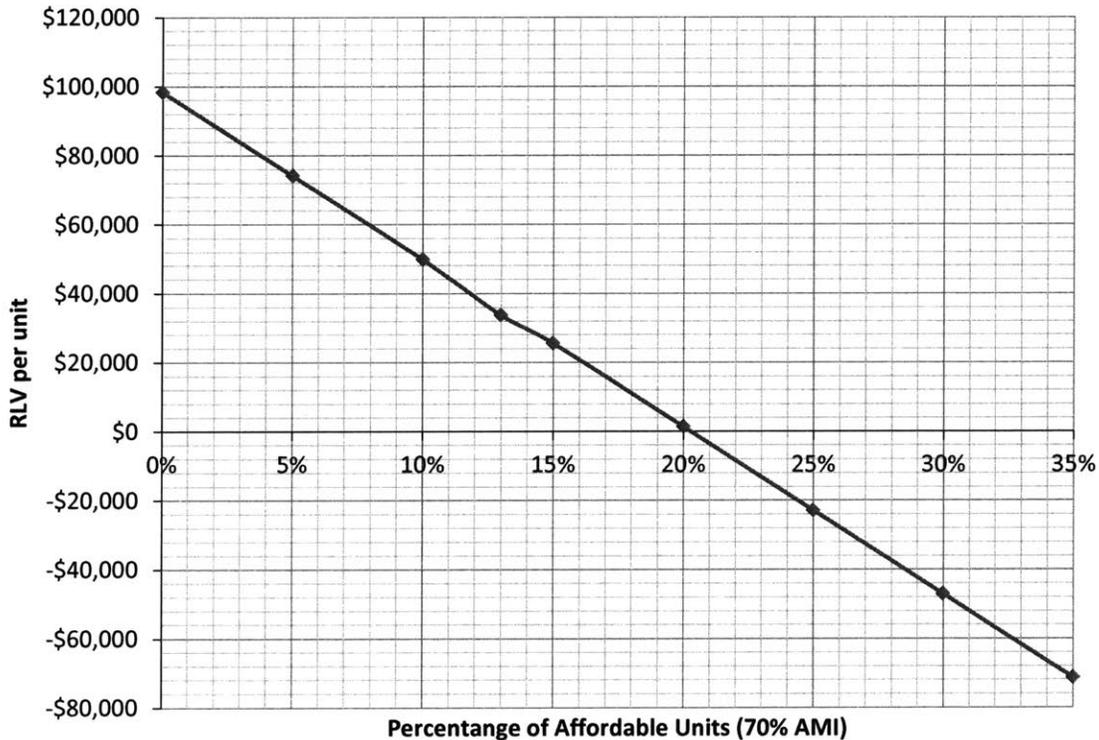
**Tier B Prototype: RLV Analysis Results**

The base case scenario for the mid-rise residential development yields a RLV of 4.04 million USD, for the 12,000 SF parcel; which translates to 33,800 USD RLV per unit (Table 3.8). An increase in the percentage of on-site affordable units by 5%, reduces the RLV per unit by around 25%, and thus the RLV becomes zero at around 20% affordable units (Figure 3.4). A deeper targeting of households by 10% AMI reduces the RLV per unit by around 13% (Figure 3.5). Table 3.9 indicates that mid-rise development would be only feasible for market rate rents of \$4.5/SF and upwards, for the ROC threshold of 6%. Even when for \$4.5/SF, the RLV per unit is very low at 950 USD per unit.

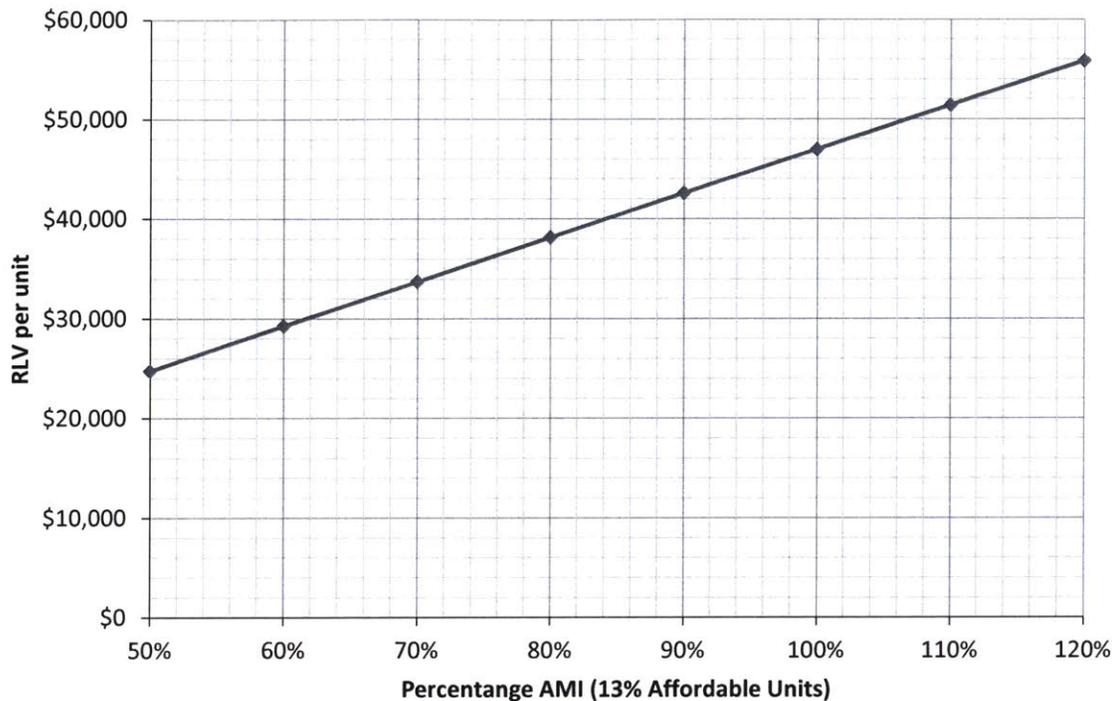
**Table 3.8. Tier B: Base case RLV (13% affordable units at 70% AMI)**

	\$/Unit	Total
Residual Land Value (back calculated as per Target ROC)	\$33,731	\$4,047,762
Total Construction Costs	\$526,278	\$63,153,409
Construction Financing Costs	<u>\$42,151</u>	<u>\$5,058,153</u>
Total Investment through Stabilization	\$602,161	\$72,259,323
Land Value as Percentage of Total Costs		5.60%
<b>Residential Income at Stabilization</b>		
Potential Rental Income	\$49,200	\$5,904,048
Vacancy	(\$2,392)	(\$287,029)
Effective Rental Income	\$46,808	\$5,617,019
Operating Expenses	<u>(\$10,681)</u>	<u>(\$1,281,702)</u>
Net Operating Income (NOI)	\$36,128	\$4,335,317
Target ROC		6.00%
Achieved Unlevered IRR at Target ROC		27.99%
MV of Income Restricted units at Stabilization	\$195,405	
MV of Market Rate units at Stabilization	\$873,129	
Diff. between Market Rate and IR units	\$677,724	

**Figure 3.4. Tier B: RLV w.r.t. Percentage of on-site Affordable Units**



**Figure 3.5. Tier B: RLV w.r.t. Target Household Income Levels (% AMI)**



**Table 3.9. Tier B: RLV w.r.t. Market rate rents and ROC**

	\$4.25	\$4.50	\$4.75	\$5.00	\$5.25
5.50%	\$13,151	\$48,878	\$84,573	\$120,311	\$155,989
5.75%	(\$10,233)	\$23,812	\$58,023	\$92,185	\$126,359
6.00%	(\$31,692)	\$958	\$33,696	\$66,429	\$99,158
6.25%	(\$51,547)	(\$20,147)	\$11,268	\$42,710	\$74,116

Note: For this test, percentage of affordable units is at 13%, targeted household income is at 70% AMI. The first row represents the different values of market rate rents assumed, while the first column represents the different values of ROC metric assumed.

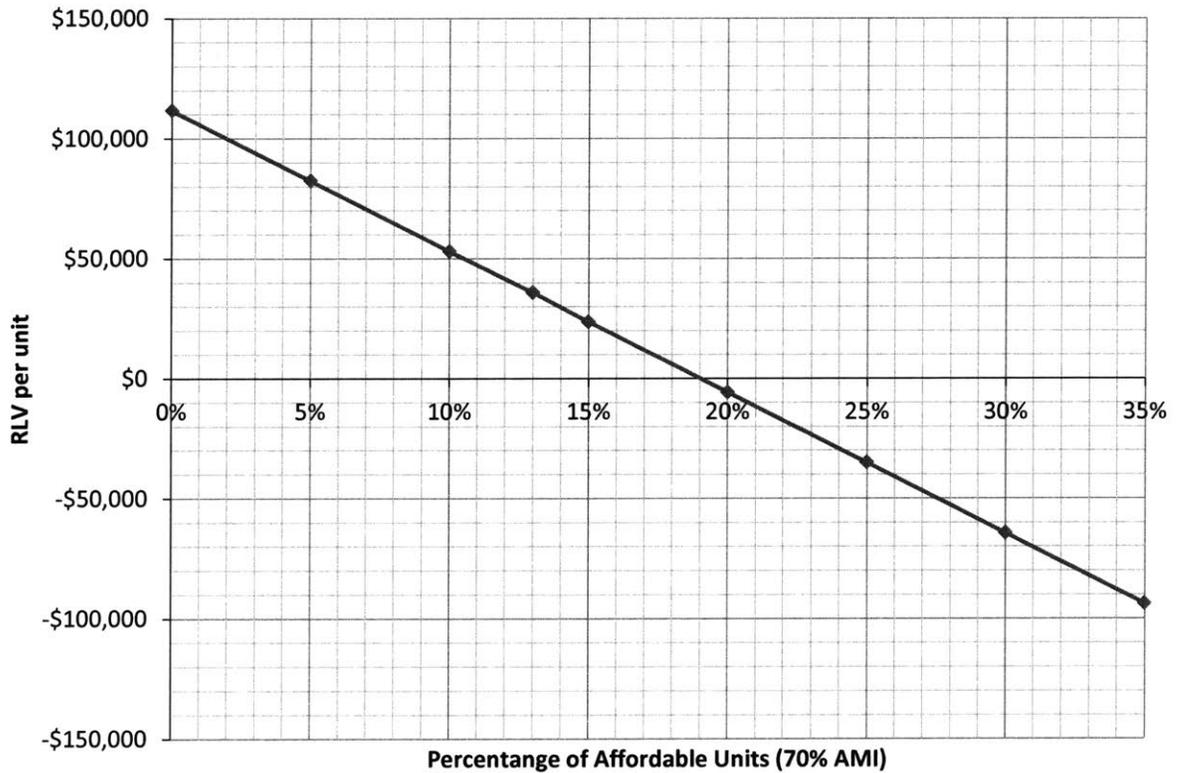
### Tier C Prototype: RLV Analysis Results

The base case scenario for the high-rise residential development yields a RLV of 8.6 million USD, for the 12,000 SF parcel; which translates to 35,800 USD RLV per unit (Table 3.10). An increase in the percentage of on-site affordable units by 5%, reduces the RLV per unit by around 26%, which is slightly higher than for the mid-rise development (Figure 3.6). A deeper targeting of households by 10% AMI reduces the RLV per unit by around 12% (Figure 3.7). Table 3.11 indicates that high-rise development would require much higher market rate rents than both mid-rise and low-rise developments, to be economically feasible. Even market rate rents of \$5/SF yields a negative RLV for a ROC threshold of 6.00%.

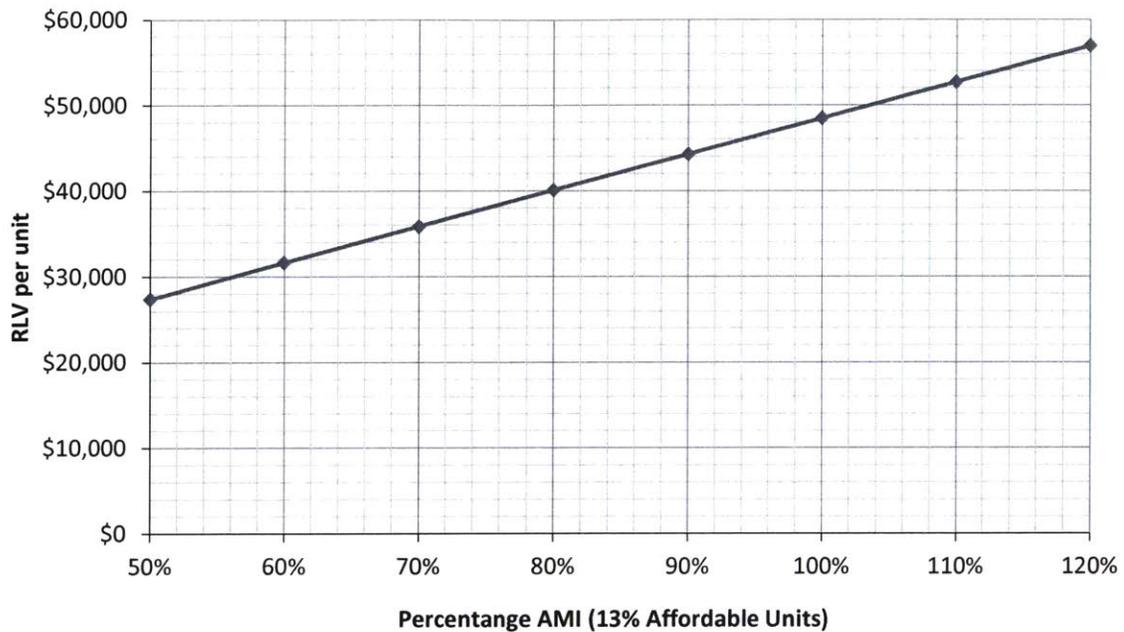
**Table 3.10. Tier C: Base case RLV (13% affordable units at 70% AMI)**

	\$/Unit	Total
Residual Land Value (back calculated as per Target ROC)	\$35,830	\$8,599,257
Total Construction Costs	\$566,761	\$136,022,727
Construction Financing Costs	<u>\$57,783</u>	<u>\$13,867,862</u>
Total Investment through Stabilization	\$660,374	\$158,489,846
Land Value as Percentage of Total Costs		5.43%
<b>Residential Income at Stabilization</b>		
Potential Rental Income	\$56,801	\$13,632,168
Vacancy	(\$2,774)	(\$665,772)
Effective Rental Income	\$54,027	\$12,966,396
Operating Expenses	<u>(\$14,403)</u>	<u>(\$3,456,640)</u>
Net Operating Income (NOI)	\$39,624	\$9,509,756
Target ROC		6.00%
Achieved Unlevered IRR at Target ROC		28.06%
MV of Income Restricted units at Stabilization	\$130,405	
MV of Market Rate units at Stabilization	\$966,518	
Diff. between Market Rate and IR units	\$836,112	

**Figure 3.6. Tier C: RLV w.r.t. Percentage of on-site Affordable Units**



**Figure 3.7. Tier C: RLV w.r.t. Target Household Income Levels (% AMI)**



**Table 3.11. Tier C: RLV w.r.t. Market rate rents and ROC**

	\$4.75	\$5.00	\$5.25	\$5.50	\$5.75
5.50%	(\$14,977)	\$20,213	\$55,429	\$90,615	\$125,840
5.75%	(\$38,884)	(\$5,299)	\$28,357	\$62,042	\$95,717
6.00%	(\$60,912)	(\$28,707)	\$3,571	\$35,848	\$68,123
6.25%	(\$81,175)	(\$50,216)	(\$19,253)	\$11,691	\$42,719

Note: For this test, percentage of affordable units is at 13%, targeted household income is at 70% AMI. The first row represents the different values of market rate rents assumed, while the first column represents the different values of ROC metric assumed.

### Key findings of the Residual Land Value Analysis

While interpreting the results presented above, it is important to keep in mind that they reflect a particular set of stylized assumptions. Each residential development project is unique and their idiosyncrasies cannot be captured in this broad brush analysis. Nonetheless, the results of this analysis provide some key (qualitative) insights regarding the impact of Boston’s IDP at the project level. The key findings of the analysis are summarized below.

1. Economic feasibility of high-rise residential developments is very sensitive to inclusionary zoning requirements, especially the on-site affordable units’ requirement. This can be seen in Figure 3.8, which plots RLV per unit vs. percentage of on-site affordable units, for all three prototypes. The curve representing high-rise development has a steeper slope than the other two curves representing low-rise and mid-rise, thus highlighting the fact that high-rise

residential projects would tend to lose their land values much faster than mid-rise and low-rise projects, as inclusionary zoning requirements become more stringent.<sup>4</sup> Policy makers should bear in mind that after a certain threshold of residual land value, other land uses may start out-bidding residential use.

2. Another key insight which we can get from Figure 3.8 is the on-site affordable units' requirement which yields a close to zero RLV. This can be particularly useful in instances where the City of Boston plans to leverage its public land holdings for residential developments. In such cases, the city can transfer the land parcel to a developer at zero land costs in return for a higher on-site affordable units' requirement. Example, in the case of a low-rise development on a public land parcel, the city can ask the developer to provide 35% of the units as affordable, compared to the currently mandated 13%, without affecting the developer returns.
3. As the height of the residential development increases from low-rise to mid-rise, there is a major increase in the construction cost because the type of construction required goes from Type V to Type I. This increase in construction cost may not always be capitalized in the form of higher rents, thus putting downward pressure on the residual land values. This pressure is exacerbated due to inclusionary zoning requirements. As can be seen in Figure 3.8, for the given set of assumptions (percentage of affordable units at 13%), a 120 unit mid-rise development yields a RLV per square feet similar to a 50 unit low-rise development, even when the market rents assumed for mid-rise was at \$4.75/SF, compared to low-rise which was at \$4.2/SF.
4. For the base case of all three prototypes, I also calculate the effective subsidy provided to the targeted households through IDP, by deducting the effective market value at stabilization of income restricted units from that of market rate units.<sup>5</sup> For low-rise developments, this subsidy value comes out to be around 460,000 USD, while for mid-rise and high-rise, it is around 677,000 USD and 836,000 USD respectively. The high value of subsidy per unit for high-rise construction explains the rapid fall in the RLV per unit due to an increase in the percentage of on-site units' requirement. Boston's IDP gives the flexibility to the developer to give an in-lieu fee instead of providing the affordable units on-site. Currently the in-lieu fee is set at 380,000 per unit (for Zone A), and needs to be paid for 18% of the units instead of 13%.

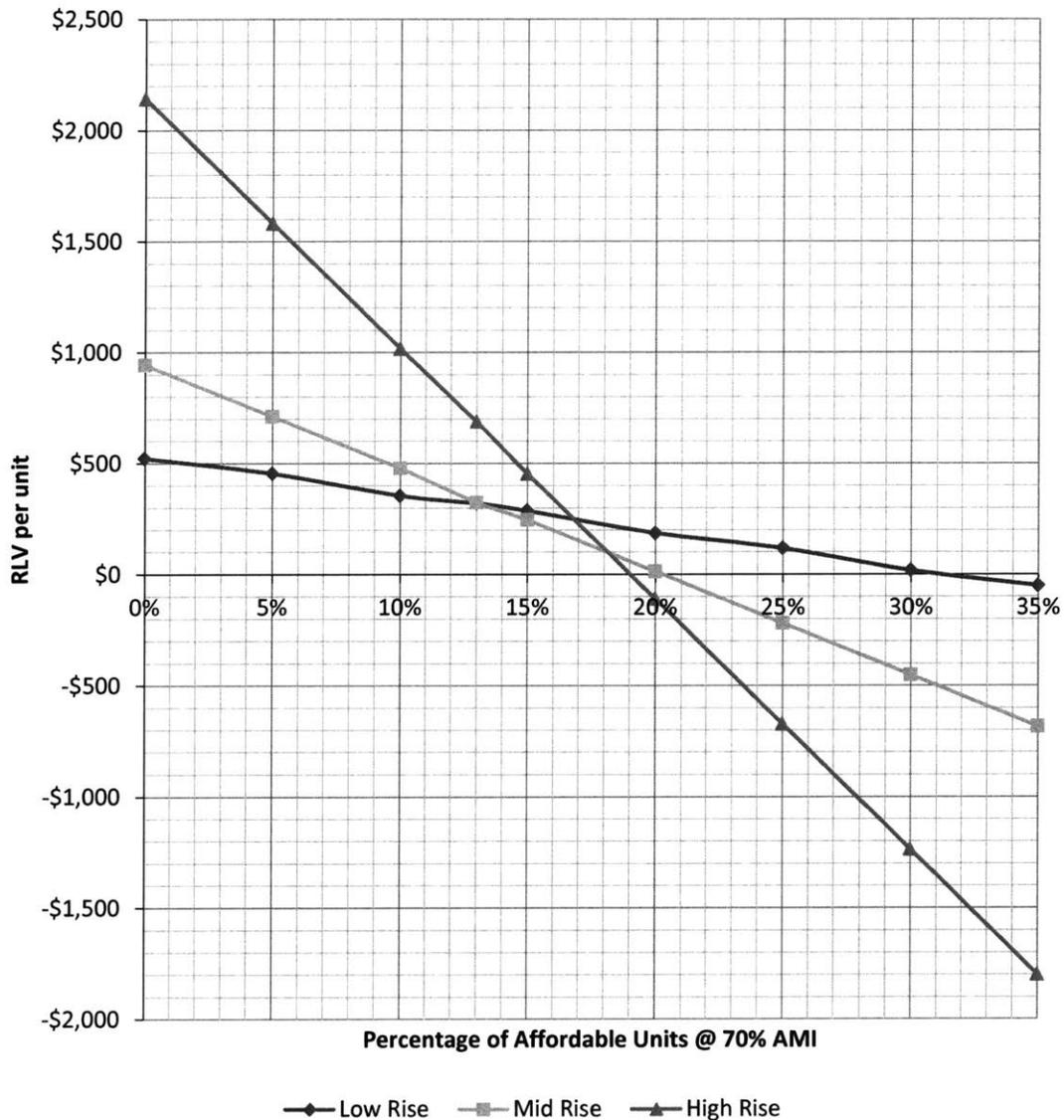
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<sup>4</sup> This test assumes that market rate rents and developer profits are constant.

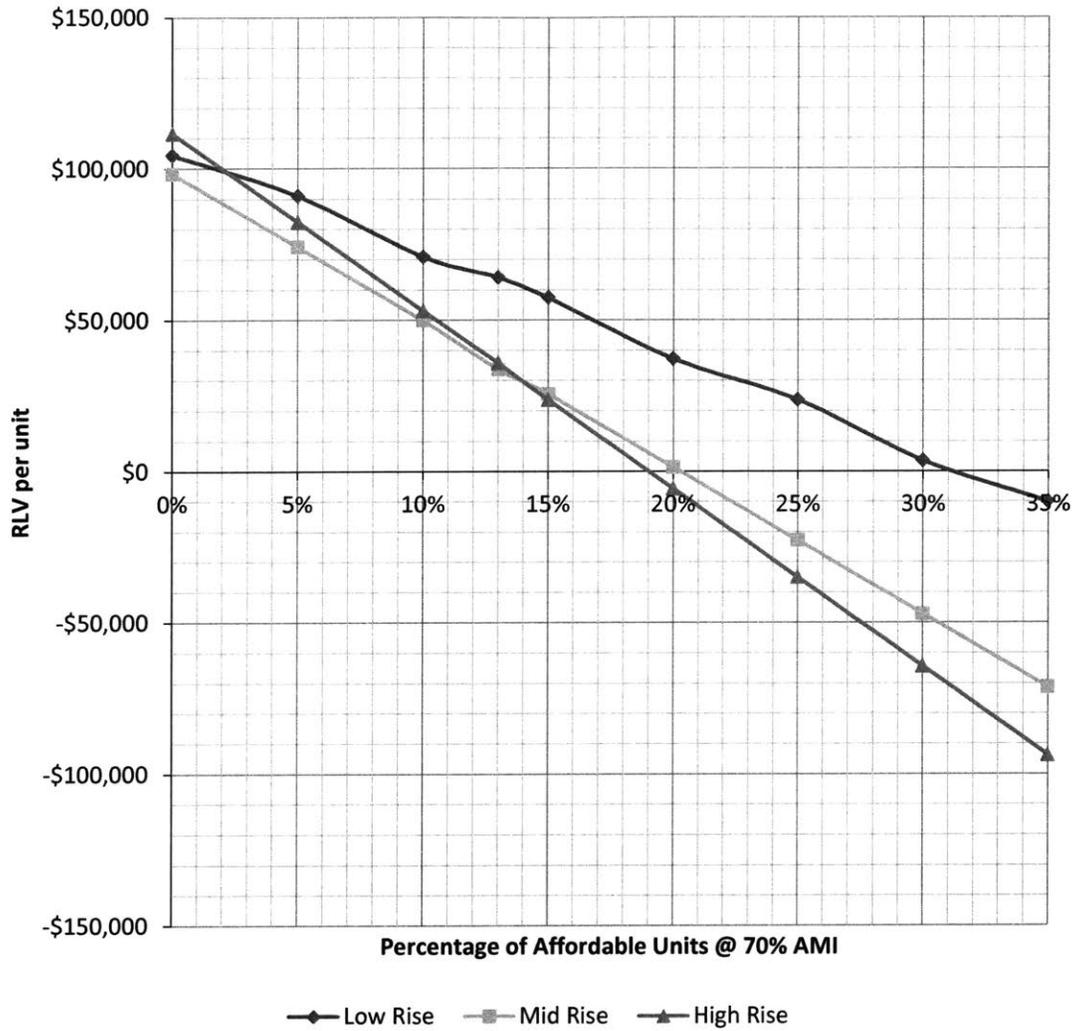
<sup>5</sup> Market value was calculated by capitalizing the net operating income per unit on the basis of going-in cap rate and then deducting the selling costs.

which effectively brings the cost of in-lie fee at 526,000 USD per unit for 13% of the total units. This value is greater than the effective subsidy calculated for the base case scenario for low-rise development, but lower than that for mid-rise and high-rise developments. Thus, it may be more profitable for the developer to pay an in-lieu fee for mid-rise and high-rise developments, than building the on-site affordable units.

**Figure 3.8. RLV per sq.ft. w.r.t. Percent. of on-site Affordable Units for three prototypes**



**Figure 3.9. RLV per unit w.r.t. Percent. of on-site Affordable Units for three prototypes**



## Chapter 04

# Incorporating an Exogenous Inclusionary Zoning Shock in the Wheaton (1999) Stock-Flow Model

In chapter 1, using the DiPasquale and Wheaton (1996) four quadrant model, I had presented how the steady state of housing market for a unique city before an exogenous inclusionary zoning shock (SS1) varies from the steady state after the shock (SS2). In this chapter, I will take the discussion further and investigate the dynamic behavior of the housing from SS1 to SS2. In particular, I will explore how market rate rents, new construction, and household size vary over time. In the following section, I will briefly discuss (a simplified version of) the Wheaton (1999) stock-flow model, and its modifications to include an exogenous shock of inclusionary zoning.

The structure of the Wheaton (1999) stock-flow model is an extension of the four quadrant model, with some of its variables linked across time.<sup>6</sup> The stock-flow framework is based on the following principles: (1) market clears in each period, equating the stock of housing to its demand (vacancy is ignored in the model); (2) the stock of housing adjusts gradually over time with new construction; (3) capital investment decisions regarding new construction are based on a forecast of asset prices at the time of their delivery (Wheaton, 1999; DiPasquale and Wheaton, 1996). In this model there is a single exogenous economic variable whose future is known with certainty. The model assumes that the demand of housing at any given period ( $D_t$ ), is directly proportional to the exogenous economic variable, Total Population ( $PP_t$ ), and responds to the prevailing rents in the market ( $R_t$ ). In every period, the market clears, equating the stock of housing ( $S_t$ ), to its demand ( $D_t$ ).

$$\text{(Eq. 4.1)} \quad S_t = D_t = \alpha_1 \cdot PP_t \cdot [R_t]^{-\beta_1}$$

In the above equation,  $\beta_1$ , refers to the long run price elasticity of demand of rental housing. The stock of housing at a given period is determined by the historical values of the model's variables and is governed by the below equation.

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<sup>6</sup> For a complete understanding of the stock-flow model, kindly refer to Wheaton (1999). While the Wheaton (1999) stock-flow model represents an office market, it is also applicable to a housing market.

$$(Eq. 4.2) \quad S_t = S_{t-1} - \delta \cdot S_{t-1} + C_{t-1}$$

Here  $C_t$ , refers to the new construction starts in a given period, and,  $\delta$ , refers to the depreciation rate of the stock. In the Wheaton (1999) model, new construction  $C_t$ , is delivered  $n$  periods after its begun, with  $n$  being an input into the model which could be varied. In the current model, I have assumed  $n=1$ , which means that it takes one year for the new construction to be delivered and be a part of the stock. The new construction,  $C_t$ , is directly proportional to the future price of the assets at the time of their delivery, which in this case would be,  $P_{t+1}$ , and depends on the long run price elasticity of supply ( $\beta_2$ ) (Eq.4.3). One important departure between the Wheaton (1999) stock-flow model and the current model is that while in Wheaton (1999), the rate of construction of new housing was assumed to be directly proportional to the asset prices; the current model assumes that the absolute amount of new construction is proportional to the asset prices.

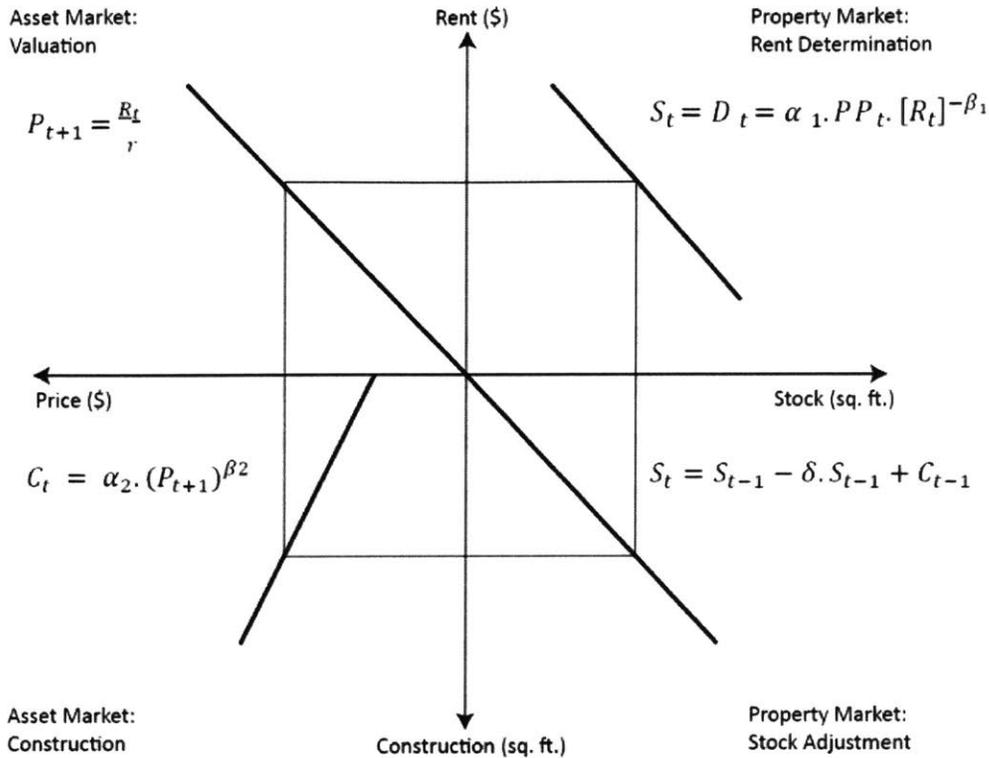
$$(Eq. 4.3) \quad C_t = \alpha_2 \cdot (P_{t+1})^{\beta_2}$$

While the Wheaton (1999) stock-flow model tests for both myopic and rational forecasting of asset prices, this model only assumes myopic price forecasting, which means that the future price of an asset during its delivery is assumed to be a capitalization of the rents at the time of its investment decision. This relationship is given by the following equation:

$$(Eq. 4.4) \quad P_{t+1} = \frac{R_t}{r}$$

In the above equation,  $r$ , refers to the capitalization rate and is assumed to be constant over time. The above set of equations (Eq.4.1 – Eq.4.4) forms the base stock-flow model and can be conceptually understood to represent their respective quadrants in the four quadrant model, as shown in Figure 4.1.

**Figure 4.1. Stock-Flow Model as an Extension of the Four Quadrant Model**



In the above described stock-flow model, an exogenous inclusionary zoning shock is introduced in the following two places: (1) Eq.4.3 which determines the new construction starts (southwest quadrant); and (2) Eq.4.1 which determines the market clearing rents (northeast quadrant). As described in Chapter 01, inclusionary zoning fundamentally divides the housing stock into two stocks, one of market rate units,  $S_{t,m}$ , and the other of income restricted units,  $S_{t,ir}$ . Thus, in order to completely understand the impact of inclusionary zoning on housing markets, we would need to develop two (inter-related) stock-flow models respectively.

In the stock-flow model for market rate units, the new construction starts in a given period after the imposition of inclusionary zoning would depend upon the 'effective' future price of the assets which the developer would expect. I will illustrate this with the help of the following stylized example. Assume an inclusionary zoning policy which requires the developer to set aside 10 percent of the new units as income restricted, with a rent ceiling set at 50 percent of the prevailing market rate rents. Also assume that the developer expects to get a rent of \$1000/month from his new market rate units. Now, for a 100 unit residential development before

inclusionary zoning, the developer would expect a total rent of \$100,000/month. But with inclusionary zoning, he would expect \$90,000/month from his 90 market rate units, and \$5000/month from his 10 income restricted units. Thus, the effective price per unit which the developer would expect from his development would be \$950/month, and not the current market rate rent of \$1000/month. This impact of inclusionary zoning on new construction starts is given by the following equation:

$$(Eq. 4.5) \quad C_t = \alpha_2 \cdot [P_{t+1} \cdot ((1 - \lambda) + \lambda \cdot s)]^{\beta_2}$$

In the above equation,  $\lambda$  refers to the required set aside percentage of income restricted units for new residential developments, while  $s$  represents the fraction of market rate rents which the income restricted households have to pay for these units. In the case of the above stylized example,  $\lambda$  would be equal to 10% and  $s$  would be equal to 0.50. Inclusionary zoning would also affect the demand for market rate housing, as it gradually takes a certain fraction of the population out of the market by providing them income restricted units. Let the population living in income restricted units in a given period be given by  $PP_{bir}$ , then the total population availing market rate units will be  $(PP_t - PP_{bir})$ . After inclusionary zoning is imposed, the market clearing rents will depend on the population availing market rate units and not the total population of the city. This is highlighted by the equation below:

$$(Eq. 4.6) \quad S_{t,m} = D_{t,m} = \alpha_1 \cdot (PP_t - PP_{bir}) \cdot [R_t]^{-\beta_1}$$

In order to arrive at the income restricted population in a given period, I assume that the average household size of the city is equal to the average household size of the income restricted population in every period.

$$(Eq. 4.7) \quad \frac{PP_{t,ir}}{S_{t,ir}} = \frac{PP_t}{(S_{t,ir} + S_{t,m})}$$

The above equation is mathematically equal to,

$$(Eq. 4.8) \quad \frac{PP_{t,m}}{S_{t,m}} = \frac{PP_t}{(S_{t,ir} + S_{t,m})}$$

where,  $PP_{bm}$  is the market rate population. By substituting the value of  $PP_{bir}$ , from Eq.4.7 to Eq.4.6, we get the following equation:

$$(Eq. 4.9) \quad S_{t,m} = D_{t,m} = \alpha_1 \cdot \left( PP_t - \frac{PP_t \cdot S_{t,ir}}{S_{t,ir} + S_{t,m}} \right) \cdot [R_t]^{-\beta_1}$$

Inclusionary zoning will not affect Eq.4.4, which governs the price of the asset based on the prevailing market clearing rent and the assumed capitalization rate. The stock adjustment process for the market rate units will be governed by the below equation.

$$(Eq. 4.10) \quad S_{t,m} = S_{t-1,m} - \delta \cdot S_{t-1,m} + C_{t-1,m}$$

In the above equation,  $C_{t,m}$ , represents the new construction starts of the market rate units, and will be a given percentage  $(1 - \lambda)$  of the total construction starts in a given period.

$$(Eq. 4.11) \quad C_{t,m} = (1 - \lambda)C_t$$

The above set of equations (Eq.4.4 – 4.11) represents the stock-flow model with the incorporation of inclusionary zoning shock, for the market rate units. Next, I will briefly describe the stock flow model for the income restricted units. The construction starts of income restricted units will be a percentage of the total new construction starts, and its stock adjustment process will be similar to Eq.4.10.

$$(Eq. 4.12) \quad C_{t,ir} = \lambda \cdot C_t$$

$$(Eq. 4.13) \quad S_{t,ir} = S_{t-1,ir} - \delta \cdot S_{t-1,ir} + C_{t-1,ir}$$

The rent for the income restricted units is assumed to be a fixed fraction of the market rate rent, and thus, will not be governed by the income restricted population or its occupied stock of housing. This can be represented as a horizontal demand function in the northeast quadrant of the four quadrant model. The stock-flow model for income restricted units can be explained using only the northeast and the southeast quadrants in the four quadrant model. This inter-connected stock-flow model with the incorporation of the inclusionary zoning shock is highlighted using the four quadrant model in Figure 4.2. In the new steady state, I assume that both the stock of market rate, and income restricted units are in equilibrium. This is highlighted by the below equations.

$$(Eq. 4.14) \quad (1 - \lambda) \cdot C_t = \delta \cdot S_{t,m}$$

$$(Eq. 4.15) \quad \lambda \cdot C_t = \delta \cdot S_{t,ir}$$

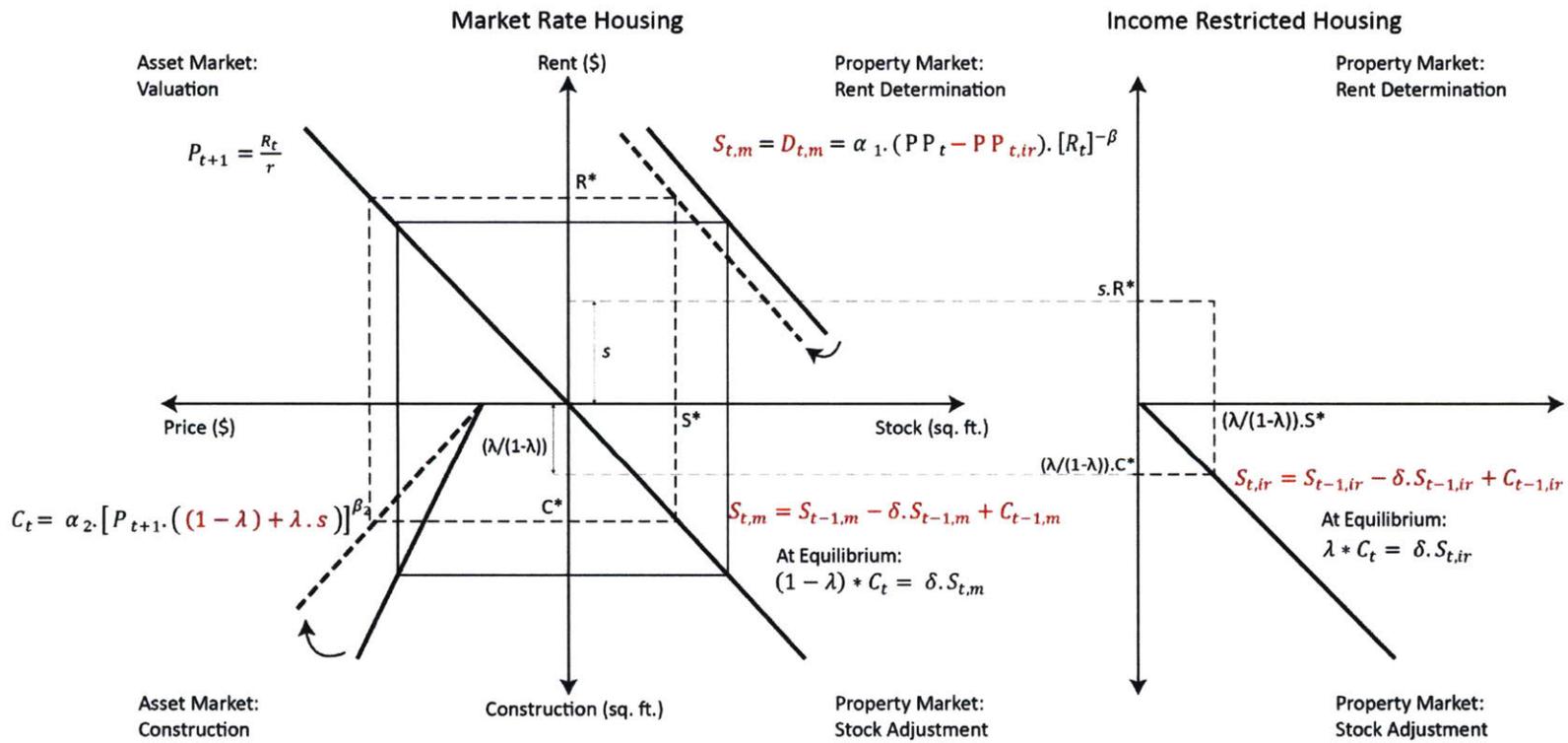


Figure 4.2. Stock-Flow Model Incorporating IZ on the Four Quadrant Model

In the above model,  $\beta_1$ ,  $\beta_2$ , and  $\delta$ , represent the behavioral parameters, while  $\lambda$  and  $s$ , represent the inclusionary zoning parameters respectively. Various analyses were done for plausible values of these parameters to represent different hypothetical housing markets and different inclusionary zoning requirements. Before I present the results of the analyses, I will briefly (re)iterate the major underlying assumptions which are common throughout the study.

**Assumption 01:**

I assume that the inclusionary zoning policy is imposed on the city at the period  $t=0$ , and remains in affect till perpetuity. This policy mandatorily applies to all new residential developments, and requires the developers to set aside a fixed percentage of on-site units ( $\lambda$ ) as income restricted. The income restricted rent in every period is a constant fraction ( $s$ ) of the market rate rents for that period. No developer incentives or cost offsets are provided as a part of the inclusionary zoning policy.

**Assumption 02:**

The affordable units delivered under this policy are income restricted till perpetuity, and inclusionary zoning is the only source of affordable housing production in the city.

**Assumption 03:**

The income restricted units produced are identical to the market rate units, and are assigned to the households through a lottery. The population availing income restricted units in every period is assumed to be out of the market and not compete for the market rate units.

**Assumption 04:**

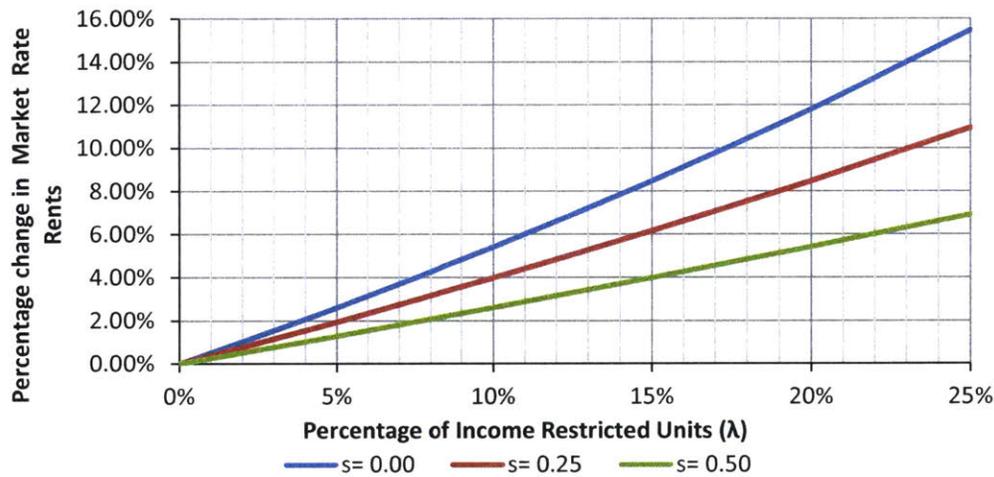
As mentioned earlier, the average household size of the income restricted population is assumed to be the same as the average household size of the total population, in every period. The model also assumes that there is no homelessness in the city. Apart from the above mentioned assumptions, the total population of the city ( $PP_t$ ) is assumed at 200,000 and remains constant unless otherwise stated. The capitalization rate is assumed at 5%. Based on the different behavioral parameters used in the various simulations, the constants  $\alpha_1$  and  $\alpha_2$  were always scaled to yield the same initial steady state stock of 100,000 units and market rate rent of \$4/SF/Month.

**Analysis 01: A Comparative Statics Analysis of varying IZ requirements**

In this analysis, unitary elasticities of demand and supply were assumed ( $\beta_1 = \beta_2 = 1$ ) along with a depreciation rate ( $\delta$ ) of 1%. Steady state values of market rate rent and total stock of housing were studied for the following values of inclusionary zoning parameters-  $\lambda$ : 5%, 10%, 15%, 20%, 25%; and  $s$ : 0.0, 0.25, and 0.50. The results are presented in Figure 4.3 and Figure 4.4.

*Result 01: Every combination of inclusionary zoning parameters resulted in a higher equilibrium rent and a lower total stock of housing at the new steady state. Increasing the value of  $\lambda$ , keeping all else constant, yields higher rents and lower total stock; while increasing the value of  $s$ , keeping all else constant yields lower rents and higher total stock. (Note: This result is valid for all plausible values of the behavioral parameters of the model.)*

**Figure 4.3. Percentage Change in Market Rate Rents ( $\beta_1 = 1, \beta_2 = 1, \delta=1\%$ )**



**Figure 4.4. Percentage Change in Total Stock ( $\beta_1 = 1, \beta_2 = 1, \delta=1\%$ )**

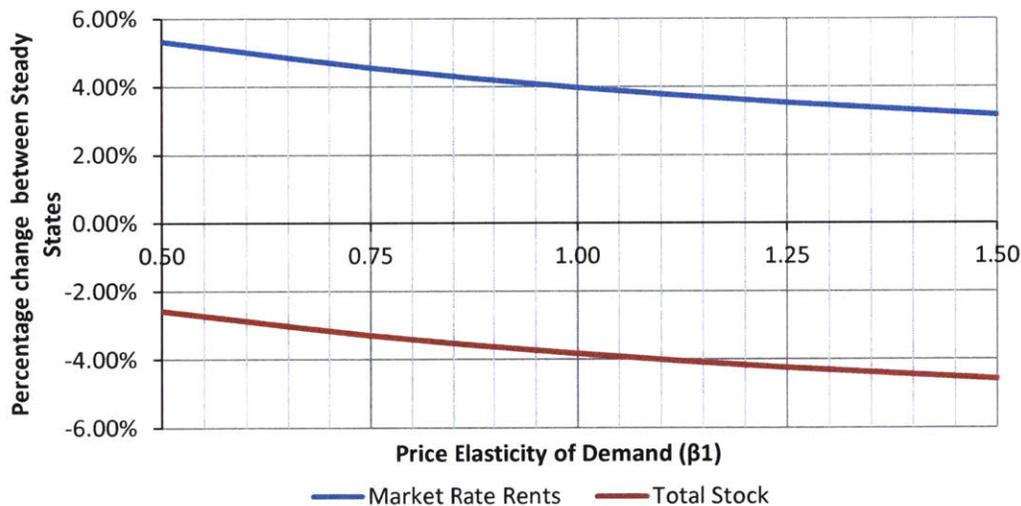


### Analysis 02: A Comparative Statics Analysis of varying Price Elasticity of Demand

In this analysis, inclusionary zoning parameters were kept constant at  $\lambda = 15\%$ , and  $s = 0.50$ . Price elasticity of supply ( $\beta_2$ ) was kept at 1, while the depreciation rate ( $\delta$ ) was assumed at 1%. New steady state outcomes were documented for the following values of price elasticity of demand:  $\beta_1 = 0.5, 0.75, 1.00, 1.25, \text{ and } 1.50$ . The results are presented in Figure 4.5.

*Result 02: Increasing the price elasticity of demand while keeping all else constant, results in a lower increase in the equilibrium rents, while a higher decrease in the total stock of housing (and also new construction starts). Another way to conceptually understand this result is that higher price elasticity of demand will tend to subdue the upward pressure put on market rate rents due to inclusionary zoning, while exaggerate the negative impact of this policy on new construction activity.*

**Figure 4.5. Percentage Change in Market Rents and Total Stock ( $\beta_2 = 1, \delta = 1\%$ )**



### Analysis 03: A Comparative Statics Analysis of varying Price Elasticity of Supply

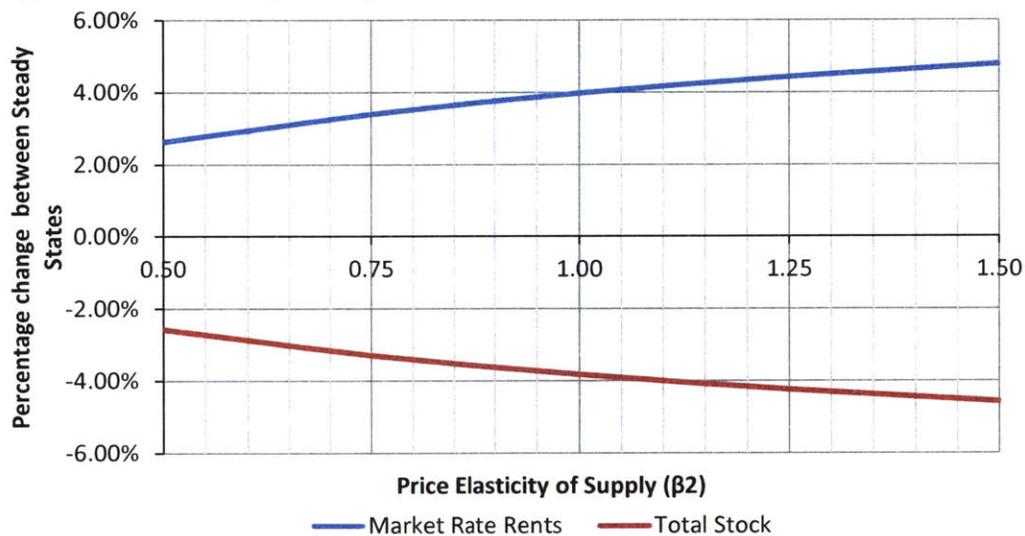
Similar to the previous analysis, inclusionary zoning parameters were kept constant at  $\lambda = 15\%$ , and  $s = 0.50$ . In this case, the price elasticity of demand ( $\beta_1$ ) was kept constant at 1, along with a constant depreciation rate ( $\delta$ ) of 1%. Various steady state outcomes for different values of price elasticity of supply ( $\beta_2$ ) were studied. The results are presented in Figure 4.6.

*Result 03: Increasing the price elasticity of supply while keeping all else constant, results in a higher increase in the equilibrium rents and along with a higher decrease in the total stock of housing (and also new construction starts). Thus, higher price elasticity of supply will tend to*

exaggerate the upward pressure put on market rate rents due to inclusionary zoning, while also exaggerating the negative pressure put on new construction activity.

Result 04: An important conclusion regarding the model which can be drawn from Analysis 02 and 03 is that simultaneously increasing the demand and supply elasticities will tend to cancel their respective impacts on the market rate rents, while amplifying their negative impacts on the new construction activity.

**Figure 4.6. Percentage Change in Market Rents and Total Stock ( $\beta_1 = 1, \delta=1\%$ )**



The above presented comparative statics analyses provide a good understanding of the impact of the behavioral and inclusionary zoning parameters on the final steady state outcomes. Next, I will discuss in detail, the dynamic behavior of the model between the two steady states, for different values of behavioral parameters tested. The inclusionary zoning parameters were kept at  $\lambda = 15\%$ , and  $s = 0.50$ , for the following simulations.

### Simulation 01: When Demand and Supply have Unit Elasticities

The first simulation was conducted for unitary elasticities of demand and supply ( $\beta_1 = \beta_2 = 1$ ) while the depreciation rate ( $\delta$ ) was assumed at 1%. The various impulse response functions are presented in Figure 4.7 - 4.11.

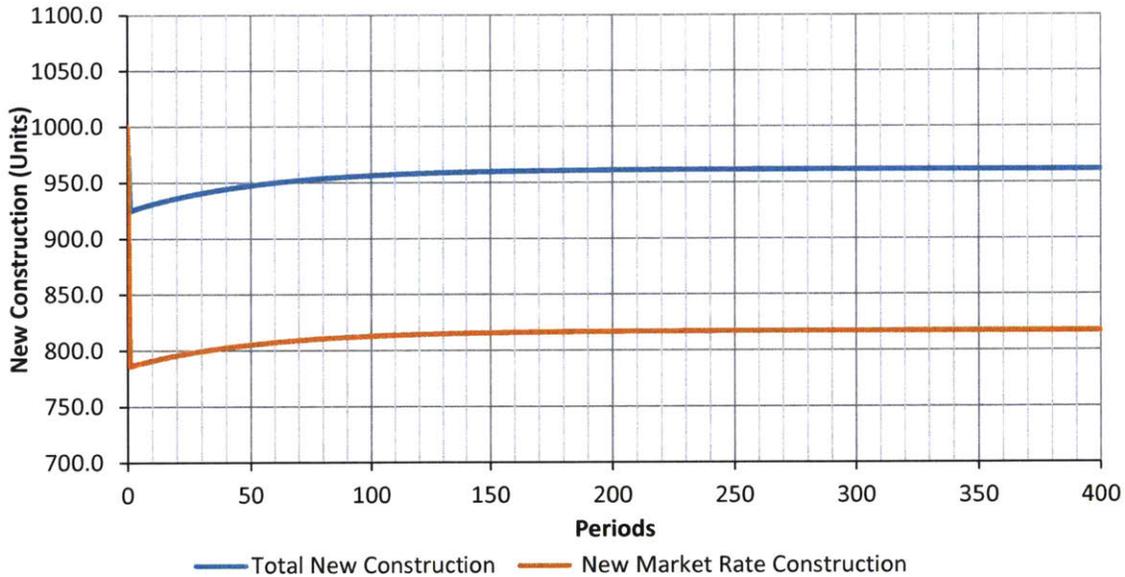
Result 05: Imposition of inclusionary zoning results in a sudden decrease in the new construction activity after which it gradually recovers. New construction activity never fully recovers to the

initial steady state levels. (Note: This behavior of the model is common for all plausible values of demand and supply elasticities).

This behavior can be easily understood by studying the stock-flow equation governing the new construction activity. Due to imposition of inclusionary zoning, there is a sudden drop in the effective rents which the developers can expect from their new properties. This drop will depend on the inclusionary zoning parameters, as highlighted in red in the below equation. Once inclusionary zoning is imposed, the expression in red stays constant (in the current simulation it is equal to 0.925), but  $R_t$  gradually increases, thus resulting in a gradual increase in the total construction activity. (Note: the extents of the sudden fall in construction activity and its gradual rise, will also depend on the price elasticity of supply,  $\beta_2$ ).

$$C_t = \alpha_2 \cdot \left[ \frac{R_t}{r} \cdot ((1 - \lambda) + \lambda \cdot s) \right]^{\beta_2}$$

**Figure 4.7. Behavior of New Construction from SS1 to SS2 ( $\beta_1 = 1, \beta_2 = 1, \delta = 1\%$ )**



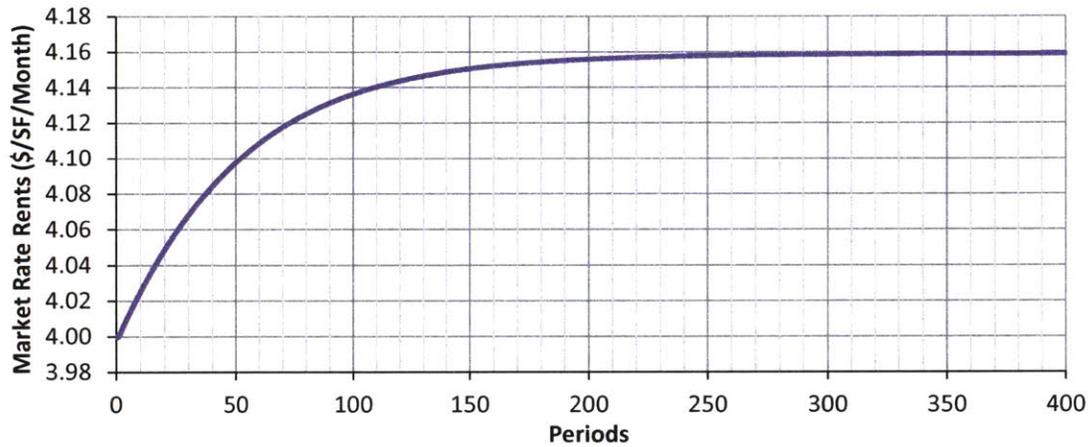
Result 06: Imposition of inclusionary zoning on the model results in a gradual increase in the market rate rents. (Note: This behavior of the model is common for all plausible values of demand and supply elasticities). For the given parameters of the model, the new steady state rent is 4% higher than in the previous steady state.

By rearranging the Eq.4.6 and Eq.4.8 of the stock flow model, we can express the market rate rent,  $R_t$ , as a function of the total population, and the total stock of housing as follows:

$$(4.16) \quad R_t = \left[ \alpha_1 \cdot \left( \frac{PP_t - PP_{t,ir}}{S_{t,m}} \right) \right]^{1/\beta_1} = \left[ \alpha_1 \cdot \left( \frac{PP_{t,m}}{S_{t,m}} \right) \right]^{1/\beta_1} = \left[ \alpha_1 \cdot \left( \frac{PP_t}{S_t} \right) \right]^{1/\beta_1}$$

As we can see from the above equation, that as  $S_t$  and  $R_t$  are inversely proportional, a gradual decline in  $S_t$  results in a gradual increase in  $R_t$ .

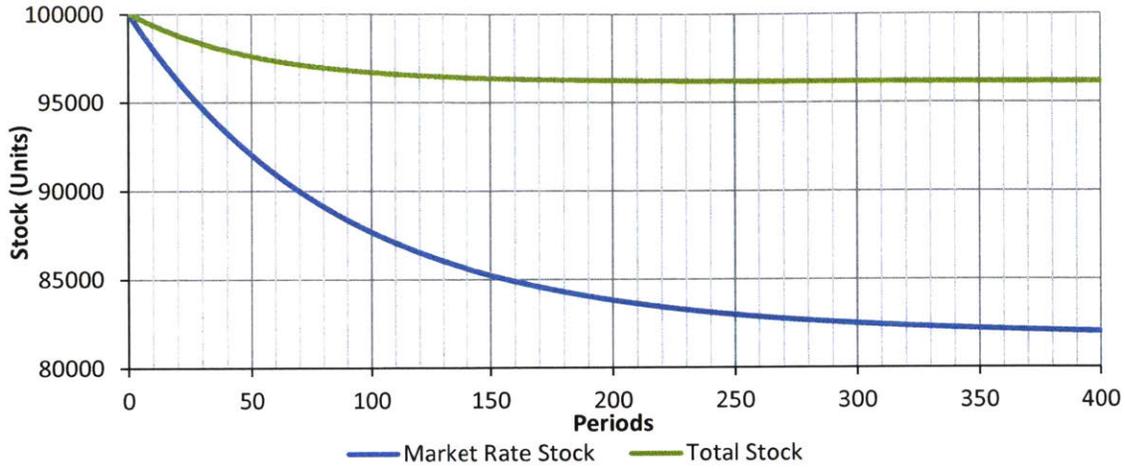
**Figure 4.8. Behavior of Market Rate Rents from SS1 to SS2 ( $\beta_1 = 1, \beta_2 = 1, \delta=1\%$ )**



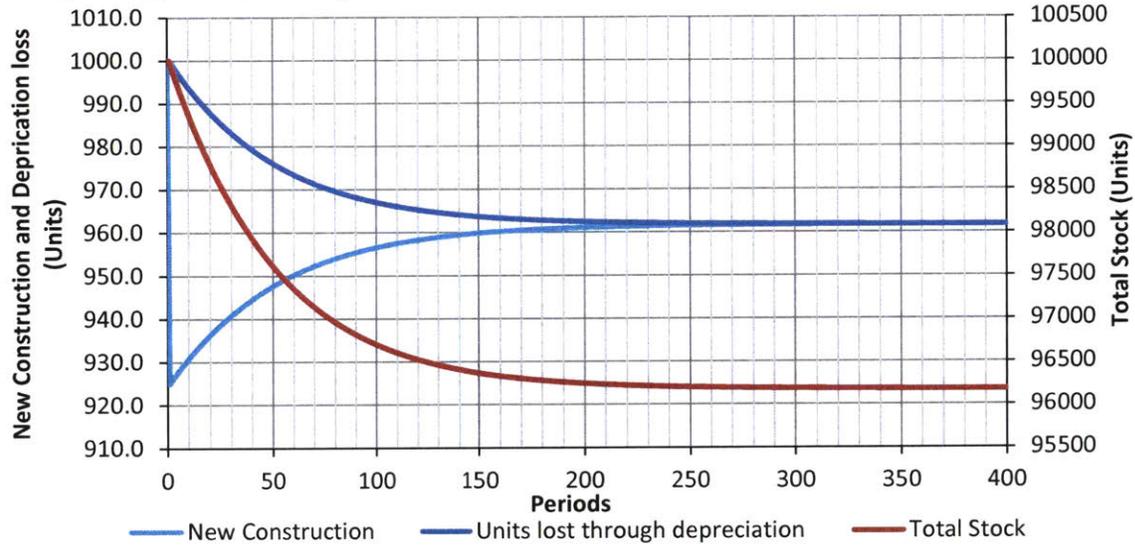
*Result 07: Imposition of inclusionary zoning on the model results in a gradual decline in the total stock of housing. This decline results in a gradual increase in the total average household size of the city. (Note: This behavior of the model is common for all plausible values of demand and supply elasticities).*

Due to the sudden fall in the total new construction just after the imposition of inclusionary zoning, the total stock of housing gradually declines at first, as units lost due to depreciation exceed the total new supply. Gradually, the total supply of new construction increases and matches the amount of units lost through depreciation, which results in the new steady state. This behavior is represented in Figure 4.9 and Figure 4.10. Declining total stock also results in a gradual increase in the average household size of the city as the same total population has to be accommodated in lesser number of units (Figure 4.11).

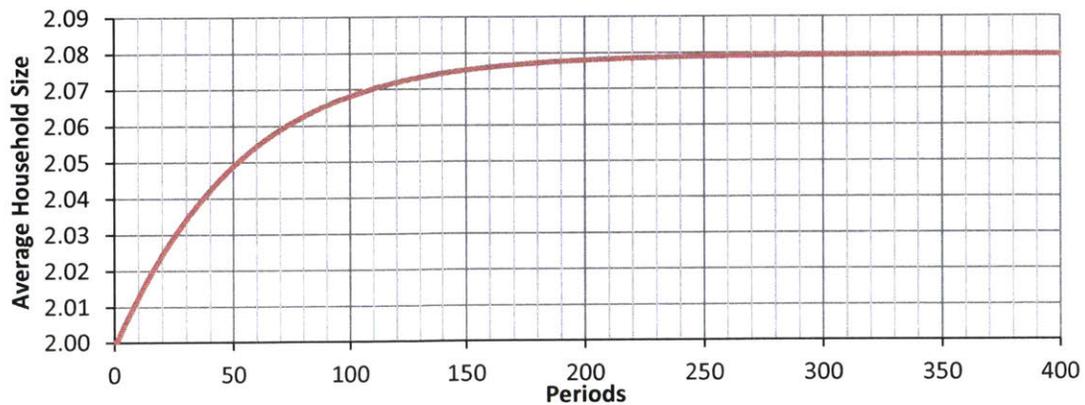
**Figure 4.9. Behavior of Stock of Housing from SS1 to SS2 ( $\beta_1 = 1, \beta_2 = 1, \delta=1\%$ )**



**Figure 4.10. Behavior of New Construction, Depreciation and Total Stock from SS1 to SS2 ( $\beta_1 = 1, \beta_2 = 1, \delta=1\%$ )**



**Figure 4.11. Behavior of Avg. Household Size from SS1 to SS2 ( $\beta_1 = 1, \beta_2 = 1, \delta=1\%$ )**



Next, I will present a framework to understand the benefits accrued, and the burden imposed due to inclusionary zoning. The income restricted households before the imposition of inclusionary zoning were paying market rate rent ( $R_{t=0}$ ). But after the policy is introduced, they pay only a fraction ( $s$ ) of the prevailing market rate rent. The difference between these two rents is the benefit accrued by the income restricted population. And thus, the product of the total income restricted population and this rent differential can be understood as the total tax generated in a given period ( $TGen_t$ ).

$$(4.17) \quad TGen_t = S_{t,ir} \cdot (R_{t=0} - s \cdot R_t)$$

The burden of inclusionary zoning on market rate households falls in the form of higher rents. This burden can be thought of as the tax paid by market rate households ( $THH_t$ ), and is given by the equation below:

$$(4.18) \quad THH_t = S_{t,m} \cdot (R_t - R_{t=0})$$

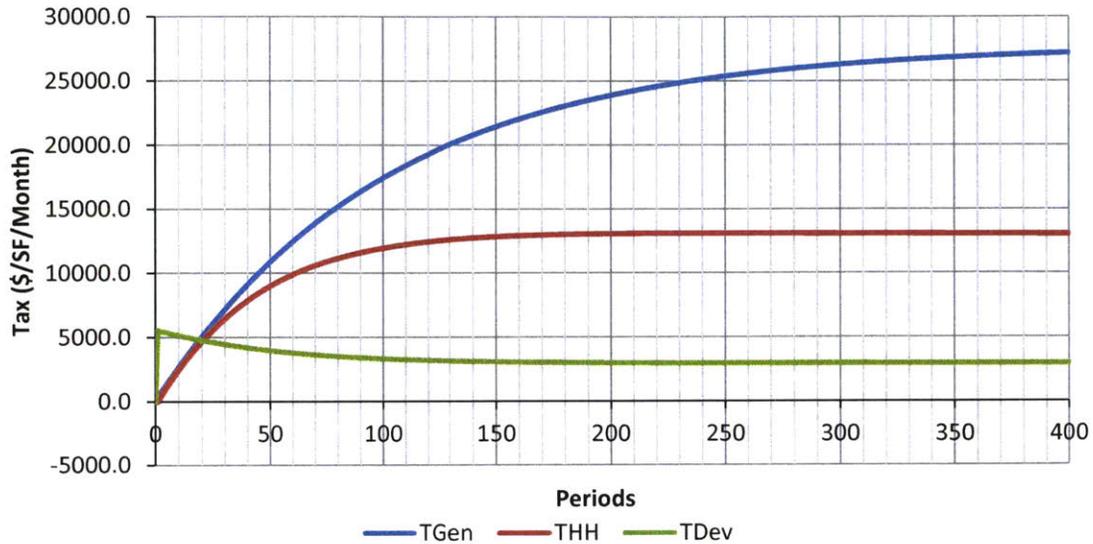
Conceptually,  $(TGen_t - THH_t)$  can be thought of as the total benefit generated due to the imposition of inclusionary zoning. The burden imposed by inclusionary zoning on developers in a given period ( $TDev_t$ ) can be understood as the difference in the market value of the total new construction before the imposition of inclusionary zoning and its effective market value afterwards. This is given by the equation below:

$$(4.19) \quad TDev_t = [P_0 - P_t(1 - \lambda + \lambda \cdot s)] \cdot C_t = \left[ \frac{R_0 - R_t(1 - \lambda + \lambda \cdot s)}{Cap Rate} \right] \cdot C_t$$

The behavior of  $THH_t$  and  $TDev_t$  is presented in Figure 4.12, and brings forward another important result of this study.

*Result 08: The burden of inclusionary zoning on developers involved in new construction is higher in the earlier periods, after which it gradually declines. Whereas the burden on the market rate households gradually increases after the imposition of inclusionary zoning.*

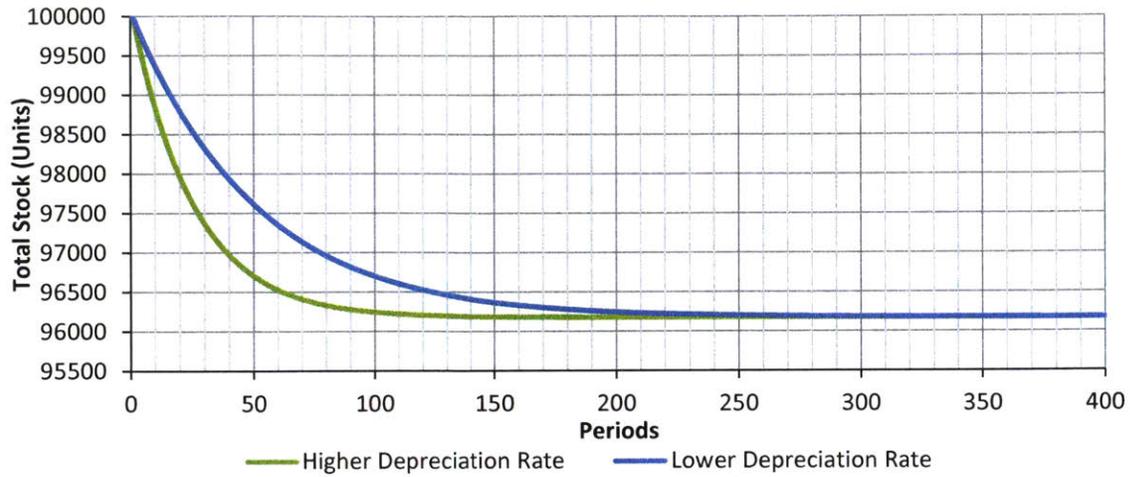
**Figure 412. Behavior of  $TGen_t$ ,  $THH_t$  and  $TDev_t$  from SS1 to SS2 ( $\beta_1=1$ ,  $\beta_2=1$ ,  $\delta=1\%$ )**



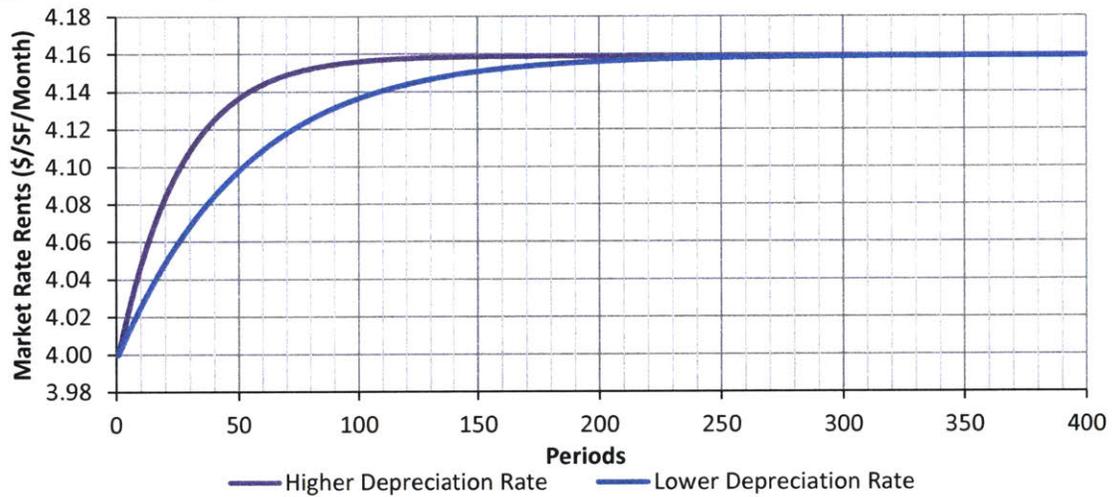
In order to understand the effect of depreciation rate on the behavior of the model,  $\delta$  was increased to 2% from 1%, while other parameters were kept the same. The constants  $\alpha_1$  and  $\alpha_2$  were scaled to give the same initial steady state as before. In this case, while the final steady state outcomes of the model are exactly the same as before, the path taken by the model from SS1 to SS2 is different and is presented in Figure 4.13 – 4.15.

*Result 09: A higher value of depreciation rate while keeping other parameters constant, results in the model to reach its new equilibrium early. Thus, the burden of inclusionary zoning on market rate households (in the initial periods) will be higher in cities with higher depreciation rate as the market rate rents and the household size will tend to increase at a faster rate to reach their equilibrium levels. While the targeted households would be better off as they can be provided income restricted units earlier than in cities with lower depreciation rates.*

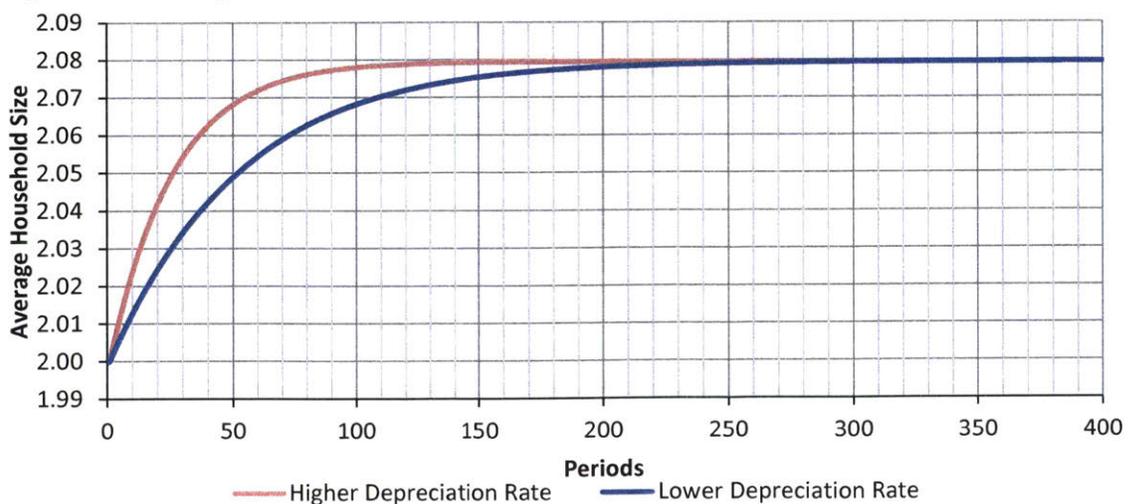
**Figure 4.13. Comparison of the Behavior of Total Stock from SS1 to SS2**



**Figure 4.14. Comparison of the Behavior of Market Rate Rents from SS1 to SS2**



**Figure 4.15. Comparison of the Behavior of Avg. Household Size from SS1 to SS2**

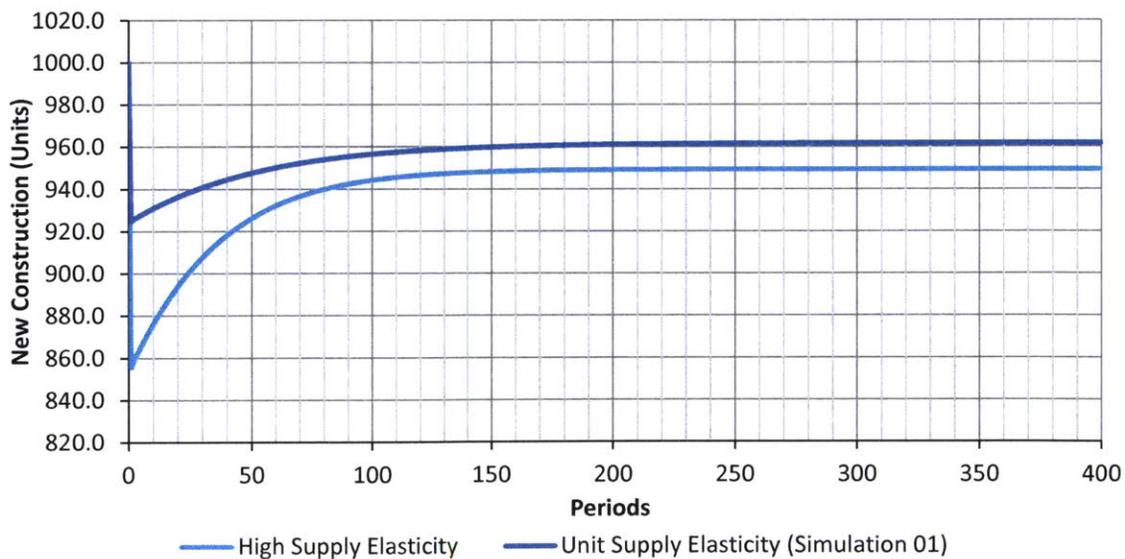


### Simulation 02: When Demand has a unit Elasticity and Supply is Highly Elastic

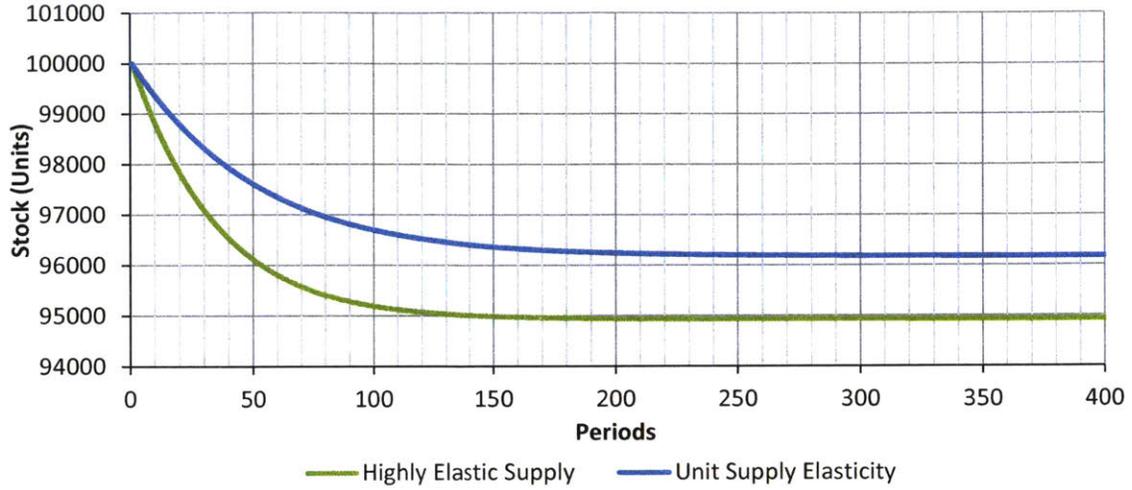
In this simulation, unit elasticity of Demand ( $\beta_1 = 1$ ) was assumed along with a highly elastic supply ( $\beta_2 = 2$ ). The depreciation rate ( $\delta$ ) was kept at 1%. I will present the results of this simulation in conjunction with Simulation 01 results ( $\beta_1 = \beta_2 = 1, \delta = 1\%$ ). This will help illustrate how increasing the supply elasticity while keeping other parameters constant, affects the behavior of the model. As the supply of new construction is more sensitive to the prices, imposition of the inclusionary zoning results in a greater decline in new construction activity in this case. Although the recovery of new construction is faster, it still does not match the new construction level of simulation 01 in any period (Figure 4.16). This results in a faster decline in the total stock, along with a faster increase in the market rate rent and in the average household size of the city. Thus, the result of this simulation can be summarized as follows:

*Result 10: A higher value of supply elasticity while keeping all else constant, results in a faster decline in the total stock of housing, along with a more rapid increase in the market rate rent and the average household size. Thus, imposition of inclusionary zoning in cities with a higher elasticity of supply will put more burden on market rate households as they have to pay a higher rent while getting to consume less housing (higher average household size), when compared to burden imposed on market rate households in cities with lower price elasticity of supply.*

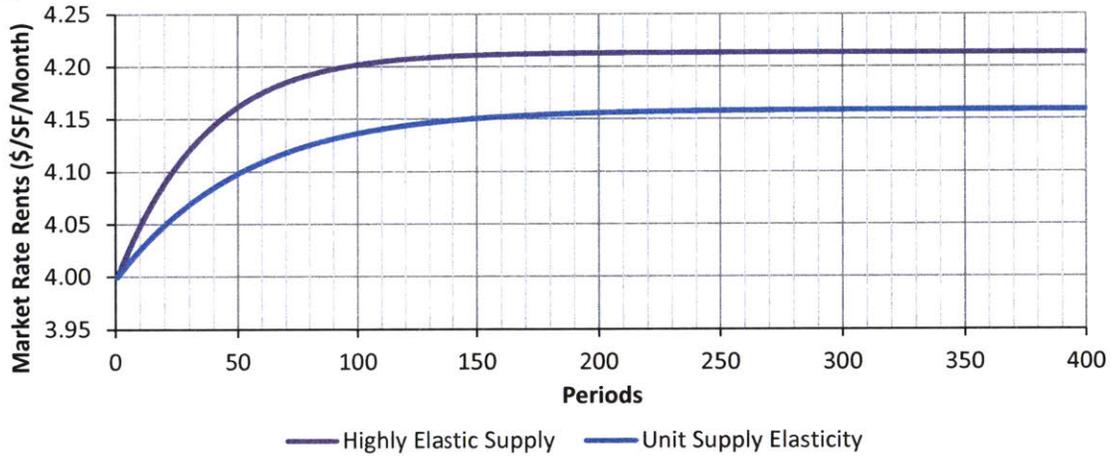
**Figure 4.16. Comparison of the Behavior of New Construction from SS1 to SS2**



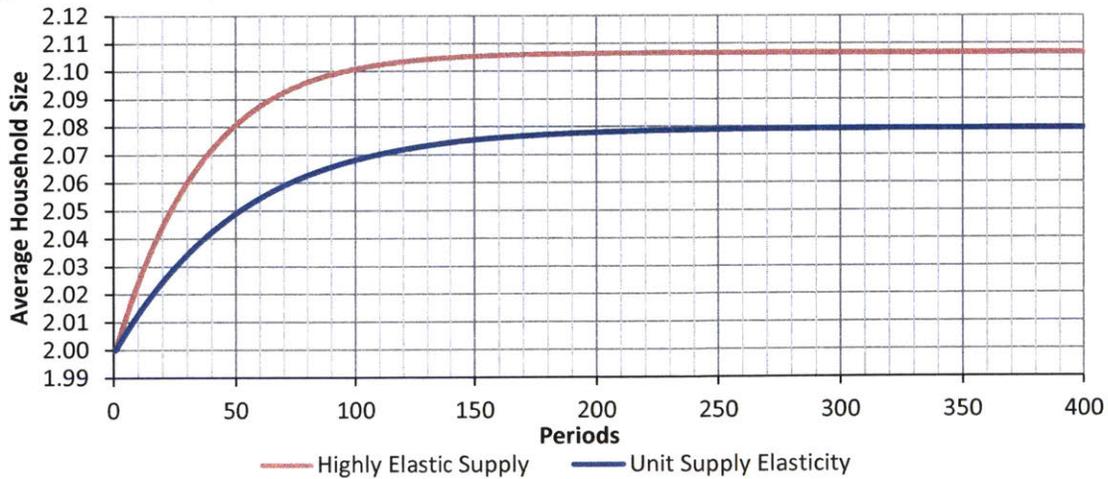
**Figure 4.17. Comparison of the Behavior of Total Stock from SS1 to SS2**



**Figure 4.18. Comparison of the Behavior of Market Rate Rents from SS1 to SS2**



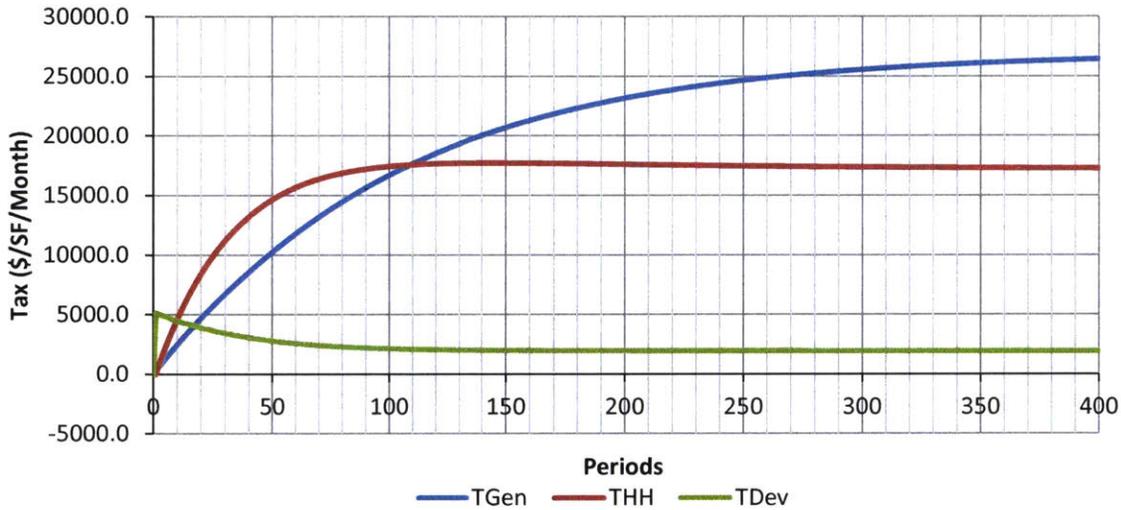
**Figure 4.19. Comparison of the Behavior of Average Household Size from SS1 to SS2**



In the previous simulation I had explained how the total benefit generated due to inclusionary zoning can be understood as the difference in the total tax generated and the total tax paid by market rate households ( $TGen_t - THH_t$ ). Figure 4.20 illustrates that in this case  $THH_t$  exceeds  $TGen_t$  for the first 110 periods of the simulation. This brings forward another important result of the stock-flow analysis:

*Result 11: As the difference between price elasticity of supply, and price elasticity of demand increases, the burden imposed by inclusionary zoning on market rate households will tend to increase, while the benefits accrued to income restricted households will tend to decrease. For certain values of  $\beta_2 - \beta_1$ , the total tax imposed by inclusionary zoning on market rate households might outweigh the total tax generated due to the policy, for the first initial periods after the imposition of inclusionary zoning.*

**Figure 4.20. Behavior of  $TGen_t$ ,  $THH_t$  and  $TDev_t$  from SS1 to SS2 ( $\beta_1=1$ ,  $\beta_2=2$ ,  $\delta=1\%$ )**



**Simulation 03: When Supply has a unit Elasticity and Demand is Highly Elastic**

In this simulation, I assume a unit elasticity of supply ( $\beta_2 = 1$ ) along with a highly elastic demand ( $\beta_1 = 2$ ). The depreciation rate ( $\delta$ ) was kept at 1%. I will present the results of this simulation in conjunction with the Simulation 01 results ( $\beta_1 = \beta_2 = 1$ ,  $\delta = 1\%$ ), to help illustrate how increasing the demand elasticity while keeping other parameters constant, affects the behavior of the model. The initial decrease in the new construction activity in this simulation is exactly the same as in Simulation 01, as the price elasticity of supply is the same in both cases (Figure 4.21). But after the initial negative shock, new construction recovers more gradually than in Simulation 03 as the market rate rents increase at a slower rate due to a higher price elasticity of demand. This

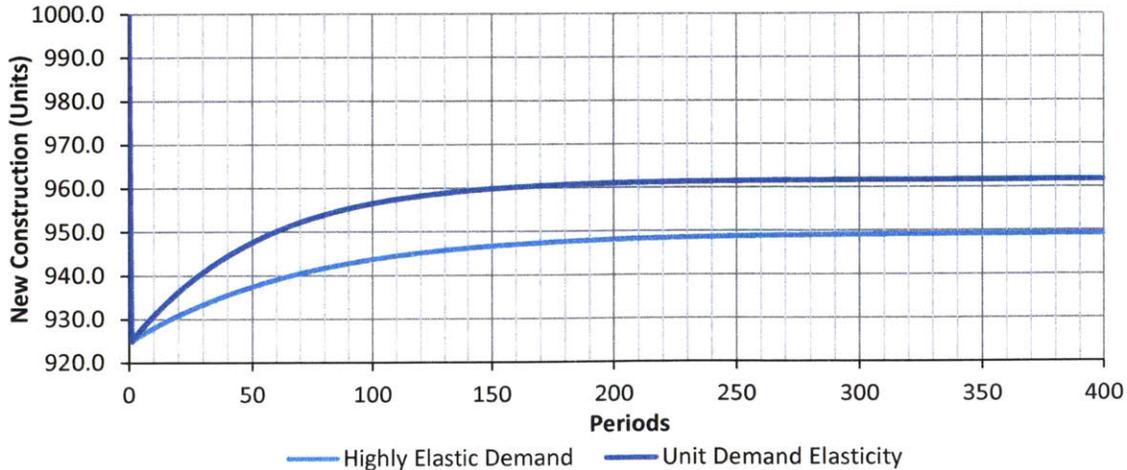
results in a faster decline in the total stock along with a faster rise in the average household size. A higher price elasticity of demand subdues the upward pressure on market rate rents which results in a slower rise in the market rate rents compared to Simulation 01. Thus, it is difficult to gauge whether imposition of inclusionary zoning leaves market rate households worse off compared to in Simulation 01, as they get to consume less housing but are also paying less market rate rents. In this case I use the below metric to compare the overall benefit accrued due to inclusionary zoning between the two simulations.

$$\left( \frac{\sum_{t=1}^{1000} THH_t}{\sum_{t=1}^{1000} TGen_t} \right)$$

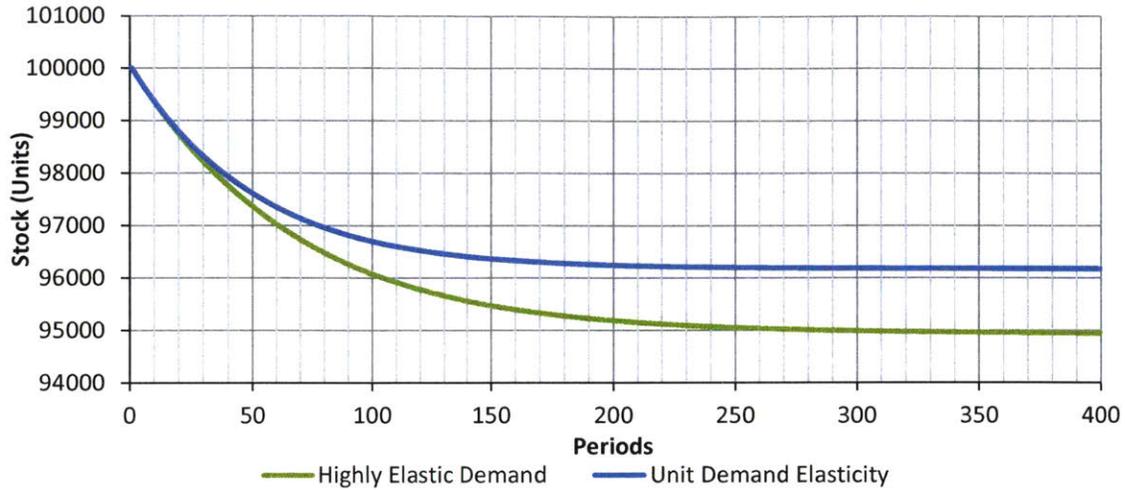
The above metric can be conceptually understood as the fraction of the total tax generated due to this policy that can be attributed to the tax imposed on market rate households. Thus, a lower value of the fraction would indicate a higher overall benefit. The value of this metric in Simulation 03 is 0.32, compared to 0.50 in Simulation 01. Hence, the results of this simulation can be summarized as:

*Result 12: Increasing the price elasticity of demand while keeping all else constant, results in a lower total stock of housing and also lower market rate rents in every period of the simulation. Thus, the burden of this policy on market rate households in cities with higher elasticity of demand, when compared cities with lower price elasticity of demand, is not very clear. If we take  $\sum THH/\sum TGen$  as the metric to compare the overall benefit generated due to this policy, then this policy performs better in cities with higher demand elasticity.*

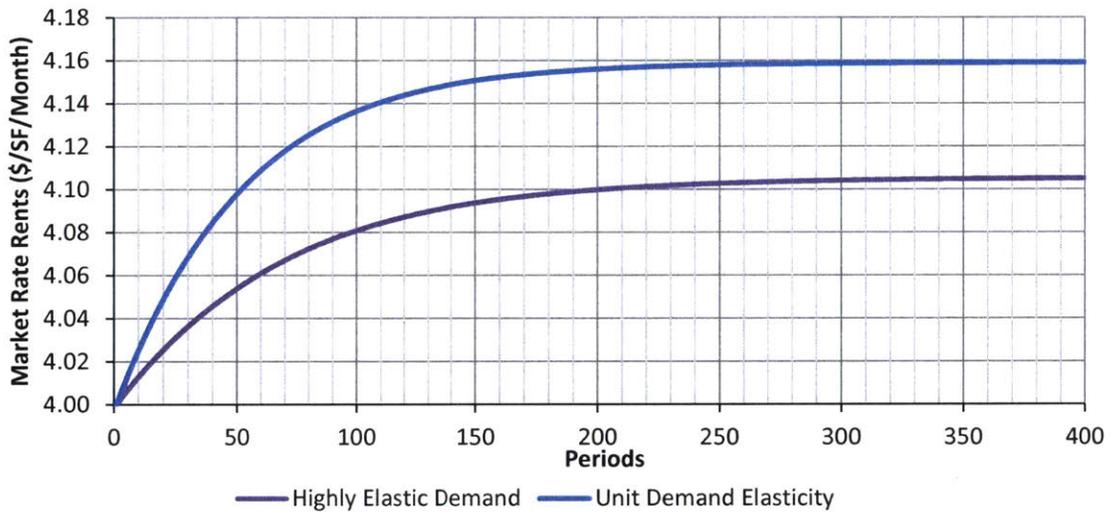
**Figure 4.21. Comparison of the Behavior of New Construction from SS1 to SS2**



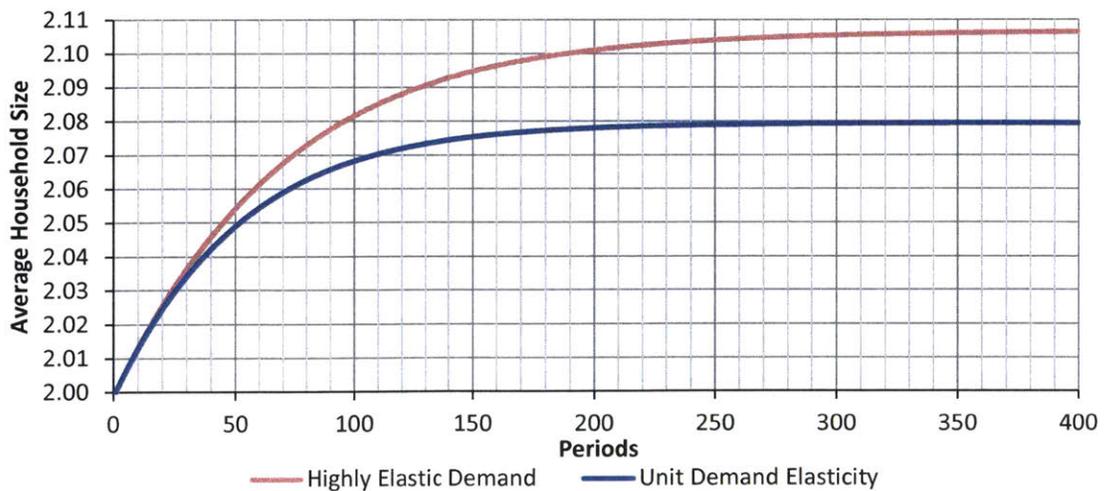
**Figure 4.22. Comparison of the Behavior of Total Stock from SS1 to SS2**



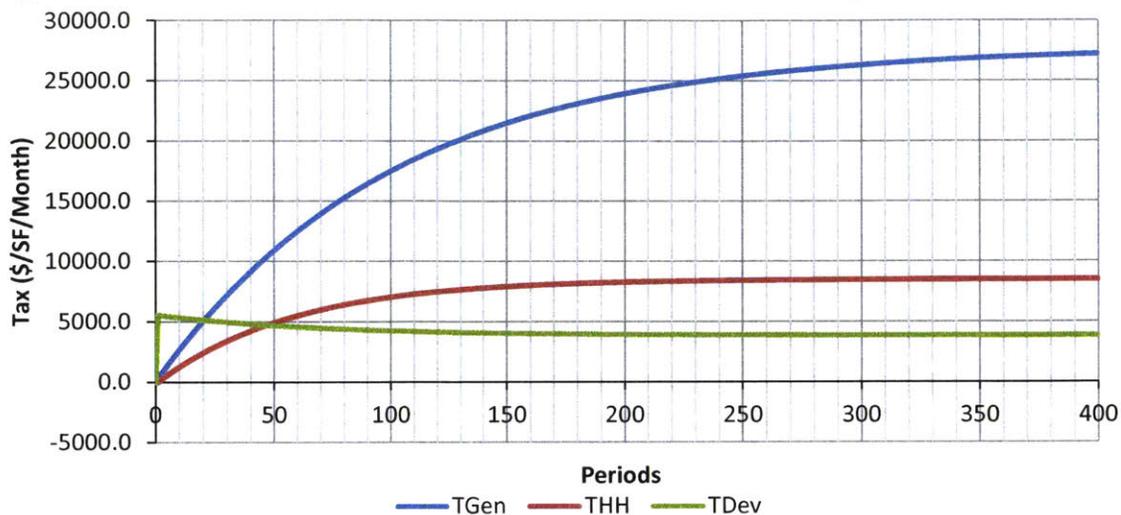
**Figure 4.23. Comparison of the Behavior of Market Rate Rents from SS1 to SS2**



**Figure 4.24. Comparison of the Behavior of Market Rate Rents from SS1 to SS2**



**Figure 4.25. Behavior of  $TGen_t$ ,  $THH_t$  and  $TDev_t$  from SS1 to SS2 ( $\beta_1=2$ ,  $\beta_2=1$ ,  $\delta=1\%$ )**

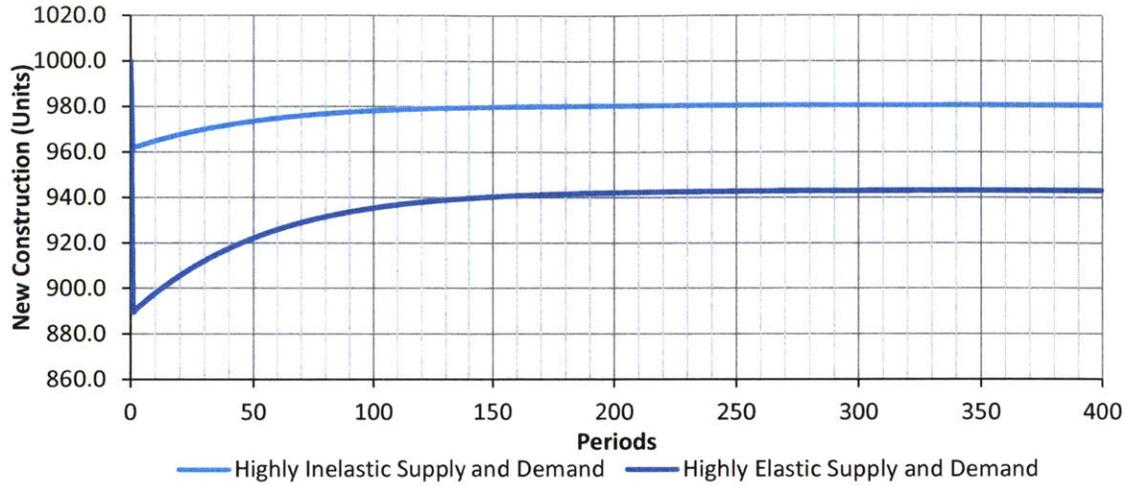


**Simulation 04: Comparing the Dynamic Behavior of the Model for Highly Inelastic Supply and Demand v.s. Highly Elastic Supply and Demand**

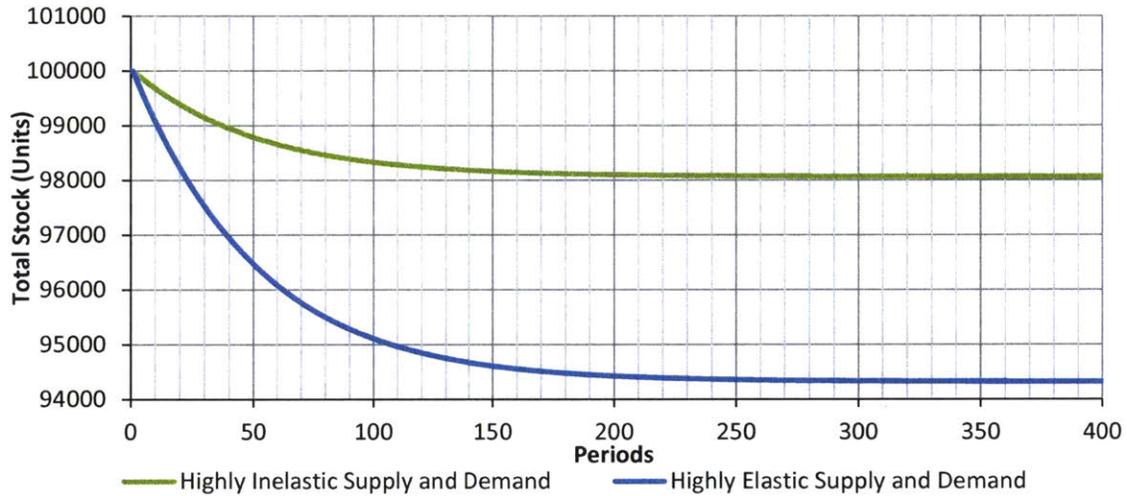
Here, I will compare the behavior of the model after the imposition of inclusionary zoning tax for the following two sets of behavioral parameters: ( $\beta_1 = 0.5$ ,  $\beta_2 = 0.5$ ,  $\delta = 1\%$ ); and ( $\beta_1 = 1.5$ ,  $\beta_2 = 1.5$ ,  $\delta = 1\%$ ). I had mentioned earlier (Result 04) that simultaneously increasing the demand and supply elasticities will tend to cancel their respective impacts on the market rate rents, while amplify their negative impacts on the new construction activity. Thus, in this case the market rate rents follows (almost) the same path in both the cases, while the negative impact of inclusionary zoning on new construction activity is stronger for higher demand and supply elasticities. This results in a faster decline in the total stock of housing along with a more rapid increase in the average household size. Thus, the results of this simulation can be summarized as follows:

*Result 13: Imposition of inclusionary zoning shock will tend to leave market rate households much worse off in cities with higher supply and demand elasticities, compared to in cities with lower supply and demand elasticities. (This simulation assumes that in both the cases supply and demand elasticities are very close to each other).*

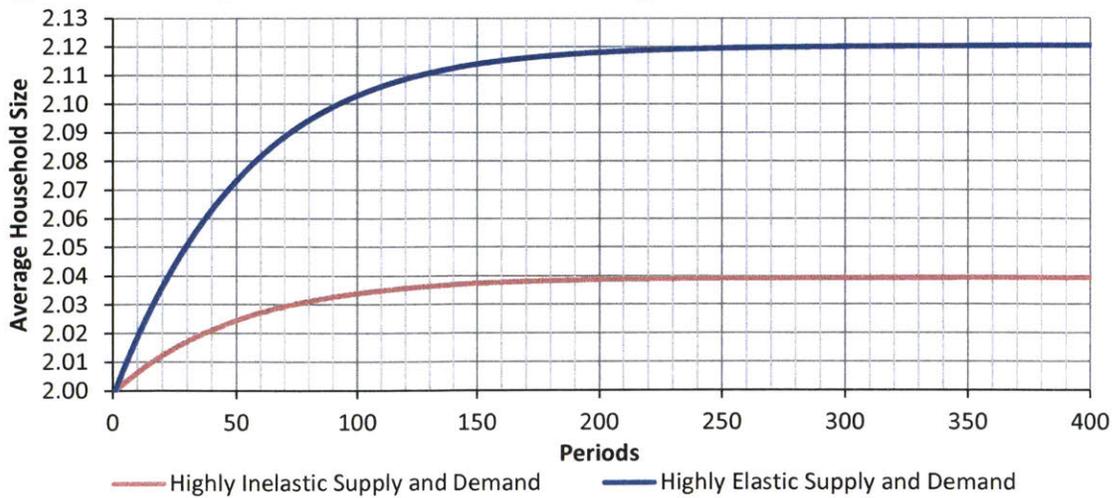
**Figure 4.26. Comparison of the Behavior of New Construction from SS1 to SS2**



**Figure 4.27. Comparison of the Behavior of Total Stock from SS1 to SS2**



**Figure 4.28. Comparison of the Behavior of Average Household Size from SS1 to SS2**



## Chapter 05

# Conclusion

Stock-Flow models of housing can give important insights into the working of housing markets. In this thesis, I develop a specific form of stock-flow model based on Wheaton (1999), to study the theoretical impact of inclusionary zoning on housing markets. To my knowledge, this is the first attempt to explain the economic outcomes of inclusionary zoning via a stock-flow model of housing. The results of the simulations illustrate that the final outcome of this policy can vary vastly depending on the behavioral parameters of the model. The extents of the burden imposed by inclusionary zoning on market-rate households and real estate developers (including landowners) will be different for different housing markets. Similarly, the benefits accrued to income restricted households will vary widely too. In certain cases, the burden imposed by inclusionary zoning might outweigh its benefits. One drawback of such an analysis is that as the model uses specific mathematical forms and parameter values, the results cannot be generalized. But such an analysis gives a more comprehensive illustration regarding the (theoretical) impacts of inclusionary zoning, than the more commonly used partial equilibrium diagrams. More importantly they can be used to understand the dynamic effects on housing markets due to inclusionary zoning, which is not captured by partial equilibrium diagrams.

The above study was supplemented with a residual land value analysis of Boston's current Inclusionary Development Policy. Through this analysis I try to understand the burden imposed by inclusionary zoning on new residential developments in the city. This analysis is very similar to predevelopment feasibility studies which developers conduct before embarking on their residential development. The results indicate that for the current market rate rents, construction costs and expected developer profits, the economic feasibility of high rise and mid-rise developments is very sensitive to the on-site inclusionary zoning requirements. The overarching goal of the thesis was to add to the existing literature on the economics of inclusionary zoning, and to produce material of pedagogical value for students of urban planning and real estate, and also relevant policy makers.

# Appendix

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